GEOS-Chem Reference, Vol. 3: "Core" Modules and Routines

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Contents

1 Routine/Function Prologues

1.1 Fortran: Module Interface GEOS-Chem include files

Here follows a list of include files used by the GEOS-Chem modules and subroutines.

1.1.1 Include File define.h

Include file "define.h" specifies C-preprocessor "switches" that are used to include or exclude certain sections of code.

REMARKS:

```
List of "Switches"
=========================================================================
(1 ) GCAP        : Enables code for GCAP   met fields & chemistry
(2 ) GEOS_3      : Enables code for GEOS-3 met fields & chemistry
(3 ) GEOS_4      : Enables code for GEOS-4 met fields & chemistry
(4 ) GEOS_5      : Enables code for GEOS-5 met fields & chemistry
(5 ) MERRA       : Enables code for MERRA  met fields & chemistry
(6 ) GRIDREDUCED : Enables code for reduced stratosphere grids
(7 ) GRID1x1     : Enables code for 1 x 1    GLOBAL        GRID
(8 ) NESTED_CH   : Enables code for CHINA  NESTED GRID
(9 ) NESTED_NA   : Enables code for N. AM. NESTED GRID
(10) NESTED_EUR  : Enables code for EUROPE NESTED GRID
(11) GRID1x125   : Enables code for 1 x 1.25 GLOBAL        GRID
(12) GRID2x25    : Enables code for 2 x 2.5  GLOBAL        GRID
(13) GRID4x5     : Enables code for 4 x 5    GLOBAL        GRID
(14) IBM_AIX     : Enables code for IBM/AIX compiler
(15) IBM_XLF     : Enables code for IBM/XLF compiler
(16) LINUX_PGI   : Enables code for Linux w/ PGI compiler
(17) LINUX_IFORT : Enables code for Linux v8 or v9 "IFORT" compiler
(18) SPARC       : Enables code for Sun w/ SPARC or Sun Studio compiler
(19) GTMM_Hg     : Enables code for Hg simulation with GTMM
                                                                        .
NOTES:
(1 ) "define.h" is #include'd at the top of CMN_SIZE.  All subroutines
      that normally reference CMN_SIZE will also reference "define.h".
(2 ) Only define the "switches" that are *absolutely* needed for a
      given implementation, as the criteria for code inclusion/exclusion
      is the #if defined() statement.  Undefined "switches" are "off".
(3 ) To turn off a switch, comment that line of code out.
```

REVISION HISTORY:

```
30 Nov 1999 - R. Yantosca - DO_MASSFLUX is obsolete, since the mass flux
                             arrays are now declared allocatable in
                            "diag_mod.f".
12 Apr 2000 - R. Yantosca - Eliminate DO_MASSB switch -- ND63 diagnostic
```

```
                            is now obsolete.
07 Jul 2000 - R. Yantosca - Add GEOS_3 and GRID1x1 switches for future use
03 Oct 2000 - R. Yantosca - Make sure that one of FULLCHEM, SMALLCHEM, or
                            LGEOSCO is turned on.  Also cosmetic changes.
03 Sep 2001 - R. Yantosca - Added new switches "DEC_COMPAQ" and "SGI"
16 Jul 2001 - R. Yantosca - Added new "LINUX" switch\
21 Nov 2001 - R. Yantosca - Added new "GEOS_4" switch for GEOS-4/fvDAS
                            met fields
20 Mar 2002 - R. Yantosca - Now enclose switch names in ' ', since the
                            PGI compiler chokes on barewords
25 Jun 2002 - R. Yantosca - Changed RCS ID tag comment character from "C"
                            to "!" to allow freeform compilation
23 Mar 2003 - R. Yantosca - Removed GEOS_2 switch; added GEOS_4 switch.
                            Also added SPARC switch to invoke Sun/Sparc
                            specific code.
27 Mar 2003 - R. Yantosca - Added IBM_AIX switch
21 Oct 2003 - R. Yantosca - Added INTEL_FC switch
31 Oct 2003 - R. Yantosca - GRID30LEV switch for 30L GEOS-3 or GEOS-4 grid
02 Dec 2003 - R. Yantosca - Renamed cpp switch "LINUX" to "LINUX_PGI".
                            Renamed cpp switch "INTEL_FC" to "LINUX_IFC".
                            Renamed cpp switch "SGI" to "SGI_MIPS".
                            Added cpp switch "LINUX_EFC".
                            Removed cpp switch SMALLCHEM.
22 Mar 2004 - R. Yantosca - Added "A_LLK_03" switch to denote GEOS-4
                            "a_llk_03" met fields.  This will be temporary
                            since "a_llk_03" met fields will be replaced by
                            a newer product.
01 Dec 2004 - R. Yantosca - Added NESTED_NA and NESTED_CH cpp switches.
                            Also add GRID1x125 cpp switch.
23 Jun 2005 - R. Yantosca - Removed obsolete A_LLK_03, LFASTJ, LSLOWJ,
                            FULLCHEM, LGEOSCO switches.  Also added extra
                            switches for GCAP and GEOS_5 met fields.
18 Oct 2005 - R. Yantosca - Added LINUX_IFORT switch to delineate Intel
                            compilers v8 or v9 from v7.
04 Aug 2006 - R. Yantosca - Removed obsolete GEOS_1, GEOS_STRAT, LINUX_IFC,
                            LINUX_EFC switches.
07 Feb 2007 - R. Yantosca - Renamed GRID30LEV to GRIDREDUCED
06 Nov 2008 - R. Yantosca - Added IN_CLOUD_OD flag for reprocessed GEOS-5
                            met.  Added GRID05x0666 flag for GEOS-5 nested
                            grids (cf. yxw, dan, bmy, hyl)
08 Jul 2009 - R. Yantosca - Deleted support for old COMPAQ and SGI_MIPS
                            compilers.  Added switch for IBM XLF compiler.
15 Oct 2009 - R. Yantosca - Remove IN_CLOUD_OD.  Added ProTex headers.
18 Dec 2009 - Aaron van D - Added NESTED_EU C-preprocessor switch
20 Jul 2010 - C. Carouge  - Added GTMM_Hg for mercury simulation.
12 Aug 2010 - R. Yantosca - Added MERRA switch for MERRA reanalysis met
```

1.2 Fortran: Module Interface CMN_SIZE

CMN_SIZE contains size parameters for GEOS-Chem arrays.

INTERFACE:

```
      MODULE CMN_SIZE_MOD
```

USES:

```
      IMPLICIT NONE
      PUBLIC

#     include "define.h"
```

DEFINED PARAMETERS:

```
      !=================================================================
      ! DISIZE = size (in degrees) of a longitude grid box
      ! DJSIZE = size (in degrees) of a latitude  grid box
      !=================================================================
#if   defined( GRID4x5 )
      REAL*8, PARAMETER :: DISIZE = 5.0d0
      REAL*8, PARAMETER :: DJSIZE = 4.0d0
#elif defined( GRID2x25 )
      REAL*8, PARAMETER :: DISIZE = 2.5d0
      REAL*8, PARAMETER :: DJSIZE = 2.0d0
#elif defined( GRID1x125 )
      REAL*8, PARAMETER :: DISIZE = 1.25d0
      REAL*8, PARAMETER :: DJSIZE = 1.0d0
#elif defined( GRID1x1 )
      REAL*8, PARAMETER :: DISIZE = 1.0d0
      REAL*8, PARAMETER :: DJSIZE = 1.0d0
#elif defined( GRID05x0666 )
      REAL*8, PARAMETER :: DISIZE = 2d0/3d0
      REAL*8, PARAMETER :: DJSIZE = 0.5d0
#endif

      !=================================================================
      ! GRID PARAMETERS
      ! IGLOB      = global longitude dimension
      ! JGLOB      = global latitude dimension
      ! LGLOB      = max number of sigma levels
      ! IIPAR      = window longitude dimension
      ! JJPAR      = window latitude dimension
      ! LLPAR      = window vertical dimension
      ! LLTROP     = maximum number of tropospheric levels for variable
      !              tropopause
      ! LLTROP_FIX = number of tropospheric levels for offline simulations
      ! PTOP       = model top pressure (mb)
```

```
      ! Most of the time, GEOS-CHEM is used for global simulations.
      ! In this case, then IIPAR=IGLOB, JJPAR=JGLOB, LLPAR=LGLOB.
      ! For nested grids, then IIPAR<IGLOB, JJPAR<JGLOB, LLPAR<LGLOB.
      !=================================================================
#if   defined( GCAP ) && defined( GRID4x5 )

      !-----------------------------------------------------------------
      ! GCAP: 4 x 5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 72
      INTEGER, PARAMETER :: JGLOB      = 45
      INTEGER, PARAMETER :: LGLOB      = 23
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
      INTEGER, PARAMETER :: LLPAR      = LGLOB
      INTEGER, PARAMETER :: LLTROP     = 12
      INTEGER, PARAMETER :: LLTROP_FIX = LLTROP
      REAL*8,  PARAMETER :: PTOP       = 0.002d0

#elif defined( GEOS_3 ) && defined( GRID4x5 )

      !-----------------------------------------------------------------
      ! GEOS-3: 4 x 5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 72
      INTEGER, PARAMETER :: JGLOB      = 46
      INTEGER, PARAMETER :: LGLOB      = 48
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 30        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP     = 24        !  -- 30 levels
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP     = 25        !  -- 48 levels
#endif
      INTEGER, PARAMETER :: LLTROP_FIX = 20
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_3 ) && defined( GRID2x25 )

      !-----------------------------------------------------------------
      ! GEOS-3: 2 x 2.5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 144
      INTEGER, PARAMETER :: JGLOB      = 91
      INTEGER, PARAMETER :: LGLOB      = 48
      INTEGER, PARAMETER :: IIPAR      = IGLOB
```

```
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 30        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP     = 24        !  -- 30 levels
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP     = 25        !  -- 48 levels
#endif
      INTEGER, PARAMETER :: LLTROP_FIX = 20
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_3 ) && defined( GRID1x1 )

      !-----------------------------------------------------------------
      ! GEOS-3: 1 x 1
      !-----------------------------------------------------------------
#if   defined( NESTED_CH )
      INTEGER, PARAMETER :: IGLOB      = 81        ! CHINA NESTED 1x1
      INTEGER, PARAMETER :: JGLOB      = 67
      INTEGER, PARAMETER :: LGLOB      = 48
#elif defined( NESTED_NA )
      INTEGER, PARAMETER :: IGLOB      = 101       ! N. AMERICA NESTED 1x1
      INTEGER, PARAMETER :: JGLOB      = 51
      INTEGER, PARAMETER :: LGLOB      = 48
#else
      INTEGER, PARAMETER :: IGLOB      = 360       ! GLOBAL GRID 1x1
      INTEGER, PARAMETER :: JGLOB      = 181
      INTEGER, PARAMETER :: LGLOB      = 48

#endif
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 30        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP     = 24        !  -- 30 levels
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP     = 25        !  -- 48 levels
#endif
      INTEGER, PARAMETER :: LLTROP_FIX = 20
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_4 ) && defined( GRID4x5 )

      !-----------------------------------------------------------------
      ! GEOS-4: 4 x 5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 72
```

```
      INTEGER, PARAMETER :: JGLOB      = 46
      INTEGER, PARAMETER :: LGLOB      = 55
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 30        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP     = 22        !  -- 30 levels
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP     = 23        !  -- 55 levels
#endif
      INTEGER, PARAMETER :: LLTROP_FIX = 17
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_4 ) && defined( GRID2x25 )

      !-----------------------------------------------------------------
      ! GEOS-4: 2 x 2.5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 144
      INTEGER, PARAMETER :: JGLOB      = 91
      INTEGER, PARAMETER :: LGLOB      = 55
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 30        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP     = 22        !  -- 30 levels
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP     = 23        !  -- 55 levels
#endif
      INTEGER, PARAMETER :: LLTROP_FIX = 17
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_4 ) && defined( GRID1x125 )

      !-----------------------------------------------------------------
      ! GEOS-4: 1 x 1.2.5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 288
      INTEGER, PARAMETER :: JGLOB      = 181
      INTEGER, PARAMETER :: LGLOB      = 55
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 30        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP     = 22        !  -- 30 levels
#else
```

```
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP     = 23        !  -- 55 levels
#endif
      INTEGER, PARAMETER :: LLTROP_FIX = 17
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_5 ) && defined( GRID4x5 )

      !-----------------------------------------------------------------
      ! GEOS-5: 4 x 5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 72
      INTEGER, PARAMETER :: JGLOB      = 46
      INTEGER, PARAMETER :: LGLOB      = 72
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 47        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 38        !  -- 47 levels
      INTEGER, PARAMETER :: LLTROP     = 38
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 40        !  -- 72 levels
      INTEGER, PARAMETER :: LLTROP     = 40
#endif
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_5 ) && defined( GRID2x25 )

      !-----------------------------------------------------------------
      ! GEOS-5: 2 x 2.5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 144
      INTEGER, PARAMETER :: JGLOB      = 91
      INTEGER, PARAMETER :: LGLOB      = 72
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 47        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 38        !  -- 47 levels
      INTEGER, PARAMETER :: LLTROP     = 38
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 40        !  -- 72 levels
      INTEGER, PARAMETER :: LLTROP     = 40
#endif
      REAL*8,  PARAMETER :: PTOP       = 0.01d0
```

```
#elif defined( GEOS_5 ) && defined( GRID1x125 )

      !-----------------------------------------------------------------
      ! GEOS-5: 1 x 1.25
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 288
      INTEGER, PARAMETER :: JGLOB      = 181
      INTEGER, PARAMETER :: LGLOB      = 72
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 47        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 38        !  -- 47 levels
      INTEGER, PARAMETER :: LLTROP     = 38
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 40        !  -- 72 levels
      INTEGER, PARAMETER :: LLTROP     = 40
#endif
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( GEOS_5 ) && defined( GRID05x0666 )

      !-----------------------------------------------------------------
      ! GEOS-5: 0.5 x 0.666
      !-----------------------------------------------------------------
#if   defined( NESTED_CH )
      INTEGER, PARAMETER :: IGLOB      = 121       ! NESTED CHINA   0.5x0.666
      INTEGER, PARAMETER :: JGLOB      = 133
      INTEGER, PARAMETER :: LGLOB      = 72
#elif defined( NESTED_NA )
      INTEGER, PARAMETER :: IGLOB      = 151       ! NESTED N.AMER. 0.5x0.666
      INTEGER, PARAMETER :: JGLOB      = 121
      INTEGER, PARAMETER :: LGLOB      = 72
#elif defined( NESTED_EU )
      INTEGER, PARAMETER :: IGLOB      = 121       ! NESTED EUROPE  0.5x0.666
      INTEGER, PARAMETER :: JGLOB      = 81
      INTEGER, PARAMETER :: LGLOB      = 72
#endif
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 47        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 38        !  -- 47 levels
      INTEGER, PARAMETER :: LLTROP     = 38
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 40        !  -- 72 levels
```

```
      INTEGER, PARAMETER :: LLTROP     = 40
#endif
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( MERRA ) && defined( GRID4x5 )

      !-----------------------------------------------------------------
      ! MERRA: 4 x 5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 72
      INTEGER, PARAMETER :: JGLOB      = 46
      INTEGER, PARAMETER :: LGLOB      = 72
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 47        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 38        !  -- 47 levels
      INTEGER, PARAMETER :: LLTROP     = 38
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 40        !  -- 72 levels
      INTEGER, PARAMETER :: LLTROP     = 40
#endif
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#elif defined( MERRA ) && defined( GRID2x25 )

      !-----------------------------------------------------------------
      ! MERRA: 2 x 2.5
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: IGLOB      = 144
      INTEGER, PARAMETER :: JGLOB      = 91
      INTEGER, PARAMETER :: LGLOB      = 72
      INTEGER, PARAMETER :: IIPAR      = IGLOB
      INTEGER, PARAMETER :: JJPAR      = JGLOB
#if   defined( GRIDREDUCED )
      INTEGER, PARAMETER :: LLPAR      = 47        ! Reduced vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 38        !  -- 47 levels
      INTEGER, PARAMETER :: LLTROP     = 38
#else
      INTEGER, PARAMETER :: LLPAR      = LGLOB     ! Full vertical grid
      INTEGER, PARAMETER :: LLTROP_FIX = 40        !  -- 72 levels
      INTEGER, PARAMETER :: LLTROP     = 40
#endif
      REAL*8,  PARAMETER :: PTOP       = 0.01d0

#endif
```

```
      !-----------------------------------------------------------------
      ! For GEOS 1x1 files
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: I1x1       = 360
      INTEGER, PARAMETER :: J1x1       = 181

      !-----------------------------------------------------------------
      ! For GEOS 05x0666 files
      !-----------------------------------------------------------------
      INTEGER, PARAMETER :: I05x0666   = 540
      INTEGER, PARAMETER :: J05x0666   = 361

      !=================================================================
      ! TRACER & EMISSION SPECIES PARAMETERS
      ! NNPAR   = max number of tracers
      ! NEMPARA = max number of anthropogenic emission species
      ! NEMPARB = max number of biogenic      emission species
      !=================================================================
      ! increase NNPAR and NEMPARA an extra amount (hotp 7/31/09)
#if   defined( TOMAS )
      INTEGER, PARAMETER :: NNPAR   = 320   ! For TOMAS (win, bmy, 1/25/10)
#elif defined( APM )
      INTEGER, PARAMETER :: NNPAR   = 154   ! For APM (G. Luo, 3/8/11)
#else
      ! increase NNPAR to 100 (FP 8/2009)
      INTEGER, PARAMETER :: NNPAR   = 75    ! For non-TOMAS simulations
      !INTEGER, PARAMETER :: NNPAR   = 100
#endif

      ! Nempara increased to 26. (fp, 2/8/10)
      ! new emissions HNO3 and O3 (phs)
      !  Add non-biogenic emission species:
      !  BENZ, TOLU, XYLE, C2H2, C2H4, GLYX, MGLY, GLYC, HAC. (tmf, 1/7/09)
      !INTEGER, PARAMETER :: NEMPARA = 21
      !  Add RCHO, HCOOH, ACTA
      !INTEGER, PARAMETER :: NEMPARA = 26
      INTEGER, PARAMETER :: NEMPARA = 29

      ! Add biogenic emissions: MBO, MONX. (tmf, 1/7/09)
       INTEGER, PARAMETER :: NEMPARB = 3
      INTEGER, PARAMETER :: NEMPARB = 17

      !=================================================================
      ! OTHER PARAMETERS
      !=================================================================

      ! NVEGTYPE - Maximum number of surface types: 74 olson
      ! NTYPE    - Maximum number of veg types in a CTM grid box
```

```
      ! NPOLY    - Number of coefficients for polynomial fits
      INTEGER, PARAMETER :: NVEGTYPE = 74
      INTEGER, PARAMETER :: NTYPE    = 15
      INTEGER, PARAMETER :: NPOLY    = 20

      ! NNSTA = max number of time series stations (in inptr.ctm)
      INTEGER, PARAMETER :: NNSTA = 800

      ! MAXIJ - Maximum number of 1st level grid boxes
      INTEGER, PARAMETER :: MAXIJ = IIPAR * JJPAR

      ! LLCONVM - Max number of layers for convection
      INTEGER, PARAMETER :: LLCONVM = LLPAR - 1

      ! NOXLEVELS = Number of levels of anthro NOx emission
      !             (e.g. surface and 100m)
      ! NOXEXTENT = Highest sigma level that receives anthro NOx emission
      INTEGER, PARAMETER :: NOXLEVELS = 2
      INTEGER, PARAMETER :: NOXEXTENT = 2

      ! MAXFAM -- Max number of families for prod and loss output
      INTEGER, PARAMETER :: MAXFAM = 40

      ! MAXMEM is maximum number of families of prod and loss
      ! moved from input_mod and diag_pl_mod to here (hotp 7/31/09)
      ! MAXMEM also increased from 10 to 20 by FP
      INTEGER, PARAMETER :: MAXMEM = 20

      ! MAXPL increased from 100 to 500 and moved from diag_pl_mod
      ! to here by FP (hotp 7/31/09)
      INTEGER, PARAMETER :: MAXPL = 500


      ! NDUST -- Number of FAST-J aerosol size bins (rvm, bmy, 11/15/01)
      INTEGER, PARAMETER :: NDUST = 7

      ! NAER -- number of other aerosol categories (rvm, bmy, 2/27/02)
      INTEGER, PARAMETER :: NAER = 5

      ! NRH -- number of relative humidity bins (rvm, bmy, 2/27/02)
      INTEGER, PARAMETER :: NRH = 5

      !NBIOMAX -- biomass burning
      ! increase NBIOMAX to 20 (hotp 7/31/09)
      ! increase NBIOMAX to 24 for dicarbonyls (ccc, 2/02/10)
      INTEGER, PARAMETER :: NBIOMAX = 24

#if   defined( TOMAS )
```

```
      ! NDSTBIN -- redimensioned for TOMAS (dwest, bmy, 2/1/10)
      INTEGER, PARAMETER :: NDSTBIN   = 30

      ! Number of TOMAS bins
      INTEGER, PARAMETER :: TOMASBIN  = 30
      INTEGER, PARAMETER :: TOMASSPEC = 8

#else

      ! NDSTBIN -- number of dust size bins for transport (tdf, bmy, 3/31/04)
      INTEGER, PARAMETER :: NDSTBIN   = 4

#endif
```

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: THIS WAS MADE INTO A MODULE IN ORDER TO REMOVE COMMON BLOCKS  %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

REVISION HISTORY:

```
(1 ) Now set LLTROP = 20 for GEOS-3 (bmy, 4/12/01)
(2 ) Eliminated obsolete commented-out code (bmy, 4/20/01)
(3 ) Now set MAXFAM = 12 for more P-L families (bmy, 6/28/01)
(4 ) Comment out {IJL}GCMPAR -- these are obosolete (bmy, 9/24/01)
(5 ) Also set LLPAR = 30 for GEOS-3, will regrid online (bmy, 9/24/01)
(6 ) Removed obsolete code from 9/01 (bmy, 10/23/01)
(7 ) Removed NAIR, LAIREMS, these are now defined
      in "aircraft_nox_mod.f" (bmy, 2/14/02)
(8 ) Eliminated commented-out code from 2/14/02.  Also added NAER
      and NRH parameters for aerosols. (rvm, bmy, 2/27/02)
(9 ) Removed IM, JM, IMX, JMX to avoid namespace pollution.  This
      is needed to get the new TPCORE to work.  Also changed RCS
      ID tag comment character from "C" to "!" to allow freeform
      compilation. (bmy, 6/25/02)
(10) Removed obsolete code from 6/02 (bmy, 8/26/02)
(11) Added NUMDEP_SULF in a common block for sulfate dry deposition.
      Also set MAXDEP=31 and NNPAR=31 for coupled fullchem/sulfate
      simulations. (rjp, bdf, bmy, 11/15/02)
(12) Removed I0, J0; these are now superseded by "grid_mod.f"
      (bmy, 2/11/03)
(13) Added parameters for GEOS-4 (bmy, 6/18/03)
(14) Now defines both 55 level and 30 level GEOS-4 grids.  Also
      define LLTROP=19 for GEOS-4 grids.  Also remove obsolete
      GEOS-2 grid declarations. (bmy, 10/31/03)
(15) LLTROP should be 17 for GEOS-4...based on the ND55 diagnostic
      when computed for 2003 met fields (bmy, 2/18/04)
```

```
(16) Increase NNPAR from 31 to 39 for carbon & dust tracers.  Also
     declare NDSTBIN as # of dust bins. (rvm, tdf, bmy, 4/1/04)
(17) Increase NNPAR to 41 for seasalt tracers (rjp, bec, bmy, 4/20/04)
(18) Increase NNPAR to 50 for SOA tracers (rjp, bmy, 7/15/04)
(19) Now use NESTED_CH and NESTED_NA cpp switches to define
     parameters for 1x1 nested grids.  Also add parameters for
     the 1 x 1.25 global grid. (bmy, 12/1/04)
(20) Now add parameters for GCAP and GEOS-5 grids.  Remove references
     to obsolete LGEOSCO and FULLCHEM Cpp switches (bmy, 6/24/05)
(21) Now add I1x1 and J1x1 parameters for data on the 1x1 GEOS
     grid. (bmy, 10/24/05)
(22) Increase NNPAR to 52 (bmy, 12/6/05)
(23) Increase NNPAR to 54 (dkh, bmy, 5/22/06)
(24) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(25) Added variable tropopause case (bmy, phs, bdf, 8/21/06)
(26) Set LLTROP to level of first box entirely above 20km for GEOS-3
    and GEOS-4 (phS, 9/14/06)
(27) Bug fix: set LLTROP_FIX = LLPAR for GCAP (bmy, 11/29/06)
(28) Reset vertical coordinates for GEOS-5.  Also renamed GRID30LEV
     to GRIDREDUCED (bmy, 4/3/07)
(29) New parameters for GEOS-5 nested grid (yxw, dan, bmy, 11/6/08)
(30) NEMPARA set to 12 to emit O3 and HNO3 (phs, 4/3/08)
(31) Add tracers to NNPAR = 73. (tmf, 1/7/09)
(32) NEMPARA set to 21 to emit new tracers for GLYX chemistry
    (tmf, ccc, 3/2/09)
(33) NEMPARB set to 3 to emit MBO, MONX (tmf, ccc, 3/2/09)
(34) Added EUROPE grid parameters (amv, 10/19/09)
18 Dec 2009 - Aaron van D - Added NESTED_EU grid parameters
18 Dec 2009 - R. Yantosca - Added ProTeX headers
25 Jan 2010 - R. Yantosca - Set NNPAR=320 for TOMAS simulations
25 Jan 2010 - R. Yantosca - Define TOMASBIN and TOMASSPEC for TOMAS sims
08 Feb 2010 - F. Paulot   - Increase NNPAR, NEMPARA and NEMPARB
08 Feb 2010 - F. Paulot   - Move MAXMEM and MAXPL from diag_pl_mod.
30 Nov 2010 - R. Yantosca - Increase LLTROP (from 38 to 40) for GEOS-5 and
                            MERRA for the full 72-layer grids (i.e. when
                            the Cpp switch GRIDREDUCED is not set).
09 Mar 2011 - R. Yantosca - Updated NNPAR for APM (G. Luo)
23 Aug 2011 - M. Long   - Converted to Module from Header file
```

1.3 Fortran: Module Interface CMN_DIAG_mod

Module CMN_DIAG_mod contains size parameters and global variables for the GEOS-Chem diagnostic arrays. This is mostly historical baggage.

INTERFACE:

```
MODULE CMN_DIAG_MOD
```

USES:

```
USE CMN_SIZE_MOD

IMPLICIT NONE
PUBLIC
```

DEFINED PARAMETERS:

```
!=================================================================
! Maximum sizes of diagnostic arrays
! Changed PD66 to 6  (bmy, 9/8/00)
! Changed PD21 to 10 (bmy, 9/30/00)
! Changed PD67 to 18 (bmy, 10/11/00)
! Changed PD46 to 4  (bmy, 1/2/01)
! Changed PD29 to 5  (bmy, 1/2/01)
! Changed PD11 to 7  (bmy, 9/4/01)
! Changed PD32 to 0  (bmy, 2/14/02)
! Changed PD21 to 20 (bmy, 2/27/02)
! Changed PD43 to 4  (bmy, 3/4/02)
! Changed PD05 to 10 (bmy, 10/18/02)
! Changed PD44 to 30 (bmy, 11/19/02)
! Changed PD43 to 5
! Changed PD67 to 22 (bmy, 6/23/03)
! Changed PD66 to 5  (bmy, 6/23/03)
! Changed PD03 to 5  (bmy, 8/20/03)
! Changed PD37 to 10 (bmy, 1/21/04)
! Changed PD06 to NDSTBIN (bmy, 4/5/04)
! Changed PD07 to 7  (bmy, 4/5/04)
! Changed PD08 to 2  (bmy, 4/20/04)
! Changed PD07 to 12 (bmy, 7/15/04)
! Changed PD21 to 26 (bmy, 1/5/05)
! Removed PD03 -- now in "diag03_mod.f" (bmy, 1/21/05)
! Removed PD41 -- now in "diag41_mod.f" (bmy, 1/21/05)
! Now set PD09 to 6 (bmy, 6/27/05)
! Removed PD04 -- now in "diag04_mod.f" (bmy, 7/26/05)
! Now set PD30 to 1 (bmy, 8/18/05)
! Now set PD46 to 6 (tmf, 1/20/09)
! Now set PD10 to 20 (phs, 9/18/07)
! Changed PD17 to 8 (tmf, 1/7/09)
! Changed PD18 to 8 (tmf, 1/7/09)
! Changed PD22 to 8 (tmf, 1/7/09)
! Changed PD37 to 35 (tmf, 1/7/09)
! Changed PD38 to 35 (tmf, 1/7/09)
! Changed PD39 to 35 (tmf, 1/7/09)
! Changed PD44 to 41 (tmf, 1/7/09)
! Now set PD52 to 1 (jaegle 2/26/09)
! Increase PD46 from 6 to 13 (mpb, ccc, 11/19/09)
! increase PD21 from 20 to 27 (clh, 05/06/10)
```

```
!=================================================================
INTEGER, PARAMETER :: PD01=3
INTEGER, PARAMETER :: PD02=3
INTEGER, PARAMETER :: PD05=10
INTEGER, PARAMETER :: PD06=NDSTBIN
INTEGER, PARAMETER :: PD07=12
INTEGER, PARAMETER :: PD08=2
INTEGER, PARAMETER :: PD09=6
INTEGER, PARAMETER :: PD10=20
INTEGER, PARAMETER :: PD11=7
INTEGER, PARAMETER :: PD12=0
INTEGER, PARAMETER :: PD13=1
INTEGER, PARAMETER :: PD14=NNPAR
INTEGER, PARAMETER :: PD15=NNPAR
INTEGER, PARAMETER :: PD16=2
INTEGER, PARAMETER :: PD17=8
INTEGER, PARAMETER :: PD18=8
INTEGER, PARAMETER :: PD19=0
INTEGER, PARAMETER :: PD20=0
INTEGER, PARAMETER :: PD21=27
INTEGER, PARAMETER :: PD22=8
INTEGER, PARAMETER :: PD23=0
INTEGER, PARAMETER :: PD24=NNPAR
INTEGER, PARAMETER :: PD25=NNPAR
INTEGER, PARAMETER :: PD26=NNPAR
INTEGER, PARAMETER :: PD27=1
INTEGER, PARAMETER :: PD28=0
INTEGER, PARAMETER :: PD29=5
INTEGER, PARAMETER :: PD30=1
INTEGER, PARAMETER :: PD31=1
INTEGER, PARAMETER :: PD32=1
INTEGER, PARAMETER :: PD33=NNPAR
INTEGER, PARAMETER :: PD34=2
INTEGER, PARAMETER :: PD35=NNPAR
INTEGER, PARAMETER :: PD36=NNPAR
INTEGER, PARAMETER :: PD37=35
INTEGER, PARAMETER :: PD38=35
INTEGER, PARAMETER :: PD39=35
INTEGER, PARAMETER :: PD40=4
INTEGER, PARAMETER :: PD43=5
INTEGER, PARAMETER :: PD44=41
INTEGER, PARAMETER :: PD45=NNPAR+1
INTEGER, PARAMETER :: PD46=13
INTEGER, PARAMETER :: PD47=NNPAR+1
INTEGER, PARAMETER :: PD48=2
INTEGER, PARAMETER :: PD49=0
INTEGER, PARAMETER :: PD50=0
INTEGER, PARAMETER :: PD51=0
```

```
      INTEGER, PARAMETER :: PD52=1
      INTEGER, PARAMETER :: PD53=0
      INTEGER, PARAMETER :: PD54=0
      INTEGER, PARAMETER :: PD55=3
      ! Potential temperature diagnostic (hotp 7/31/09)
      INTEGER, PARAMETER :: PD57=1
      INTEGER, PARAMETER :: PD58=12
#if   defined( TOMAS )
      ! Special settings for TOMAS aerosol microphysics (win, bmy, 1/22/10)
      INTEGER, PARAMETER :: PD59=TOMASBIN*TOMASSPEC
      INTEGER, PARAMETER :: PD60=TOMASBIN*TOMASSPEC
      INTEGER, PARAMETER :: PD61=2
#else
      ! Normal settings for non-TOMAS simulations
      INTEGER, PARAMETER :: PD59=0
      INTEGER, PARAMETER :: PD60=1
      INTEGER, PARAMETER :: PD61=0
#endif
      INTEGER, PARAMETER :: PD62=NNPAR
      INTEGER, PARAMETER :: PD63=0
      INTEGER, PARAMETER :: PD64=0
      INTEGER, PARAMETER :: PD65=LLPAR*MAXFAM
      INTEGER, PARAMETER :: PD66=6
      INTEGER, PARAMETER :: PD67=23 ! (Lin, 31/03/09)
      INTEGER, PARAMETER :: PD68=4
      INTEGER, PARAMETER :: PD69=1
      INTEGER, PARAMETER :: PD70=0

      !=================================================================
      ! Variables for printing out selected tracers in diagnostic output
      !=================================================================
      INTEGER, PARAMETER :: MAX_DIAG   = 70
#if   defined( TOMAS )
      INTEGER, PARAMETER :: MAX_TRACER = NNPAR+1   ! For TOMAS (win, 1/25/10)
#elif defined( APM )
      INTEGER, PARAMETER :: MAX_TRACER = NNPAR+100 ! For APM (G. Luo 3/8/11)
#else
      INTEGER, PARAMETER :: MAX_TRACER = NNPAR+6   ! For non-TOMAS simulations
#endif
```

PUBLIC DATA MEMBERS:

```
      !=================================================================
      ! Diagnostic counters & time variables
      !=================================================================
      INTEGER :: KDA48, NJDAY(366)

      !=================================================================
```

```
! Variables for the number of levels in multi-level diagnostics
! Removed LD03 -- this is now in diag03_mod.f (bmy, 1/21/05)
! Added LD09 (bmy, 6/27/05)
! Added LD54 (phs, 9/22/06)
! Added LD10 (phs, 9/18/07)
! Added LD31 (bmy, 5/8/07)
! Added LD52 (jaegle, 02/26/09)
! Added LD59, LD60, LD61 (bmy, 1/22/10)
! Added LD57 (hotp 7/31/09)
!=================================================================
INTEGER :: LD12, LD13, LD14, LD15, LD16, LD17, LD18, LD21, LD22
INTEGER :: LD24, LD25, LD26, LD37, LD38, LD39, LD43, LD45, LD47
INTEGER :: LD54, LD64, LD65, LD66, LD68, LD01, LD02, LD05, LD07
INTEGER :: LD09, LD10, LD31, LD52, LD19, LD57, LD58, LD59, LD60
INTEGER :: LD61

!=================================================================
! NDxx diagnostic flags
!=================================================================
INTEGER :: ND01, ND02, ND05, ND06, ND07, ND08, ND09, ND10, ND11
INTEGER :: ND12, ND13, ND14, ND15, ND16, ND17, ND18, ND19, ND20
INTEGER :: ND21, ND22, ND23, ND24, ND25, ND26, ND27, ND28, ND29
INTEGER :: ND30, ND31, ND32, ND33, ND34, ND35, ND36, ND37, ND38
INTEGER :: ND39, ND40, ND43, ND44, ND45, ND46, ND47, ND48, ND49
INTEGER :: ND50, ND51, ND52, ND53, ND54, ND55, ND57, ND58, ND59
INTEGER :: ND60, ND61, ND62, ND63, ND64, ND65, ND66, ND67, ND68
INTEGER :: ND69, ND70, ND71, ND72, ND73, ND74, ND75

!=================================================================
! Variables for printing out selected tracers in diagnostic output
!=================================================================
INTEGER :: TINDEX(MAX_DIAG,MAX_TRACER)
INTEGER :: TCOUNT(MAX_DIAG)
INTEGER :: TMAX(MAX_DIAG)

!=================================================================
! NO, J-Value, and 2-PM diagnostic arrays (bmy, 9/25/98)
! Move this here for now (bmy, 7/20/04)
!=================================================================
REAL*8  :: HR1_NO, HR2_NO, HR1_JV,  HR2_JV
REAL*8  :: HR1_OH, HR2_OH, HR1_OTH, HR2_OTH
```

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%  NOTE: THIS MODULE IS DEPRECATED.  AT SOME POINT WE NEED TO DO A  %%%
%%%  TOTAL REWRITE OF THE GEOS-CHEM DIAGNOSTICS.  MANY OF THESE FLAGS %%%
%%%  CAN BE BUNDLED INTO A DERIVED TYPE FOR THE DIAGNOSTICS, THUS     %%%
%%%  SIMPLIFYING THE CODE.  FOR NOW, LEAVE AS-IS.                     %%%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

REVISION HISTORY:

```
(1 ) Changed RCS ID tag comment character from "C" to "!" to allow freeform
     compilation.  Also added & continuation characters in column 73
     to allow header files to be included in F90 freeform files.
     Also converted PARAMETER statements to F90 syntax. (bmy, 6/25/02)
(2 ) Add LD05 for sulfate prod/loss (rjp, bdf, bmy, 9/20/02)
(3 )  Removed obsolete variables NTAU0, IDAY0, JDATE0, JYEAR0, KDACC,
      KDADYN, KDACONV, KDASRCE, KDACHEM, KDA3FLDS, KDA6FLDS, KDI6FLDS,
      KDKZZFLDS (bmy, 2/11/03)
(4 ) Fix for LINUX - remove & from column 73 (bmy, 6/27/03)
(5 ) Added LD03 for Kr85 Prod/loss diagnostic (bmy, 8/20/03)
(6 ) Removed obsolete arrays (bmy, 1/21/05)
(7 ) Rename MAXDIAG to MAX_DIAG and MAXTRACER to MAX_TRACER in order to
     avoid name conflicts with "gamap_mod.f" (bmy, 5/3/05)
(8 ) Remove reference to TRCOFFSET (bmy, 5/16/06)
(9 ) Added multi level LD54 to common CDIAG1 (phs, 9/22/06)
(10) Added multi level LD10 to common CDIAG1. Set PD10 to 20.  Set
     PD66 to 6. (phs, 9/18/07)
(11) Added LD52 to common CDIAG1 (jaegle, 02/26/09)
(12) Add GLYX, MGLY, SOAG, SOAM, and a few other tracers to AD17, AD18
     for archiving rainout and washout fraction. (tmf, 1/7/09)
(13) Add GLYX, MGLY J value archive. (tmf, 1/7/09)
(14) Add GLYX, MGLY, SOAG, SOAM, and a few other tracers to AD37, AD38,
     AD39
     for archiving rainout and washout flux. (tmf, 1/7/09)
(15) Add GLYX, MGLY, GLYC, 6 PANs, SOAG, SOAM dry dep,
     PD44 = 41.(tmf, 1/7/09)
(16) Add biogenic C2H4 emission, PD46 = 6. (tmf, 1/20/09)
(17) Add one met field to ND67 (EFLUX). (ccc, 5/14/09)
(18) Add declarations for PD58 and PD60, LD19, LD58. (kjw,8/18/09)
(19) Redimension PD59, PD60, PD61 for TOMAS microphysics.  Added LD59, LD60,
     LD61 to common block.  Reset MAX_TRACER to NNPAR+1 for TOMAS.
     (win, bmy, 1/22/10)
(20) Add LD57 and PD57 (potential temperature) (hotp, 3/15/10)
03 Aug 2010 - R. Yantosca - Added ProTeX headers
03 Aug 2010 - P. Kasibhatla & R. Yantosca - Now set MAX_TRACER to NNPAR+6
                                            to match ND09 diagnostic
09 Mar 2011 - R. Yantosca - Updated MAX_TRACER for APM (G. Luo)
03 Aug 2011 - M. Long     - Converted from Header file to Module
```

1.4 Fortran: Module Interface cmn_fj_mod

Module cmn_fj_mod contains parameters and global variables used to interface between Harvard chemistry and UC-Irvine Fast-J photolysis programs.

INTERFACE:

```
MODULE CMN_FJ_MOD
```

USES:

```
USE CMN_SIZE_MOD, ONLY : IIPAR, JJPAR, LLPAR

IMPLICIT NONE
PUBLIC
```

DEFINED PARAMETERS:

```
! Global array sizes in longitude, latitude, altitude
INTEGER, PARAMETER :: IPAR = IIPAR
INTEGER, PARAMETER :: JPAR = JJPAR
INTEGER, PARAMETER :: LPAR = LLPAR

! max # of photolysis rxns = 4 + IPHOT (see comode.h)
! FP increased JPMAX since IPHOT was increased (hotp 7/31/09)
!INTEGER, PARAMETER :: JPMAX = 79
INTEGER, PARAMETER :: JPMAX = 89
```

PUBLIC DATA MEMBERS:

```
! Variables for number of layers and number of photolysis rxns
INTEGER            :: JPNL, JPPJ

! Branches for photolysis species
INTEGER            :: BRANCH(JPMAX)

! Names of photolysis species
! FP increased length of RNAMES for species indistinguishable
! with only 4 characters (hotp 7/31/09)
! used in jv_index and rd_js.f
!CHARACTER (LEN=4)  :: RNAMES
CHARACTER (LEN=7)  :: RNAMES(JPMAX)

! Mapping array from Harvard species names to UCI species names
INTEGER            :: RINDEX(JPMAX)

! Output J-values
REAL*8             :: ZPJ(LPAR,JPMAX,IPAR,JPAR)
```

REMARKS:

```
Based on code from Oliver Wild (9 Jul 1999)
```

REVISION HISTORY:

```
(1 ) Uses Fortran 90 declarations for parameters and variables
(2 ) Pass CTM size parameters and preprocessor switches via CMN_SIZE.
(3 ) Update JPMAX for new chemistry mechanism (amf, bmy, 4/20/00)
(4 ) Return JPMAX to original setting (bmy, 9/25/00)
(5 ) Return JPMAX to 55 for peroxy recycling (again) (bmy, 12/20/00)
(6 ) Now need to use the window parameters IIPAR,JJPAR,LLPAR (bmy, 9/25/01)
(7 ) Changed RCS ID tag comment character from "C" to "!" to allow freeform
     compilation. (bmy, 6/25/02)
(8 ) Replaced ESIG array with ETAA and ETAB arrays for the hybrid
     pressure formulation.  Also deleted PREST, since we don't need that
     anymore. (bmy, 8/23/02)
(9 ) Removed ETAA and ETAB arrays.  We now compute PJ directly from the
     GET_PEDGE routine. (bmy, 10/30/07)
(10) Increase photolysis rxns JPMAX = 79 (tmf, 1/7/09)
(11) Increase photolysis rxns JPMAX = 89 for Isoprene (fp, 2/2/10)
(12) Increase species name length. (fp, 2/2/10)
23 Aug 2011 - M. Long   - Converted to Module from Header file
```

1.5 Fortran: Module Interface jv_cmn_mod

Module jv_cmn_mod contains global variables (formerly in common blocks) for the FAST-J code (cf. Wild/Prather 7/99).

INTERFACE:

```
      MODULE JV_CMN_MOD
```

USES:

```
      USE CMN_SIZE_MOD, ONLY : NDUST, NAER, NRH
      USE CMN_FJ_MOD,   ONLY : JPMAX, LPAR, IPAR, JPAR

      IMPLICIT NONE
      PUBLIC
  !DEFINED PARAMETERS
      ! NB  Number of levels in CTM plus one for above model top
      ! NC  Number of levels in the fundamental Fast-J grid
      ! NS  Maximum number of species which require J-values calculating
      ! NW  Maximum number of wavelength bins that can be used
      ! NP  Maximum number of aerosol/cloud types that can be used
      ! MX  Number of aerosol/cloud types supplied from CTM
      INTEGER, PARAMETER :: NB      = LPAR+1
      INTEGER, PARAMETER :: NC      = 2*NB
      INTEGER, PARAMETER :: NS      = 51
      INTEGER, PARAMETER :: NW      = 15
      INTEGER, PARAMETER :: NP      = 56
      INTEGER, PARAMETER :: MX      = 35
```

```
REAL*8,  PARAMETER :: RAD     = 6375.d5
REAL*8,  PARAMETER :: ZZHT    = 5.d5
REAL*8,  PARAMETER :: dtaumax = 1.d0
REAL*8,  PARAMETER :: dtausub = 1.d0
REAL*8,  PARAMETER :: dsubdiv = 10.d0
REAL*8,  PARAMETER :: szamax  = 98.0d0
```

PUBLIC DATA MEMBERS:

```
! Character variables
CHARACTER*20 TITLEA(NP)
CHARACTER*78 TITLE0
CHARACTER*7  TITLEJ(3,NS), jlabel(JPMAX)

!-----------------------------------------------------------------------
! These common blocks MUST NOT be held local (bmy, 5/2/00)

REAL*8  :: WBIN(NW+1),WL(NW),FL(NW),QO2(NW,3),QO3(NW,3)
REAL*8  :: Q1D(NW,3),QQQ(NW,2,NS-3),QRAYL(NW),TQQ(3,NS)
REAL*8  :: WAA(4,NP),QAA(4,NP)
REAL*8  :: PAA(8,4,NP),RAA(4,NP),SSA(4,NP),QBC(NW)

INTEGER :: NJVAL,NW1,NW2,NAA,NLBATM

REAL*8  :: WAA_AOD(NP),QAA_AOD(NP),PAA_AOD(8,NP)
REAL*8  :: RAA_AOD(NP),SSA_AOD(NP)

REAL*8  :: TREF(51,18,12),OREF(51,18,12),BREF(51)
REAL*8  :: ODMDUST(IPAR,JPAR,LPAR,NDUST)
REAL*8  :: ODAER(IPAR,JPAR,LPAR,NAER*NRH)

REAL*8  :: jfacta(JPMAX),zpdep(NW,7)
INTEGER :: npdep,jpdep(NS),jind(JPMAX)

INTEGER :: MIEDX(MX)

!-----------------------------------------------------------------------
! Split off GLYX-chemistry specific arrays into separate common blocks
! (ccarouge, bmy, 8/20/09)
INTEGER :: PDEPF(7)

REAL*8  :: MGLYPDEP(NW, 3)

!-----------------------------------------------------------------------
! These common blocks MUST be held local for the parallelization
! (bmy, 5/2/00)
REAL*8   :: TJ(NB),PJ(NB+1),DM(NB),DO3(NB),DBC(NB),Z(NB)
REAL*8   :: AER(MX,NB),AMF(NB,NB),RFLECT,SZA,U0,TANHT
REAL*8   :: zj(LPAR,JPMAX)
```

```
      REAL*8   :: FFF(NW,lpar),VALJ(NS)
      INTEGER  :: jadsub(NC)

$OMP THREADPRIVATE( TJ, PJ, DM, DO3, DBC, Z)
$OMP THREADPRIVATE( AER, AMF, RFLECT, SZA, U0, TANHT)
$OMP THREADPRIVATE( zj )
$OMP THREADPRIVATE( FFF, VALJ )
$OMP THREADPRIVATE( jadsub )
```

REMARKS:

```
NOTES for CTM Interface (bmy, 10/27/99, 3/23/03)
=================================================================
(1) Change JPNL and JPPJ from parameters to variables, which are
    set in "inphot.f".  This allows the user to switch the number
    of levels at run-time via the CTM inputs.

(2) Now make RAD, ZZHT, DTAUMAX, DTAUSUB, DSUBDIV, SZAMAX into
    parameters instead of holding them in common blocks.

(3) Create new common blocks /WLLOC/ and /JVLOC/ to hold certain
    quantities -Xlocal for parallel code (ppm, 4/98, bmy, 9/21/99)

(4) The common blocks that must be held -Xlocal are:
       /ATMOS/, /JVSUB/, /WLLOC/, /JVLOC/

(4a) Declare the above commons THREADPRIVATE for the Compaq
     Alpha platform (bmy, 7/10/01)

(5) Break MIEDX off from the WLLOC common block, since it must
    not be declared LOCAL for the parallelization. (bmy, 5/2/00)

(6) For including aerosol optical depths: (rvm, bmy, 9/30/00)
    (a) Increase MX from 3 to 10 .
    (c) Add ODMDUST(IPAR,JPAR,LPAR,NDUST) to common block /CLIM/

(7) Move NDUST to CMN_SIZE to avoid conflicts (bmy, 11/15/01)

(8) For updating aerosol optical depths again (rvm, bmy, 2/27/02):
    (a) Change NP from 21 to 56
    (b) Change MX from 10 to 35
    (c) Add ODAER(IPAR,JPAR,LPAR,NAER*NRH) to common block /CLIM/

(9) Changed RCS ID tag comment character from "C" to "!" to allow freeform
     compilation.  Also added & continuation characters in column 73
     to allow header files to be included in F90 freeform files.
     Also changed comment character from "C" to "!" to allow this
     file to be inlined into freeform source code. (bmy, 6/25/02)
```

```
.
(10) Renamed cpp switch from DEC_COMPAQ to COMPAQ.  Also declare common
     blocks ATMOS, JVLOC, WLLOC, JVSUB as !$OMP THREADPRIVATE for
     all platforms. (bmy, 3/23/03)
.
(11) Added new pressure denpendencies algorithm parameters
      for MGLY. (tmf, 1/7/09)
.
(12) Added 'pdepf' as pressure dependancy function selector. (tmf, 1/31/06)
.
(13) Split off PDEPF and MGLYPDEP into separate common blocks to avoid
     warnings on IFORT 9 (ccarouge, bmy, 8/20/09)
.
(14) Add new optical variables for AOD calculation (clh, 05/06/10)
```

REVISION HISTORY:

```
23 Aug 2011 - M. Long   - Converted to Module from Header file
```

1.6 Fortran: Module Interface jv_mie_mod.F

This include file contains physical constants for the GEOS-Chem column chemistry code.

INTERFACE:

```
MODULE JV_MIE_MOD
```

USES:

```
IMPLICIT NONE
PUBLIC
```

DEFINED PARAMETERS:

```
! NL    Maximum number of levels after insertion of extra Mie levels
! N__   Number of levels in Mie grid: 2*(2*lpar+2+jaddto(1))+3
! M__   Number of Gauss points used
INTEGER, PARAMETER :: NL  = 1500
INTEGER, PARAMETER :: N__ = 2*NL
INTEGER, PARAMETER :: M__ = 4
```

PUBLIC DATA MEMBERS:

```
! Arrays
REAL*8  :: A(M__),           B(M__,M__),   C1(M__)
REAL*8  :: H(M__),           AA(M__,M__),  CC(M__,M__)
REAL*8  :: S(M__,M__),       W(M__,M__),   U1(M__,M__)
REAL*8  :: V1(M__),          WT(M__),      EMU(M__)
REAL*8  :: PM(M__,2*M__),    PM0(2*M__),   POMEGA(2*M__,N__)
REAL*8  :: ZTAU(N__),        FZ(N__),      FJ(N__)
```

```
      REAL*8  :: DD(M__,M__,N__),  RR(M__,N__)
      REAL*8  :: ZREFL,            ZFLUX

      ! Scalars
      REAL*8  :: RADIUS,           ZUO
      INTEGER :: ND,               N
      INTEGER :: M,                MFIT

      !=================================================================
      ! Declare the following global variables as THREADPRIVATE for the
      ! OpenMP parallelization on all platforms (bmy, 3/23/03)
      !=================================================================
$OMP THREADPRIVATE( A,B,C1,H,AA,CC,S,W,U1,V1,WT,EMU,PM,PM0,POMEGA )
$OMP THREADPRIVATE( ZTAU,FZ,FJ,DD,RR,ZREFL,ZFLUX,RADIUS,ZUO )
$OMP THREADPRIVATE( ND,N,M,MFIT )
```

REMARKS:

```
Keep increasing NL if necessary.  This will avoid the "too many levels
in photolysis" error.
```

REVISION HISTORY:

```
(1 ) Changed RCS ID tags to by adding a ! comment character to allow
     freeform compilation.  Also added & continuation characters in
     column 73 to allow header files to be included in F90 freeform files.
     Also changed comment character from "C" to "!", to allow this
     file to be inlined into freeform source code. (bmy, 6/25/02)
(2 ) Now declare common blocks /MIEBLK/ and /MINDEX/ as THREADPRIVATE for
     all platforms (bmy, 3/23/03)
(3 ) Set NL to 1000 to avoid SMVGEAR crash with GEOS-5.2.0 on Sept 1st 2008
03 Aug 2011 - M. Long     - Converted from Header file to Module
```

1.7 Fortran: Module Interface geos_chem

Program GEOS_CHEM is the main level driver program for the GEOS-Chem model of atmospheric chemistry and composition.

INTERFACE:

```
      PROGRAM GEOS_CHEM
```

USES:

```
      USE A3_READ_MOD,       ONLY : GET_A3_FIELDS
      USE A3_READ_MOD,       ONLY : OPEN_A3_FIELDS
      USE A3_READ_MOD,       ONLY : UNZIP_A3_FIELDS
      USE A6_READ_MOD,       ONLY : GET_A6_FIELDS
      USE A6_READ_MOD,       ONLY : OPEN_A6_FIELDS
```

```
      USE A6_READ_MOD,       ONLY : UNZIP_A6_FIELDS
      USE BENCHMARK_MOD,     ONLY : STDRUN
! (hotp 5/24/09) Modified for SOA from aroms
!USE CARBON_MOD,        ONLY : WRITE_GPROD_APROD
! Add RECOMPUTE_OD to call AOD calculation twice (skim, 02/02/11)
      USE CHEMISTRY_MOD,     ONLY : DO_CHEMISTRY, RECOMPUTE_OD
      USE CONVECTION_MOD,    ONLY : DO_CONVECTION
      USE COMODE_MOD,        ONLY : INIT_COMODE
      USE GCKPP_COMODE_MOD,  ONLY : INIT_GCKPP_COMODE
      USE DIAG_MOD,          ONLY : DIAGCHLORO
      USE DIAG41_MOD,        ONLY : DIAG41,          ND41
      USE DIAG42_MOD,        ONLY : DIAG42,          ND42
      USE DIAG48_MOD,        ONLY : DIAG48,          ITS_TIME_FOR_DIAG48
      USE DIAG49_MOD,        ONLY : DIAG49,          ITS_TIME_FOR_DIAG49
      USE DIAG50_MOD,        ONLY : DIAG50,          DO_SAVE_DIAG50
      USE DIAG51_MOD,        ONLY : DIAG51,          DO_SAVE_DIAG51
      USE DIAG51b_MOD,       ONLY : DIAG51b,         DO_SAVE_DIAG51b
      USE DIAG_OH_MOD,       ONLY : PRINT_DIAG_OH
      USE DAO_MOD,           ONLY : AD,              AIRQNT
      USE DAO_MOD,           ONLY : AVGPOLE,         CLDTOPS
      USE DAO_MOD,           ONLY : CONVERT_UNITS,   COPY_I6_FIELDS
      USE DAO_MOD,           ONLY : COSSZA,          INIT_DAO
      USE DAO_MOD,           ONLY : INTERP,          PS1
      USE DAO_MOD,           ONLY : PS2,             PSC2
      USE DAO_MOD,           ONLY : T,               TS
      USE DAO_MOD,           ONLY : SUNCOS,          SUNCOS_MID
      USE DAO_MOD,           ONLY : MAKE_RH
!Add MAKE_GTMM_RESTART for mercury simulation (ccc, 11/19/09)
      USE DEPO_MERCURY_MOD,  ONLY : MAKE_GTMM_RESTART, UPDATE_DEP
      USE DRYDEP_MOD,        ONLY : DO_DRYDEP
      USE EMISSIONS_MOD,     ONLY : DO_EMISSIONS
      USE ERROR_MOD,         ONLY : DEBUG_MSG,       ERROR_STOP
      USE FILE_MOD,          ONLY : IU_BPCH,         IU_DEBUG
      USE FILE_MOD,          ONLY : IU_ND48,         IU_SMV2LOG
      USE FILE_MOD,          ONLY : CLOSE_FILES
      USE GLOBAL_CH4_MOD,    ONLY : INIT_GLOBAL_CH4, CH4_AVGTP
      USE GCAP_READ_MOD,     ONLY : GET_GCAP_FIELDS
      USE GCAP_READ_MOD,     ONLY : OPEN_GCAP_FIELDS
      USE GCAP_READ_MOD,     ONLY : UNZIP_GCAP_FIELDS
      USE GWET_READ_MOD,     ONLY : GET_GWET_FIELDS
      USE GWET_READ_MOD,     ONLY : OPEN_GWET_FIELDS
      USE GWET_READ_MOD,     ONLY : UNZIP_GWET_FIELDS
      USE I6_READ_MOD,       ONLY : GET_I6_FIELDS_1
      USE I6_READ_MOD,       ONLY : GET_I6_FIELDS_2
      USE I6_READ_MOD,       ONLY : OPEN_I6_FIELDS
      USE I6_READ_MOD,       ONLY : UNZIP_I6_FIELDS
      USE INPUT_MOD,         ONLY : READ_INPUT_FILE
      USE LAI_MOD,           ONLY : RDISOLAI
```

```
USE LIGHTNING_NOX_MOD, ONLY : LIGHTNING
USE LOGICAL_MOD,       ONLY : LEMIS,     LCHEM, LUNZIP,  LDUST
USE LOGICAL_MOD,       ONLY : LLIGHTNOX, LPRT,  LSTDRUN, LSVGLB
USE LOGICAL_MOD,       ONLY : LWAIT,     LTRAN, LUPBD,   LCONV
USE LOGICAL_MOD,       ONLY : LWETD,     LTURB, LDRYD,   LMEGAN
USE LOGICAL_MOD,       ONLY : LDYNOCEAN, LSOA,  LVARTROP,LKPP
USE LOGICAL_MOD,       ONLY : LLINOZ,    LWINDO
! Add LGTMM logical for mercury simulation (ccc, 11/19/09)
USE LOGICAL_MOD,       ONLY : LGTMM
USE MEGAN_MOD,         ONLY : INIT_MEGAN
USE MEGAN_MOD,         ONLY : UPDATE_T_15_AVG
USE MEGAN_MOD,         ONLY : UPDATE_T_DAY
USE PBL_MIX_MOD,       ONLY : DO_PBL_MIX
USE OCEAN_MERCURY_MOD, ONLY : MAKE_OCEAN_Hg_RESTART
USE OCEAN_MERCURY_MOD, ONLY : READ_OCEAN_Hg_RESTART
USE PLANEFLIGHT_MOD,   ONLY : PLANEFLIGHT
USE PLANEFLIGHT_MOD,   ONLY : SETUP_PLANEFLIGHT
USE PRESSURE_MOD,      ONLY : INIT_PRESSURE
USE PRESSURE_MOD,      ONLY : SET_FLOATING_PRESSURE, get_pedge
! add support for saving APROD, GPROD (dkh, 11/09/06)
USE SOAPROD_MOD,       ONLY : SET_SOAPROD, MAKE_SOAPROD_FILE
USE SOAPROD_MOD,       ONLY : READ_SOAPROD_FILE
! hotp 5/25/09
USE SOAPROD_MOD,       ONLY : FIRST_APRODGPROD
USE TIME_MOD,          ONLY : GET_NYMDb,        GET_NHMSb
USE TIME_MOD,          ONLY : GET_NYMD,         GET_NHMS
USE TIME_MOD,          ONLY : GET_A3_TIME,      GET_FIRST_A3_TIME
USE TIME_MOD,          ONLY : GET_A6_TIME,      GET_FIRST_A6_TIME
USE TIME_MOD,          ONLY : GET_I6_TIME,      GET_MONTH
USE TIME_MOD,          ONLY : GET_TAU,          GET_TAUb
USE TIME_MOD,          ONLY : GET_TS_CHEM,      GET_TS_DYN
USE TIME_MOD,          ONLY : GET_ELAPSED_SEC,  GET_TIME_AHEAD
USE TIME_MOD,          ONLY : GET_DAY_OF_YEAR,  ITS_A_NEW_DAY
USE TIME_MOD,          ONLY : ITS_A_NEW_SEASON, GET_SEASON
USE TIME_MOD,          ONLY : ITS_A_NEW_MONTH,  GET_NDIAGTIME
USE TIME_MOD,          ONLY : ITS_A_LEAPYEAR,   GET_YEAR
USE TIME_MOD,          ONLY : ITS_TIME_FOR_A3,  ITS_TIME_FOR_A6
USE TIME_MOD,          ONLY : ITS_TIME_FOR_I6,  ITS_TIME_FOR_CHEM
USE TIME_MOD,          ONLY : ITS_TIME_FOR_CONV,ITS_TIME_FOR_DEL
USE TIME_MOD,          ONLY : ITS_TIME_FOR_DIAG,ITS_TIME_FOR_DYN
USE TIME_MOD,          ONLY : ITS_TIME_FOR_EMIS,ITS_TIME_FOR_EXIT
USE TIME_MOD,          ONLY : ITS_TIME_FOR_UNIT,ITS_TIME_FOR_UNZIP
USE TIME_MOD,          ONLY : ITS_TIME_FOR_BPCH
USE TIME_MOD,          ONLY : SET_CT_CONV,      SET_CT_DYN
USE TIME_MOD,          ONLY : SET_CT_EMIS,      SET_CT_CHEM
USE TIME_MOD,          ONLY : SET_CT_DIAG
USE TIME_MOD,          ONLY : SET_DIAGb,        SET_DIAGe
USE TIME_MOD,          ONLY : SET_CURRENT_TIME, PRINT_CURRENT_TIME
```

```
      USE TIME_MOD,          ONLY : SET_ELAPSED_MIN,  SYSTEM_TIMESTAMP
      USE TIME_MOD,          ONLY : TIMESTAMP_DIAG
      USE TIME_MOD,          ONLY : GET_HOUR,         GET_MINUTE
      USE TIME_MOD,          ONLY : GET_FIRST_I6_TIME
      USE TPCORE_BC_MOD,     ONLY : SAVE_GLOBAL_TPCORE_BC
      USE TRACER_MOD,        ONLY : CHECK_STT, N_TRACERS, STT, TCVV
      USE TRACER_MOD,        ONLY : ITS_AN_AEROSOL_SIM
      USE TRACER_MOD,        ONLY : ITS_A_CH4_SIM
      USE TRACER_MOD,        ONLY : ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,        ONLY : ITS_A_H2HD_SIM
      USE TRACER_MOD,        ONLY : ITS_A_MERCURY_SIM
      USE TRACER_MOD,        ONLY : ITS_A_TAGCO_SIM
      USE TRANSPORT_MOD,     ONLY : DO_TRANSPORT
      USE TROPOPAUSE_MOD,    ONLY : READ_TROPOPAUSE, CHECK_VAR_TROP
      USE TROPOPAUSE_MOD,    ONLY : DIAG_TROPOPAUSE
      USE RESTART_MOD,       ONLY : MAKE_RESTART_FILE, READ_RESTART_FILE
      USE UPBDFLX_MOD,       ONLY : DO_UPBDFLX,        UPBDFLX_NOY
      USE UVALBEDO_MOD,      ONLY : READ_UVALBEDO
      USE WETSCAV_MOD,       ONLY : INIT_WETSCAV,      DO_WETDEP
      USE XTRA_READ_MOD,     ONLY : GET_XTRA_FIELDS,   OPEN_XTRA_FIELDS
      USE XTRA_READ_MOD,     ONLY : UNZIP_XTRA_FIELDS
      USE ERROR_MOD,         ONLY : IT_IS_NAN, IT_IS_FINITE   !yxw
      USE ERROR_MOD,         ONLY : SAFE_DIV
      ! To save CSPEC_FULL restart (dkh, 02/12/09)
      USE LOGICAL_MOD,       ONLY : LSVCSPEC
      USE RESTART_MOD,       ONLY : MAKE_CSPEC_FILE
      ! Added (lin, 03/31/09)
      USE LOGICAL_MOD,       ONLY : LNLPBL
      USE VDIFF_MOD,         ONLY : DO_PBL_MIX_2
      USE LINOZ_MOD,         ONLY : LINOZ_READ
      USE TRACERID_MOD,      ONLY : IS_Hg2

      ! For GTMM for mercury simulations. (ccc, 6/7/10)
      USE WETSCAV_MOD,       ONLY : GET_WETDEP_IDWETD
      USE MERCURY_MOD,       ONLY : PARTITIONHG

      ! For MERRA met fields (bmy, 8/19/10)
      USE MERRA_A1_MOD,      ONLY : GET_MERRA_A1_FIELDS
      USE MERRA_A1_MOD,      ONLY : OPEN_MERRA_A1_FIELDS
      USE MERRA_A3_MOD,      ONLY : GET_MERRA_A3_FIELDS
      USE MERRA_A3_MOD,      ONLY : OPEN_MERRA_A3_FIELDS
      USE MERRA_CN_MOD,      ONLY : GET_MERRA_CN_FIELDS
      USE MERRA_CN_MOD,      ONLY : OPEN_MERRA_CN_FIELDS
      USE MERRA_I6_MOD,      ONLY : GET_MERRA_I6_FIELDS_1
      USE MERRA_I6_MOD,      ONLY : GET_MERRA_I6_FIELDS_2
      USE MERRA_I6_MOD,      ONLY : OPEN_MERRA_I6_FIELDS
      USE TIME_MOD,          ONLY : GET_A1_TIME
      USE TIME_MOD,          ONLY : GET_FIRST_A1_TIME
```

```
      USE TIME_MOD,          ONLY : ITS_TIME_FOR_A1

      USE CMN_SIZE_MOD             ! Size parameters
      USE COMODE_LOOP_MOD          ! SMVGEAR common blocks
      USE CMN_DIAG_MOD             ! Diagnostic switches, NJDAY
      USE CMN_GCTM_MOD             ! Physical constants

      IMPLICIT NONE
#     include "define.h"
```

REMARKS:

```
      .
      GGGGGG  EEEEEEE  OOOOO  SSSSSSS       CCCCCC H     H EEEEEEE M     M
     G        E       O     O S           C       H     H E       M M M M
     G   GGG  EEEEEE  O     O SSSSSSS     C       HHHHHHH EEEEEE  M  M  M
     G     G  E       O     O       S     C       H     H E       M     M
      GGGGGG  EEEEEEE  OOOOO  SSSSSSS       CCCCCC H     H EEEEEEE M     M
                                                                          .
                                                                          .
                 (formerly known as the Harvard-GEOS model)
            for 4 x 5, 2 x 2.5 global grids and 1 x 1 nested grids
                                                                          .
        Contact: GEOS-Chem Support Team (geos-chem-support@as.harvard.edu)

                                                                          .
   See the GEOS-Chem Web Site:
                                                                          .
      http://acmg.seas.harvard.edu/geos/
                                                                          .
   and the GEOS-Chem User's Guide:
                                                                          .
      http://acmg.seas.harvard.edu/geos/doc/man/
                                                                          .
   and the GEOS-Chem wiki:
                                                                          .
      http://wiki.seas.harvard.edu/geos-chem/
                                                                          .
   for the most up-to-date GEOS-Chem documentation on the following topics:
                                                                          .
      - installation, compilation, and execution
      - coding practice and style
      - input files and met field data files
      - horizontal and vertical resolution
      - modification history
```

REVISION HISTORY:

```
   13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

```
13 Aug 2010 - R. Yantosca - Add modifications for MERRA (treat like GEOS-5)
19 Aug 2010 - R. Yantosca - Now call MERRA met field reader routines
02 Feb 2011 - S. Kim      - Call Compute_OD after wet deposition
05 Oct 2011 - R. Yantosca - Now get SUNCOS30 array from routine COSSZA
07 Oct 2011 - R. Yantosca - Rename SUNCOS30 to SUNCOS_MID, which is the
                            cos(SZA) at the midpt of the chemistry timestep
```

1.7.1 display_grid_and_model

Internal Subroutine DISPLAY_GRID_AND_MODEL displays the appropriate messages for the given model grid and machine type. It also prints the starting time and date (local time) of the GEOS-Chem simulation.

INTERFACE:

```
SUBROUTINE DISPLAY_GRID_AND_MODEL
```

REVISION HISTORY:

```
02 Dec 2003 - R. Yantosca - Initial version
13 Aug 2010 - R. Yantosca - Added ProTeX headers
13 Aug 2010 - R. Yantosca - Added extra output
```

1.7.2 ctm_flush

Internal subroutine CTM_FLUSH flushes certain diagnostic file buffers to disk.

CTM_FLUSH should normally be called after each diagnostic output, so that in case the run dies, the output files from the last diagnostic timestep will not be lost.

FLUSH is an intrinsic FORTRAN subroutine and takes as input the unit number of the file to be flushed to disk.

INTERFACE:

```
SUBROUTINE CTM_FLUSH
```

REVISION HISTORY:

```
31 Aug 2000 - R. Yantosca - Initial version
13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.7.3 display_end_time

Internal subroutine DISPLAY_END_TIME prints the ending time of the GEOS-Chem simulation.

INTERFACE:

```
      SUBROUTINE DISPLAY_END_TIME
```

REVISION HISTORY:

```
    03 May 2005 - R. Yantosca - Initial version
    13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.8 Fortran: Module Interface acetone_mod

Module ACETONE_MOD contains subroutines to emit the biogenic flux of acetone into the full chemistry simulation.

INTERFACE:

```
      MODULE ACETONE_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_ACETONE
      PUBLIC :: EMISS_BIOACET
      PUBLIC :: OCEAN_SOURCE_ACET
      PUBLIC :: OCEAN_SINK_ACET
      PUBLIC :: READ_JO1D
      PUBLIC :: READ_RESP
```

REMARKS:

```
    References:
    ============================================================================
    (1 ) Jacob, D.J., B.D. Field, E. Jin, I. Bey, Q. Li, J.A. Logan, and
         R.M. Yantosca, "Atmospheric budget of acetone", Geophys. Res. Lett.,
         107(D11), 4100, 2002.
    (2 ) Nightingale et al [2000a], J. Geophys. Res, 14, 373-387
    (3 ) Nightingale et al [2000b], Geophys. Res. Lett, 27, 2117-2120
```

REVISION HISTORY:

```
NOTES:
18 Sep 2001 - B. Field, R. Yantosca - Initial version
(1 ) Added changes from bdf and updated comments (bmy, 9/5/01)
(2 ) Updated comments (bmy, 9/12/01)
(3 ) Removed VERBOSE flag and all "print-to-log-file" diagnostics.  The
      ND11 diagnostic produces the same totals. (bdf, bmy, 9/18/01)
(4 ) Now cal GET_TAU0 w/ 3 arguments instead of 2.  Also minor bug
      fix in READ_RESP (bmy, 11/15/01)
(5 ) Implemented fix for ocean source/sink from Mat Evans.  Also deleted
      obsolete code from 11/01. (bmy, 11/26/01)
(6 ) Eliminated more obsolete code from 11/01 (bmy, 2/27/02)
(7 ) Removed duplicate variable definitions (bmy, 3/20/02)
(8 ) Now divide module header into MODULE PRIVATE, MODULE VARIABLES, and
      MODULE ROUTINES sections.  Updated comments (bmy, 5/28/02)
(9 ) Bug fix: Now apply true exponential loss in OCEAN_SINK_ACET, instead
      of just the 1st order approximation. (bdf, bmy, 7/11/02)
(10) Scale the ocean source of acetone for GEOS-3 meteorology in order to
      match the total listed in Jacob et al 2002. (bdf, bmy, 9/16/02)
(11) Now references "error_mod.f" (bmy, 10/15/02)
(12) Minor modifications to READ_JO1D, READ_RESP (bmy, 3/14/03)
(13) Add surface area scale factor for ocean source for 1x1 nested
      grids.  (yxw, bmy, 5/16/03)
(14) Scale ACET ocean source to Jacob et al 2002 for GEOS-4, and now
      account for surface area ratio for all GEOS grids. (bmy, 3/15/04)
(15) Now references "directory_mod.f" (bmy, 7/19/04)
(16) Now can read data from GEOS and GCAP grids.  Also now use Nightingale
      et al 2000b formulation for piston velocity KL. (swu, bmy, 8/16/05)
(17) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(18) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(19) Updates for nested EU and NA grids (amv, bmy, 12/18/09)
(20) Updates for GEOS-4 1 x 1.25 grid (lok, bmy, 1/13/10)
13 Aug 2010 - R. Yantosca - Add modifications for MERRA (treat like GEOS-5)
04 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.8.1 read_jo1d

Subroutine READ_JO1D reads in the J-Values for O1D from disk that are needed for the biogenic acetone fluxes,

INTERFACE:

```
SUBROUTINE READ_JO1D( THISMONTH )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0
```

```
      USE BPCH2_MOD,     ONLY : READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : ALLOC_ERR
      USE ERROR_MOD,     ONLY : ERROR_STOP
      USE TRANSFER_MOD,  ONLY : TRANSFER_2D

      USE CMN_SIZE_MOD                ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: THISMONTH   ! Current month
```

REMARKS:

```
    J-values for O1D are are stored in the JO1D module array in [s^-1].
```

REVISION HISTORY:

```
    14 Sep 2001 - B. Field    - Initial version
    (1 ) Now use TRANSFER_2D from "transfer_mod" to cast from REAL*4 to REAL*8
         and to resize data block to (IIPAR,JJPAR).  Also use 3-argument
         form of GET_TAU0 (bmy, 11/15/01)
    (2 ) Removed obsolete code from 11/01 (bmy, 11/26/01, bmy, 2/27/02)
    (3 ) Now reference routines ALLOC_ERR and ERROR_STOP from "error_mod.f"
         (bmy, 10/15/02)
    (4 ) Now call READ_BPCH2 with QUIET=.TRUE. to suppress printing of extra
         info to stdout.  Also made cosmetic changes. (bmy, 3/14/03)
    (5 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/19/04)
    (6 ) Now can read data from GEOS and GCAP grids (bmy, 8/16/05)
    (7 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
    04 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.8.2 read_resp

Subroutine READ_RESP reads in the monthly heterotrophic respiration measured in g of plant matter/m$\hat{2}$ flowing out of the biosphere. This is needed for the biogenic acetone fluxes.

INTERFACE:

```
      SUBROUTINE READ_RESP( THISMONTH )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D
      USE BPCH2_MOD,     ONLY : GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0
      USE BPCH2_MOD,     ONLY : READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : ALLOC_ERR
```

```
      USE TRANSFER_MOD,  ONLY : TRANSFER_2D

      USE CMN_SIZE_MOD                  ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: THISMONTH   ! Current month
```

REMARKS:

```
    Respiration values are stored in the RESP module array in [g C/m2/s].
```

REVISION HISTORY:

```
    14 Sep 2001 - B. Field    - Initial version
    (1 ) Now use TRANSFER_2D from "transfer_mod" to cast from REAL*4 to REAL*8
         and to resize data block to (IIPAR,JJPAR).  Bug fix: THISMONTH > 12
         is never valid.  Also use 3-argument form of GET_TAU0 (bmy, 11/15/01)
    (2 ) Removed obsolete code from 11/01 (bmy, 11/26/01, bmy, 2/27/02)
    (3 ) Now reference ALLOC_ERR from "error_mod.f".  Also use version of
         GET_TAU0 w/ 3 arguments. (bmy, 10/15/02)
    (4 ) Now call READ_BPCH2 with QUIET=.TRUE. to suppress printing of extra
         info to stdout.  Also made cosmetic changes. (bmy, 3/14/03)
    (5 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
    (6 ) Now can read files for both GEOS and GCAP grids (bmy, 8/16/05)
    (7 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
    04 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.8.3 ocean_source_acet

Subroutine OCEAN_SOURCE_ACET specifies the ocean source of acetone.

INTERFACE:

```
      SUBROUTINE OCEAN_SOURCE_ACET( I, J, ACETONE )
```

USES:

```
      USE ERROR_MOD, ONLY : CHECK_VALUE
      USE DAO_MOD,   ONLY : ALBD, TS
      USE DIAG_MOD,  ONLY : AD11
      USE GRID_MOD,  ONLY : GET_AREA_CM2
      USE TIME_MOD,  ONLY : GET_TS_EMIS

      USE CMN_SIZE_MOD                  ! Size parameters
      USE CMN_DIAG_MOD                  ! ND11
      USE CMN_DEP_MOD                   ! FRCLND
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)    :: I         ! GEOS-Chem longitude index
      INTEGER, INTENT(IN)    :: J         ! GEOS-Chem latitude index
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8,  INTENT(INOUT) :: ACETONE   ! Acetone emission [atoms C/s]
```

REMARKS:

REVISION HISTORY:

```
    14 Sep 2001 - B. Field    - Initial version
    (1 ) Now compute u = SQRT( U10M^2 + V10M^2 ) as SQRT( SFCWINDSQR(I,J) ).
         This is necessary since U10M and V10M are missing for 1996, and
         need to be computed from UWND and VWND.  (bmy, 9/5/01)
    (2 ) Bug fixes: multiply kg by 360000 and use exponent to the -0.5 power
         in the expression for Kl.  Also update value of the OCEAN_SCALE
         factor to 3.63e11.  Also updated comments. (bdf, bmy, 9/5/01)
    (3 ) Bug fix: ACETONE has units of [atoms C/box/s], to match those of
         EMISRR.  This involves an extra division by DTSRCE. (bmy, 9/14/01)
    (4 ) Removed diagnostic variable OCEAN_SOURCE (bmy, 9/18/01)
    (5 ) JO1D(IREF,JREF) is now JO1D(I,J).  Bug fix: Zero the ocean source
         of acetone in grid boxes that are covered by less than 50% ocean.
         Bug fix: make sure -5 <= TC <= 30, in order to prevent the power
         series for Schmidt # from going negative.  Also eliminate IREF,
         JREF, we don't need them anymore. (mje, rvm, bmy, 11/26/01)
    (6 ) Eliminated obsolete code from 11/01 (bmy, 2/27/02)
    (7 ) Scale the ocean source of acetone for GEOS-3 meteorology in order to
         match the total listed in Jacob et al 2002. (bdf, bmy, 9/16/02)
    (8 ) Now use function GET_AREA_CM2 of "grid_mod.f" to return the
         grid box area in cm2.  Use function GET_TS_EMIS from "time_mod.f".
         Remove reference to CMN header file. (bmy, 2/11/03)
    (9 ) Apply surface area scale factor for 1x1 nested grids, in order to
         make the total ocean source the same as for 4x5. (yxw, bmy, 5/16/03)
    (10) Scale the ocean source to Jacob et al 2002 for GEOS-4.  Also account
         for surface area ratio for all GEOS grids. (bmy, 3/15/04)
    (11) Added space in #ifdef block for GEOS-4 x 1x125 grid (bmy, 12/1/04)
    (12) Now use Nightingale et al 2000b formulation for piston velocity KL.
         (swu, bmy, 8/16/05)
    (13) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
    (14) Adjust SCALE_FACTOR for 0.5 x 0.667 grid (dan, bmy, 11/6/08)
    (15) Additional scale factors for NESTED_NA and NESTED_EU calculated and
         included (amv, bmy, 12/18/09)
    (16) Added scale factor for GEOS-4 1 x 1.25 grid (lok, bmy, 1/13/10)
    13 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
    04 Nov 2010 - R. Yantosca - Added ProTeX headers
    04 Nov 2010 - R. Yantosca - Cleaned up #if statements for clarity
```

1.8.4 ocean_sink_acet

Subroutine OCEAN_SINK_ACET applies the ocean sink to global acetone concentrations.

INTERFACE:

```
SUBROUTINE OCEAN_SINK_ACET( ACETONE )
```

USES:

```
USE DAO_MOD,  ONLY : ALBD
USE DAO_MOD,  ONLY : TS
USE DIAG_MOD, ONLY : AD11
USE GRID_MOD, ONLY : GET_AREA_CM2
USE TIME_MOD, ONLY : GET_TS_CHEM

USE CMN_SIZE_MOD                              ! Size parameters
USE CMN_DIAG_MOD                              ! ND11
USE CMN_DEP_MOD                               ! FRCLND
```

INPUT/OUTPUT PARAMETERS:

```
REAL*8, INTENT(INOUT) :: ACETONE(IIPAR,JJPAR)   ! Acetone mass [kg C]
```

REVISION HISTORY:

```
14 Sep 2001 - B. Field    - Initial version
(1 ) Remove references to F77_CMN_UV10M and F77_CMN_LWI -- these are now
     obsolete in GEOS-CHEM versions 4.18 and higher (bmy, 9/5/01)
(2 ) Now compute u = SQRT( U10M^2 + V10M^2 ) as SQRT( SFCWINDSQR(I,J) ).
     This is necessary since U10M and V10M are missing for 1996, and
     need to be computed from UWND and VWND.  (bmy, 8/2/01)
(3 ) Now declare OCEANSINK_SCALE = 0.15 as a parameter.  This is the
     optimized value of BETA from Emily Jin's analysis.  Also updated
     comments. (bdf, bmy, 9/5/01)
(4 ) Updated comments.  Also parallellized DO loops. (bmy, 9/14/01)
(5 ) Removed diagnostic variable OCEAN_LOSS (bmy, 9/18/01)
(6 ) Bug fix: Zero the ocean sink of acetone in grid boxes where there
     is less than 50% of ocean, and where there is ice on the surface.
     Bug fix: Make sure -5 <= TC <= 30, in order to prevent the power
     series for Schmidt # from going negative.  Also eliminate IREF,
     JREF, we don't need them. (mje, rvm, bmy, 11/26/01)
(7 ) Eliminated obsolete code from 11/01 (bmy, 2/27/02)
(8 ) Bug fix: now use true exponential for loss instead of just 1st
     order term.  Also added PRE_ACET variable to save previous acetone
     mass for diagnostic, before applying loss.  (bdf, bmy, 7/11/02)
(9 ) Now use function GET_AREA_CM2 of "grid_mod.f" to return the
     grid box area in cm2.  Now use function GET_TS_CHEM from
     "time_mod.f".  Remove reference to CMN header file. (bmy, 2/11/03)
(12) Now use Nightingale et al 2000b formulation for piston velocity KL.
```

```
      (swu, bmy, 8/16/05)
04 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.8.5 emiss_bioacet

Subroutine EMISS_BIOACET computes the biogenic emissions of ACETONE from monoterpenes, isoprene, methyl butenol, dry leaf matter, and grasslands.

INTERFACE:

```
      SUBROUTINE EMISS_BIOACET( I,    J,    TMMP,  EMMO,
     &                          EMIS, EMMB, GRASS, ACETONE )
```

USES:

```
      USE DIAG_MOD, ONLY : AD11
      USE GRID_MOD, ONLY : GET_AREA_M2
      USE GRID_MOD, ONLY : GET_XMID
      USE GRID_MOD, ONLY : GET_YMID
      USE TIME_MOD, ONLY : GET_TS_EMIS

      USE CMN_SIZE_MOD                 ! Size parameters
      USE CMN_DIAG_MOD                 ! ND11
      USE CMN_MONOT_MOD                ! BASEMONOT
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)    :: I         ! Grid box longitude index
      INTEGER, INTENT(IN)    :: J         ! Grid box latitude index
      REAL*8,  INTENT(IN)    :: TMMP      ! Surface temperature [K]
      REAL*8,  INTENT(IN)    :: EMMO      ! Monoterpene emission [atoms C]
      REAL*8,  INTENT(IN)    :: EMIS      ! Isoprene emission [atoms C]
      REAL*8,  INTENT(IN)    :: EMMB      ! Methylbutenol emission  [atoms C]
      REAL*8,  INTENT(IN)    :: GRASS     ! Isoprene from grasslands [atoms C]
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8,  INTENT(INOUT) :: ACETONE   ! Biogenic acetone [atoms C/s]
```

REVISION HISTORY:

```
18 Sep 2001 - B. Field    - Initial version
(1 ) Now pass acetone array (e.g. from STT) thru the argument list, since
     this avoids dependence on IDTACET in this program (bmy, 8/1/01)
(2 ) Updated scale factors (bdf, bmy, 9/5/01)
(3 ) Updated comments (bmy, 9/14/01)
(4 ) Removed diagnostic variables: MONOTERPENES, ISOPRENE, ISOP_TOTAL,
     MONO_TOTAL, NA_TOT, RESP_TOT, GRASS_TOT.  These have now been
     supplanted by the ND11 acetone source diagnostic. (bdf, bmy, 9/18/01)
```

```
(5 ) XRESP(I+I0,J+J0) is now XRESP(I,J) (bmy, 11/26/01)
(6 ) Eliminated obsolete code from 11/01 (bmy, 2/27/02)
(7 ) Removed duplicate definitions of EMMB and GRASS (bmy, 3/20/02)
(8 ) Now use functions from "grid_mod.f" to get surface area, lon, and
     lat of grid box (I,J).  Use function GET_AREA_M2 to get the grid
     box surface area in m2, then convert to cm2.  Now use function
     GET_TS_EMIS from "time_mod.f".  Remove reference to CMN header
     file. (bmy, 2/11/03)
04 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.8.6 cleanup_acetone

Subroutine CLEANUP_ACETONE deallocates module arrays

INTERFACE:

```
SUBROUTINE CLEANUP_ACETONE
```

REVISION HISTORY:

```
14 Sep 2001 - R. Yantosca - Initial version
04 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.9 Fortran: Module Interface arctas_ship_emiss_mod

Module ARCTAS_SHIP_EMISS_MOD contains variables and routines to read the Arctas Ship emissions.

INTERFACE:

```
MODULE ARCTAS_SHIP_EMISS_MOD
```

USES:

```
IMPLICIT NONE
#     include "define.h"
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: CLEANUP_ARCTAS_SHIP
PUBLIC  :: EMISS_ARCTAS_SHIP
PUBLIC  :: GET_ARCTAS_SHIP
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: INIT_ARCTAS_SHIP
      PRIVATE :: READ_ARCTAS_SHIP
      PRIVATE :: TOTAL_EMISS_TG
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
31 Aug 2010 - R. Yantosca - Updated comments
```

REMARKS:

```
(1) Part of the ARCTAS pre-campaign composite inventory distributed by
     David Streets.
(2) Only SO2 differs from existing EDGAR inventory. All other
     species are disregarded for now, except CO2 that we did not have
     before.
(3) The ship emission is based on the work by Eyring et al., JGR 2005,
    which estimates the total international ship emissions for 1985, 1990,
    2001, and 2020 (projection). The ship emission for each individual year
    is interpreted based on the above years, and the spatial pattern
    (gridded) is mapped based on the EDGAR gridded ship emission for 2000
    (total amount from EDGAR is scaled to Eyring-based number).
    If you want to reference the work on publication or website, you may
    either mention "Diehl et al., manuscript in preparation, 2009" or
    refer to the AeroCom readme document for hindcast emissions for ship
    (prepared by Diehl):
    http://www-lscedods.cea.fr/aerocom/AEROCOM_HC/readme_ship/.
    If you have further questions, please contact Thomas directly
    (thomas.diehl@nasa.gov).
```

1.9.1 get_arctas_ship

Function GET_ARCTAS_SHIP returns the ARCTAS_SHIP emission for GEOS-Chem grid box (I,J) and tracer N. Emissions can be returned in units of [kg/s] or [molec/cm2/s].

INTERFACE:

```
      FUNCTION GET_ARCTAS_SHIP( I, J, N, MOLEC_CM2_S, KG_S )
     &     RESULT( VALUE )
```

USES:

```
      USE TRACER_MOD,   ONLY : ITS_A_CO2_SIM
      USE TRACER_MOD,   ONLY : XNUMOL
      USE TRACERID_MOD, ONLY : IDTSO2
```

INPUT PARAMETERS:

```
      ! Longitude, latitude, and tracer indices
      INTEGER, INTENT(IN)           :: I, J, N
```

```
! OPTIONAL -- return emissions in [molec/cm2/s]
LOGICAL, INTENT(IN), OPTIONAL :: MOLEC_CM2_S

! OPTIONAL -- return emissions in [kg/s]
LOGICAL, INTENT(IN), OPTIONAL :: KG_S
```

RETURN VALUE:

```
! Emissions output
REAL*8                        :: VALUE
```

REVISION HISTORY:

28 Jan 2009 - P. Le Sager - Initial Version

1.9.2 emiss_arctas_ship

Subroutine EMISS_ARCTAS_SHIP reads the ARCTAS_SHIP emissions from disk.

INTERFACE:

```
SUBROUTINE EMISS_ARCTAS_SHIP( YEAR )
```

USES:

```
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE TRACER_MOD,     ONLY : ITS_A_CO2_SIM

USE CMN_SIZE_MOD       ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)     :: YEAR   ! Year of data to read
```

REVISION HISTORY:

28 Jan 2009 - P. Le Sager - Initial Version

1.9.3 read_arctas_ship

Subroutine READ_ARCTAS_SHIP reads data from one ARCTAS_SHIP data file from disk, at GENERIC 1x1 resolution and regrids them to the current model resolution.

INTERFACE:

```
 SUBROUTINE READ_ARCTAS_SHIP( FILENAME, CATEGORY,
&                             TRACERN,  ARR,      YEAR )
```

USES:

```
USE BPCH2_MOD,        ONLY : GET_TAU0,      READ_BPCH2
USE REGRID_1x1_MOD,   ONLY : DO_REGRID_1x1, DO_REGRID_G2G_1x1
USE SCALE_ANTHRO_MOD, ONLY : GET_ANNUAL_SCALAR_1x1

USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

```
! Year of data to read
INTEGER,          INTENT(IN)    :: YEAR

! Tracer number
INTEGER,          INTENT(IN)    :: TRACERN

! Filename & category under which data is stored in bpch file
CHARACTER(LEN=*), INTENT(IN)    :: FILENAME, CATEGORY
```

INPUT/OUTPUT PARAMETERS:

```
! Array containing output data
REAL*8,           INTENT(INOUT) :: ARR(IIPAR,JJPAR)
```

REVISION HISTORY:

28 Jan 2009 - P. Le Sager - Initial Version

REMARKS:

(1) Even though the inventory was prepared for Arctas 2008 campaign, CO2 base year is 2000, and SO2 base year is 2006. Input YEAR is used to scale SO2 into 1985-2005

1.9.4 TOTAL_EMISS_TG

Subroutine TOTAL_EMISS_TG prints the totals for the anthropogenic or biomass emissions.

INTERFACE:

```
SUBROUTINE TOTAL_EMISS_TG
```

USES:

```
USE TRACER_MOD, ONLY : ITS_A_CO2_SIM

USE CMN_SIZE_MOD   ! Size parameters
```

REVISION HISTORY:

28 Jan 2009 - P. Le Sager - Initial Version

1.9.5 INIT_ARCTAS_SHIP

Subroutine INIT_ARCTAS_SHIP allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_ARCTAS_SHIP
```

USES:

```
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE GRID_MOD,    ONLY : GET_AREA_CM2
USE LOGICAL_MOD, ONLY : LARCSHIP
USE TRACER_MOD,  ONLY : ITS_A_CO2_SIM

USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.9.6 CLEANUP_ARCTAS_SHIP

Subroutine CLEANUP_ARCTAS_SHIP deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_ARCTAS_SHIP
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.10 Fortran: Module Interface bravo_mod

Overview

Module BRAVO_MOD contains variables and routines to read the BRAVO Mexican anthropogenic emission inventory for NOx, CO, and SO2. (rjp, kfb, bmy, 6/22/06, 1/30/09)

References

1. Kuhns, H., M. Green, and Etyemezian, V, *Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study Emissions Inventory*, Desert Research Institute, 2003.

INTERFACE:

```
MODULE BRAVO_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_BRAVO
      PUBLIC  :: EMISS_BRAVO
      PUBLIC  :: GET_BRAVO_MASK
      PUBLIC  :: GET_BRAVO_ANTHRO
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: BRAVO_SCALE_FUTURE
      PRIVATE :: INIT_BRAVO
      PRIVATE :: READ_BRAVO_MASK
```

REVISION HISTORY:

```
(1 ) Now pass the unit string to DO_REGRID_G2G_1x1 (bmy, 8/9/06)
(2 ) Now scale emissions using int-annual scale factors (amv, 08/24/07)
(3 ) Now accounts for FSCLYR (phs, 3/17/08)
(4 ) Added ProTeX headers (bmy, 1/30/09)
31 Aug 2010 - R. Yantosca - Updated comments
```

1.10.1 get_bravo_mask

Function GET_BRAVO_MASK returns the value of the Mexico mask for BRAVO emissions at grid box (I,J). MASK=1 if (I,J) is in the BRAVO Mexican region, or MASK=0 otherwise.

INTERFACE:

```
      FUNCTION GET_BRAVO_MASK( I, J ) RESULT( MASK )
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I        ! Longitude index
      INTEGER, INTENT(IN) :: J        ! Latitude  index
```

RETURN VALUE:

```
      REAL*8              :: MASK     ! Returns the mask value @ (I,J)
```

REVISION HISTORY:

```
22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
```

1.10.2 get_bravo_anthro

Function GET_BRAVO_ANTHRO returns the BRAVO emission for GEOS-Chem grid box (I,J) and tracer N. Units are [molec/cm2/s].

INTERFACE:

```
      FUNCTION GET_BRAVO_ANTHRO( I, J, N ) RESULT( BRAVO )
```

USES:

```
      USE TRACERID_MOD, ONLY : IDTNOX, IDTCO, IDTSO2
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I       ! Longitude index
      INTEGER, INTENT(IN) :: J       ! Latitude index
      INTEGER, INTENT(IN) :: N       ! Tracer number
  RETURN VALUE:

      REAL*8              :: BRAVO   ! Returns emissions at (I,J)
```

REVISION HISTORY:

```
    22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
    (1 ) added SOx, SOx ship and NH3 emissions, plus optional kg/s output
         (amv, 06/2008)
    (2 ) Now returns ship emissions if requested (phs, 6/08)
    (3 ) Added checks to avoid calling unavailable ship emissions (phs, 6/08)
```

1.10.3 emiss_bravo

Subroutine EMISS_BRAVO reads the BRAVO emission fields at 1x1 resolution and regrids them to the current model resolution.

INTERFACE:

```
      SUBROUTINE EMISS_BRAVO
```

USES:

```
      USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
      USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
      USE LOGICAL_MOD,       ONLY : LFUTURE
      USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1, DO_REGRID_G2G_1x1
      USE SCALE_ANTHRO_MOD, ONLY : GET_ANNUAL_SCALAR_1x1
      USE TIME_MOD,          ONLY : GET_YEAR

      USE CMN_SIZE_MOD         ! Size parameters
      USE CMN_O3_MOD           !
```

REVISION HISTORY:

```
22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
(1 ) Now pass the unit string to DO_REGRID_G2G_1x1 (bmy, 8/9/06)
```

1.10.4 bravo_scale_future

Subroutine BRAVO_SCALE_FUTURE applies the IPCC future scale factors to the BRAVO anthropogenic emissions.

INTERFACE:

```
SUBROUTINE BRAVO_SCALE_FUTURE
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_COff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NOxff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_SO2ff

USE CMN_SIZE_MOD             ! Size parameters
```

REVISION HISTORY:

```
30 May 2006 - S. Wu & R. Yantosca - Initial version
```

1.10.5 total_anthro_Tg

Subroutine TOTAL_ANTHRO_TG prints the amount of BRAVO anthropogenic emissions that are emitted each year.

INTERFACE:

```
SUBROUTINE TOTAL_ANTHRO_TG( YEAR )
```

USES:

```
! References to F90 modules
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE TRACERID_MOD, ONLY : IDTNOX, IDTCO, IDTSO2

USE CMN_SIZE_MOD     ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)   :: YEAR
```

REVISION HISTORY:

```
22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
(1 ) Now YEAR is input to reflect scaling factors applied (phs, 3/17/08)
```

1.10.6 read_bravo_mask

Subroutine READ_BRAVO_MASK reads the Mexico mask from disk. The Mexico mask is the fraction of the grid box (I,J) which lies w/in the BRAVO Mexican emissions region.

INTERFACE:

```
SUBROUTINE READ_BRAVO_MASK
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1,   DO_REGRID_G2G_1x1
USE TRANSFER_MOD,   ONLY : TRANSFER_2D

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
(1 ) Now pass UNIT to DO_REGRID_G2G_1x1 (bmy, 8/9/06)
```

1.10.7 init_bravo

Subroutine INIT_BRAVO allocates and zeroes BRAVO module arrays, and also creates the mask which defines the Mexico region

INTERFACE:

```
SUBROUTINE INIT_BRAVO
```

USES:

```
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE GRID_MOD,    ONLY : GET_XMID, GET_YMID
USE LOGICAL_MOD, ONLY : LBRAVO

USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
```

1.10.8 CLEANUP_BRAVO

Subroutine CLEANUP_BRAVO deallocates all BRAVO module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_BRAVO
```

REVISION HISTORY:

```
    22 Jun 2006 - R. Park, F. Boersma, R. Yantosca - Initial version
```

1.11 Fortran: Module Interface cac_anthro_mod

Module CAC_ANTHRO_MOD contains variables and routines to read the Criteria Air Contaminant Canadian anthropogenic emissions (amv, phs, 1/28/2009)

INTERFACE:

```
      MODULE CAC_ANTHRO_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_CAC_ANTHRO
      PUBLIC :: EMISS_CAC_ANTHRO
      PUBLIC :: EMISS_CAC_ANTHRO_05x0666
      PUBLIC :: GET_CANADA_MASK
      PUBLIC :: GET_CAC_ANTHRO
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: CAC_SCALE_FUTURE
      PRIVATE :: READ_CANADA_MASK
      PRIVATE :: READ_CANADA_MASK_05x0666
      PRIVATE :: INIT_CAC_ANTHRO
      PRIVATE :: TOTAL_ANTHRO_TG
```

REVISION HISTORY:

```
    28 Jan 2009 - P. Le Sager - Initial Version
    18 Dec 2009 - Aaron van D - Added EMISS_CAC_ANTHRO_05x0666 routine
    18 Dec 2009 - Aaron van D - Added READ_CANADA_MASK_05x0666 routine
```

1.11.1 get_canada_mask

Function GET_CANADA_MASK returns the value of the Canadian geographic mask at grid box (I,J). MASK=1 if (I,J) is within Canada, MASK=0 otherwise. (amv, phs, 1/28/09)

INTERFACE:

```
FUNCTION GET_CANADA_MASK( I, J ) RESULT( THISMASK )
```

INPUT PARAMETERS:

```
! Longitude and latitude indices
INTEGER, INTENT(IN) :: I, J
```

REVISION HISTORY:

28 Jan 2009 - P. Le Sager - Initial Version

1.11.2 get_cac_anthro

Function GET_CAC_ANTHRO returns the Critical Air Contaminants emission for GEOS-Chem grid box (I,J) and tracer N. Emissions can be returned in units of [kg/s] or [molec/cm2/s]. (amv, phs, 1/28/09)

INTERFACE:

```
FUNCTION GET_CAC_ANTHRO( I,    J,     N,
&                        MOLEC_CM2_S, KG_S ) RESULT( VALUE )
```

USES:

```
USE TRACER_MOD,   ONLY : XNUMOL
USE TRACERID_MOD, ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3
```

INPUT PARAMETERS:

```
! Longitude, latitude, and tracer indices
INTEGER, INTENT(IN)           :: I, J, N

! OPTIONAL -- return emissions in [molec/cm2/s]
LOGICAL, INTENT(IN), OPTIONAL :: MOLEC_CM2_S

! OPTIONAL -- return emissions in [kg/s]
LOGICAL, INTENT(IN), OPTIONAL :: KG_S
```

RETURN VALUE:

```
! Emissions output
REAL*8                        :: VALUE
```

REVISION HISTORY:

28 Jan 2009 - P. Le Sager - Initial Version

1.11.3 emiss_cac_anthro

Subroutine EMISS_CAC_ANTHRO reads the Critical Air Contaminants emission fields at 1x1 resolution and regrids them to the current model resolution. (amv, phs, 1/28/2009)

INTERFACE:

```
SUBROUTINE EMISS_CAC_ANTHRO
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
USE LOGICAL_MOD,       ONLY : LFUTURE
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1
USE TIME_MOD,          ONLY : GET_YEAR
USE SCALE_ANTHRO_MOD,  ONLY : GET_ANNUAL_SCALAR_1x1

USE CMN_SIZE_MOD          ! Size parameters
USE CMN_O3_MOD            ! FSCALYR
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

REMARKS:

```
(1 ) Emissions are read for a year b/w 2002-2005, and scaled
      (except NH3) between 1985-2003 if needed (phs, 3/10/08)
(2 ) Now accounts for FSCALYR (phs, 3/17/08)
18 Dec 2009 - Aaron van D - Use 2005 scale factors for years beyond 2005
```

1.11.4 emiss_cac_anthro_05x0666

Subroutine EMISS_CAC_ANTHRO_05x0666 reads the Critical Air Contaminants emission fields at nested NA resolution (1/2 x 2/3) (amv, phs, 11/03/2009)

INTERFACE:

```
SUBROUTINE EMISS_CAC_ANTHRO_05x0666
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR
USE LOGICAL_MOD,       ONLY : LFUTURE
USE TIME_MOD,          ONLY : GET_YEAR
USE SCALE_ANTHRO_MOD,  ONLY : GET_ANNUAL_SCALAR_05x0666_NESTED

USE CMN_SIZE_MOD          ! Size parameters
USE CMN_O3_MOD            ! FSCALYR
```

REVISION HISTORY:

```
03 Nov 2009 - A. van Donkelaar - Initial Version
```

REMARKS:

```
(1 ) Emissions are read for a year b/w 2002-2005, and scaled
      (except NH3) between 1985-2003 if needed (phs, 3/10/08)
(2 ) Now accounts for FSCALYR (phs, 3/17/08)
```

1.11.5 cac_scale_future

Subroutine CAC_SCALE_FUTURE applies the IPCC future scale factors to the Criteria Air Contaminant anthropogenic emissions. (amv, phs, 1/28/09)

INTERFACE:

```
SUBROUTINE CAC_SCALE_FUTURE
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_COff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NH3an
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NOxff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_SO2ff

USE CMN_SIZE_MOD             ! Size parameters
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.11.6 total_anthro_tg

Subroutine TOTAL_ANTHRO_TG prints the totals for the anthropogenic emissions of NOx, CO, SO2 and NH3. (amv, phs, 1/28/09)

INTERFACE:

```
SUBROUTINE TOTAL_ANTHRO_TG( YEAR )
```

USES:

```
USE CMN_SIZE_MOD            ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: YEAR   ! Year of data to compute totals
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.11.7 read_canada_mask

Subroutine READ_CANADA_MASK reads and regrids the Canadian geographic mask from disk. (amv, phs, 1/28/09)

INTERFACE:

```
SUBROUTINE READ_CANADA_MASK
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_TAU0, READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_G2G_1x1, DO_REGRID_1x1

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.11.8 read_canada_mask_05x0666

Subroutine READ_CANADA_MASK_05x0666 reads the Canadian geographic mask from disk. (amv, phs, 1/28/09)

INTERFACE:

```
SUBROUTINE READ_CANADA_MASK_05x0666
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_TAU0, READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR
USE REGRID_1x1_MOD, ONLY : DO_REGRID_G2G_1x1, DO_REGRID_1x1

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
11 Nov 2009 - A. van Donkelaar - Initial Version
```

1.11.9 init_cac_anthro

Subroutine INIT_CAC_ANTHRO allocates and zeroes all module arrays. (phs, 1/28/09)

INTERFACE:

```
SUBROUTINE INIT_CAC_ANTHRO
```

USES:

```
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE GRID_MOD,    ONLY : GET_AREA_CM2
      USE LOGICAL_MOD, ONLY : LCAC

      USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
    28 Jan 2009 - P. Le Sager - Initial Version
```

1.11.10 cleanup_cac_anthro

Subroutine CLEANUP_CAC_ANTHRO deallocates all module arrays. (phs, 1/28/09)

INTERFACE:

```
      SUBROUTINE CLEANUP_CAC_ANTHRO
```

REVISION HISTORY:

```
    28 Jan 2009 - P. Le Sager - Initial Version
```

1.12 Fortran: Module Interface chemistry_mod

Module CHEMISTRY_MOD is used to call the proper chemistry subroutine for the various GEOS-Chem simulations.

INTERFACE:

```
      MODULE CHEMISTRY_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: DO_CHEMISTRY
      PUBLIC :: GCKPP_DRIVER
      PUBLIC :: RECOMPUTE_OD
```

REVISION HISTORY:

```
    (1 ) Bug fix in DO_CHEMISTRY (bnd, bmy, 4/14/03)
    (2 ) Now references DEBUG_MSG from "error_mod.f" (bmy, 8/7/03)
    (3 ) Now references "tagged_ox_mod.f"(bmy, 8/18/03)
```

```
(4 ) Now references "Kr85_mod.f" (jsw, bmy, 8/20/03)
(5 ) Bug fix: Now also call OPTDEPTH for GEOS-4 (bmy, 1/27/04)
(6 ) Now references "carbon_mod.f" and "dust_mod.f" (rjp, tdf, bmy, 4/5/04)
(7 ) Now references "seasalt_mod.f" (rjp, bec, bmy, 4/20/04)
(8 ) Now references "logical_mod.f", "tracer_mod.f", "diag20_mod.f", and
     "diag65_mod.f", and "aerosol_mod." (bmy, 7/20/04)
(9 ) Now references "mercury_mod.f" (bmy, 12/7/04)
(10) Updated for SO4s, NITs chemistry (bec, bmy, 4/13/05)
(11) Now call CHEM_HCN_CH3CN from "hcn_ch3cn_mod.f".  Also remove all
     references to the obsolete CO-OH param simulation. (xyp, bmy, 6/24/05)
(12) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(13) Now call MAKE_RH from "main.f" (bmy, 3/16/06)
(14) Updated for SOA from isoprene (dkh, bmy, 6/1/06)
(15) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(16) For now, replace use RPMARES instead of ISORROPIA. (bmy, 4/2/08)
(17) Added KPP chemistry driver subroutine (phs,ks,dhk, 09/15/09)
(18) Added public member function recompute_OD (skim, 02/03/11)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
28 Jan 2010 - C. Carouge, R. Yantosca - Modified for ISORROPIA II
```

1.12.1 do_chemistry

Subroutine DO_CHEMISTRY is the driver routine which calls the appropriate chemistry subroutine for the various GEOS-Chem simulations.

INTERFACE:

```
SUBROUTINE DO_CHEMISTRY
```

USES:

```
USE ACETONE_MOD,     ONLY : OCEAN_SINK_ACET
USE AEROSOL_MOD,     ONLY : AEROSOL_CONC, AEROSOL_RURALBOX
USE AEROSOL_MOD,     ONLY : RDAER,        SOILDUST
USE C2H6_MOD,        ONLY : CHEMC2H6
USE CARBON_MOD,      ONLY : CHEMCARBON
USE CH3I_MOD,        ONLY : CHEMCH3I
USE DAO_MOD,         ONLY : CLDF,    DELP
USE DAO_MOD,         ONLY : OPTDEP,  OPTD,   T
USE DRYDEP_MOD,      ONLY : DRYFLX, DRYFLXRnPbBe, DRYFLXH2HD
USE DUST_MOD,        ONLY : CHEMDUST, RDUST_ONLINE
USE ERROR_MOD,       ONLY : DEBUG_MSG
USE GLOBAL_CH4_MOD,  ONLY : CHEMCH4
USE H2_HD_MOD,       ONLY : CHEM_H2_HD
USE HCN_CH3CN_MOD,   ONLY : CHEM_HCN_CH3CN
USE ISOROPIAII_MOD,  ONLY : DO_ISOROPIAII
USE LOGICAL_MOD,     ONLY : LCARB, LCHEM,  LCRYST, LDUST
USE LOGICAL_MOD,     ONLY : LPRT,  LSSALT, LSULF,  LSOA
```

```
      USE MERCURY_MOD,     ONLY : CHEMMERCURY
      USE OPTDEPTH_MOD,    ONLY : OPTDEPTH
      USE RnPbBe_MOD,      ONLY : CHEMRnPbBe
      USE RPMARES_MOD,     ONLY : DO_RPMARES
      USE SEASALT_MOD,     ONLY : CHEMSEASALT
      USE SULFATE_MOD,     ONLY : CHEMSULFATE
      USE TAGGED_CO_MOD,   ONLY : CHEM_TAGGED_CO
      USE TAGGED_OX_MOD,   ONLY : CHEM_TAGGED_OX
      USE TIME_MOD,        ONLY : GET_ELAPSED_MIN, GET_TS_CHEM
      USE TRACER_MOD,      ONLY : N_TRACERS,       STT
      USE TRACER_MOD,      ONLY : ITS_A_C2H6_SIM
      USE TRACER_MOD,      ONLY : ITS_A_CH3I_SIM
      USE TRACER_MOD,      ONLY : ITS_A_CH4_SIM
      USE TRACER_MOD,      ONLY : ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,      ONLY : ITS_A_H2HD_SIM
      USE TRACER_MOD,      ONLY : ITS_A_HCN_SIM
      USE TRACER_MOD,      ONLY : ITS_A_MERCURY_SIM
      USE TRACER_MOD,      ONLY : ITS_A_RnPbBe_SIM
      USE TRACER_MOD,      ONLY : ITS_A_TAGCO_SIM
      USE TRACER_MOD,      ONLY : ITS_A_TAGOX_SIM
      USE TRACER_MOD,      ONLY : ITS_AN_AEROSOL_SIM
      USE TRACER_MOD,      ONLY : ITS_NOT_COPARAM_OR_CH4
      USE TRACERID_MOD,    ONLY : IDTACET, IDTISOP
      USE LOGICAL_MOD,     ONLY : LNLPBL ! (Lin, 03/31/09)

      USE CMN_SIZE_MOD          ! Size parameters
      USE COMODE_LOOP_MOD       ! NPHOT
      USE CMN_DIAG_MOD          ! NDxx flags
```

REVISION HISTORY:

```
(1 ) Now reference DELP, T from "dao_mod.f" since we need to pass this
     to OPTDEPTH for GEOS-1 or GEOS-STRAT met fields (bnd, bmy, 4/14/03)
(2 ) Now references DEBUG_MSG from "error_mod.f" (bmy, 8/7/03)
(3 ) Removed call to CHEMO3, it's obsolete.  Now calls CHEM_TAGGED_OX !
     from "tagged_ox_mod.f" when NSRCX==6.  Now calls Kr85 chemistry if
     NSRCX == 12 (jsw, bmy, 8/20/03)
(4 ) Bug fix: added GEOS-4 to the #if block in the call to OPTDEPTH.
     (bmy, 1/27/04)
(5 ) Now calls CHEMCARBON and CHEMDUST to do carbon aerosol & dust
     aerosol chemistry (rjp, tdf, bmy, 4/2/04)
(6 ) Now calls CHEMSEASALT to do seasalt aerosol chemistry
     (rjp, bec, bmy, 4/20/04)
(7 ) Now references "logical_mod.f" & "tracer_mod.f".  Now references
     AEROSOL_CONC, AEROSOL_RURALBOX, and RDAER from "aerosol_mod.f".
     Now includes "F77_CMN_DIAG" and "comode.h".  Also call READER, READCHEM,
     and INPHOT to initialize the FAST-J arrays so that we can save out !
     AOD's to the ND21 diagnostic for offline runs. (bmy, 7/20/04)
(8 ) Now call routine CHEMMERCURY from "mercury_mod.f" for an offline
```

```
      Hg0/Hg2/HgP simulation. (eck, bmy, 12/7/04)
(9 ) Now do not call DO_RPMARES if we are doing an offline aerosol run
      with crystalline sulfur & aqueous tracers (cas, bmy, 1/7/05)
(10) Now use ISOROPIA for aer thermodyn equilibrium if we have seasalt
      tracers defined, or RPMARES if not.  Now call CHEMSEASALT before
      CHEMSULFATE.  Now do aerosol thermodynamic equilibrium before
      aerosol chemistry for offline aerosol runs.  Now also reference
      CLDF from "dao_mod.f" (bec, bmy, 4/20/05)
(11) Now modified for GCAP met fields.  Now call CHEM_HCN_CH3CN from
      "hcn_ch3cn_mod.f".  Also remove allreferences to the obsolete
       CO-OH param simulation. (xyp, bmy, 6/23/05)
(12) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(13) Now call MAKE_RH from "main.f" (bmy, 3/16/06)
(14) Removed ISOP_PRIOR as a local variable (dkh, bmy, 6/1/06)
(15) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(16) Now use DRYFLXH2HD and CHEM_H2_HD for H2/HD sim (lyj, phs, 9/18/07)
(17) Bug fix: now hardwired to use RPMARES since ISORROPIA can return very
      unphysical values at low RH.  Wait for ISORROPIA II. (bmy, 4/2/08)
(18) The dry deposition diagnostic (ND44) is done in vdiff_mod if using non-
      local PBL (lin, ccc, 5/29/09)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
28 Jan 2010 - C. Carouge, R. Yantosca - Modified for ISORROPIA II
```

1.12.2 gckpp_driver

Subroutine GCKPP_DRIVER is the driver routine to perform integration with the full KPP chemistry mechanism.

INTERFACE:

```
SUBROUTINE GCKPP_DRIVER( KTLOOP, JLOOPLO, R_KPP, NSPEC_GC )
```

USES:

```
USE COMODE_MOD,           ONLY : JLOP,   CSPEC
USE COMODE_MOD,           ONLY : IXSAVE, IYSAVE,    IZSAVE
USE GCKPP_COMODE_MOD,     ONLY : HSAVE_KPP
USE TIME_MOD,             ONLY : GET_TS_CHEM
USE GCKPP_UTIL,           ONLY : SHUFFLE_KPP2USER
USE GCKPP_INITIALIZE,     ONLY : INITIALIZE
USE GCKPP_MODEL
USE GCKPP_GLOBAL
USE GCKPP_RATES,          ONLY : UPDATE_RCONST
USE GCKPP_MONITOR,        ONLY : SPC_NAMES
USE GCKPP_FUNCTION
USE ERROR_MOD,            ONLY : ERROR_STOP
USE GCKPP_INTEGRATOR,     ONLY : NHNEW, NHEXIT, INTEGRATE
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: KTLOOP       ! Local loop index
      INTEGER, INTENT(IN) :: JLOOPLO      ! JLOOPLO + KLOOP = JLOOP
      REAL*8,  INTENT(IN) :: R_KPP(:,:)   ! Array of reaction rates
      INTEGER, INTENT(IN) :: NSPEC_GC     ! # of active chemical species
```

REMARKS:

```
    Variables used to pass the last/first step size b/w call
                                                                          .
    For Rosenbrock:
    ----------------
        Nhexit=2, Nhnew = 3
    OUT
        RSTATUS(2)  -> Hexit, last accepted step before exit
        RSTATUS(3)  -> Hnew, last predicted step (not yet taken)
        For multiple restarts, use Hnew as Hstart in the subsequent run
    IN
        RCNTRL(3)   -> Hstart, starting value for the integration step size
                                                                          .
                                                                          .
    For LSODE:
    ------------
    OUT
        RSTATUS(1)  -> Texit, the time corresponding to the
                       computed Y upon return
        RSTATUS(2)  -> Hexit, last predicted step before exit
        For multiple restarts, use Hexit as Hstart in the following run
    IN
        RCNTRL(3)  -> Hstart, starting value for the integration step size
                                                                          .
                                                                          .
    For RADAU5:
    ------------
    OUT
        RSTATUS(1)  -> final time
    IN
        RCNTRL(3)   -> not used
                                                                          .
                                                                          .
   For RUNGE-KUTTA
   ---------------
   OUT
       same as Rosenbrock
```

REVISION HISTORY:

```
    24 Jan 2008 - Kumaresh    - Based on Daven Henze's GCKPP_DRIVER.
    16 Sep 2009 - R. Yantosca - Commented, and updated to call various
```

```
03 Dec 2009 - C. Carouge  - Use CSPEC instead of CSPEC_FOR_KPP
                            to save memory space
17 Dec 2009 - R. Yantosca - Added ProTeX headers
20 Jan 2010 - C. Carouge  - Now call GCKPP_DRIVER from physproc.f to save
                            memory.
20 Jan 2010 - C. Carouge  - Now use the # of active species from GC to
                            update CSPEC and not the of variable species
                            from KPP.
```

1.12.3 recompute_od

Subroutine RECOMPUTE_OD will update the optical depth values before accumulating or writing the diagnostics.

INTERFACE:

```
SUBROUTINE RECOMPUTE_OD
```

USES:

```
! References to F90 modules
USE AEROSOL_MOD,     ONLY : AEROSOL_CONC
USE AEROSOL_MOD,     ONLY : RDAER, SOILDUST
USE DUST_MOD,        ONLY : RDUST_ONLINE, RDUST_OFFLINE
USE ERROR_MOD,       ONLY : DEBUG_MSG
USE LOGICAL_MOD,     ONLY : LCARB, LCHEM, LCRYST, LDUST
USE LOGICAL_MOD,     ONLY : LPRT, LSSALT, LSULF,  LSOA
USE TIME_MOD,        ONLY : GET_MONTH, GET_YEAR
USE TRACER_MOD,      ONLY : ITS_A_FULLCHEM_SIM
USE TRACER_MOD,      ONLY : ITS_AN_AEROSOL_SIM
```

REVISION HISTORY:

```
03 Fev 2011 - Adapted from chemdr.f by skim
```

1.13 Fortran: Module Interface co2_mod

Module CO2_MOD contains variables and routines used for the CO2 simulation. A tagged CO2 simulation capability has now been added.

References:

- Andres, R.J, G. Marland, I. Fung, and E. Matthews, *A 1x1 distribution of carbon dioxide emissions from fossil fuel consumption and cement manufacture*, Glob. Biogeochem. Cycles, **10**, 419-429, 1996.
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- Kim et al. (2005) *System for assessing Aviation's Global Emissions (SAGE) Version 1.5 global Aviation Emissions Inventories for 2000-2004*
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- Potter et al. (1993), *Terrestrial Ecosystem Production: A process model based on global satellite and surface data*, Glob. Biogeochem. Cycles, **7**(4), 811-841.
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- Suntharalingam et al. (2005) *Infulence of reduced carbon emissions and oxidation on the distribution of atmospheric CO2: Implications for inversion analysis*, BGC, 19, GB4003.
- Takahashi, T, R. Feely, R. Weiss, R. Wanninkof, D. Chipman, S. Sutherland, and T. Takahashi (1997), *Global air-sea flux of CO2: An estimate based on measurements of sea-air pCO2 difference*, Proceedings of the National Academy of Sciences, **94**, 8292-8299.
- Takahashi, T, et al. (2009), *Climatological mean and decadal change in surface ocean pCO2, and net sea-air CO2 flux over the global oceans*, **Deep-Sea Research II**, doi:10.1016/jdsr2/2008.12.009.
- Yevich, R. and J. A. Logan, *An assesment of biofuel use and burning of agricultural waste in the developing world*, Glob. Biogeochem. Cycles, **17**, 1095, doi:10.1029/2002GB001952, 2003.
- Sausen, R. and Schumann, U. "Estimates of the Climate Response to Aircraft CO2 and NOx Emissions Scenarios", Climate Change, 44: 27-58, 2000
- Wilkersen, J.T. et al. *Analysis of emission data from global commercial Aviation: 2004 and 2006*, Atmos. chem. Phys. Disc., **10**, 2945-2983, 2010.

INTERFACE:

```
MODULE CO2_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_CO2
      PUBLIC  :: EMISSCO2
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: READ_CHEMCO2
      PRIVATE :: READ_FOSSILCO2
      PRIVATE :: CHEM_SURF
      PRIVATE :: AVIATION_DOM_CORR
      PRIVATE :: READ_OCEANCO2
      PRIVATE :: READ_ANNUAL_BIOFUELCO2
      PRIVATE :: READ_SHIPCO2_EDGAR
      PRIVATE :: READ_SHIPCO2_ICOADS
      PRIVATE :: READ_AVIATION_CO2
      PRIVATE :: READ_ANNUAL_BIONET_CO2
      PRIVATE :: READ_BBIO_DAILYAVERAGE
      PRIVATE :: READ_BBIO_DIURNALCYCLE
      PRIVATE :: TOTAL_BIOMASS_TG
      PRIVATE :: DEF_BIOSPH_CO2_REGIONS_F
      PRIVATE :: DEF_OCEAN_CO2_REGIONS_F
      PRIVATE :: DEF_FOSSIL_CO2_REGIONS_F
      PRIVATE :: INIT_CO2
```

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%   BUYER BEWARE! Tagged CO2 tracers only work for 2 x 2.5 grid!   %%%
%%%   Someone will have to make this more general later on...        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

.

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam - Initial version
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(2 ) Now references biomass_mod.f (bmy, 9/27/06)
(3 ) Tagged CO2 capability developed (dbj)
(4 ) Implemented monthly and annual fossil fuel inventories
      (R.Nassar 2009-03-10)
(5 ) Implemented CO2 emissions from shipping and aviation (R.Nassar 2010)
(6 ) Implemented monthly CO2 chemical production and surface correction
```

```
      (R.Nassar 2010)
25 Feb 2011 - R. Nassar  - Now read updated CDIAC CO2 emissions data
07 Sep 2011 - P. Kasibhatla - Modified to include GFED3
```

1.13.1 emissco2

Subroutine EMISSCO2 is the driver routine for CO2 emissions.

INTERFACE:

```
SUBROUTINE EMISSCO2
```

USES:

```
USE BIOMASS_MOD,  ONLY : BIOMASS
USE DIAG04_MOD,   ONLY : AD04, ND04
USE DIAG04_MOD,   ONLY : AD04_plane,    AD04_chem
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE TIME_MOD,     ONLY : GET_DAY,       GET_DAY_OF_YEAR
USE TIME_MOD,     ONLY : GET_HOUR,      GET_MONTH
USE TIME_MOD,     ONLY : GET_YEAR,      GET_TS_CHEM, GET_TS_EMIS
USE TIME_MOD,     ONLY : ITS_A_NEW_DAY, ITS_A_NEW_MONTH
USE TRACER_MOD,   ONLY : N_TRACERS,     STT
USE TRACERID_MOD, ONLY : IDBCO2
USE LOGICAL_MOD,  ONLY : LGENFF,      LANNFF,   LMONFF, LSTREETS
USE LOGICAL_MOD,  ONLY : LSEASBB,     LGFED2BB, L8DAYBB, LBIOFUEL
USE LOGICAL_MOD,  ONLY : LGFED3BB, L8DAYBB3
USE LOGICAL_MOD,  ONLY : LBIODAILY,   LBIODIURNAL
USE LOGICAL_MOD,  ONLY : LBIONETORIG, LBIONETCLIM
USE LOGICAL_MOD,  ONLY : LOCN1997,    LOCN2009ANN, LOCN2009MON
USE LOGICAL_MOD,  ONLY : LSHIPEDG,    LSHIPICO,    LPLANE
USE LOGICAL_MOD,  ONLY : LBIOSPHTAG,  LFOSSILTAG,  LFFBKGRD
USE LOGICAL_MOD,  ONLY : LSHIPTAG,    LPLANETAG
USE LOGICAL_MOD,  ONLY : LSHIPSCALE,  LPLANESCALE
USE LOGICAL_MOD,  ONLY : LCHEMCO2

USE CMN_SIZE_MOD    ! Size parameters
```

REMARKS:

```
The initial condition for CO2 has to be at least 50 ppm or higher or else
the balanced biosphere fluxes will make STT negative. (pns, bmy, 8/16/05)
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam - Initial version
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
```

```
(2 ) We now get CO2 biomass emissions from biomass_mod.f.  This allows us
     to use either GFED2 or default Duncan et al biomass emissions.
     (bmy, 9/27/06)
(3 ) Tagged tracer capability added. This requires the editable region
     files Regions_land.dat and Regions_ocean.dat in the run directory
     (rnassar,dbj, 2009)
(4 ) New tracers for emissions from international and domestic shipping,
     international and domestic aviation, and the chemical CO2 source
     from the oxidation of CO, CH4, and other organics (rnassar,dbj, 2009)
```

1.13.2 read_chemco2

Reads the chemical source of CO2 [molec/cm3/s] from disk.

INTERFACE:

```
SUBROUTINE READ_CHEMCO2
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE BPCH2_MOD,     ONLY : GET_MODELNAME, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,   READ_BPCH2
USE TIME_MOD,      ONLY : GET_MONTH,  GET_YEAR

USE CMN_SIZE_MOD      ! Size parameters
```

REMARKS:

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.3 read_fossilco2

Subroutine READ_FOSSILCO2 reads in fossil fuel CO2 emissions from a bpch file.

INTERFACE:

```
SUBROUTINE READ_FOSSILCO2
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D
```

```
      USE TIME_MOD,      ONLY : GET_YEAR, GET_MONTH
      USE LOGICAL_MOD,   ONLY : LGENFF, LANNFF, LMONFF, LCHEMCO2, LPLANE

      USE CMN_SIZE_MOD      ! Size parameters
```

REMARKS:

```
    Original data provided by Robert Andres (CDIAC), personal communication
                                                                             .
    If GENFF=T, then annual data for 1995 are read (but tau is for 1985)
    If ANNFF=T, then annual data for a given year (1985-2006) are read
    If MONFF=T, then annual data for a given month (198501-200612) are read
                                                                             .
    ANNFF and MONFF for 2007-2009 were developed based on scaling using
    preliminary data on the CDIAC website for 2007-2008 and LeQuere et al.
    (2009) for 2009
                                                                             .
        -- Ray Nassar 2010-03-10
```

REVISION HISTORY:

```
    16 Aug 2005 - P. Suntharalingam   - Initial version
    18 May 2010 - R. Nassar, D. Jones - Updated
    25 Feb 2011 - R. Nassar           - Now point to annual_v2010 and
                                        monthly_v2010 directories, which
                                        contain updated CO2 data from CDIAC
```

1.13.4 chem_surf

This subroutine reads the fossil fuel distribution from file to be used for part of the spatial distribution of the CO2 surface correction, based on a value of 4.89Suntharalingam et al. (2005).

INTERFACE:

```
      SUBROUTINE CHEM_SURF
```

USES:

```
      USE BPCH2_MOD,      ONLY : GET_TAU0,   READ_BPCH2
      USE BPCH2_MOD,      ONLY : GET_NAME_EXT_2D, GET_RES_EXT
      USE DIRECTORY_MOD,  ONLY : DATA_DIR
      USE LOGICAL_MOD,    ONLY : LGENFF, LANNFF, LMONFF
      USE TRANSFER_MOD,   ONLY : TRANSFER_2D
      USE TIME_MOD,       ONLY : GET_YEAR,GET_MONTH
      USE GRID_MOD,       ONLY : GET_AREA_CM2

      USE CMN_SIZE_MOD       ! Size parameters
```

REMARKS:

```
Methane source distribution are read for the same purpose from 2004 data
provided by Kevin Wecht.
                                                                             .
Monoterpenes and Isoprene are read and treated as representative NMVOCs.
                                                                             .
   -- Ray Nassar 2010-03-27
```

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Initial version
25 Feb 2011 - R. Nassar           - Now point to annual_v2010 and
                                    monthly_v2010 directories, which
                                    contain updated CO2 data from CDIAC
EOP!EOP
------------------------------------------------------------------------------
BOC
```

LOCAL VARIABLES:

```
      CHARACTER(LEN=255)      :: FILENAME
      CHARACTER(LEN=4)        :: YEAR_STR
      CHARACTER(LEN=2)        :: MONTH_STR

      INTEGER                 :: I, J, YEAR, MONTH
      INTEGER, PARAMETER      :: NDAYS2004(12) = (/31,29,31,30,31,30,
     &                                             31,31,30,31,30,31/)

      REAL*4                  :: ARRAY(IIPAR,JJPAR,1)

      REAL*8                  :: TAU, MONFAC, NMHCFAC, A_CM2(JJPAR)

      REAL*8                  :: FOSS_MASS(IIPAR,JJPAR),  FOSS_SUM
      REAL*8                  :: LIVE_MASS(IIPAR,JJPAR),  LIVE_SUM
      REAL*8                  :: WASTE_MASS(IIPAR,JJPAR), WASTE_SUM
      REAL*8                  :: RICE_MASS(IIPAR,JJPAR),  RICE_SUM
      REAL*8                  :: WET_MASS(IIPAR,JJPAR),   WET_SUM
      REAL*8                  :: OTHER_MASS(IIPAR,JJPAR), OTHER_SUM
      REAL*8                  :: ISO_MASS(IIPAR,JJPAR),   ISO_SUM
      REAL*8                  :: MONO_MASS(IIPAR,JJPAR),  MONO_SUM
      REAL*8                  :: TOT_MASS(IIPAR,JJPAR),   TOT_SUM

      REAL*8                  :: FOSSIL_CORR(IIPAR,JJPAR)
      REAL*8                  :: LIVE_CORR(IIPAR,JJPAR)
      REAL*8                  :: WASTE_CORR(IIPAR,JJPAR)
      REAL*8                  :: RICE_CORR(IIPAR,JJPAR)
      REAL*8                  :: WET_CORR(IIPAR,JJPAR)
      REAL*8                  :: OTHER_CORR(IIPAR,JJPAR)
      REAL*8                  :: ISO_CORR(IIPAR,JJPAR)
```

```
      REAL*8                  :: MONO_CORR(IIPAR,JJPAR)

      REAL*8, PARAMETER       :: PERCENT_CORRECTION = 4.89d0

      !For # molecules <--> mass in kg
      REAL*8, PARAMETER       :: CH4FAC = 6.022d23/16d-3
      REAL*8, PARAMETER       :: CFAC   = 6.022d23/12d-3

      !-----------------------------------------------------------------
      ! Get month and year
      !-----------------------------------------------------------------
      MONTH  = GET_MONTH()
      YEAR   = GET_YEAR()

      WRITE( YEAR_STR,  '(i4)'   ) YEAR
      WRITE( MONTH_STR, '(i2.2)' ) MONTH

      DO J = 1, JJPAR
         A_CM2(J) = GET_AREA_CM2(J)
      ENDDO

      !-----------------------------------------------------------------
      ! Read Generic or annual or monthly fossil fuel emissions file
      !-----------------------------------------------------------------
      IF ( LMONFF ) THEN
         LGENFF = .FALSE.
         LANNFF = .FALSE.
      ENDIF

      IF ( LANNFF ) THEN
         LGENFF = .FALSE.
      ENDIF

      IF ( LGENFF ) THEN

         TAU      = GET_TAU0( 1, 1, 1985 )
         FILENAME = TRIM( DATA_DIR )                                  //
     &              'CO2_200508/fossil95_CO2.'                        //
     &               GET_NAME_EXT_2D() // '.'      // GET_RES_EXT()

      ELSE IF ( LANNFF ) THEN

         TAU      = GET_TAU0( 1, 1, YEAR )
         FILENAME = TRIM( DATA_DIR )                                  //
     &              'CO2_201003/fossilfuel_andres/annual_v2010/ff.'   //
     &              YEAR_STR          // '.'                         //
     &              GET_NAME_EXT_2D() // '.'       //  GET_RES_EXT()
```

```
      ELSE IF ( LMONFF ) THEN

         TAU      = GET_TAU0( MONTH, 1, YEAR )
         FILENAME = TRIM( DATA_DIR )                                  //
     &              'CO2_201003/fossilfuel_andres/monthly_v2010/ff.' //
     &              YEAR_STR          // MONTH_STR // '.'            //
     &              GET_NAME_EXT_2D() // '.'       // GET_RES_EXT()

      ENDIF

      CALL READ_BPCH2( FILENAME, 'CO2-SRCE', 1,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )

      DO J = 1, JJPAR
      DO I = 1, IIPAR
         FOSSIL_corr(I,J) = (PERCENT_CORRECTION/100d0)*ARRAY(I,J,1)
      ENDDO
      ENDDO

      !-----------------------------------------------------------------
      ! Read Monthly CH4 emissions
      !-----------------------------------------------------------------
      TAU      = GET_TAU0( MONTH, 1, 2004 )

      FILENAME = TRIM( DATA_DIR )                 //
     &           'CO2_201003/ChemSrc/CH4_source.' //
     &           GET_NAME_EXT_2D() // '.'         //
     &           GET_RES_EXT()

      ! %%% Livestock %%%
      WRITE( 6, 40 ) TRIM( FILENAME )
 40   FORMAT( '     - READ_LIVESTOCK: Reading ', a )

      CALL READ_BPCH2( FILENAME, 'CH4-EMIS', 4,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  LIVE_MASS)

      ! %%% Waste %%%
      WRITE( 6, 50 ) TRIM( FILENAME )
 50   FORMAT( '     - READ_WASTE: Reading ', a )

      CALL READ_BPCH2( FILENAME, 'CH4-EMIS', 5,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  WASTE_MASS)
```

```
      ! %%% Rice %%%
      WRITE( 6, 60 ) TRIM( FILENAME )
 60   FORMAT( '     - READ_RICE: Reading ', a )

      CALL READ_BPCH2( FILENAME, 'CH4-EMIS', 7,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  RICE_MASS)

      ! %%% Wetlands %%%
      WRITE( 6, 100 ) TRIM( FILENAME )
 100  FORMAT( '     - READ_WETLANDS: Reading ', a )

      CALL READ_BPCH2( FILENAME, 'CH4-EMIS', 10,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  WET_MASS)

      ! %%% Natural %%%
      WRITE( 6, 120 ) TRIM( FILENAME )
 120  FORMAT( '     - READ_OTHER_NATURAL: Reading ', a )

      CALL READ_BPCH2( FILENAME, 'CH4-EMIS', 12,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  OTHER_MASS)

      !-----------------------------------------------------------------
      ! Print raw monthly totals in Tg CH4
      !-----------------------------------------------------------------
      LIVE_SUM  = sum(LIVE_MASS(:,:)*1d-9)
      WASTE_SUM = sum(WASTE_MASS(:,:)*1d-9)
      RICE_SUM  = sum(RICE_MASS(:,:)*1d-9)
      WET_SUM   = sum(WET_MASS(:,:)*1d-9)
      OTHER_SUM = sum(OTHER_MASS(:,:)*1d-9)

      write(6,200) " GLOBAL LIVESTOCK    ", LIVE_SUM, "  TgCH4/month"
      write(6,200) " GLOBAL WASTE        ", WASTE_SUM,"  TgCH4/month"
      write(6,200) " GLOBAL RICE         ", RICE_SUM, "  TgCH4/month"
      write(6,200) " GLOBAL WETLANDS     ", WET_SUM,  "  TgCH4/month"
      write(6,200) " GLOBAL OTHER NATURAL", OTHER_SUM,"  TgCH4/month"

      !-----------------------------------------------------------------
      ! Convert kg/gridbox/month to molecules/cm2/s
      !-----------------------------------------------------------------
      MONFAC = ndays2004(month)*86400d0

      DO J = 1, JJPAR
```

```
      DO I = 1, IIPAR
         LIVE_CORR(I,J)      = LIVE_MASS(I,J)*CH4FAC/MONFAC/A_CM2(J)
         WASTE_CORR(I,J)     = WASTE_MASS(I,J)*CH4FAC/MONFAC/A_CM2(J)
         RICE_CORR(I,J)      = RICE_MASS(I,J)*CH4FAC/MONFAC/A_CM2(J)
         WET_CORR(I,J)       = WET_MASS(I,J)*CH4FAC/MONFAC/A_CM2(J)
         OTHER_CORR(I,J)     = OTHER_MASS(I,J)*CH4FAC/MONFAC/A_CM2(J)
      ENDDO
      ENDDO

      !-----------------------------------------------------------------
      ! Read Monthly Isoprene emissions
      !-----------------------------------------------------------------
      TAU = GET_TAU0( MONTH, 1, 2004 )

      FILENAME = TRIM( DATA_DIR )                              //
     &           'CO2_201003/ChemSrc/Isoprene-2004.'           //
     &           GET_NAME_EXT_2D()  // '.' // GET_RES_EXT()

      WRITE( 6, 150 ) TRIM( FILENAME )
 150  FORMAT( '     - READ_ISOPRENE: Reading ', a )

      CALL READ_BPCH2( FILENAME, 'BIOGSRCE', 1,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  ISO_corr)

      !-----------------------------------------------------------------
      ! Read Monthly Monoterpene emissions
      !-----------------------------------------------------------------

      FILENAME = TRIM( DATA_DIR )                              //
     &           'CO2_201003/ChemSrc/Monoterpene-2004.'        //
     &           GET_NAME_EXT_2D() // '.' // GET_RES_EXT()

      WRITE( 6, 160 ) TRIM( FILENAME )
 160  FORMAT( '     - READ_MONOTERPENE: Reading ', a )

      ! NOTE: use same TAU0 as for isoprene
      CALL READ_BPCH2( FILENAME, 'BIOGSRCE', 4,
     &                 TAU,       IIPAR,     JJPAR,
     &                 1,         ARRAY,     QUIET=.TRUE. )
      CALL TRANSFER_2D( ARRAY(:,:,1),  MONO_corr)

      !-----------------------------------------------------------------
      ! Take the sum of all surface corrections.
      !-----------------------------------------------------------------
      ! NMHCFAC is a scale factor which combines the CO yield from
      ! monoterpenes and isoprenes (~0.2) but increase it to use their
```

```
      ! spatial distribution as a proxy for other NMHCs.
      !-----------------------------------------------------------------

      NMHCFAC = 0.333d0

      DO J = 1, JJPAR
      DO I = 1, IIPAR
         EMIS_SUB(I,J) = FOSSIL_corr(I,J)
     &                 + LIVE_corr(I,J)
     &                 + WASTE_corr(I,J)
     &                 + RICE_corr(I,J)
     &                 + WET_corr(I,J)
     &                 + OTHER_corr(I,J)
     &                 + ISO_corr(I,J)*NMHCFAC
     &                 + MONO_corr(I,J)*NMHCFAC
      ENDDO
      ENDDO

      !-----------------------------------------------------------------

      DO J = 1, JJPAR
      DO I = 1, IIPAR
         FOSS_MASS(I,J) = FOSSIL_CORR(I,J)*A_CM2(J)*MONFAC/CFAC
         ISO_MASS(I,J)  = ISO_CORR(I,J)*A_CM2(J)*NMHCFAC*MONFAC/CFAC
         MONO_MASS(I,J) = MONO_CORR(I,J)*A_CM2(J)*NMHCFAC*MONFAC/CFAC
         TOT_MASS(I,J)  = EMIS_SUB(I,J)*A_CM2(J)*MONFAC/CFAC
      ENDDO
      ENDDO

      FOSS_SUM = sum(FOSS_MASS(:,:)*1d-9)
      ISO_SUM  = sum(ISO_MASS(:,:)*1d-9)
      MONO_SUM = sum(MONO_MASS(:,:)*1d-9)
      TOT_SUM  = sum(TOT_MASS(:,:)*1d-9)

  write(6,200) " GLOBAL FOSS CORR       ", FOSS_SUM, " TgC/month"
  write(6,200) " GLOBAL ISOPRENE        ", ISO_SUM,  " TgC/month"
  write(6,200) " GLOBAL MONTERPENE      ", MONO_SUM, " TgC/month"
  write(6,200) " GLOBAL TOTAL SURF CORR ", TOT_SUM,  " TgC/month"

  200  FORMAT( A, F9.5, A )

      END SUBROUTINE CHEM_SURF
  EOC
  ------------------------------------------------------------------------------
                         University of Toronto and                            !
           Harvard University Atmospheric Chemistry Modeling Group            !
  ------------------------------------------------------------------------------
%//////////////////////////////////////////////////////////
```

```
\mbox{}\hrulefill\


  \subsubsection [aviation\_dom\_corr] {aviation\_dom\_corr}


  This subroutine downscales national fossil fuels emissions
    for the CO2 which is atttibuted to domestic aviation based on Kim et al.
    (2005,2007).  It should only be used when the aviation emissions are
    turned on since these emissions will instead be emitted throughout the
    troposphere.
  \\
  \\{\bf INTERFACE:}
\begin{verbatim}      SUBROUTINE AVIATION_DOM_CORR( EMFOSS )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_TAU0,   READ_BPCH2
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE LOGICAL_MOD,   ONLY : LGENFF
      USE TRANSFER_MOD,  ONLY : TRANSFER_2D
      USE TIME_MOD,      ONLY : GET_YEAR, ITS_A_LEAPYEAR
      USE GRID_MOD,      ONLY : GET_AREA_CM2

      USE CMN_SIZE_MOD      ! Size parameters
```

INPUT PARAMETERS:

```
      REAL*8, INTENT(INOUT)  :: EMFOSS(IIPAR,JJPAR)  ! Fuel to be scaled
```

REVISION HISTORY:

```
    18 May 2010 - R. Nassar, D. Jones - Initial version
    25 Feb 2011 - R. Nassar           - Now point to annual_v2010 and
                                        monthly_v2010 directories, which
                                        contain updated CO2 data from CDIAC
```

1.13.5 read_oceanco2

Subroutine READ_OCEANCO2 reads in either

- Annual mean oceanic CO2 exchange from Takahashi 1997
- Annual mean oceanic CO2 exchange from Takahashi 2009
- Aonthly mean oceanic CO2 exchange from Takahashi 2009

from a binary punch file.

INTERFACE:

```
SUBROUTINE READ_OCEANCO2
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TIME_MOD,      ONLY : GET_MONTH
USE TRANSFER_MOD,  ONLY : TRANSFER_2D
USE LOGICAL_MOD,   ONLY : LOCN1997, LOCN2009ANN, LOCN2009MON

USE CMN_SIZE_MOD      ! Size parameters
```

REMARKS:

```
See References Above
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam   - Initial version
18 May 2010 - R. Nassar, D. Jones - Updated
25 Feb 2011 - R. Nassar           - Now point to annual_v2010 and
                                    monthly_v2010 directories, which
                                    contain updated CO2 data from CDIAC
```

1.13.6 read_annual_biofuelco2

Subroutine READ_ANNUAL_BIOFUELCO2 reads in annual mean biofuel CO2 emissions from a binary punch file.

INTERFACE:

```
SUBROUTINE READ_ANNUAL_BIOFUELCO2
```

USES:

```
! References to F90 modules
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D

USE CMN_SIZE_MOD      ! Size parameters
```

REMARKS:

```
References:
(1 ) Yevich and Logan 2001 gridded (1x1) dataset in combination with
      emission factors for CO2 per kg drymatter burned
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam   - Initial version
18 May 2010 - R. Nassar, D. Jones - Updated
```

1.13.7 read_shipco2_edgar

Subroutine READ_SHIPCO2_EDGAR reads in annual mean ship CO2 emissions from a binary punch file. Scaling is based on Endresen et al. (2007).

INTERFACE:

```
SUBROUTINE READ_SHIPCO2_EDGAR
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR, DATA_DIR_1x1
USE TRANSFER_MOD,   ONLY : TRANSFER_2D
USE REGRID_1x1_MOD, ONLY : DO_REGRID_G2G_1x1, DO_REGRID_1x1
USE GRID_MOD,       ONLY : GET_AREA_CM2
USE TIME_MOD,       ONLY : GET_YEAR

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.8 read_shipco2_icoads

Subroutine READ_SHIPCO2_ICOADS reads in ICOADS monthly ship CO2 emissions

INTERFACE:

```
SUBROUTINE READ_SHIPCO2_ICOADS
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR, DATA_DIR_1x1
USE TRANSFER_MOD,   ONLY : TRANSFER_2D
```

```
      USE FILE_MOD,       ONLY : IU_FILE, IOERROR
      USE REGRID_1x1_MOD, ONLY : DO_REGRID_G2G_1x1, DO_REGRID_1x1
      USE GRID_MOD,       ONLY : GET_AREA_CM2
      USE TIME_MOD,       ONLY : GET_YEAR, GET_MONTH

      USE CMN_SIZE_MOD       ! Size parameters
```

REMARKS:

```
    This subroutine reads from bpch files at GEOS 1x1 (half-polar) resolution
    although the original data are provided as 0.1 deg x 0.1 deg. Regridding to
    the current resolution is carried out in the code.
                                                                              .
    References:
    (1) Corbett and Koehler (2003) "Updated emissions from ocean shipping",
         JGR 108, D20, 4650.
    (2) Corbett and Koehler (2004) "Considering alternative input parameters in
         an activity-based ship fuel consumption and emissions model: Reply ..."
         JGR, 109, D23303.
    (3) Endresen et al. (2007) "A historical reconstruction of ships fuel
         consumption and emissions", JGR, 112, D12301.
                                                                              .
    NOTE: The Corbett website values do not sum to the values in any Corbett
    et al. or Wang (2008) papers. It is not clear if this relates to the
    ongoing dispute between Corbett et al.(2003,2004) and Endresen et al.
    (2003,2004,2007)
```

REVISION HISTORY:

```
    18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.9 read_aviation_co2

Subroutine READ_AVIATION_CO2 reads monthly mean aircraft fuel emissions and converts them to CO2 emissions.

INTERFACE:

```
      SUBROUTINE READ_AVIATION_CO2
```

USES:

```
      ! Reference to F90 modules
      USE BPCH2_MOD,     ONLY : GET_RES_EXT, GET_TAU0, READ_BPCH2
      USE DAO_MOD,       ONLY : BXHEIGHT
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE FILE_MOD,      ONLY : IU_FILE, IOERROR
      USE TIME_MOD,      ONLY : GET_MONTH, GET_YEAR

      USE CMN_SIZE_MOD      ! Size parameters
```

REMARKS:

```
This is a modified version of READ_AIRCRAFT_SO2 from:
                                          rjp, bdf, bmy, 9/18/02, 10/3/05
                                                                          .
The sulfate data are based on an inventory by the Atmospheric Effects of
Aviation Project (AEAP) for the year 1992.
                                                                          .
CO2 emission factor of 3155 g/kg fuel was taken from
(1) Kim et al. (2005) System for assessing Aviation's Global Emissions
     (SAGE) Federal Aviation Administration Office of Environment and
     Energy Version 1.5 (FAA-EE-2005-02), Global Aviation Emissions
     Inventories for 2000 through 2004.
(2) Kim et al. (2007) System for assessing Aviation's Global Emissions
     (SAGE) Part 1: Model description and inventory results
```

REVISION HISTORY:

```
(1 ) Extracted from old module routine SULFATE_READMON (bmy, 9/18/02)
(2 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(3 ) Now read files from "sulfate_sim_200508/".  Now read data for both
      GCAP and GEOS grids (bmy, 8/16/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(6 ) Reading of GlobPTot values from input.geos has not yet been implemented
18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.10 read_annual_bionet_co2

Subroutine READ_ANNUAL_BIONET_CO2 reads in annual mean values of for Net Terrestrial exchange from a binary punch file.

INTERFACE:

```
SUBROUTINE READ_ANNUAL_BIONET_CO2
```

USES:

```
! References to F90 modules
USE BPCH2_MOD,      ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR, DATA_DIR_1x1
USE FILE_MOD,       ONLY : IU_FILE, IOERROR
USE TRANSFER_MOD,   ONLY : TRANSFER_2D
USE LOGICAL_MOD,    ONLY : LBIONETORIG,   LBIONETCLIM
USE REGRID_1x1_MOD, ONLY : DO_REGRID_G2G_1x1, DO_REGRID_1x1

USE CMN_SIZE_MOD       ! Size parameters
```

REMARKS:

```
The two choices are:
(1 ) Old Net Terrestrial Exchange for Year 2000 from David Baker
      (pers. comm.) from undocumented Transcom 3 inversion results
(2 ) New Baker et al [2006] Transcom 3 climatology 1991-2000 minus
     GFEDv2 climatology 1997-2007.

References:
(1 ) Baker et al. (2006), Transcom3 inversion intercomparison: Impact of
      Transport model errors on the interannual vaiability of regional CO2
      fluxes, 1988-2003, Glob. Biogeochem. Cycles, 20, GB1002.
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam   - Initial version
18 May 2010 - R. Nassar, D. Jones - Updated
```

1.13.11 read_bbio_dailyaverage

Subroutine READ_DAILY_BBIO_CO2 reads in daily values for balanced biospheric exchange from a binary punch file.

INTERFACE:

```
SUBROUTINE READ_BBIO_DAILYAVERAGE( MONTH, DAY, DOY )
```

USES:

```
! References to F90 modules
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D
USE TIME_MOD,      ONLY : GET_YEAR,        ITS_A_LEAPYEAR

USE CMN_SIZE_MOD      ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: MONTH   ! Current month (1-12)
INTEGER, INTENT(IN) :: DAY     ! Current day (1-31)
INTEGER, INTENT(IN) :: DOY     ! Current day of year (0-366)
```

REMARKS:

```
Data Source: CASA gridded (1x1) dataset for from M. Thompson
Monthly values interpolated to daily values : 365 daily files
NB : These files DO NOT have the diurnal cycle in daily emissions
See routine ' ' to read in files with diurnal cycle imposed
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam   - Initial version
18 May 2010 - R. Nassar, D. Jones - Added fixes for leapyears
```

1.13.12 read_bbio_diurnalcycle

Subroutine READ_BBIO_DIURNALCYCLE reads CASA daily Net Ecosystem Production (NEP) fluxes but with a diurnal cycle imposed.

INTERFACE:

```
SUBROUTINE READ_BBIO_DIURNALCYCLE( MONTH, DAY, HOUR, DOY )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,        READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D
USE TIME_MOD,      ONLY : GET_YEAR, ITS_A_LEAPYEAR

USE CMN_SIZE_MOD      ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: MONTH   ! Current month (1-12)
INTEGER, INTENT(IN) :: DAY     ! Current day (1-31)
INTEGER, INTENT(IN) :: HOUR    ! Current hour (0-23)
INTEGER, INTENT(IN) :: DOY     ! Current day of year (0-365)
```

REMARKS:

```
References
(1 ) Olsen and Randerson (2004), Differences between surface and column
      atmospheric CO2 and implications for carbon cycle research, J.
      Geophys. Res., 109, D02301,
(2 ) Potter et al. (1993), terrestrial Ecosystem Production: A process
      model based on global satellite and surface data, Glob. Biogeochem.
      Cycles, 7(4), 811-841.
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam   - Initial version
18 May 2010 - R. Nassar, D. Jones - Added fixes for leapyears
```

1.13.13 total_biomass_tg

Subroutine TOTAL_BIOMASS_Tg prints the amount of biomass burning emissions that are emitted each month in Tg or Tg

INTERFACE:

```
SUBROUTINE TOTAL_BIOMASS_Tg( BBARRAY, MOLWT, NAME )
```

USES:

```
USE GRID_MOD, ONLY : GET_AREA_CM2

USE CMN_SIZE_MOD  ! Size parameters
```

INPUT PARAMETERS:

```
REAL*8,           INTENT(IN) :: MOLWT                 ! Mol wt [kg/mole]
CHARACTER(LEN=*), INTENT(IN) :: NAME                  ! Species name
REAL*8,           INTENT(IN) :: BBARRAY(IIPAR,JJPAR)  ! BB Emissions
                                                      ! [molec/cm2/month]
```

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Updated
```

1.13.14 def_biosph_co2_regions_f

Subroutine DEF_BIOSPH_CO2_REGIONS defines the land biospheric and ocean CO2 exchange regions.

INTERFACE:

```
SUBROUTINE DEF_BIOSPH_CO2_REGIONS_F( REGION )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE FILE_MOD,      ONLY : IU_FILE, IOERROR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D

USE CMN_SIZE_MOD      ! Size parameters
```

OUTPUT PARAMETERS:

```
INTEGER, INTENT(OUT)   :: REGION(IIPAR,JJPAR)
```

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%   BUYER BEWARE! Tagged CO2 tracers only work for 2 x 2.5 grid!   %%%
%%%   Someone will have to make this more general later on...        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%!
```

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.15 def_ocean_co2_regions_f

Subroutine DEF_OCEAN_CO2_REGIONS defines CO2 regions for ocean exchange.

INTERFACE:

```
SUBROUTINE DEF_OCEAN_CO2_REGIONS_F( REGION )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE FILE_MOD,      ONLY : IU_FILE, IOERROR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D

USE CMN_SIZE_MOD      ! Size parameters
```

OUTPUT PARAMETERS:

```
INTEGER, INTENT(OUT)  :: REGION(IIPAR,JJPAR)
```

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%   BUYER BEWARE! Tagged CO2 tracers only work for 2 x 2.5 grid!   %%%
%%%   Someone will have to make this more general later on...        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%!
```

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.16 def_fossil_co2_regions_f

Subroutine DEF_FOSSIL_CO2_REGIONS defines CO2 regions for anthropogenic emissions

INTERFACE:

```
SUBROUTINE DEF_FOSSIL_CO2_REGIONS_F( REGION )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE FILE_MOD,      ONLY : IU_FILE, IOERROR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D

USE CMN_SIZE_MOD      ! Size parameters
```

OUTPUT PARAMETERS:

```
INTEGER, INTENT(OUT)   :: REGION(IIPAR,JJPAR)
```

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%   BUYER BEWARE! Tagged CO2 tracers only work for 2 x 2.5 grid!   %%%
%%%   Someone will have to make this more general later on...        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%!
```

REVISION HISTORY:

```
18 May 2010 - R. Nassar, D. Jones - Initial version
```

1.13.17 init_co2

Subroutine INIT_CO2 allocates memory to module arrays and reads in annual mean emissions.

INTERFACE:

```
SUBROUTINE INIT_CO2
```

USES:

```
! References to F90 modules
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE LOGICAL_MOD, ONLY : LGENFF,  LANNFF,   LMONFF, LSTREETS
USE LOGICAL_MOD, ONLY : LSEASBB, LGFED2BB, L8DAYBB, LBIOFUEL
USE LOGICAL_MOD, ONLY : LGFED3BB, L8DAYBB3
USE LOGICAL_MOD, ONLY : LBIODAILY,   LBIODIURNAL
USE LOGICAL_MOD, ONLY : LBIONETORIG, LBIONETCLIM
USE LOGICAL_MOD, ONLY : LOCN1997,    LOCN2009ANN, LOCN2009MON
USE LOGICAL_MOD, ONLY : LFFBKGRD
USE LOGICAL_MOD, ONLY : LSHIPEDG,    LSHIPICO,    LPLANE
USE LOGICAL_MOD, ONLY : LBIOSPHTAG,  LFOSSILTAG
USE LOGICAL_MOD, ONLY : LSHIPTAG,    LPLANETAG
USE TRACER_MOD,  ONLY : N_TRACERS

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
16 Aug 2005 - P. Suntharalingam   - Initial version
18 May 2010 - R. Nassar, D. Jones - Updated
```

1.13.18 cleanup_co2

Subroutine CLEANUP_CO2 deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_CO2
```

REVISION HISTORY:

```
   16 Aug 2005 - P. Suntharalingam   - Initial version
   18 May 2010 - R. Nassar, D. Jones - Updated
```

1.14 Fortran: Module Interface comode_mod

Module COMODE_MOD contains allocatable arrays for SMVGEAR that were previously contained in common blocks in header file "comode.h".

INTERFACE:

```
      MODULE COMODE_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      !=========================================================================
      ! ABSHUM    : array for absolute humidity [H2O molec/cm3]
      ! AIRDENS   : array for air density [molec/cm3]
      ! CSPEC     : array of chemical species concentration [molec/cm3]
      ! CSPEC_FULL: array of chemical species for full potential troposphere
      ! CSUMA     : array for time of sunrise/sunset, from midnight [s]
      ! CSUMC     : array for temporary storage
      ! ERADIUS   : array for aerosol or dust radii [cm]
      ! ERRMX2    : array for storing stiffness values
      ! IXSAVE    : array of grid box longitude indices
      ! IYSAVE    : array of grid box latitude indices
      ! IZSAVE    : array of grid box altitude indices
      ! JLOP      : array of 1-D grid box indices
      ! PRESS3    : array for grid box pressure [mb]
      ! REMIS     : array for emissions from GEOS-CHEM [molec/cm3]
      ! T3        : array for grid box temperature [K]
      ! TAREA     : array for surface area of aerosol or dust [cm2/cm3]
      ! VOLUME    : array for grid box volume [cm3]
      !=========================================================================
```

```
REAL*8,  ALLOCATABLE, PUBLIC :: ABSHUM(:)
REAL*8,  ALLOCATABLE, PUBLIC :: AIRDENS(:)
REAL*8,  ALLOCATABLE, PUBLIC :: CSPEC(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: CSPEC_FULL(:,:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: CSUMA(:)
REAL*8,  ALLOCATABLE, PUBLIC :: CSUMC(:)
REAL*8,  ALLOCATABLE, PUBLIC :: ERADIUS(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ERRMX2(:)
INTEGER, ALLOCATABLE, PUBLIC :: IXSAVE(:)
INTEGER, ALLOCATABLE, PUBLIC :: IYSAVE(:)
INTEGER, ALLOCATABLE, PUBLIC :: IZSAVE(:)
INTEGER, ALLOCATABLE, PUBLIC :: JLOP(:,:,:)
INTEGER, ALLOCATABLE, PUBLIC :: JLOP_PREVIOUS(:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PRESS3(:)
REAL*8,  ALLOCATABLE, PUBLIC :: REMIS(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: T3(:)
REAL*8,  ALLOCATABLE, PUBLIC :: TAREA(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: VOLUME(:)
REAL*8,  ALLOCATABLE, PUBLIC :: WTAREA(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: WERADIUS(:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: CLEANUP_COMODE
PUBLIC :: INIT_COMODE
```

REMARKS:

```
In case you were wondering, "comode" stands for:
   "COMmon blocks: Ordinary Differential Equations"
```

REVISION HISTORY:

```
31 Aug 2000 - R. Yantosca - Initial version
(1 ) Now zero CSPEC after allocating memory (bmy, 9/8/00)
(2 ) Now declare more SMVGEAR arrays allocatable (bmy, 10/19/00)
(3 ) Updated comments (bmy, 9/4/01)
(4 ) Now make ERADIUS, TAREA 2-D arrays, for het chem (bmy, 11/15/01)
(5 ) DARSFCA is now obsolete, remove it.  Now allocate ERADIUS and
      TAREA arrays to be of size (ITLOOP,NDUST+NAER).  (rvm, bmy, 2/27/02)
(5 ) Removed obsolete code from 2/02 (bmy, 4/15/02)
(6 ) Now divide module header into MODULE PRIVATE, MODULE VARIABLES, and
      MODULE ROUTINES sections.  Updated comments (bmy, 5/28/02)
(7 ) Now references "error_mod.f" (bmy, 10/15/02)
(8 ) Now add CSUMA, CSUMC, ERRMX2 arrays for SMVGEAR II (bmy, 7/18/03)
(9 ) Now also references "tracer_mod.f" (bmy, 9/28/04)
(10) Add WTAREA and WERADIUS variables.
     For SOA production from reactive uptake of dicarbonyls,
     archived WTAREA and WERADIUS should include dusts,
     but excludes BCPO and OCPO (tmf, ccc, 1/7/09)
```

```
(11) Added 3 *_KPP arrays (phs,ks,dhk, 09/15/09)
(12) Removed 3 *_KPP arrays (phs, 09/16/09)
21 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.14.1 init_comode

Subroutine INIT_COMODE allocates memory for allocatable arrays that were previously contained in common blocks in "comode.h".

INTERFACE:

```
SUBROUTINE INIT_COMODE
```

USES:

```
USE ERROR_MOD,  ONLY : ALLOC_ERR
USE TRACER_MOD, ONLY : ITS_AN_AEROSOL_SIM
USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM

USE CMN_SIZE_MOD
USE COMODE_LOOP_MOD
```

REVISION HISTORY:

```
31 Aug 2000 - R. Yantosca - Initial version
(1 ) Now references ALLOC_ERR from "error_mod.f" (bmy, 10/15/02)
(2 ) Cosmetic chagnes (bmy, 2/27/03)
(3 ) Now allocate CSUMA, CSUMC, ERRMX2; cosmetic changes (bmy, 7/18/03)
(4 ) Now allocate certain arrays for offline aerosol sim (bmy, 9/28/04)
21 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.14.2 cleanup_comode

Subroutine CLEANUP_COMODE deallocates memory from allocatable arrays that were previously contained in common blocks in "comode.h"

INTERFACE:

```
SUBROUTINE CLEANUP_COMODE
```

REVISION HISTORY:

```
31 Aug 2000 - R. Yantosca - Initial version
(1 ) Now deallocate CSPEC, CSUMA, ERRMX2; cosmetic changes (bmy, 7/18/03)
21 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.15 Fortran: Module Interface convection_mod

Module CONVECTION_MOD contains routines which select the proper convection code for GEOS-3, GEOS-4, GEOS-5, MERRA, or GCAP met field data sets.

INTERFACE:

```
      MODULE CONVECTION_MOD
```

USES:

```
      USE GC_TYPE_MOD
      USE SMV_ERRCODE_MOD
      USE SMV_PHYSCONST_MOD

      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: DO_CONVECTION
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: DO_GEOS4_CONVECT
      PRIVATE :: DO_GCAP_CONVECT
      PRIVATE :: NFCLDMX
      PRIVATE :: DO_MERRA_CONVECTION
```

REVISION HISTORY:

```
   27 Jan 2004 - R. Yantosca - Initial version
   (1 ) Contains new updates for GEOS-4/fvDAS convection.  Also now references
        "error_mod.f".  Now make F in routine NFCLDMX a 4-D array to avoid
        memory problems on the Altix. (bmy, 1/27/04)
   (2 ) Bug fix: Now pass NTRACE elements of TCVV to FVDAS_CONVECT in routine
        DO_CONVECTION (bmy, 2/23/04)
   (3 ) Now references "logical_mod.f" and "tracer_mod.f" (bmy, 7/20/04)
   (4 ) Now also references "ocean_mercury_mod.f" and "tracerid_mod.f"
        (sas, bmy, 1/19/05)
   (5 ) Now added routines DO_GEOS4_CONVECT and DO_GCAP_CONVECT by breaking
        off code from DO_CONVECTION, in order to implement GCAP convection
        in a much cleaner way. (swu, bmy, 5/25/05)
   (6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   (7 ) Shut off scavenging in shallow convection for GCAP (swu, bmy, 11/1/05)
   (8 ) Modified for tagged Hg simulation (cdh, bmy, 1/6/06)
   (9 ) Bug fix: now only call ADD_Hg2_WD if LDYNOCEAN=T (phs, 2/8/07)
   (10) Fix for GEOS-5 met fields in routine NFCLDMX (swu, 8/15/07)
   (11) Resize DTCSUM array in NFCLDMX to save memory (bmy, 1/31/08)
```

```
    13 Aug 2010 - R. Yantosca - Added ProTeX headers
    13 Aug 2010 - R. Yantosca - Treat MERRA in the same way as for GEOS-5
    29 Sep 2010 - R. Yantosca - Added modifications for MERRA
    05 Oct 2010 - R. Yantosca - Added ND14 and ND38 diagnostics to
                                DO_MERRA_CONVECTION routine
    16 Aug 2011 - J. Fisher   - Minor bug fixes in DO_MERRA_CONVECTION
    15 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.15.1 do_convection

Subroutine DO_CONVECTION calls the appropriate convection driver program for different met field data sets.

INTERFACE:

```
      SUBROUTINE DO_CONVECTION
```

USES:

```
      USE DAO_MOD,      ONLY : AD
      USE DAO_MOD,      ONLY : BXHEIGHT
      USE DAO_MOD,      ONLY : T
      USE DAO_MOD,      ONLY : CLDMAS
      USE DAO_MOD,      ONLY : CMFMC
      USE DAO_MOD,      ONLY : DQRCU
      USE DAO_MOD,      ONLY : DTRAIN
      USE DAO_MOD,      ONLY : PFICU
      USE DAO_MOD,      ONLY : PFLCU
      USE DAO_MOD,      ONLY : REEVAPCN
      USE DIAG_MOD,     ONLY : CONVFLUP
      USE DIAG_MOD,     ONLY : AD38
      USE ERROR_MOD,    ONLY : GEOS_CHEM_STOP
      USE GRID_MOD,     ONLY : GET_AREA_M2
      USE LOGICAL_MOD,  ONLY : LDYNOCEAN
      USE PRESSURE_MOD, ONLY : GET_PEDGE
      USE TRACER_MOD,   ONLY : ITS_A_MERCURY_SIM
      USE TRACER_MOD,   ONLY : N_TRACERS
      USE TRACER_MOD,   ONLY : TCVV
      USE TRACER_MOD,   ONLY : TRACER_MW_KG
      USE TRACER_MOD,   ONLY : STT
      USE TRACERID_MOD, ONLY : IDTHg2
      USE TRACERID_MOD, ONLY : IDTHgP
      USE TIME_MOD,     ONLY : GET_TS_DYN
      USE WETSCAV_MOD,  ONLY : COMPUTE_F
      USE WETSCAV_MOD,  ONLY : H2O2s
      USE WETSCAV_MOD,  ONLY : SO2s
#if   defined( APM )
      USE TRACER_MOD,   ONLY : N_APMTRA
```

```
#endif

      USE CMN_SIZE_MOD     ! Size parameters
      USE CMN_DIAG_MOD     ! Diagnostic flags
```

REVISION HISTORY:

```
   25 May 2005 - S. Wu       - Initial version
   08 Feb 2007 - R. Yantosca - Now reference "F77_CMN_SIZE".  Now references
                               CLDMAS, CMFMC, DTRAIN from "dao_mod.f" so that
                               we can pass either GEOS-5 or GEOS-3 meteorology
                               to NFCLDMX.
   13 Aug 2010 - R. Yantosca - Added ProTeX headers
   13 Aug 2010 - R. Yantosca - Treat MERRA in the same way as for GEOS-5
   29 Sep 2010 - R. Yantosca - Now call DO_MERRA_CONVECTION for MERRA met
   05 Oct 2010 - R. Yantosca - Now attach diagnostics to MERRA conv routine
   06 Oct 2010 - R. Yantosca - Parallelized call to DO_MERRA_CONVECTION
   15 Oct 2010 - H. Amos     - Now get BXHEIGHT, T from dao_mod.f
   15 Oct 2010 - R. Yantosca - Now get LDYNOCEAN from logical_mod.f
   15 Oct 2010 - R. Yantosca - Now get ITS_A_MERCURY_SIM from tracer_mod.f
   15 Oct 2010 - R. Yantosca - Now get IDTHg2, IDTHgP from tracerid_mod.f
   15 Oct 2010 - R. Yantosca - Now get H2O2s, SO2s from wetscav_mod.f
   15 Oct 2010 - H. Amos     - Now pass BXHEIGHT, T, to DO_MERRA_CONVECTION
   15 Oct 2010 - R. Yantosca - Now pass H2O2s, SO2s to DO_MERRA_CONVECTION
   15 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
   29 Aug 2011 - R. Yantosca - Bug fix: reposition #if defined(APM) statement
```

1.15.2 do_geos4_convect

Subroutine DO_GEOS4_CONVECT is a wrapper for the GEOS-4/fvDAS convection code. This was broken off from the old DO_CONVECTION routine above.

INTERFACE:

```
      SUBROUTINE DO_GEOS4_CONVECT
```

USES:

```
      USE DAO_MOD,           ONLY : HKETA, HKBETA, ZMEU, ZMMU, ZMMD
      USE DIAG_MOD,          ONLY : AD37
      USE ERROR_MOD,         ONLY : DEBUG_MSG
      USE FVDAS_CONVECT_MOD, ONLY : INIT_FVDAS_CONVECT, FVDAS_CONVECT
      USE LOGICAL_MOD,       ONLY : LPRT
      USE TIME_MOD,          ONLY : GET_TS_CONV
      USE TRACER_MOD,        ONLY : N_TRACERS, STT, TCVV
      USE PRESSURE_MOD,      ONLY : GET_PEDGE
      USE WETSCAV_MOD,       ONLY : COMPUTE_F
```

```
#if   defined( APM )
      USE TRACER_MOD,        ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD          ! Size parameters
      USE CMN_DIAG_MOD          ! ND37, LD37
```

REVISION HISTORY:

```
   25 May 2005 - S. Wu       - Initial version
   (1 ) Now use array masks to flip arrays vertically in call to FVDAS_CONVECT
        (bmy, 5/25/05)
   (2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   (3 ) Add a check to set negative values in STT to TINY (ccc, 4/15/09)
   13 Aug 2010 - R. Yantosca - Added ProTeX headers
   15 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.15.3 do_gcap_convect

Subroutine DO_GCAP_CONVECT is a wrapper for the GCAP convection code. This was broken off from the old DO_CONVECTION routine above.

INTERFACE:

```
      SUBROUTINE DO_GCAP_CONVECT
```

USES:

```
      USE DAO_MOD,           ONLY : DETRAINE, DETRAINN, DNDE
      USE DAO_MOD,           ONLY : DNDN,     ENTRAIN,  UPDN, UPDE
      USE DIAG_MOD,          ONLY : AD37
      USE ERROR_MOD,         ONLY : DEBUG_MSG
      USE GCAP_CONVECT_MOD, ONLY : GCAP_CONVECT
      USE LOGICAL_MOD,       ONLY : LPRT
      USE TIME_MOD,          ONLY : GET_TS_CONV
      USE TRACER_MOD,        ONLY : N_TRACERS, STT, TCVV
      USE PRESSURE_MOD,      ONLY : GET_PEDGE, GET_PCENTER
      USE WETSCAV_MOD,       ONLY : COMPUTE_F
#if   defined( APM )
      USE TRACER_MOD,        ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD          ! Size parameters
      USE CMN_DIAG_MOD          ! ND37, LD37
```

REVISION HISTORY:

```
   25 May 2005 - S. Wu       - Initial version
```

```
(1 ) Now use array masks to flip arrays vertically in call to GCAP_CONVECT
     (bmy, 5/25/05)
(2 ) Shut off scavenging in shallow convection for GCAP below 700 hPa
     (swu, bmy, 11/1/05)
(3 ) Add a check to set negative values in STT to TINY (ccc, 4/15/09)
13 Aug 2010 - R. Yantosca - Added ProTeX headers
15 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.15.4 nfcldmx

Subroutine NFCLDMX is S-J Lin's cumulus transport module for 3D GSFC-CTM, modified for the GEOS-Chem model. The "NF" stands for "no flipping", and denotes that you don't have to flip the tracer array Q in the main program before passing it to NFCLDMX.

NOTE: NFCLDMX can be used with GEOS-1, GEOS-STRAT, and GEOS-3 met fields. For GEOS-4/fVDAS, you must use the routines in "fvdas_convect_mod.f"

INTERFACE:

```
      SUBROUTINE NFCLDMX( NC, TCVV, CLDMAS, DTRN, Q )
```

USES:

```
      USE DAO_MOD,          ONLY : AD  !,   CLDMAS, DTRN=>DTRAIN
      USE DIAG_MOD,         ONLY : AD37, AD38,   CONVFLUP
      USE GRID_MOD,         ONLY : GET_AREA_M2
      USE LOGICAL_MOD,      ONLY : LDYNOCEAN, LGTMM
      USE DEPO_MERCURY_MOD, ONLY : ADD_Hg2_WD, ADD_HgP_WD
      USE PRESSURE_MOD,     ONLY : GET_BP, GET_PEDGE
      USE TIME_MOD,         ONLY : GET_TS_CONV
      USE TRACER_MOD,       ONLY : ITS_A_MERCURY_SIM
      USE TRACERID_MOD,     ONLY : IS_Hg2, IS_HgP
      USE WETSCAV_MOD,      ONLY : COMPUTE_F
      USE DEPO_MERCURY_MOD, ONLY : ADD_Hg2_SNOWPACK !CDH
      USE DAO_MOD,          ONLY : SNOMAS, SNOW  !,   CLDMAS, DTRN=>DTRAIN

      USE CMN_SIZE_MOD     ! Size parameters
      USE CMN_DIAG_MOD     ! Diagnostic switches & arrays

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      ! TOTAL number of tracers (soluble + insoluble)  [unitless]
      INTEGER, INTENT(IN)    :: NC
```

```
      ! CLDMAS : Cloud mass flux (at upper edges of each level) [kg/m2/s]
      REAL*8,  INTENT(IN)    :: CLDMAS(IIPAR,JJPAR,LLPAR)

      ! Detrainment mass flux [kg/m2/s]
      REAL*8,  INTENT(IN)    :: DTRN(IIPAR,JJPAR,LLPAR)

      ! MW air (g/mol) / MW of tracer (g/mol) [unitless]
      REAL*8,  INTENT(IN)    :: TCVV(NC)
```

INPUT/OUTPUT PARAMETERS:

```
      ! Tracer concentration [v/v]
      REAL*8,  INTENT(INOUT) :: Q(IIPAR,JJPAR,LLPAR,NC)
```

REMARKS:

```
    (1) The "NF" stands for "no flipping", and denotes that you don't have to
    flip the tracer array Q in the main program before passing it to NFCLDMX.
    (bmy, 2/12/97, 1/31/08)
    (2) This version has been customized to work with GEOS-5 met fields.
    Reference:
    ============================================================================
    Lin, SJ.  "Description of the parameterization of cumulus transport
       in the 3D Goddard Chemistry Transport Model, NASA/GSFC, 1996.
    Vertical indexing:
    ============================================================================
    The indexing of the vertical sigma levels has been changed from
    SJ-Lin's original code:
                   Old Method          New Method
                    (SJ Lin)
                  ------------------------------------ Top of Atm.
                     k = 1               k = NLAY
                  ==================================== Max Extent
                     k = 2               k = NLAY-1      of Clouds
                  ------------------------------------


                      ...                 ...
                  ------------------------------------
                     k = NLAY-3          k = 4
                  ------------------------------------
                     k = NLAY-2          k = 3
                  ------------------------------------ Cloud base
                     k = NLAY-1          k = 2
                  -    -    -    -    -    -    -    -
                     k = NLAY            k = 1
                  ==================================== Ground
        which means that:
                   Old Method                      New Method
```

```
              (SJ Lin)
          k-1      ^                        k+1      ^
          ---------|---------               ---------|---------
                   |                                 |
                 CMFMC(k)                          CMFMC(k)

                                 becomes
          k     DTRAIN(k),                  k     DTRAIN(k),
                QC(k), Q(k)                       QC(k), Q(k)

                   ^                                 ^
          ---------|---------               ---------|---------
                   |                                 |
          k+1   CMFMC(k+1)                  k-1   CMFMC(k-1)
    i.e., the lowest level    used to be  NLAY  but is now  1
          the level below k   used to be  k+1   but is now  k-1.
          the level above k   used to be  k-1   but is now  k+1
          the top of the atm. used to be  1     but is now  NLAY.
```

The old method required that the vertical dimensions of the CMFMC, DTRAIN, and Q arrays had to be flipped before and after calling CLDMX. Also, diagnostic arrays generated within CLDMX also had to be flipped. The new indexing eliminates this requirement (and also saves on array operations).

Major Modifications:

```
==============================================================================
Original Author:   Shian-Jiann Lin, Code 910.3, NASA/GSFC
Original Release:  12 February 1997
                   Version 3, Detrainment and Entrainment are considered.
                   The algorithm reduces to that of version 2 if Dtrn = 0.
                                                                             .
Modified By:       Bob Yantosca, for Harvard Atmospheric Sciences
Modified Release:  27 January 1998
                   Version 3.11, contains features of V.3 but also
                   scavenges soluble tracer in wet convective updrafts.
                                                                             .
                   28 April 1998
                   Version 3.12, now includes mass flux diagnostic
                                                                             .
                   11 November 1999
                   Added mass-flux diagnostics
                                                                             .
                   04 January 2000
                   Updated scavenging constant AS2
                                                                             .
                   14 March 2000
                   Added new wet scavenging code and diagnostics
                   based on the GMI algorithm
                                                                             .
                   02 May 2000
```

```
Added parallel loop over tracers!
```

REVISION HISTORY:

```
12 Feb 1997 - M. Prather  - Initial version
(1 ) NFCLDMX is written in Fixed-Form Fortran 90.
(2 ) Added TCVV to the argument list.  Also cleaned up argument
     and local variable declarations. (bey, bmy, 11/10/99)
(3 ) AD38 and CONVFLUP are now declared allocatable in "diag_mod.f".
     (bmy, 11/29/99)
(4 ) Bug fix for tagged CO tracer run (bey, bmy, 1/4/00)
(5 ) Add new routines for computing scavenging coefficients,
     as well as adding the AD37 diagnostic array. (bmy, 3/14/00)
(6 ) Updated comments (bmy, 10/2/01)
(7 ) Now print a header to stdout on the first call, to confirm that
     NFCLDMX has been called (bmy, 4/15/02)
(8 ) Remove PZ from the arg list -- it isn't used! (bmy, 8/22/02)
(9 ) Fixed ND38 diagnostic so that it now reports correctly (must divide
     by DNS).  Updatec comments, cosmetic changes. (bmy, 1/27/03)
(10) Bug fix: remove duplicate K from PRIVATE declaration (bmy, 3/23/03)
(11) Now removed all arguments except NC, TCVV, Q from the arg list -- the
     other arguments can be supplied via F90 modules.  Now references
     "dao_mod.f", "grid_mod.f", "pressure_mod.f", and "time_mod.f".
     (bmy, 3/27/03)
(12) Bundled into "convection_mod.f" (bmy, 6/26/03)
(13) Make sure K does not go out of bounds in ND38 diagnostic.  Now make
     F a 4-D array in order to avoid memory problems on the Altix.
     (bmy, 1/27/04)
(14) Now references both "ocean_mercury_mod.f" and "tracerid_mod.f".
     Now call ADD_Hg2_WD from "ocean_mercury_mod.f" to pass the amt of Hg2
     lost by wet scavenging (sas, bmy, 1/19/05)
(15) Now references IS_Hg2 from "tracerid_mod.f".  Now pass tracer # IC
     to ADD_Hg2_WD. (cdh, bmy, 1/6/06)
(16) Bug fix: now only call ADD_Hg2_WD if LDYNOCEAN=T (phs, 2/8/07)
(17) Now make CLDMAS, DTRN as arguments, so that we can pass either
     GEOS-3 or GEOS-3 met data.  Redimension DTCSUM with NC instead of
     NNPAR.  In many cases, NC is less than NNPAR and this will help to
     save memory especially when running at 2x25 or greater resolution
     (bmy, 1/31/08)
(18) Add a check to set negative values in Q to TINY (ccc, 4/15/09)
(19) Updates for mercury simulation (ccc, 5/17/10)
13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.15.5 do_merra_convection

Subroutine DO_MERRA_CONVECTION (formerly called NFCLDMX) is S-J Lin's cumulus transport module for 3D GSFC-CTM, modified for the GEOS-Chem model.

INTERFACE:

```
 SUBROUTINE DO_MERRA_CONVECTION( IDENT,    DIMINFO,  COEF,
&                                IDT,      OPTIONS,  AD,
&                                AREA_M2,  BXHEIGHT, CMFMC,
&                                DQRCU,    DTRAIN,   F,
&                                PEDGE,    PFICU,    PFLCU,
&                                REEVAPCN, T,        TS_DYN,
&                                Q,        DIAG14,   DIAG38,
&                                H2O2s,    SO2s,     I,
&                                J,        RC )
```

USES:

```
USE ERROR_MOD,        ONLY : IT_IS_NAN, IT_IS_FINITE
USE ERROR_MOD,        ONLY : GEOS_CHEM_STOP  ! hma Nov 3, debug
USE DEPO_MERCURY_MOD, ONLY : ADD_Hg2_SNOWPACK
USE DEPO_MERCURY_MOD, ONLY : ADD_Hg2_WD
USE DEPO_MERCURY_MOD, ONLY : ADD_HgP_WD
USE MERCURY_MOD,      ONLY : PARTITIONHg
USE TRACERID_MOD,     ONLY : IS_Hg2
USE TRACERID_MOD,     ONLY : IS_HgP
USE WETSCAV_MOD,      ONLY : WASHOUT
USE WETSCAV_MOD,      ONLY : LS_K_RAIN
USE WETSCAV_MOD,      ONLY : LS_F_PRIME
```

INPUT PARAMETERS:

```
TYPE(SPEC_2_TRAC), INTENT(IN) :: COEF        ! Obj w/ spec <-> trac map
TYPE(GC_DIMS),     INTENT(IN) :: DIMINFO     ! Obj w/ array dimensions
TYPE(ID_TRAC),     INTENT(IN) :: IDT         ! Obj w/ tracer ID flags
TYPE(GC_OPTIONS),  INTENT(IN) :: OPTIONS     ! Obj w/ logical switches
REAL*8,            INTENT(IN) :: AD(:)       ! Air mass [kg]
REAL*8,            INTENT(IN) :: AREA_M2     ! Surface area [m2]
REAL*8,            INTENT(IN) :: BXHEIGHT(:) ! Box height [m]
REAL*8,            INTENT(IN) :: CMFMC(:)    ! Cloud mass flux [kg/m2/s]
REAL*8,            INTENT(IN) :: DQRCU(:)    ! Precip production rate:
                                             !  convective [kg/kg/s]
REAL*8,            INTENT(IN) :: DTRAIN(:)   ! Detrainment flux [kg/m2/s]
REAL*8,            INTENT(IN) :: F(:,:)      ! Fraction of soluble tracer
                                             !  for updraft scavenging
                                             !  [unitless].  ! This is
                                             !  computed by routine
                                             !  COMPUTE_UPDRAFT_FSOL
REAL*8,            INTENT(IN) :: PEDGE(:)    ! P @ level box edges [hPa]
REAL*8,            INTENT(IN) :: PFICU(:)    ! Dwnwd flux of convective
                                             !  ice precip [kg/m2/s]
REAL*8,            INTENT(IN) :: PFLCU(:)    ! Dwnwd flux of convective
                                             !  liquid precip [kg/m2/s]
```

```
      REAL*8,            INTENT(IN) :: REEVAPCN(:) ! Evap of precip'ing conv.
                                                   !  condensate [kg/kg/s]
      REAL*8,            INTENT(IN) :: T(:)        ! air temperature [K]
      REAL*8,            INTENT(IN) :: TS_DYN      ! Dynamic timestep [min]
      INTEGER,           INTENT(IN) :: I, J        ! Lon & lat indices
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(GC_IDENT), INTENT(INOUT) :: IDENT       ! Obj w/ info from ESMF etc.
      REAL*8,         INTENT(INOUT) :: H2O2s(:)
      REAL*8,         INTENT(INOUT) :: SO2s(:)
      REAL*8,         INTENT(INOUT) :: Q(:,:)      ! Tracer conc. [mol/mol]
```

OUTPUT PARAMETERS:

```
      REAL*8,           INTENT(OUT) :: DIAG14(:,:) ! Array for ND14 diagnostic
      REAL*8,           INTENT(OUT) :: DIAG38(:,:) ! Array for ND38 diagnostic
      INTEGER,          INTENT(OUT) :: RC          ! Return code
```

REMARKS:

```
    Reference:
    ============================================================================
    Lin, SJ.  "Description of the parameterization of cumulus transport
       in the 3D Goddard Chemistry Transport Model, NASA/GSFC, 1996.

                                                                              .
    Unit conversion for BMASS:
        Ps - Pt (mb)| P2 - P1 | 100 Pa |  s^2  | 1  |  1 kg        kg
       -------------+---------+--------+-------+----+--------  =  -----
                    | Ps - Pt |   mb   | 9.8 m | Pa | m^2 s^2      m^2

                                                                              .
    NOTE: We are passing I & J down to this routine so that it can call the
    proper code from "mercury_mod.f".  Normally, we wouldn't pass I & J as
    arguments to columnized code.  This prevents rewriting the mercury_mod.f
    routines ADD_Hg2_
```

REVISION HISTORY:

```
    15 Jul 2009 - R. Yantosca - Columnized and cleaned up.
                              - CLDMAS renamed to CMFMC and DTRN renamed
                                to DTRAIN for consistency w/ GEOS-5.
    17 Jul 2009 - R. Yantosca - Now do unit conversion of Q array from
                                [kg] --> [v/v] and vice versa internally
    14 Dec 2009 - R. Yantosca - Now remove internal unit conversion, since
                                Q now comes in as [mol/mol] (=[v/v]) from the
                                calling routine.
    14 Dec 2009 - R. Yantosca - Remove COEF from the argument list
    06 May 2010 - R. Yantosca - Now add IDENT via the argument list
    29 Sep 2010 - R. Yantosca - Modified for MERRA met fields
```

```
    05 Oct 2010 - R. Yantosca - Now pass COEF via the argument list
    05 Oct 2010 - R. Yantosca - Attach ND14 and ND38 diagnostics
    15 Oct 2010 - H. Amos     - Added BXHEIGHT and T as arguments
    15 Oct 2010 - R. Yantosca - Added I, J, H2O2s and SO2s as arguments
    15 Oct 2010 - H. Amos     - Added scavenging below cloud base
    06 Apr 2011 - M.Fu, H.Amos- Bug fix: make sure washout adheres to the same
                                algorithm as in the wet deposition code.
    27 Jul 2011 - R. Yantosca - Declare CLDBASE as INTEGER to avoid PGI errors
    16 Aug 2011 - J. Fisher   - Bug fix: use IS_Hg2() and IS_HgP to test if
                                a tracer is Hg2 or HgP (for tagged species)
    16 Aug 2011 - J. Fisher   - Now use WETLOSS instead of TO_SUM in the ND38
                                diagnostic below the cloud.  Using TO_SUM leads
                                us to over-count the tracer scavenged out of
                                the column.
```

1.16 Fortran: Module Interface dao_mod

Module DAO_MOD contains both arrays that hold DAO met fields, as well as subroutines that compute, interpolate, or otherwise process DAO met field data.

INTERFACE:

```
      MODULE DAO_MOD
```

USES:

```
      USE CMN_SIZE_MOD          ! Size parameters
      USE CMN_GCTM_MOD          ! Physical constants

      IMPLICIT NONE
#     include "define.h"

      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: AVGPOLE
      PUBLIC  :: AIRQNT
      PUBLIC  :: AIRQNT_FULLGRID
      PUBLIC  :: CLEANUP_DAO
      PUBLIC  :: CONVERT_UNITS
      PUBLIC  :: COPY_I6_FIELDS
      PUBLIC  :: COSSZA
      PUBLIC  :: GET_OBK
      PUBLIC  :: INIT_DAO
      PUBLIC  :: INTERP
      PUBLIC  :: IS_LAND
```

```
PUBLIC  :: IS_WATER
PUBLIC  :: IS_ICE
PUBLIC  :: IS_NEAR
PUBLIC  :: MAKE_AVGW
PUBLIC  :: MAKE_RH
```

PUBLIC DATA MEMBERS:

```
! 2-D data fields
REAL*8,  ALLOCATABLE, PUBLIC :: ALBD1   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ALBD2   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ALBD    (:,:)
INTEGER, ALLOCATABLE, PUBLIC :: CLDTOPS (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: CLDFRC  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: EFLUX   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: EVAP    (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: FRLAKE  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: FRLAND  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: FROCEAN (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: FRLANDIC(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: FRSEAICE(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: FRSNO   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: GRN     (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: GWETROOT(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: GWETTOP (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: HFLUX   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: LAI     (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: LWI_GISS(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: LWI     (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: MOLENGTH(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: OICE    (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PARDF   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PARDR   (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PBL     (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PHIS    (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PREACC  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PREANV  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PRECON  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PRELSC  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PRECSNO (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PS1     (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PS2     (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PSC2    (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: RADLWG  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: RADSWG  (:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE00(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE10(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE20(:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE30(:,:)
```

```
      REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE40(:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE50(:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE60(:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE70(:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE80(:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SEAICE90(:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SLP     (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SNICE   (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SNODP   (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SNOMAS  (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SNOW    (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: SUNCOS  (:  )
      REAL*8,  ALLOCATABLE, PUBLIC :: SUNCOS_MID(:  )
      REAL*8,  ALLOCATABLE, PUBLIC :: TO31    (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TO32    (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TO3     (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TTO3    (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TROPP1  (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TROPP2  (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TROPP   (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TS      (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: TSKIN   (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: U10M    (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: USTAR   (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: V10M    (:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: Z0      (:,:)

      ! 3-D data fields
      REAL*8,  ALLOCATABLE, PUBLIC :: AD      (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: AIRDEN  (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: AIRVOL  (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: AVGW    (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: BXHEIGHT(:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQRCU   (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQRLSAN (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: CLDF    (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: CLDMAS  (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: CMFMC   (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DELP    (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DETRAINE(:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DETRAINN(:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DNDE    (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DNDN    (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQIDTMST(:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQLDTMST(:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQRCON  (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQRLSC  (:,:,:)
      REAL*8,  ALLOCATABLE, PUBLIC :: DQVDTMST(:,:,:)
```

```
REAL*8,  ALLOCATABLE, PUBLIC :: DTRAIN  (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ENTRAIN (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: HKBETA  (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: HKETA   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: MFXC    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: MFYC    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: MFZ     (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: MOISTQ  (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: OPTDEP  (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: OPTD    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PFICU   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PFILSAN (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PFLCU   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PFLLSAN (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: PV      (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: QI      (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: QL      (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: REEVAPCN(:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: REEVAPLS(:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: RH1     (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: RH2     (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: RH      (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SPHU1   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SPHU2   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: SPHU    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: T       (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: TAUCLI  (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: TAUCLW  (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: TMPU1   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: TMPU2   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: UPDE    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: UPDN    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: UWND1   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: UWND2   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: UWND    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: VWND1   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: VWND2   (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: VWND    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ZMEU    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ZMMD    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: ZMMU    (:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: AIRDEN_FULLGRID(:,:,:)
REAL*8,  ALLOCATABLE, PUBLIC :: T_FULLGRID     (:,:,:)
```

REVISION HISTORY:

```
26 Jun 2010 - R. Yantosca - Initial version
(1 ) Added sea level pressure (SLP) met field for GEOS-3 (bmy, 10/10/00)
(2 ) Moved MAKE_QQ to "wetscav_mod.f" (bmy, 10/12/00)
```

```
(3 ) Now get LWI from ALBEDO for GEOS-3 in routines IS_LAND and
     IS_WATER (bmy, 4/4/01)
(4 ) Define OPTDEP allocatable array for GEOS-3 -- this is the grid
     box optical depth and is now stored as a met field (bmy, 8/15/01)
(5 ) Updated comments (bmy, 9/4/01)
(6 ) Now make AVGW an allocatable module array.  Also replace obsolete
     parameters {IJL}GCMPAR with IIPAR,JJPAR,LLPAR. (bmy, 9/27/01)
(7 ) Remove arguments LMAKEPW, PW, and LM from AIRQNT (bmy, 10/3/01)
(8 ) Remove obsolete code from 9/01 (bmy, 10/23/01)
(9 ) Bug fixes in IS_LAND and IS_WATER.  Also cosmetic changes and
     updated some comments. (mje, bmy, 1/9/02)
(10) Now add additional array PSC2 in order to pass to TPCORE, which will
     fix the mixing ratio bug.  Compute PSC2 in subroutine INTERP.
     Now bundle "convert_units.f" into "dao_mod.f".  Updated comments.
     (bmy, 3/27/02)
(11) Updated comments (bmy, 5/28/02)
(12) Replaced all instances of IM with IIPAR and JM with JJPAR, in order
     to prevent namespace confusion for the new TPCORE (bmy, 6/25/02)
(13) Eliminated PS, PSC arrays.  Now reference "pressure_mod.f".  Also
     updated AIRQNT for hybrid grid.  Added routine MAKE_RH to this
     module. (dsa, bdf, bmy, 8/27/02)
(14) Added arrays AD, BXHEIGHT, and T to "dao_mod.f".  Also removed
     obsolete code from 8/02 from several module routines.  Now
     references "error_mod.f".  Remove all references to QQ, it is now
     declared in "wetscav_mod.f".  (bmy, 11/8/02)
(15) Now references "grid_mod.f".  Also added PHIS field, which was
     formerly stored as PALTD in "CMN".  Added bug fix in routine
     AVGPOLE for 1x1 nested grid. (bmy, 3/11/03)
(16) Added SUNCOSB array for SMVGEAR II.  Also removed KZZ array, since
     that is now obsolete. (bmy, 4/28/03)
(17) Now moved MAKE_CLDFRC into "a6_read_mod.f".  Added HKBETA, HKETA,
     TSKIN, GWETTOP, ZMEU, ZMMD, ZMMU, PARDF, PARDR fields for
     GEOS-4/fvDAS. (bmy, 6/25/03)
(18) Added CLDFRC, RADSWG, RADLWG, SNOW arrays (bmy, 12/9/03)
(19) Added routine COPY_I6_FIELDS w/ parallel DO-loops (bmy, 4/13/04)
(20) Now also allocate AVGW for offline aerosol simulation (bmy, 9/28/04)
(21) AVGPOLE now uses NESTED_CH and NESTED_NA cpp switches (bmy, 12/1/04)
(22) Now modified for GEOS-5 and GCAP met fields (swu, bmy, 5/25/05)
(23) Now allocate SNOW and GWET for GCAP (bmy, 8/17/05)
(24) Now also add TSKIN for GEOS-3 (tmf, bmy, 10/20/05)
(25) Modifications for near-land formulation (ltm, bmy, 5/16/06)
(26) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(27) Modified for variable tropopause (phs, bdf, 9/14/06)
(28) Add in extra fields for GEOS-5.  Updated COSSZA.  Now cap var trop
     at 200hPa near poles in INTERP (bmy, phs, 9/18/07)
(29) Bug fix in INIT_DAO for CMFMC array (bmy, jaf, 6/11/08)
(30) Add heat flux EFLUX for GEOS5. (lin, ccc, 5/29/09)
(31) Add fractions of land and water, FRLAND, FROCEAN, FRLANDIC, FRLAKE
```

```
      for methane (kjw, 8/18/09)
(32) Bug fix in AVGPOLE (bmy, 12/18/09)
(33) Remove obsolete SUNCOSB array (bmy, 4/28/10)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
18 Aug 2010 - R. Yantosca - Added modifications for MERRA data
18 Aug 2010 - R. Yantosca - Move F77_CMN_SIZE, F77_CMN_DIAG to top of module
25 Aug 2010 - R. Yantosca - Now read LWI (land/water/ice) for MERRA met
05 Oct 2011 - R. Yantosca - Add SUNCOS_30 array to hold the cos(SZA)
                            computed @ 30 mins after each GMT hour.
07 Oct 2011 - R. Yantosca - Rename SUNCOS30 to SUNCOS_MID, which is the
                            cos(SZA) at the midpt of the chemistry timestep
```

1.16.1 avgpole

Subroutine AVGPOLE computes average quantity near polar caps, defined by (J = 1, 2) and (J = JJPAR-1, JJPAR).

INTERFACE:

```
      SUBROUTINE AVGPOLE( Z )
```

USES:

```
      USE GRID_MOD, ONLY : GET_AREA_M2
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8, INTENT(INOUT) :: Z(IIPAR,JJPAR)   ! Quantity to be averaged
                                                !  over the pole (usually PS)
```

REVISION HISTORY:

```
30 Jan 1998 - R. Yantosca - Initial version
(1 ) AVGPOLE is written in Fixed-Form Fortran 90.  Use F90 syntax
      for declarations, etc (bmy, 4/14/99)
(2 ) MAIN now passes the Harvard CTM variable for surface area of
      a gridbox, DXYP(JJPAR), to AVGPOLE.  Use window offset
      J+J0 when accessing DXYP.  Add JJPAR to the parameter list.
(3 ) Added this routine to "dao_mod.f" (bmy, 6/27/00)
(4 ) Updated comments (bmy, 4/4/01)
(5 ) Now replaced DXYP(J) with routine GET_AREA_M2 of "grid_mod.f"
      Now also return immediately if GRID1x1 is selected. (bmy, 3/11/03)
(6 ) Now use cpp switches NESTED_CH and NESTED_NA to denote nested
      grids...GRID1x1 can now also denote a global grid (bmy, 12/1/04)
(7 ) Also need to RETURN for 0.5 x 0.666 nested grid simulations
      (mpb, bmy, 12/18/09)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.16.2 airqnt

Subroutine AIRQNT calculates the volume [m$\hat{3}$ and cm$\hat{3}$], mass [kg], density, [kg/m$\hat{3}$], and pressure thickness [hPa] of air for each grid box (I,J,L). The quantity (surface pressure - PTOP) [hPa] at each surface grid box (I,J) is also computed.

INTERFACE:

```
SUBROUTINE AIRQNT
```

USES:

```
USE GRID_MOD,     ONLY : GET_AREA_M2
USE PRESSURE_MOD, ONLY : GET_BP, GET_PEDGE
```

REMARKS:

```
DAO met fields updated by AIRQNT:
============================================================================
(1 ) BXHEIGHT (REAL*8 ) : Vertical extent of a grid box   [m       ]
(2 ) DELP     (REAL*8 ) : Delta-P extent  of a grid box   [mb      ]
(3 ) AIRVOL   (REAL*8 ) : Volume  of air  in a grid box   [m^3     ]
(4 ) AD       (REAL*8 ) : Mass    of air  in a grid box   [kg      ]
(5 ) AIRDEN   (REAL*8 ) : Density of air  in a grid box   [kg/m^3  ]
```

REVISION HISTORY:

```
30 Jan 1998 - R. Yantosca - Initial version
(1 ) AIRQNT is written in Fixed-Form Fortran 90.  Use F90 syntax
     for declarations etc. (bmy, 4/14/99)
(2 ) AIRQNT can now compute PW from PS (if LMAKEPW=T) or PS from PW.
(3 ) AIRQNT should also be called after TPCORE, since TPCORE changes
     the PW values.  AIRQNT must then be called to compute the post-TPCORE
     values of AD, BXHEIGHT, AIRVOL, and AIRDEN.
(4 ) The AIRDEN and DELP arrays are now dimensioned as (LLPAR,IIPAR,JJPAR)
     for better efficiency when processing a whole (I,J) column layer by
     layer.  In FORTRAN, the best efficiency is obtained when the leftmost
     array index corresponds to the innermost loop.
(5 ) Remove PTOP from the arg list.  PTOP is now a parameter in
    "F77_CMN_SIZE".  Also updated comments. (bmy, 2/22/00)
(6 ) Replace IM, JM, LM with IIPAR, JJPAR, LLPAR as loop boundaries.
     This ensures that all quantities get defined up to the top of
     the atmosphere. (bmy, 6/15/00)
(7 ) Added to "dao_mod.f" (bmy, 6/26/00)
(8 ) Updated comments (bmy, 4/4/01)
(9 ) P(IREF,JREF) is now P(I,J).  T(IREF,JREF,L) is now T(I,J,L).  Also
     removed LM from the arg list, it is obsolete.  Also updated
     comments. (bmy, 9/26/01)
(10) Remove PW -- it is now obsolete.  Also make PW a local variable,
     we need to preserve the way it computes P so as to avoid numerical
```

```
      drift. (bmy, 10/4/01)
(11) Removed obsolete code from 9/01 and 10/01 (bmy, 10/23/01)
(12) Removed LMAKEPW from arg list.  Added parallel DO loops (bmy, 11/15/01)
(13) Removed obsolete code from 11/01 (bmy, 1/9/02)
(14) Now rename G_SIGE to SIGE, and dimension it (1:LLPAR+1).  Updated
      comments, cosmetic changes. (bmy, 4/4/02)
(15) Removed obsolete, commented-out code (bmy, 6/25/02)
(16) Removed PS, P, SIGE from the arg list for hybrid grid.  Now reference
      routines GET_PEDGE and GET_BP from "pressure_mod.f".  Removed
      obsolete, commented-out code. (dsa, bdf, bmy, 8/27/02)
(17) Now only pass DXYP via the arg list -- the other arguments are actually
      are already contained within "dao_mod.f" (bmy, 11/15/02)
(18) Now replace DXYP(JREF) with routine GET_AREA_M2 of "grid_mod.f".
      (bmy, 3/11/03)
(19) Now move computation of DELP into main loop.  Also remove P, LOGP,
      JREF, DSIG variables -- these are obsolete for fvDAS.  (bmy, 6/19/03)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.16.3 airqnt_fullgrid

Subroutine AIRQNT_FULLGRID calculates the same quantities as AIRQNT, but for the full, unlumped vertical grid of the GEOS GCM.

INTERFACE:

```
SUBROUTINE AIRQNT_FULLGRID
```

USES:

```
USE GRID_MOD,     ONLY : GET_AREA_M2
USE PRESSURE_MOD, ONLY : GET_PEDGE_FULLGRID
```

REMARKS:

```
DAO met fields updated by AIRQNT_FULLGRID:
============================================================================
(1 ) AIRDEN_FULLGRID (REAL*8 ) : Density of air  in a grid box   [kg/m^3  ]
NOTES:
(1 ) Modified from AIRQNT in DAO_MOD (cdh, 1/22/09)
```

1.16.4 interp

Subroutine INTERP linearly interpolates GEOS-Chem I6 fields (winds, surface pressure, temperature, surface albedo, specific humidity etc.) to the current dynamic timestep.

INTERFACE:

```
SUBROUTINE INTERP( NTIME0, NTIME1, NTDT )
```

USES:

```
USE GRID_MOD,    ONLY : GET_YEDGE
USE LOGICAL_MOD, ONLY : LVARTROP
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: NTIME0   ! Elapsed time [s] at start of 6hr step
INTEGER, INTENT(IN)  :: NTIME1   ! Elapsed time [s] at current time
INTEGER, INTENT(IN)  :: NTDT     ! Length of dynamic timestep [s]
```

REMARKS:

```
Different met fields are archived at I6 (instantaneous 6-hr) time
resolution depending on the specific product.  For example, relative
humidity is an instantaneous 6hr field in MERRA and a 6-hr time averaged
field in GEOS-5.
```

REVISION HISTORY:

```
30 Jan 1998 - R. Yantosca - Initial version
(1 ) INTERP is written in Fixed-Form Fortran 90.
(2 ) Subtract PINT from PSC since the only subroutine that uses PSC
     is TPCORE.  This prevents having to subtract and add PINT to PSC
     before and after each call of TPCORE.
(3 ) Pass the Harvard CTM temperature variable T(IGCMPAR,JGCMPAR,LGCMPAR)
     to INTERP via the argument list (instead of including file CMN).
     It is computationally inefficient to keep two large arrays for
     the same quantity.  Use the proper window offsets with T.
(4 ) Added to "dao_mod.f" (bmy, 6/26/00)
(5 ) Updated comments (bmy, 4/4/01)
(6 ) Replaced {IJL}GCMPAR w/ IIPAR,JJPAR,LLPAR.  Also now use parallel
     DO-loop for interpolation.  Updated comments. (bmy, 9/26/01)
(7 ) Removed obsolete code from 9/01 (bmy, 10/23/01)
(8 ) Add PSC2 as the surface pressure at the end of the dynamic timestep.
     This needs to be passed to TPCORE and AIRQNT so that the mixing ratio
     can be converted to mass properly.  Removed PINT from the arg list,
     since we don't need it anymore.  Also updated comments and made
     some cosmetic changes.  (bmy, 3/27/02)
(9 ) Removed obsolete, commented-out code (bmy, 6/25/02)
(10) Eliminated PS, PSC from the arg list, for floating-pressure fix.
     (dsa, bdf, bmy, 8/27/02)
(11) Met field arrays are module variables, so we don't need to pass them
     as arguments. (bmy, 11/20/02)
(12) Removed NDT from the arg list since that is always 21600.  For GEOS-4
     met fields, only interpolate PSC2; the other fields are 6-h averages.
     Eliminate TC variable, it's obsolete.  Now use double precision to
     compute TM and TC2 values.  Renamed NTIME to NTIME1 and NTIME1 to
     NTIME0.  Updated comments. (bmy, 6/19/03)
(13) Now modified for GEOS-5 and GCAP met fields. (swu, bmy, 5/25/05)
```

```
(14) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(15) Now interpolate TROPP, only if variable tropopause is used
     (phs, 9/12/06)
(16) Don't interpolate TROPP for GEOS-5 (bmy, 1/17/07)
(17) Now limit tropopause pressure to 200 mbar at latitudes above 60deg
     (phs, 9/18/07)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
18 Aug 2010 - R. Yantosca - Rewrite #if block logic for clarity
```

1.16.5 is_land

Function IS_LAND returns TRUE if surface grid box (I,J) is a land box.

INTERFACE:

```
FUNCTION IS_LAND( I, J ) RESULT ( LAND )
```

USES:

```
USE TIME_MOD, ONLY : GET_YEAR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: I           ! Longitude index of grid box
INTEGER, INTENT(IN)  :: J           ! Latitude  index of grid box
```

RETURN VALUE:

```
LOGICAL              :: LAND        ! =T if it is a land box
```

REVISION HISTORY:

```
26 Jun 2000 - R. Yantosca - Initial version
(1 ) Now use ALBEDO field to determine land or land ice boxes for GEOS-3.
     (bmy, 4/4/01)
(2 ) For 4x5 data, regridded albedo field can cause small inaccuracies
     near the poles (bmy, 4/4/01)
(3 ) Add references to F77_CMN_SIZE and CMN, so that we can use the JYEAR
     variable to get the current year.  Also, for 1998, we need to compute
     if is a land box or not from the surface albedo, since for this
     year the LWI/SURFTYPE field is not given.  For other years than 1998,
     we use LWI(I,J) < 50 as our land box criterion.  Deleted obsolete
     code and updated comments.(mje, bmy, 1/9/02)
(4 ) Deleted GEOS-2 #ifdef statement.  GEOS-2 met fields never really
     materialized, we use GEOS-3 instead. (bmy, 9/18/02)
(5 ) Now uses function GET_YEAR from "time_mod.f".  Removed reference
     to CMN header file. (bmy, 3/11/03)
(6 ) Added code to determine land boxes for GEOS-4 (bmy, 6/18/03)
(7 ) Now modified for GEOS-5 and GCAP met fields (swu, bmy, 5/25/05)
```

```
(8 ) Now return TRUE only for land boxes (w/ no ice) (bmy, 8/10/05)
(9 ) Now use NINT to round LWI for GEOS-4/GEOS-5 (ltm, bmy, 5/9/06)
(10) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
25 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
```

1.16.6 is_water

Function IS_WATER returns TRUE if surface grid box (I,J) is an ocean or an ocean-ice box.

INTERFACE:

```
FUNCTION IS_WATER( I, J ) RESULT ( WATER )
```

USES:

```
USE TIME_MOD, ONLY : GET_YEAR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: I           ! Longitude index of grid box
INTEGER, INTENT(IN)  :: J           ! Latitude  index of grid box
```

RETURN VALUE:

```
LOGICAL              :: WATER       ! =T if this is a water box
```

REVISION HISTORY:

```
30 Jan 1998 - R. Yantosca - Initial version
(1 ) Now use ALBEDO field to determine water or water ice boxes for GEOS-3.
     (bmy, 4/4/01)
(2 ) For 4x5 data, regridded albedo field can cause small inaccuracies
     near the poles (bmy, 4/4/01)
(3 ) Add references to F77_CMN_SIZE and CMN, so that we can use the JYEAR
     variable to get the current year.  Also, for 1998, we need to compute
     if is an ocean box or not from the surface albedo, since for this
     year the LWI/SURFTYPE field is not given.  For other years than 1998,
     we use LWI(I,J) >= 50 as our ocean box criterion.  Deleted obsolete
     code and updated comments. (mje, bmy, 1/9/02)
(4 ) Deleted GEOS-2 #ifdef statement.  GEOS-2 met fields never really
     materialized, we use GEOS-3 instead. (bmy, 9/18/02)
(5 ) Now uses function GET_YEAR from "time_mod.f".  Removed reference
     to CMN header file. (bmy, 3/11/03)
(6 ) Added code to determine water boxes for GEOS-4 (bmy, 6/18/03)
(7 ) Now modified for GEOS-5 and GCAP met fields (swu, bmy, 5/25/05)
(8 ) Now remove test for sea ice (bmy, 8/10/05)
(9 ) Now use NINT to round LWI for GEOS-4/GEOS-5 (ltm, bmy, 5/9/06)
(10) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06
16 Aug 2010 - R. Yantosca - Added ProTeX headers
25 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
```

1.16.7 is_ice

Function IS_ICE returns TRUE if surface grid box (I,J) contains either land-ice or sea-ice.

INTERFACE:

```
FUNCTION IS_ICE( I, J ) RESULT ( ICE )
```

USES:

```
USE TIME_MOD, ONLY : GET_YEAR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: I          ! Longitude index of grid box
INTEGER, INTENT(IN)  :: J          ! Latitude  index of grid box
```

RETURN VALUE:

```
LOGICAL              :: ICE        ! =T if this is an ice box
```

REVISION HISTORY:

```
09 Aug 2005 - R. Yantosca - Initial version
(1 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
25 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
```

1.16.8 is_near

Function IS_NEAR returns TRUE if surface grid box (I,J) contains any land above a certain threshold (THRESH) or any of the adjacent boxes up to NEIGHBOR boxes away contain land.

INTERFACE:

```
FUNCTION IS_NEAR( I, J, THRESH, NEIGHBOR ) RESULT ( NEAR )
```

INPUT PARAMETERS:

```
! Arguments
INTEGER, INTENT(IN) :: I, J        ! Lon & lat grid box indices
INTEGER, INTENT(IN) :: NEIGHBOR    ! # of neighbor boxes to consider
REAL*8,  INTENT(IN) :: THRESH      ! LWI threshold for near-land
```

RETURN VALUE:

```
LOGICAL             :: NEAR        ! # of near land boxes
```

REMARKS:

```
Typical values for:
   GCAP   : THRESH =  0.2, NEIGHBOR = 1
   GEOS-3 : THRESH = 80.0, NEIGHBOR = 1
   GEOS-4 : THRESH =  0.2, NEIGHBOR = 1
   GEOS-5 : THRESH =  0.2, NEIGHBOR = 1

NOTE: This routine is mostly obsolete now.
```

REVISION HISTORY:

```
09 May 2006 - R. Yantosca - Initial version
(1 ) Modified for GCAP and GEOS-3 met fields (bmy, 5/16/06)
(2 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
19 Aug 2010 - R. Yantosca - Rewrote logic of #if block for clarity
25 Aug 2010 - R. Yantosca - Treat MERRA in same way as GEOS-5
```

1.16.9 make_avgw

Subroutine MAKE_AVGW converts DAO specific humidity SPHU to AVGW, which is the mixing ratio of water vapor.

INTERFACE:

```
SUBROUTINE MAKE_AVGW
```

REVISION HISTORY:

```
30 Jan 1998 - R. Yantosca - Initial version
(1 ) AVGW was originally indexed by (L,I,J).  Reorder the indexing to
      (I,J,L) to take advantage of the way FORTRAN stores by columns.
      An (L,I,J) ordering can lead to excessive disk swapping.
(2 ) Now dimension AVGW as (IIPAR,JJPAR,LLPAR).  Also use parallel
      DO-loop to compute AVGW.  Updated comments. (bmy, 9/24/01)
(3 ) Removed obsolete code from 9/01 (bmy, 10/23/01)
(4 ) SPHU and AVGW are declared w/in "dao_mod.f", so we don't need to pass
      these as arguments anymore (bmy, 11/15/02)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.16.10 make_rh

Subroutine MAKE_RH computes relative humidity from specific humidity and temperature.

INTERFACE:

```
SUBROUTINE MAKE_RH
```

USES:

```
USE PRESSURE_MOD, ONLY : GET_PCENTER
```

REMARKS:

```
Module variables used:
============================================================================
(1 ) SPHU (REAL*8) : Array containing 3-D specific humidity [g H2O/kg air]
(2 ) TMPU (REAL*8) : Array containing 3-D temperature field [K]
(3 ) RH   (REAL*8) : Output array for relative humidity     [%]
```

REVISION HISTORY:

```
13 Oct 1999 - R. Yantosca - Initial version
(1 ) Use F90 syntax for declarations, etc.
(2 ) Cosmetic changes (bmy, 10/12/99)
(3 ) Now use GET_PCENTER from "pressure_mod.f" to compute the pressure
      at the midpoint of grid box (I,J,L).  Updated comments, cosmetic
      changes.  Added parallel DO-loops.  Remove reference to "CMN"
      header file.  Added to "dao_mod.f" (dsa, bdf, bmy, 8/27/02)
(4 ) Removed obsolete code from 8/02 (bmy, 9/18/02)
(5 ) Now remove SPHU, TMPU, RH from the arg list, since these are now
      all contained w/in this dao_mod.f as module variables. (bmy, 9/23/02)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.16.11 get_obk

Function GET_OBK returns the Monin-Obhukov length at a grid box (I,J).

INTERFACE:

```
FUNCTION GET_OBK( I, J ) RESULT( OBK )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I     ! Longitude index
INTEGER, INTENT(IN) :: J     ! Latitude  index
```

RETURN VALUE:

```
REAL*8              :: OBK   ! Monin-Obhukhov length
```

REMARKS:

REVISION HISTORY:

```
25 May 2005 - R. Yantosca - Initial version
16 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.16.12 cossza

COSSZA computes the cosine of the solar zenith angle at the current time, and at the midpoint of the chemistry timestep interval.

INTERFACE:

```
SUBROUTINE COSSZA( JDAY, SUNCOS, SUNCOS_MID )
```

USES:

```
USE GRID_MOD, ONLY : GET_YMID_R
USE TIME_MOD, ONLY : GET_HOUR
USE TIME_MOD, ONLY : GET_MINUTE
USE TIME_MOD, ONLY : GET_LOCALTIME
USE TIME_MOD, ONLY : GET_TS_CHEM
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: JDAY              ! Day of year (0-365)
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: SUNCOS(MAXIJ)     ! cos(SZA) @ current time
REAL*8,  INTENT(OUT) :: SUNCOS_MID(MAXIJ) ! cos(SZA) @ midpt of chem step
```

REMARKS:

```
Hour angle (AHR) is a function of longitude.  AHR is zero at solar noon,
and increases by 15 deg for every hour before or after solar noon.  Hour
angle can be thought of as the time in hours since the sun last passed
the meridian (i.e. the time since the last local noon).
                                                                             .
The cosine of the solar zenith angle (SZA) is given by:
                                                                             .
   cos(SZA) = sin(LAT)*sin(DEC) + cos(LAT)*cos(DEC)*cos(AHR)
                                                                             .
where LAT = the latitude angle,
      DEC = the solar declination angle,
      AHR = the hour angle, all in radians.
                                                                             .
If SUNCOS < 0, then the sun is below the horizon, and therefore does not
contribute to any solar heating.
```

REVISION HISTORY:

```
21 Jan 1998 - R. Yantosca - Initial version
(1 ) COSSZA is written in Fixed-Form Fortran 90.
(2 ) Use IMPLICIT NONE
(3 ) Use C-preprocessor #include statement to include F77_CMN_SIZE, which
      has IIPAR, JJPAR, LLPAR, IIPAR, JJPAR, LGLOB.
(4 ) Use IM and JM (in F77_CMN_SIZE) as loop limits.
```

```
(5 ) Include Harvard CTM common blocks and rename variables where needed.
(6 ) Use SUNCOS(MAXIJ) instead of a 2D array, in order for compatibility
     with the Harvard CTM subroutines.  SUNCOS loops over J, then I.
(7 ) Added DO WHILE loops to reduce TIMLOC into the range 0h - 24h.
(8 ) Cosmetic changes.  Also use F90 declaration statements (bmy, 6/5/00)
(9 ) Added to "dao_mod.f".  Also updated comments. (bmy, 9/27/01)
(10) Replaced all instances of IM with IIPAR and JM with JJPAR, in order
     to prevent namespace confusion for the new TPCORE (bmy, 6/25/02)
(11) Deleted obsolete code from 6/02 (bmy, 8/21/02)
(12) Removed RLAT and XLON from the arg list.  Now compute these using
     functions from "grid_mod.f" (bmy, 2/3/03)
(13) Now uses GET_LOCALTIME from "time_mod.f" to get the local time.
     Added parallel DO loop. Removed NHMSb, NSEC arguments. (bmy, 2/13/07)
(14) Now compute SUNCOS at the midpoint of the relevant time interval
     (i.e. the chemistry timestep).   Also make the A and B coefficients
     parameters instead of variables. (bmy, 4/27/10)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
05 Oct 2011 - R. Yantosca - Now also return the cosine of the solar
                            zenith angle at 30m after the GMT hour.
07 Oct 2011 - R. Yantosca - Now return SUNCOS_MID, the cos(SZA) at the
                            midpt of the chem step (not always at 00:30).
```

1.16.13 convert_units

Subroutine CONVERT_UNITS converts the units of STT from [kg] to [v/v] mixing ratio, or vice versa.

INTERFACE:

```
SUBROUTINE CONVERT_UNITS( IFLAG, N_TRACERS, TCVV, AD, STT )
```

USES:

```
USE ERROR_MOD,  ONLY : ERROR_STOP
```

INPUT PARAMETERS:

```
! =1 then convert from [kg ] --> [v/v]
! =2 then convert from [v/v] --> [kg ]
INTEGER, INTENT(IN)    :: IFLAG

! Number of tracers
INTEGER, INTENT(IN)    :: N_TRACERS

! Array containing [Air MW / Tracer MW] for tracers
REAL*8,  INTENT(IN)    :: TCVV(N_TRACERS)

! Array containing grid box air masses
REAL*8,  INTENT(IN)    :: AD(IIPAR,JJPAR,LLPAR)
```

OUTPUT PARAMETERS:

```
!  Array containing tracer conc. [kg] or [v/v]
REAL*8,  INTENT(INOUT) :: STT(IIPAR,JJPAR,LLPAR,N_TRACERS)
```

REVISION HISTORY:

```
15 Jun 1998 - R. Yantosca - Initial version
(1 ) CONVERT_UNITS is written in Fixed-Form Fortran 90.
(2 ) Cosmetic changes, updated comments (bmy, 4/19/00)
(3 ) Now use SELECT CASE statement.  Also added parallel DO-loops
     with the new Open-MP compiler directives. (bmy, 4/27/00)
(4 ) Bundled into "dao_mod.f".  Now pass NTRACE, TCVV, AD, STT as args.
     Now use explicit DO-loops for I-J-L w/in parallel loops.  Updated
     comments, cosmetic changes. (bmy, 3/29/02)
(5 ) Removed obsolete, commented-out code.  Also now use F90 intrinsic
     REPEAT to write a line of "="'s to the screen. (bmy, 6/25/02)
(6 ) Updated comments.  Now reference ERROR_STOP from "error_mod.f"
     (bmy, 10/15/02)
(7 ) Renamed NTRACE to N_TRACERS for consistency (bmy, 7/19/04)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.16.14 copy_i6_fields

Subroutine COPY_I6_FIELDS copies the I-6 fields at the end of a 6-hr timestep. The I-6 fields at the end of a given 6-hr timestep become the fields at the beginning of the next 6-hr timestep.

INTERFACE:

```
SUBROUTINE COPY_I6_FIELDS
```

REVISION HISTORY:

```
13 Apr 2004 - R. Yantosca - Initial version
(1 ) Added parallel DO-loops (bmy, 4/13/04)
(2 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(3 ) Added TROPP (phs 11/10/06)
(4 ) Don't copy TROPP2 to TROPP1 for GEOS-5 (bmy, 1/17/07)
16 Aug 2010 - R. Yantosca - Added ProTeX headers
20 Aug 2010 - R. Yantosca - Rewrite #if block for clarity
20 Aug 2010 - R. Yantosca - Added #if block for MERRA met fields
```

1.16.15 init_dao

Subroutine INIT_DAO allocates memory for all allocatable module arrays.

INTERFACE:

```
      SUBROUTINE INIT_DAO
```

USES:

```
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE LOGICAL_MOD, ONLY : LWETD, LDRYD, LCHEM
      USE TRACER_MOD,  ONLY : ITS_AN_AEROSOL_SIM, ITS_A_FULLCHEM_SIM
```

REVISION HISTORY:

```
    26 Jun 2000 - R. Yantosca - Initial version
    (1 ) Now allocate AVGW for either NSRCX == 3 or NSRCX == 5 (bmy, 9/24/01)
    (2 ) Removed obsolete code from 9/01 (bmy, 10/23/01)
    (3 ) Add PSC2 array for TPCORE mixing ratio fix.   (bmy, 3/27/02)
    (4 ) Elimintated PS, PSC arrays for floating-pressure fix.
         (dsa, bdf, bmy, 8/20/02)
    (5 ) Added AD, BXHEIGHT, T to "dao_mod.f" as allocatable arrays, to remove
         historical baggage and centralize variables.  Also remove GEOS_2
         flag from C-preprocessor statements.  Also allocate RH array
         but only if we are doing a sulfate simulation.  Now references
         ALLOC_ERR from "error_mod.f" (bmy, 10/15/02)
    (6 ) Now allocate PHIS array (bmy, 3/11/03)
    (7 ) Now allocate SUNCOSB array for SMVGEAR II.  Also removed KZZ array,
         that is now obsolete. (bdf, bmy, 4/28/03)
    (8 ) Now order all arrays in alphabetical order.  Also added new fields
         for GEOS-4/fvDAS: HKBETA, HKETA, ZMEU, ZMMD, ZMMU, TSKIN, PARDF,
         and PARDR. (bmy, 6/25/03)
    (9 ) Now allocate CLDFRC, RADLWG, RADSWG, SNOW arrays.  USTAR, CLDFRC,
         and Z0 and RADSWG are now 2-D arrays. (bmy, 12/9/03)
    (10) Allocate RADLWG and SNOW for both GEOS-3 & GEOS-4 (bmy, 4/2/04)
    (11) Now reference inquiry functions from "tracer_mod.f".  Now reference
         LWETD, LDRYD, LCHEM from "logical_mod.f".  Now allocate RH regardless
         of simulation. (bmy, 7/20/04)
    (12) Now also allocate AVGW for offline aerosol simulations (bmy, 9/27/04)
    (13) Now modified for GCAP met fields.  Removed references to CO-OH param
         simulation.  Now allocate AVGW only for fullchem or offline aerosol
         simulations. (bmy, 6/24/05)
    (14) Now allocate SNOW and GWETTOP for GCAP (bmy, 8/17/05)
    (15) Now also add TSKIN for GEOS-3 (bmy, 10/20/05)
    (16) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
    (17) Reorganized for GEOS-5 met fields (bmy, 1/17/07)
    (18) Bug fix: should be CMFMC=0 after allocating CMFMC (jaf, bmy, 6/11/08)
    (19) Remove obsolete SUNCOSB array (bmy, 4/28/10)
    16 Aug 2010 - R. Yantosca - Added ProTeX headers
    18 Aug 2010 - R. Yantosca - Now allocate met fields for MERRA
    20 Aug 2010 - R. Yantosca - Bug fix, now allocate REEVAPCN
```

1.16.16 cleanup_dao

Subroutine CLEANUP_DAO deallocates all met field arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_DAO
```

REVISION HISTORY:

```
   26 Jun 2000 - R. Yantosca - Initial version
   (1 ) Now deallocate SLP met field for GEOS-3 (bmy, 10/10/00)
   (2 ) Now deallocate OPTDEP met field for GEOS-3 (bmy, 8/15/01)
   (3 ) Now deallocate AVGW (bmy, 9/24/01)
   (4 ) Remove TAUCLD deallocation -- it's obsolete (bmy, 10/23/01)
   (5 ) Add call to deallocate PSC2 array (bmy, 3/27/02)
   (6 ) Elimintated PS, PSC arrays for floating-pressure fix.
        (dsa, bdf, bmy, 8/20/02)
   (7 ) Now deallocate AD, BXHEIGHT, and T arrays (bmy, 9/18/02)
   (8 ) Now deallocate PHIS array (bmy, 3/11/03)
   (9 ) Now deallocate SUNCOSB array.  Remove reference to KZZ, since
        that is now obsolete. (bmy, 4/28/03)
   (10) Now list all arrays in order.  Now also deallocate new arrays
        for GEOS-4/fvDAS. (bmy, 6/25/03)
   (11) Now deallocate CLDFRC, RADLWG, RADSWG, SNOW arrays (bmy, 12/9/03)
   (12) Now deallocate GCAP met fields (bmy, 5/25/05)
   (13) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
   (14) Deallocate additional arrays for GEOS-5 (bmy, 1/17/07)
   (15) Remove obsolete SUNCOSB (bmy, 4/28/10)
   16 Aug 2010 - R. Yantosca - Added ProTeX headers
   18 Aug 2010 - R. Yantosca - Now deallocate MERRA met field arrays
   05 Oct 2011 - R. Yantosca - Now deallocate SUNCOS_MID
```

1.17 Fortran: Module Interface depo_mercury_mod

Module DEPO_MERCURY_MOD contains routines to handle deposition fluxes for mercury.

INTERFACE:

```
      MODULE DEPO_MERCURY_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: ADD_Hg2_DD
      PUBLIC :: ADD_Hg2_WD
      PUBLIC :: ADD_HgP_DD
      PUBLIC :: ADD_HgP_WD
      PUBLIC :: ADD_HG2_SNOWPACK
      PUBLIC :: RESET_HG_DEP_ARRAYS
      PUBLIC :: CHECK_DIMENSIONS
      PUBLIC :: READ_GTMM_RESTART
      PUBLIC :: MAKE_GTMM_RESTART
      PUBLIC :: UPDATE_DEP
      PUBLIC :: INIT_DEPO_MERCURY
      PUBLIC :: CLEANUP_DEPO_MERCURY
```

PUBLIC DATA MEMBERS:

```
      PUBLIC :: DD_HG2, DD_HGP, WD_HG2, WD_HGP
      PUBLIC :: HG2mth_wd, HG0mth_dd, HG2mth_dd
      PUBLIC :: SNOW_HG
      PUBLIC :: LHGSNOW
      REAL*8,  ALLOCATABLE :: DD_Hg2(:,:,:)
      REAL*8,  ALLOCATABLE :: DD_HgP(:,:,:)
      REAL*8,  ALLOCATABLE :: WD_Hg2(:,:,:)
      REAL*8,  ALLOCATABLE :: WD_HgP(:,:,:)
      REAL*8,  ALLOCATABLE :: HG0mth_dd(:,:)
      REAL*8,  ALLOCATABLE :: HG2mth_dd(:,:)
      REAL*8,  ALLOCATABLE :: HG2mth_wd(:,:)
      REAL*8,  ALLOCATABLE :: SNOW_HG(:,:,:) !CDH Hg stored in snow+ice
      REAL*8,  ALLOCATABLE :: Hg0dryGEOS(:,:), HgIIdryGEOS(:,:),
     &                        HgIIwetGEOS(:,:)
  !PRIVATE DATA MEMBERS:
      CHARACTER(LEN=255)   :: GTMM_RST_FILE
      LOGICAL              :: LHGSNOW
```

REVISION HISTORY:

```
    23 Apr 2010 - C. Carouge  - Initial version
    12 Apr 2011 - J. Fisher   - Add missing code from Holmes 2010
```

1.17.1 add_Hg2_dd

Subroutine ADD_Hg2_DD computes the amount of Hg(II) dry deposited out of the atmosphere into the column array DD_Hg2.

INTERFACE:

```
      SUBROUTINE ADD_Hg2_DD( I, J, N, DRY_Hg2)
  !USES
      USE TRACERID_MOD, ONLY : GET_Hg2_CAT
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)   :: I, J, N   ! GEOS-Chem long, lat and tracer index
      REAL*8,  INTENT(IN)   :: DRY_Hg2   ! Hg(II) dry deposited out of the
                                         ! atmosphere [kg]
```

REVISION HISTORY:

```
    19 Jan 2005 - S. Strode, C. Holmes - Initial version
    (1 ) DD_Hg2 is now a 3-D array.  Also pass N via the argument list. Now
         call GET_Hg2_CAT to return the Hg category #. (cdh, bmy, 3/28/06)
    23 Apr 2010 - C. Carouge  - Moved from ocean_mercury_mod.f to
                                depo_mercury_mod.f
```

1.17.2 add_Hg2_wd

Subroutine ADD_Hg2_WD computes the amount of Hg(II) wet scavenged out of the atmosphere into the column array WD_Hg2.

INTERFACE:

```
      SUBROUTINE ADD_Hg2_WD( I, J, N, WET_Hg2 )
   !USES
      USE TRACERID_MOD, ONLY : GET_Hg2_CAT
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)   :: I, J, N   ! GEOS-Chem long, lat and tracer index
      REAL*8,  INTENT(IN)   :: WET_Hg2   ! Hg(II) scavenged out of the
                                         ! atmosphere [kg]
```

REVISION HISTORY:

```
    19 Jan 2005 - S. Strode, C. Holmes - Initial version
    (1 ) WD_Hg2 is now a 3-D array.  Also pass N via the argument list. Now
         call GET_Hg2_CAT to return the Hg category #. (cdh, bmy, 3/28/06)
    23 Apr 2010 - C. Carouge  - Moved from ocean_mercury_mod.f to
                                depo_mercury_mod.f
```

1.17.3 add_HgP_dd

Subroutine ADD_HgP_DD computes the amount of HgP dry deposited out of the atmosphere into the column array DD_HgP.

INTERFACE:

```
      SUBROUTINE ADD_HgP_DD( I, J, N, DRY_HgP )
   !USES
      USE TRACERID_MOD, ONLY : GET_HgP_CAT
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)   :: I, J, N   ! GEOS-Chem long, lat and tracer index
      REAL*8,  INTENT(IN)   :: DRY_HgP   ! HgP dry deposited out of the
                                         ! atmosphere [kg]
```

REVISION HISTORY:

```
    19 Jan 2005 - S. Strode, C. Holmes - Initial version
    (1 ) DD_HgP is now a 3-D array.  Also pass N via the argument list. Now
          call GET_HgP_CAT to return the Hg category #. (cdh, bmy, 3/28/06)
    23 Apr 2010 - C. Carouge  - Moved from ocean_mercury_mod.f to
                                depo_mercury_mod.f
```

1.17.4 add_HgP_wd

Subroutine ADD_HgP_WD computes the amount of HgP wet scavenged out of the atmosphere into the column array WD_HgP.

INTERFACE:

```
      SUBROUTINE ADD_HgP_WD( I, J, N, WET_HgP )
   !USES
      USE TRACERID_MOD, ONLY : GET_HgP_CAT
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)   :: I, J, N   ! GEOS-Chem long, lat and tracer index
      REAL*8,  INTENT(IN)   :: WET_HgP   ! HgP scavenged out of the
                                         ! atmosphere [kg]
```

REVISION HISTORY:

```
    19 Jan 2005 - S. Strode, C. Holmes - Initial version
    (1 ) WD_HgP is now a 3-D array.  Also pass N via the argument list. Now
          call GET_HgP_CAT to return the Hg category #. (cdh, bmy, 3/28/06)
    23 Apr 2010 - C. Carouge  - Moved from ocean_mercury_mod.f to
                                depo_mercury_mod.f
```

1.17.5 add_hg2_snowpack

Subroutine ADD_Hg2_SNOWPACKS adds Hg2 deposition to snowpack.

INTERFACE:

```
      SUBROUTINE ADD_HG2_SNOWPACK( I, J, N, DEP_Hg2 )
```

USES:

```
      USE DAO_MOD,           ONLY : SNOW, SNOMAS
      USE DAO_MOD,           ONLY : IS_ICE, IS_LAND
      USE DAO_MOD,           ONLY : FRSNO, FRSEAICE, FRLANDIC
      USE TRACERID_MOD,      ONLY : GET_Hg2_CAT, GET_HgP_CAT
      USE TRACERID_MOD,      ONLY : IS_Hg2,      IS_HgP

#     include "define.h"
```

INPUT PARAMETERS:

```
      ! Arguments as input
      INTEGER, INTENT(IN)   :: I, J, N
      REAL*8,  INTENT(IN)   :: Dep_Hg2
```

REVISION HISTORY:

```
   02 Sep 2008 - C. Holmes   - Initial version
   23 Apr 2010 - C. Carouge  - Moved from mercury_mod.f to depo_mercury_mod.f
   25 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
   26 Apr 2011 - J. Fisher   - Use MERRA land fraction information
   12 Apr 2011 - J. Fisher   - Add missing code from Holmes 2010
   13 Apr 2011 - R. Yantosca - Bug fix: reference IS_LAND from dao_mod.f
```

1.17.6 reset_hg_dep_arrays

Subroutine RESET_Hg_DEP_ARRAYS resets the wet and dry deposition arrays for Hg(II) and Hg(p) to zero. This allows us to call OCEAN_MERCURY_FLUX and LAND_MERCURY_FLUX in any order in MERCURY_MOD.

INTERFACE:

```
      SUBROUTINE RESET_HG_DEP_ARRAYS
```

REVISION HISTORY:

```
   02 Sep 2008 - C. Holmes   - Initial version
   23 Apr 2010 - C. Carouge  - Moved from ocean_mercury_mod.f to
                               depo_mercury_mod.f
```

1.17.7 make_gtmm_restart

MAKE_GTMM_RESTART writes a GTMM restart file with deposition fluxes and store deposition fluxes for continuous runs.

INTERFACE:

```
      SUBROUTINE MAKE_GTMM_RESTART( NYMD, NHMS, TAU )
```

USES:

```
USE BPCH2_MOD
USE DIAG_MOD,      ONLY : AD39, AD44, AD38
USE DIRECTORY_MOD, ONLY : RUN_DIR
USE FILE_MOD,      ONLY : IU_FILE
USE GRID_MOD,      ONLY : GET_XOFFSET, GET_YOFFSET
USE TIME_MOD,      ONLY : EXPAND_DATE
USE TRACERID_MOD,  ONLY : ID_Hg0, ID_Hg2, ID_Hg_tot
USE TIME_MOD,      ONLY : GET_CT_DYN, GET_CT_CHEM

USE CMN_SIZE_MOD          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)   :: NYMD    ! Year-Month-Date
INTEGER, INTENT(IN)   :: NHMS    ! and Hour-Min-Sec for which to create
                                 ! a restart file
REAL*8,  INTENT(IN)   :: TAU     ! GEOS-CHEM TAU value corresponding to
                                 ! NYMD, NHMS
```

REVISION HISTORY:

```
15 Sep 2009 - C. Carouge - Initial version
```

1.17.8 read_gtmm_restart

Subroutine READ_GTMM_RESTART reads dry and wet deposition for mercury from GTMM restart.

INTERFACE:

```
SUBROUTINE READ_GTMM_RESTART( YYYYMMDD, HHMMSS,
&                             Hg0dryGEOS, HgIIdryGEOS, HgIIwetGEOS )
```

USES:

```
USE BPCH2_MOD,     ONLY : OPEN_BPCH2_FOR_READ
USE DIRECTORY_MOD, ONLY : RUN_DIR
USE ERROR_MOD,     ONLY : DEBUG_MSG
USE FILE_MOD,      ONLY : IU_FILE,     IOERROR
USE TIME_MOD,      ONLY : EXPAND_DATE
USE TRACER_MOD,    ONLY : STT,         TRACER_NAME, TRACER_MW_G
USE TRACERID_MOD,  ONLY : GET_Hg0_CAT, GET_Hg2_CAT, N_Hg_CATS
USE TRACERID_MOD,  ONLY : ID_Hg0,      ID_Hg2

USE CMN_SIZE_MOD
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)   :: YYYYMMDD, HHMMSS
```

OUTPUT PARAMETERS:

```
REAL*8, DIMENSION(IIPAR, JJPAR)   :: Hg0dryGEOS
REAL*8, DIMENSION(IIPAR, JJPAR)   :: HgIIdryGEOS
REAL*8, DIMENSION(IIPAR, JJPAR)   :: HgIIwetGEOS
```

REVISION HISTORY:

```
15 Sep 2009 - C. Carouge - Initial version
```

1.17.9 update_dep

Subroutine UPDATE_DEP update the monthly average for wet and dry deposition of Hg0 and Hg2 for mercury from GTMM restart.

INTERFACE:

```
SUBROUTINE UPDATE_DEP( NN )
```

USES:

```
USE DIAG_MOD,     ONLY : AD38,   AD39,   AD44
USE LOGICAL_MOD,  ONLY : LGTMM
USE TIME_MOD,     ONLY : GET_CT_DYN,  GET_CT_CHEM
USE TRACERID_MOD, ONLY : IDTHg0, IDTHg2
```

INPUT PARAMETERS:

```
INTEGER :: NN    ! Hg2 ID for wet deposition
```

REVISION HISTORY:

```
04 June 2010  - C. Carouge  - Initial version
```

1.17.10 check_dimensions

Subroutine CHECK_DIMENSIONS makes sure that the dimensions of the Hg restart file extend to cover the entire grid.

INTERFACE:

```
SUBROUTINE CHECK_DIMENSIONS( NI, NJ, NL )
```

USES:

```
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
USE CMN_SIZE_MOD
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: NI, NJ, NL
```

REVISION HISTORY:

```
    30 Aug 2010 - S. Strode, C. Holmes - Initial version
```

1.17.11 init_depo_mercury

Subroutine INIT_DEPO_MERCURY initialize deposition arrays for mercury.

INTERFACE:

```
      SUBROUTINE INIT_DEPO_MERCURY( THIS_Hg_RST_FILE )
   !USES
      USE ERROR_MOD,    ONLY : ALLOC_ERR
      USE LOGICAL_MOD,  ONLY : LGTMM
      USE TRACERID_MOD, ONLY : N_Hg_CATS

      USE CMN_SIZE_MOD     ! Size parameters
```

INPUT PARAMETERS:

```
      ! Name of the GTMM restart file
      CHARACTER(LEN=*), INTENT(IN) :: THIS_Hg_RST_FILE
```

REVISION HISTORY:

```
    23 Apr 2010 - C. Carouge   - Moved arrays allocation from
                                 ocean_mercury_mod.f
```

1.17.12 cleanup_depo_mercury

Subroutine CLEANUP_DEPO_MERCURY deallocate all arrays

INTERFACE:

```
      SUBROUTINE CLEANUP_DEPO_MERCURY
```

REVISION HISTORY:

```
    23 Apr 2010 - C. Carouge - Moved from ocean_mercury_mod.f
```

1.18 Fortran: Module Interface diag03_mod

Module DIAG03_MOD contains arrays and routines for archiving the ND03 diagnostic – Hg emissions, mass, and production.

INTERFACE:

```
      MODULE DIAG03_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

DEFINED PARAMETERS:

```
      INTEGER, PUBLIC, PARAMETER   :: PD03    = 18         ! Dim of AD03 array
      INTEGER, PUBLIC, PARAMETER   :: PD03_PL = 8          ! # of PL-HG2 diags
```

PUBLIC DATA MEMBERS:

```
      ! Scalars
      INTEGER, PUBLIC              :: ND03                 ! ND03 on/off flag
      INTEGER, PUBLIC              :: LD03                 ! # of levels

      ! Arrays
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03(:,:,:)          ! Diagnostic arrays
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_Hg0(:,:,:)  !  for the prod/loss
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_Br(:,:,:)   !  and mass of
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_OH(:,:,:)   !  various Hg
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_O3(:,:,:)   !  species
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_SS(:,:,:)   !
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_nat(:,:,:)      !
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_SSR(:,:)    !
      REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Br(:,:,:,:)     !
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: ZERO_DIAG03
      PUBLIC :: WRITE_DIAG03
      PUBLIC :: INIT_DIAG03
      PUBLIC :: CLEANUP_DIAG03
```

REMARKS:

```
    Nomenclature:
    ============================================================================
    (1 ) Hg(0)  a.k.a. Hg0     : Elemental   mercury
    (2 ) Hg(II) a.k.a. Hg2     : Divalent    mercury
    (3 ) HgP                   : Particulate mercury
```

REVISION HISTORY:

```
21 Jan 2005 - R. Yantosca - Initial version
(1 ) Updated for GCAP grid (bmy, 6/28/05)
(2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(3 ) Add 2 extra diagnostics to ND03. Set PD03=15.  (cdh, bmy, 12/15/05)
(4 ) Add loss of Hg2 by sea salt (eck, bmy, 4/6/06)
(5 ) Replace TINY(1d0) w/ 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(6 ) Updates to mercury simulation (ccc, 5/17/10)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.18.1 zero_diag03

Subroutine ZERO_DIAG03 zeroes all module arrays.

INTERFACE:

```
SUBROUTINE ZERO_DIAG03
```

USES:

```
! References to F90 modules
USE TRACERID_MOD, ONLY : N_Hg_CATS

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
21 Jan 2005 - R. Yantosca - Initial version
(1 ) Now references N_Hg_CATS from "tracerid_mod.f".  Now zero AD03_Hg2_SS
     array. (bmy, 4/6/06)
(2 ) Now use broadcast assignment and double precision 0D0 to zero arrays,
     rather than nested DO loops and single precision 0E0. (cdh, 8/14/08)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.18.2 write_diag03

Subroutine WRITE_DIAG03 writes the ND03 diagnostic arrays to the binary punch file at the proper time.

INTERFACE:

```
SUBROUTINE WRITE_DIAG03
```

USES:

```
      USE BPCH2_MOD,    ONLY : BPCH2
      USE BPCH2_MOD,    ONLY : GET_MODELNAME
      USE BPCH2_MOD,    ONLY : GET_HALFPOLAR
      USE FILE_MOD,     ONLY : IU_BPCH
      USE GRID_MOD,     ONLY : GET_XOFFSET
      USE GRID_MOD,     ONLY : GET_YOFFSET
      USE TIME_MOD,     ONLY : GET_CT_EMIS
      USE TIME_MOD,     ONLY : GET_DIAGb
      USE TIME_MOD,     ONLY : GET_DIAGe
      USE TIME_MOD,     ONLY : GET_CT_CHEM
      USE TRACERID_MOD, ONLY : N_Hg_CATS

      USE CMN_SIZE_MOD     ! Size parameters
      USE CMN_DIAG_MOD     ! TINDEX
```

REMARKS:

```
 # : Field    : Description                    : Units    : Scale factor
-----------------------------------------------------------------------------
The following list is outdated and not reliable (cdh, 7/5/11)
(1 ) HG-SRCE  : Anthropogenic HG0 emission     : kg       : 1
(2 ) HG-SRCE  : Total mass of oceanic Hg0      : kg       : 1
(3 ) HG-SRCE  : Oceanic Hg0 emission           : kg       : 1
(4 ) HG-SRCE  : Land reemission                : kg       : 1
(5 ) HG-SRCE  : Land natural emission          : kg       : 1
(6 ) HG-SRCE  : Anthropogenic Hg2 emission     : kg       : 1
(7 ) HG-SRCE  : Total mass of oceanic Hg2      : kg       : 1
(8 ) HG-SRCE  : Mass of Hg2 sunk in the ocean  : kg       : 1
(9 ) HG-SRCE  : Anthropogenic HgP emission     : kg       : 1
(10) HG-SRCE  : Henry's law piston velocity Kw : cm/h     : em timesteps  (anls, redo)
(11) HG-SRCE  : Mass of Hg(C)                  : kg       : 1
(12) HG-SRCE  : Converted to Colloidal         : kg       : 1
(13) HG-SRCE  : Biomass burning emissions      : kg       : 1
(14) HG-SRCE  : Emissions from vegetation      : kg       : 1
(15) HG-SRCE  : Emissions from soils           : kg       : 1
(16) HG-SRCE  : Flux-up Hg0 volat from ocean   : kg       : 1
(17) HG-SRCE  : Flux-down Hg0 dry dep to ocean : kg       : 1
(18) PL-HG2-$ : Production of Hg2 from Hg0     : kg       : 1
(19) PL-HG2-$ : Production of Hg2 from rxn w/OH : kg      : 1
(20) PL-HG2-$ : Production of Hg2 from rxn w/O3 : kg      : 1
(21) PL-HG2-$ : Loss of Hg2 from rxn w/ seasalt : kg      : 1
```

REVISION HISTORY:

```
21 Jan 2005 - R. Yantosca - Initial version
(1 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
     value for GEOS or GCAP grids. (bmy, 6/28/05)
(2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
```

```
(3 ) Add HgC ocean mass and converted to colloidal to ND03 diagnostic.
     The units of the Kw and conversion terms in ND03 should be kg
     and not divided by the scale factor. (cdh, sas, bmy, 2/26/02)
(4 ) Replace TINY(1d0) w/ 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(5 ) Fixed tracer numbers (NN) for 'PL-HG2-$' diagnostic quantities.
     (cdh, 8/13/08)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.18.3 init_diag03

Subroutine INIT_DIAG03 allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG03
```

USES:

```
USE ERROR_MOD,    ONLY : ALLOC_ERR
USE TRACERID_MOD, ONLY : N_Hg_CATS

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
21 Jan 2005 - R. Yantosca - Initial version
(1 ) Now allocates AD03_Hg2_SS (eck, bmy, 4/6/06)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.18.4 cleanup_diag03

Subroutine CLEANUP_DIAG03 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG03
```

REVISION HISTORY:

```
21 Jan 2005 - R. Yantosca - Initial version
(1 ) Now deallocates AD03_Hg2_SS (eck, bmy, 4/6/06)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.19 Fortran: Module Interface diag04_mod

Module DIAG04_MOD contains arrays and routines for archiving the ND04 diagnostic – CO2 emissions and fluxes.

INTERFACE:

```
      MODULE DIAG04_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PUBLIC
```

PUBLIC DATA MEMBERS:

```
      ! Scalars
      INTEGER              :: ND04, LD04
      INTEGER, PARAMETER   :: PD04 = 10

      ! Arrays
      REAL*4,  ALLOCATABLE :: AD04(:,:,:)
      REAL*4,  ALLOCATABLE :: AD04_plane(:,:,:)
      REAL*4,  ALLOCATABLE :: AD04_chem(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_DIAG04
      PUBLIC :: INIT_DIAG04
      PUBLIC :: WRITE_DIAG04
      PUBLIC :: ZERO_DIAG04
```

PRIVATE MEMBER FUNCTIONS:

REMARKS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%   BUYER BEWARE! Tagged CO2 tracers only work for 2 x 2.5 grid!   %%%
%%%   Someone will have to make this more general later on...        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

.

REVISION HISTORY:

```
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(2 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
      (bmy, 9/5/06)
(3 ) Modified for ship emissions (2-D), aircraft emissions (3-D) and
     chemical source for CO2 (3-D) (RayNassar, 2009-12-23)
20 May 2010 - R. Yantosca - Added ProTeX headers
```

1.19.1 zero_diag04

Subroutine ZERO_DIAG04 zeroes the ND04 diagnostic array.

INTERFACE:

```
SUBROUTINE ZERO_DIAG04
```

USES:

```
USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
26 Jul 2005 - R. Yantosca - Initial version
18 May 2010 - R. Nassar   - Also zero AD04_PLANE, AD04_CHEM arrays
18 May 2010 - R. Yantosca - Added ProTeX headers
```

1.19.2 write_diag04

Subroutine WRITE_DIAG04 writes the ND04 diagnostic arrays to the binary punch file at the proper time.

INTERFACE:

```
SUBROUTINE WRITE_DIAG04
```

USES:

```
USE BPCH2_MOD, ONLY : BPCH2, GET_MODELNAME, GET_HALFPOLAR
USE FILE_MOD,  ONLY : IU_BPCH
USE GRID_MOD,  ONLY : GET_XOFFSET, GET_YOFFSET
USE TIME_MOD,  ONLY : GET_CT_EMIS, GET_DIAGb,  GET_DIAGe

USE CMN_SIZE_MOD  ! Size parameters
USE CMN_DIAG_MOD  ! TINDEX
```

REMARKS:

```
 # : Field     : Description                  : Units       : Scale factor
-----------------------------------------------------------------------------
(1 ) CO2-SRCE  : CO2 fossil fuel emissions    : molec/cm2/s : SCALE
(2 ) CO2-SRCE  : CO2 ocean emissions          : molec/cm2/s : SCALE
(3 ) CO2-SRCE  : CO2 balanced biosphere       : molec/cm2/s : SCALE
(4 ) CO2-SRCE  : CO2 biomass emissions        : molec/cm2/s : SCALE
(5 ) CO2-SRCE  : CO2 biofuel emissions        : molec/cm2/s : SCALE
(6 ) CO2-SRCE  : CO2 net terrestrial exchange : molec/cm2/s : SCALE
(7 ) CO2-SRCE  : CO2 ship emissions           : molec/cm2/s : SCALE
(8 ) CO2-SRCE  : CO2 aircraft emissions (3-D) : molec/cm2/s : SCALE
(9 ) CO2-SRCE  : CO2 chemical source (3-D)    : molec/cm2/s : SCALE
(10) CO2-SRCE  : CO2 chem source surf correct : molec/cm2/s : SCALE!
```

REVISION HISTORY:

```
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(2 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
18 May 2010 - R. Nassar   - Now write out AD04_PLANE, AD04_CHEM
18 May 2010 - R. Yantosca - Added ProTeX headers
```

1.19.3 init_diag04

Subroutine INIT_DIAG04 allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG04
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
26 Jul 2005 - R. Yantosca - Initial version
18 May 2010 - R. Nassar   - Now initialize AD04_PLANE, AD04_CHEM
18 May 2010 - R. Yantosca - Added ProTeX headers
```

1.19.4 cleanup_diag04

Subroutine CLEANUP_DIAG04 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG04
```

REVISION HISTORY:

```
26 Jul 2005 - R. Yantosca - Initial version
18 May 2010 - R. Nassar   - Now ce
18 May 2010 - R. Yantosca - Added ProTeX headers
```

1.20 Fortran: Module Interface diag41_mod

Module DIAG41_MOD contains arrays and routines for archiving the ND41 diagnostic – Afternoon PBL heights.

INTERFACE:

```
      MODULE DIAG41_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      INTEGER, PUBLIC            :: ND41
      INTEGER, PUBLIC, PARAMETER :: PD41 = 2
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: ZERO_DIAG41
      PUBLIC :: WRITE_DIAG41
      PUBLIC :: DIAG41
      PUBLIC :: INIT_DIAG41
      PUBLIC :: CLEANUP_DIAG41
```

REVISION HISTORY:

```
   17 Feb 2005 - R. Yantosca - Initial version
   (1 ) Updated for GCAP grid (bmy, 6/28/05)
   (2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   (3 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
        (bmy, 9/5/06)
   02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.20.1 zero_diag41

Subroutine ZERO_DIAG41 zeroes the ND41 diagnostic arrays.

INTERFACE:

```
      SUBROUTINE ZERO_DIAG41
```

USES:

```
      USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
   17 Feb 2005 - R. Yantosca - Initial version
   02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.20.2 write_diag41

Subroutine WRITE_DIAG41 writes the ND41 diagnostic arrays to the binary punch file at the proper time.

INTERFACE:

```
SUBROUTINE WRITE_DIAG41
```

USES:

```
USE BPCH2_MOD, ONLY : BPCH2
USE BPCH2_MOD, ONLY : GET_HALFPOLAR
USE BPCH2_MOD, ONLY : GET_MODELNAME
USE FILE_MOD,  ONLY : IU_BPCH
USE GRID_MOD,  ONLY : GET_XOFFSET
USE GRID_MOD,  ONLY : GET_YOFFSET
USE TIME_MOD,  ONLY : GET_CT_EMIS
USE TIME_MOD,  ONLY : GET_DIAGb
USE TIME_MOD,  ONLY : GET_DIAGe

USE CMN_SIZE_MOD  ! Size parameters
USE CMN_DIAG_MOD  ! TINDEX
```

REMARKS:

```
ND41: Afternoon PBL depth (between 1200 and 1600 Local Time)

 #  Field    : Description             : Units  : Scale factor
-----------------------------------------------------------------
(1) PBLDEPTH : Afternoon PBL heights   : m      : GOOD_CT
```

REVISION HISTORY:

```
17 Feb 2005 - R. Yantosca - Initial version
(1 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
     value for GEOS or GCAP grids. (bmy, 6/28/05)
(2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(3 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.20.3 diag41

Subroutine DIAG41 produces monthly mean boundary layer height in meters between 1200-1600 local time for the U.S. geographical domain.

INTERFACE:

```
SUBROUTINE DIAG41
```

USES:

```
USE PBL_MIX_MOD, ONLY : GET_PBL_TOP_L
USE PBL_MIX_MOD, ONLY : GET_PBL_TOP_m
USE TIME_MOD,    ONLY : GET_LOCALTIME

USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
18 Nov 1999 - A. Fiore, S. Wu - Initial version
(1 ) DIAG41 is written in Fixed-Format F90.
(2 ) XTRA2 must be computed by turning TURBDAY on first.  Also,
     XTRA2 is a global-size array, so use window offsets IREF, JREF
     to index it correctly. (bmy, 11/18/99)
(3 ) Do a little rewriting so that the DO-loops get executed
     in the correct order (J first, then I). (bmy, 11/18/99)
(4 ) AD41 is now declared allocatable in "diag_mod.f". (bmy, 12/6/99)
(5 ) AFTTOT is now declared allocatable in "diag_mod.f". (bmy, 3/17/00)
(6 ) Remove NYMD from the argument list -- it wasn't used (bmy, 6/22/00)
(7 ) XTRA2(IREF,JREF,5) is now XTRA2(I,J).  Also updated comments.
     (bmy, 9/25/01)
(8 ) Removed obsolete code from 9/01 (bmy, 10/23/01)
(9 ) Now reference BXHEIGHT from "dao_mod.f".  Also removed obsolete
     code. (bmy, 9/18/02)
(10) Now use function GET_LOCALTIME from "dao_mod.f" (bmy, 2/11/03)
(11) Bug fix in DO-loop for calculating local time (bmy, 7/9/03)
(12) For GEOS-4, PBL depth is already in meters, so we only have to
     multiply that by the GOOD array.  Also now references PBL array
     from "dao_mod.f".  Bug fix: now use barometric law to compute PBL
     height in meters for GEOS-1, GEOS-STRAT, GEOS-3.  This eliminates an
     overprediction of the PBL height. (swu, bmy, 11/6/03)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.20.4 init_diag41

Subroutine CLEANUP_DIAG41 allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG41
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
17 Feb 2005 - R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.20.5 cleanup_diag41

Subroutine CLEANUP_DIAG41 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG41
```

REVISION HISTORY:

```
17 Feb 2005 - R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.21 Fortran: Module Interface diag42_mod

Module DIAG42_MOD contains arrays and routines for archiving the ND42 diagnostic – secondary organic aerosols [ug/m3].

INTERFACE:

```
MODULE DIAG42_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

DEFINED PARAMETERS:

```
      ! Maximum number of output:
      ! SOA1, SOA2, SOA3, SOA4, SOA5, SUM(SOA1-3), SUM(SOA1-4), SUM(SOA1-5),
      ! SUM(SOA1-5+OC), SUM(SOA1-5+OC), SUM(SOA1-5+OC), OC, BC, SOA4, NH4, NIT,
      ! SSALT, SUM(aerosols), SOAG, SOAM, SUM(SOA1-5+SOAG+SOAM),
      ! SUM(SOA1-5+SOAG+SOAM+OC), SUM(SOA1-5+SOAG+SOAM),
      ! SUM(SOA1-5+SOAG+SOAM+OC)
      INTEGER, PUBLIC, PARAMETER   :: PD42 = 24
```

PUBLIC DATA MEMBERS:

```
      INTEGER, PUBLIC              :: ND42           ! ND42 on/off flag
      INTEGER, PUBLIC              :: LD42           ! # of levels for ND42

      ! Arrays
      REAL*4,  PUBLIC, ALLOCATABLE :: AD42(:,:,:,:)   ! Array for SOA [ug/m3]
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: DIAG42
PUBLIC :: ZERO_DIAG42
PUBLIC :: WRITE_DIAG42
PUBLIC :: INIT_DIAG42
PUBLIC :: CLEANUP_DIAG42
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
(1 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(2 ) Now use ratio of 2.1 instead of 1.4 for SOA4 (dkh, bmy, 3/29/07)
(3 ) Add diagnostics for SOAG and SOAM (tmf, 1/7/09)
(4 ) Increase PD42 to 24. (fp, hotp, 2/3/10)

02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.21.1 diag42

Subroutine DIAG42 archives SOA concentrations [ug/m3] for the ND42 diagnostic.

INTERFACE:

```
SUBROUTINE DIAG42
```

USES:

```
! References to F90 modules
USE DAO_MOD,      ONLY : AIRVOL, T
!USE DIAG_MOD,     ONLY : LTOTH
USE PRESSURE_MOD, ONLY : GET_PCENTER
USE TRACER_MOD,   ONLY : STT
USE TRACERID_MOD, ONLY : IDTSOA1, IDTSOA2, IDTSOA3, IDTSOA4
USE TRACERID_MOD, ONLY : IDTSOA5
USE TRACERID_MOD, ONLY : IDTOCPI, IDTOCPO
USE TRACERID_MOD, ONLY : IDTSOAG, IDTSOAM
! consider additional species (hotp 10/26/07)
USE TRACERID_MOD, ONLY : IDTSO4, IDTNIT, IDTNH4, IDTSALA, IDTSALC
USE TRACERID_MOD, ONLY : IDTBCPI, IDTBCPO

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DIAG_MOD     ! NDxx flags
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
(1 ) Now use ratio of 2.1 instead of 1.4 for SOA4 (dkh, bmy, 3/29/07)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.21.2 zero_diag42

Subroutine ZERO_DIAG42 zeroes all module arrays.

INTERFACE:

```
SUBROUTINE ZERO_DIAG42
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.21.3 write_diag42

Subroutine WRITE_DIAG42 writes the ND42 diagnostic arrays to the binary punch file at the proper time.

INTERFACE:

```
SUBROUTINE WRITE_DIAG42
```

USES:

```
USE BPCH2_MOD,    ONLY : BPCH2
USE BPCH2_MOD,    ONLY : GET_MODELNAME
USE BPCH2_MOD,    ONLY : GET_HALFPOLAR
!USE DIAG_MOD,     ONLY : CTOTH
USE FILE_MOD,     ONLY : IU_BPCH
USE GRID_MOD,     ONLY : GET_XOFFSET
USE GRID_MOD,     ONLY : GET_YOFFSET
USE TIME_MOD,     ONLY : GET_CT_DIAG
USE TIME_MOD,     ONLY : GET_DIAGb
USE TIME_MOD,     ONLY : GET_DIAGe

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DIAG_MOD     ! TINDEX
```

REMARKS:

```
 # : Field    : Description                 : Units    : Scale factor
-----------------------------------------------------------------------
(1 ) IJ-SOA-$ : SOA1                        : ug/m3    : SCALE_OTH
(2 ) IJ-SOA-$ : SOA2                        : ug/m3    : SCALE_OTH
(3 ) IJ-SOA-$ : SOA3                        : ug/m3    : SCALE_OTH
(4 ) IJ-SOA-$ : SOA4                        : ug/m3    : SCALE_OTH
(5 ) IJ-SOA-$ : SOA1 + SOA2 + SOA3          : ug/m3    : SCALE_OTH
(6 ) IJ-SOA-$ : SOA1 + SOA2 + SOA3 + SOA4   : ug/m3    : SCALE_OTH
(7 ) IJ-SOA-$ : Sum of all Org Carbon       : ug C/m3  : SCALE_OTH
(8 ) IJ-SOA-$ : Sum of all Org Carbon @ STP : ug C/sm3 : SCALE_OTH
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
(1 ) Replace TINY(1d0) with 1d-32 to avoid problems  on SUN 4100 platform
      (bmy, 9/5/06)
(2 ) Use TS_DIAG for scaling instead of TS_DYN. (ccc, 8/18/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.21.4 init_diag42

Subroutine INIT_DIAG42 allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG42
```

USES:

```
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE LOGICAL_MOD, ONLY : LSOA

USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.21.5 cleanup_diag42

Subroutine CLEANUP_DIAG42 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG42
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.22 Fortran: Module Interface diag49_mod

Module DIAG49_MOD contains variables and routines to save out 3-D instantaneous time-series output to disk.

INTERFACE:

```
      MODULE DIAG49_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      LOGICAL, PUBLIC :: DO_SAVE_DIAG49
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: DIAG49
      PUBLIC  :: ITS_TIME_FOR_DIAG49
      PUBLIC  :: INIT_DIAG49
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: ITS_TIME_TO_CLOSE_FILE
      PRIVATE :: GET_I
```

REMARKS:

```
    ND49 tracer numbers:
    ============================================================================
    1 - N_TRACERS : GEOS-CHEM transported tracers            [v/v        ]
    76            : OH concentration                         [molec/cm3  ]
    77            : NO2 concentration                        [v/v        ]
    78            : PBL heights                              [m          ]
    79            : PBL heights                              [levels     ]
    80            : Air density                              [molec/cm3  ]
    81            : 3-D Cloud fractions                      [unitless   ]
    82            : Column optical depths                    [unitless   ]
    83            : Cloud top heights                        [hPa        ]
    84            : Sulfate aerosol optical depth            [unitless   ]
    85            : Black carbon aerosol optical depth       [unitless   ]
    86            : Organic carbon aerosol optical depth     [unitless   ]
    87            : Accumulation mode seasalt optical depth  [unitless   ]
    88            : Coarse mode seasalt optical depth        [unitless   ]
    89            : Total dust optical depth                 [unitless   ]
    90            : Total seasalt tracer concentration       [unitless   ]
    91            : Pure O3 (not Ox) concentration           [v/v        ]
    92            : NO concentration                         [v/v        ]
    93            : NOy concentration                        [v/v        ]
    94            : Grid box heights                         [m          ]
    95            : Relative Humidity                        [%          ]
    96            : Sea level pressure                       [hPa        ]
    97            : Zonal wind (a.k.a. U-wind)               [m/s        ]
    98            : Meridional wind (a.k.a. V-wind)          [m/s        ]
    99            : PEDGE-$ (Pressure @ level edges          [hPa        ]
```

```
100           : Temperature                                [K          ]
101           : PAR direct                                 [hPa        ]
102           : PAR diffuse                                [hPa        ]
103           : Daily LAI                                  [hPa        ]
104           : Temperature at 2m                          [K          ]
105           : Isoprene emissions                         [atomC/cm2/s]
106           : Total Monoterpene emissions                [atomC/cm2/s]
107           : Methyl Butanol emissions                   [atomC/cm2/s]
108           : Alpha-Pinene emissions                     [atomC/cm2/s]
109           : Beta-Pinene emissions                      [atomC/cm2/s]
110           : Limonene emissions                         [atomC/cm2/s]
111           : Sabinene emissions                         [atomC/cm2/s]
112           : Myrcene emissions                          [atomC/cm2/s]
113           : 3-Carene emissions                         [atomC/cm2/s]
114           : Ocimene emissions                          [atomC/cm2/s]
115-121       : size resolved dust optical depth           [unitless   ]
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Bug fix: get I0, J0 properly for nested grids (bmy, 11/9/04)
(2 ) Now references "pbl_mix_mod.f" (bmy, 2/16/05)
(3 ) Now saves 3-D cld frac & grid box height (bmy, 4/20/05)
(4 ) Remove TRCOFFSET since it's always zero  Also now get HALFPOLAR for
     both GCAP and GEOS grids.  (bmy, 6/28/05)
(5 ) Bug fix: do not save SLP if it's not allocated (bmy, 8/2/05)
(6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(7 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(8 ) Modified INIT_DIAG49 to save out transects (cdh, bmy, 11/30/06)
(9 ) Bug fix: accumulate into Q(X,Y,K) for dust OD (qli, bmy, 4/30/07)
(10) Minor bug fixes in DIAG49 (cdh, bmy, 2/11/08)
(11) Bug fix: replace "PS-PTOP" with "PEDGE-$"
(12) Modified to archive O3, NO, NOy as tracers 89, 90, 91  (tmf, 9/26/07)
(13) Bug fix DIAG49 for diagnostic output of SLP (tai, bmy, 10/13/09)
(14) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
(15) Bug fix in ITS_TIME_TO_CLOSE: compare HR1 to 00 not 24. (ccc, 11/11/10)
(16) Now do not scale AOD output (recalculated in RDAER AND DUST_MOD)
     (skim, 02/02/11)
12 Nov 2010 - R. Yantosca - Changed tracer 99 to be PEDGE-$ (pressure at
                            level edges) instead of Psurface-PTOP.
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.22.1 diag49

Subroutine DIAG49 produces time series (instantaneous fields) for a geographical domain from the information read in timeseries.dat. Output will be in binary punch (BPCH) format.

INTERFACE:

```
SUBROUTINE DIAG49
```

USES:

```
USE BPCH2_MOD,    ONLY : BPCH2,   OPEN_BPCH2_FOR_WRITE
USE DAO_MOD,      ONLY : AD,      AIRDEN, BXHEIGHT, CLDF
USE DAO_MOD,      ONLY : CLDTOPS, OPTD,   RH,       SLP
USE DAO_MOD,      ONLY : T,       UWND,   VWND
USE DAO_MOD,      ONLY : TS
USE DAO_MOD,      ONLY : PARDF, PARDR
USE LAI_MOD,      ONLY : ISOLAI
USE FILE_MOD,     ONLY : IU_ND49
USE GRID_MOD,     ONLY : GET_XOFFSET,        GET_YOFFSET
USE TIME_MOD,     ONLY : EXPAND_DATE
USE TIME_MOD,     ONLY : GET_NYMD,           GET_NHMS
USE TIME_MOD,     ONLY : GET_NYMD_DIAG,      GET_TS_DIAG
USE TIME_MOD,     ONLY : GET_TAU,            GET_HOUR
USE TIME_MOD,     ONLY : ITS_A_NEW_DAY,      TIMESTAMP_STRING
USE PBL_MIX_MOD,  ONLY : GET_PBL_TOP_L,      GET_PBL_TOP_m
USE TRACER_MOD,   ONLY : ITS_A_FULLCHEM_SIM, N_TRACERS
USE TRACER_MOD,   ONLY : STT,                TCVV
USE TRACER_MOD,   ONLY : XNUMOLAIR
USE PRESSURE_MOD, ONLY : GET_PEDGE
USE TRACERID_MOD, ONLY : IDTHNO3, IDTHNO4, IDTN2O5, IDTNOX
USE TRACERID_MOD, ONLY : IDTPAN,  IDTPMN,  IDTPPN,  IDTOX
USE TRACERID_MOD, ONLY : IDTR4N2, IDTSALA, IDTSALC

USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ        ! FAST-J stuff, includes F7
USE JV_CMN_MOD        ! ODAER, QAA, QAA_AOD (clh)
USE CMN_O3_MOD ! Pure O3, SAVENO2
USE CMN_GCTM_MOD        ! XTRA2
```

REVISION HISTORY:

```
09 Apr 1999 - I. Bey, R. Martin, R. Yantosca - Initial version
(1 ) Now bundled into "diag49_mod.f".  Now reference STT from
     "tracer_mod.f".  Now scale aerosol & dust OD's to 400 nm.
     (bmy, rvm, aad, 7/9/04)
(2 ) Updated tracer # for NO2 (bmy, 10/25/04)
(3 ) Remove reference to "CMN".  Also now get PBL heights in meters and
     model layers from GET_PBL_TOP_m and GET_PBL_TOP_L of "pbl_mix_mod.f".
     (bmy, 2/16/05)
(4 ) Now reference CLDF and BXHEIGHT from "dao_mod.f".  Now save 3-D cloud
     fraction as tracer #79 and box height as tracer #93.  Now remove
     reference to PBL from "dao_mod.f"(bmy, 4/20/05)
(5 ) Remove references to TRCOFFSET because it is always zero (bmy, 6/24/05)
(6 ) Now do not save SLP data if it is not allocated (bmy, 8/2/05)
```

```
(7 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(8 ) Now references XNUMOLAIR from "tracer_mod.f".  Bug fix: now must sum
     aerosol OD's over all RH bins.  Also zero Q array. (bmy, 11/1/05)
(9 ) Bug fix: accumulate into Q(X,Y,K) for dust OD (qli, bmy, 4/30/07)
(10) Bug fix: UNIT should be "levels" for tracer 77.  Also RH should be
     tracer #17 under "TIME-SER" category. (cdh, bmy, 2/11/08)
(11) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, phs, 10/7/08)
(12) Change the new day condition to open a new file. (ccc, 8/12/09)
(13) Change the timestamp for the filename when closing (ccc, 8/12/09)
(14) Add outputs for EMISS_BVOC (10 tracers), TS, PARDR, PARDF and ISOLAI
     (mpb, 11/19/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.22.2 its_time_to_close_file

Function ITS_TIME_TO_CLOSE_FILE returns TRUE if it's time to close the ND49 bpch file before the end of the day.

INTERFACE:

```
FUNCTION ITS_TIME_TO_CLOSE_FILE() RESULT( ITS_TIME )
```

USES:

```
USE TIME_MOD, ONLY : GET_HOUR
USE TIME_MOD, ONLY : GET_MINUTE
```

RETURN VALUE:

```
LOGICAL :: ITS_TIME
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) The time is already updated to the next time step (ccc, 8/12/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.22.3 its_time_for_diag49

Function ITS_TIME_FOR_DIAG49 returns TRUE if ND49 is turned on and it is time to call DIAG49 – or FALSE otherwise.

INTERFACE:

```
FUNCTION ITS_TIME_FOR_DIAG49() RESULT( ITS_TIME )
```

USES:

```
      USE TIME_MOD,  ONLY : GET_ELAPSED_MIN
      USE TIME_MOD,  ONLY : GET_TS_DIAG
      USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
```

RETURN VALUE:

```
      LOGICAL :: ITS_TIME
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    (1 ) Add a check on the output frequency for validity compared to time
         steps used. (ccc, 5/21/09)
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.22.4 get_i

Function GET_I returns the absolute longitude index (I), given the relative longitude index (X).

INTERFACE:

```
      FUNCTION GET_I( X ) RESULT( I )
```

USES:

```
      USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: X   ! Relative longitude index (used by Q array)
```

RETURN VALUE:

```
      INTEGER             :: I   ! Absolute longitude index
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.22.5 init_diag49

Subroutine INIT_DIAG49 allocates and zeroes all module arrays. It also gets values for module variables from "input_mod.f".

INTERFACE:

```
      SUBROUTINE INIT_DIAG49( DO_ND49, N_ND49, TRACERS, IMIN,
     &                        IMAX,    JMIN,   JMAX,    LMIN,
     &                        LMAX,    FREQ,   FILE )
```

USES:

```
      USE BPCH2_MOD, ONLY : GET_MODELNAME
      USE BPCH2_MOD, ONLY : GET_HALFPOLAR
      USE GRID_MOD,  ONLY : GET_XOFFSET
      USE GRID_MOD,  ONLY : GET_YOFFSET
      USE GRID_MOD,  ONLY : ITS_A_NESTED_GRID
      USE ERROR_MOD, ONLY : ERROR_STOP

      USE CMN_SIZE_MOD ! Size parameters
```

INPUT PARAMETERS:

```
      ! DO_ND49 : Switch to turn on ND49 timeseries diagnostic
      ! N_ND50  : Number of ND49 read by "input_mod.f"
      ! TRACERS : Array w/ ND49 tracer #'s read by "input_mod.f"
      ! IMIN    : Min longitude index read by "input_mod.f"
      ! IMAX    : Max longitude index read by "input_mod.f"
      ! JMIN    : Min latitude index read by "input_mod.f"
      ! JMAX    : Min latitude index read by "input_mod.f"
      ! LMIN    : Min level index read by "input_mod.f"
      ! LMAX    : Min level index read by "input_mod.f"
      ! FREQ    : Frequency for saving to disk [min]
      ! FILE    : ND49 output file name read by "input_mod.f"
      LOGICAL,            INTENT(IN) :: DO_ND49
      INTEGER,            INTENT(IN) :: N_ND49, TRACERS(100)
      INTEGER,            INTENT(IN) :: IMIN,   IMAX
      INTEGER,            INTENT(IN) :: JMIN,   JMAX
      INTEGER,            INTENT(IN) :: LMIN,   LMAX
      INTEGER,            INTENT(IN) :: FREQ
      CHARACTER(LEN=255), INTENT(IN) :: FILE
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    (1 ) Now get I0 and J0 correctly for nested grid simulations (bmy, 11/9/04)
    (2 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
         value for GEOS or GCAP grids. (bmy, 6/28/05)
    (3 ) Now allow ND49_IMIN to be equal to ND49_IMAX and ND49_JMIN to be
         equal to ND49_JMAX.  This will allow us to save out longitude
         or latitude transects.  (cdh, bmy, 11/30/06)
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23 Fortran: Module Interface diag50_mod

Module DIAG50_MOD contains variables and routines to generate 24-hour average time-series data.

INTERFACE:

```
      MODULE DIAG50_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      LOGICAL, PUBLIC :: DO_SAVE_DIAG50    ! On/off flag for ND50 diagnostic
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_DIAG50
      PUBLIC  :: DIAG50
      PUBLIC  :: INIT_DIAG50
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: ACCUMULATE_DIAG50
      PRIVATE :: ITS_TIME_FOR_WRITE_DIAG50
      PRIVATE :: WRITE_DIAG50
      PRIVATE :: GET_I
```

REMARKS:

```
    ND50 tracer numbers:
    ============================================================================
    1 - N_TRACERS : GEOS-CHEM transported tracers            [v/v      ]
    76            : OH concentration                         [molec/cm3]
    77            : NO2 concentration                        [v/v      ]
    78            : PBL heights                              [m        ]
    79            : PBL heights                              [levels   ]
    80            : Air density                              [molec/cm3]
    81            : 3-D Cloud fractions                      [unitless ]
    82            : Column optical depths                    [unitless ]
    83            : Cloud top heights                        [hPa      ]
    84            : Sulfate aerosol optical depth            [unitless ]
    85            : Black carbon aerosol optical depth       [unitless ]
    86            : Organic carbon aerosol optical depth     [unitless ]
    87            : Accumulation mode seasalt optical depth  [unitless ]
    88            : Coarse mode seasalt optical depth        [unitless ]
    89            : Total dust optical depth                 [unitless ]
    90            : Total seasalt tracer concentration       [unitless ]
```

```
91            : Pure O3 (not Ox) concentration          [v/v      ]
92            : NO concentration                        [v/v      ]
93            : NOy concentration                       [v/v      ]
94            : Grid box height                         [m        ]
95            : Relative humidity                       [%        ]
96            : Sea level pressure                      [hPa      ]
97            : Zonal wind (a.k.a. U-wind)              [m/s      ]
98            : Meridional wind (a.k.a. V-wind)         [m/s      ]
99            : P(surface) - PTOP                       [hPa      ]
100           : Temperature                             [K        ]
115-121       : size resolved dust optical depth        [unitless ]
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Rewritten for clarity and to save extra quantities (bmy, 7/20/04)
(2 ) Added COUNT_CHEM to count the chemistry timesteps per day, since some
     quantities are only archived after a fullchem call (bmy, 10/25/04)
(3 ) Bug fix: Now get I0 and J0 properly for nested grids (bmy, 11/9/04)
(4 ) Now only archive AOD's once per chemistry timestep (bmy, 1/14/05)
(5 ) Now references "pbl_mix_mod.f" (bmy, 2/16/05)
(6 ) Now save cloud fractions & grid box heights (bmy, 4/20/05)
(7 ) Remove TRCOFFSET since it's always zero.  Also now get HALFPOLAR for
     both GCAP and GEOS grids. (bmy, 6/24/05)
(8 ) Bug fix: don't save SLP unless it is allocated (bmy, 8/2/05)
(9 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(10) Modified INIT_DIAG49 to save out transects (cdh, bmy, 11/30/06)
(11) Now use 3D timestep counter for full chem in the trop (phs, 1/24/07)
(12) Renumber RH diagnostic in WRITE_DIAG50 (bmy, 2/11/08)
(13) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, 10/7/08)
(14) Modified to archive O3, NO, NOy as tracers 89, 90, 91  (tmf, 9/26/07)
(15) Updates & bug fixes in WRITE_DIAG50 (ccc, tai, bmy, 10/13/09)
(16) Updates to AOD output.  Also have the option to write to HDF
     (amv, bmy, 12/21/09)
(17) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
02 Dec 2010 - R. Yantosca - Added ProTeX headers
03 Feb 2011 - S. Kim      - Now do not scale the AOD output
                            (recalculated in RDAER AND DUST_MOD)
```

1.23.1 DIAG50

Subroutine DIAG50 generates 24hr average time series. Output is to binary punch file format or HDF5 file.

INTERFACE:

```
SUBROUTINE DIAG50
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23.2 accumulate_diag50

Subroutine ACCUMULATE_DIAG50 accumulates tracers into the Q array.

INTERFACE:

```
SUBROUTINE ACCUMULATE_DIAG50
```

USES:

```
USE COMODE_MOD,     ONLY : JLOP
USE DAO_MOD,        ONLY : AD,      AIRDEN, BXHEIGHT, CLDF
USE DAO_MOD,        ONLY : CLDTOPS, OPTD,   RH,       T
USE DAO_MOD,        ONLY : UWND,    VWND,   SLP
USE PBL_MIX_MOD,    ONLY : GET_PBL_TOP_L, GET_PBL_TOP_m
USE PRESSURE_MOD,   ONLY : GET_PEDGE
USE TIME_MOD,       ONLY : GET_ELAPSED_MIN, GET_TS_CHEM
USE TIME_MOD,       ONLY : TIMESTAMP_STRING
USE TRACER_MOD,     ONLY : STT, TCVV, ITS_A_FULLCHEM_SIM
USE TRACER_MOD,     ONLY : N_TRACERS
USE TRACER_MOD,     ONLY : XNUMOLAIR
USE TRACERID_MOD,   ONLY : IDTHNO3, IDTHNO4, IDTN2O5, IDTNOX
USE TRACERID_MOD,   ONLY : IDTPAN,  IDTPMN,  IDTPPN,  IDTOX
USE TRACERID_MOD,   ONLY : IDTR4N2, IDTSALA, IDTSALC
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP

USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ  ! includes F77_CMN_SIZE
USE JV_CMN_MOD  ! ODAER, QAA, QAA_OUT
USE COMODE_LOOP_MOD  ! NPVERT
USE CMN_O3_MOD    ! FRACO3, FRACNO, SAVEO3, SAVENO2, SAVEHO2, FRACNO2
USE CMN_GCTM_MOD  ! SCALE_HEIGHT
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Rewrote to remove hardwiring and for better efficiency.  Added extra
     diagnostics and updated numbering scheme.  Now scale aerosol & dust
     optical depths to 400 nm. (rvm, aad, bmy, 7/20/04)
(2 ) Now reference GET_ELAPSED_MIN and GET_TS_CHEM from "time_mod.f".
     Also now use extra counter COUNT_CHEM to count the number of
```

```
      chemistry timesteps since NO, NO2, OH, O3 only when a full-chemistry
      timestep happens. (bmy, 10/25/04)
(3 ) Only archive AOD's when it is a chem timestep (bmy, 1/14/05)
(4 ) Remove reference to "CMN".  Also now get PBL heights in meters and
      model layers from GET_PBL_TOP_m and GET_PBL_TOP_L of "pbl_mix_mod.f".
      (bmy, 2/16/05)
(5 ) Now reference CLDF and BXHEIGHT from "dao_mod.f".  Now save 3-D
      cloud fraction as tracer #79 and box height as tracer #93.  Now
      remove references to CLMOSW, CLROSW, and PBL from "dao_mod.f".
      (bmy, 4/20/05)
(6 ) Remove references to TRCOFFSET because it's always zero (bmy, 6/24/05)
(7 ) Now do not save SLP data if it is not allocated (bmy, 8/2/05)
(8 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(9 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(10) Now account for time spent in the trop for non-tracers (phs, 1/24/07)
(11) IS_CHEM check is not appropriate anymore. Keep COUNT_CHEM3D for
     species known in troposphere only (ccc, 8/12/09)
(12) Output AOD at 3rd jv_spec.dat row wavelength.  Include all seven dust
      bin's individual AOD (amv, bmy, 12/21/09)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23.3 its_time_for_write_diag50

Function ITS_TIME_FOR_WRITE_DIAG50 returns TRUE if it's time to write the ND50 bpch file to disk. We test the time at the next dynamic timestep, so that we can close the file before the end of the run properly.

INTERFACE:

```
FUNCTION ITS_TIME_FOR_WRITE_DIAG50() RESULT( ITS_TIME )
```

USES:

```
USE TIME_MOD, ONLY : GET_HOUR
USE TIME_MOD, ONLY : GET_MINUTE
USE TIME_MOD, ONLY : GET_TS_DYN
```

RETURN VALUE:

```
LOGICAL :: ITS_TIME
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) The time is already updated to the next time step in main.f
      (ccc, 8/12/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23.4 write_diag50

Subroutine WRITE_DIAG50 computes the 24-hr time-average of quantities and saves to bpch file format.

INTERFACE:

```
      SUBROUTINE WRITE_DIAG50
```

USES:

```
      USE BPCH2_MOD,  ONLY : BPCH2
      USE BPCH2_MOD,  ONLY : GET_MODELNAME
      USE BPCH2_MOD,  ONLY : GET_HALFPOLAR
      USE BPCH2_MOD,  ONLY : OPEN_BPCH2_FOR_WRITE
      USE ERROR_MOD,  ONLY : ALLOC_ERR
      USE FILE_MOD,   ONLY : IU_ND50
      USE GRID_MOD,   ONLY : GET_XOFFSET
      USE GRID_MOD,   ONLY : GET_YOFFSET
      USE LOGICAL_MOD,ONLY : LND50_HDF
      USE TIME_MOD,   ONLY : EXPAND_DATE
      USE TIME_MOD,   ONLY : GET_NYMD_DIAG
      USE TIME_MOD,   ONLY : GET_NHMS
      USE TIME_MOD,   ONLY : GET_TAU
      USE TIME_MOD,   ONLY : GET_TS_DYN
      USE TIME_MOD,   ONLY : TIMESTAMP_STRING
      USE TRACER_MOD, ONLY : N_TRACERS

#if   defined( USE_HDF5 )
      ! Only include this if we are linking to HDF5 library (bmy, 12/21/09)
      USE HDF_MOD,    ONLY : OPEN_HDF
      USE HDF_MOD,    ONLY : CLOSE_HDF
      USE HDF_MOD,    ONLY : WRITE_HDF
      USE HDF5,       ONLY : HID_T
      INTEGER(HID_T)      :: IU_ND50_HDF
#endif

      USE CMN_SIZE_MOD  ! Size Parameters
```

REVISION HISTORY:

```
   20 Jul 2004 - R. Yantosca - Initial version
   (1 ) Rewrote to remove hardwiring and for better efficiency.  Added extra
        diagnostics and updated numbering scheme. (bmy, 7/20/04)
   (2 ) Now only archive NO, NO2, OH, O3 on every chemistry timestep (i.e.
        only when fullchem is called).  Also remove reference to FIRST.
        (bmy, 10/25/04)
   (3 ) Now divide tracers 82-87 (i.e. various AOD's) by GOOD_CT_CHEM since
        these are only updated once per chemistry timestep (bmy, 1/14/05)
```

```
(4 ) Now save grid box heights as tracer #93.  Now save 3-D cloud fraction
     as tracer #79. (bmy, 4/20/05)
(5 ) Remove references to TRCOFFSET because it's always zero (bmy, 6/24/05)
(6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(7 ) DIVISOR is now a 3-D array.  Now zero COUNT_CHEM3D.  Now zero Q
     array with array assignment statement. (phs, 1/24/07)
(8 ) RH should be tracer #17 under "TIME-SER" category (bmy, 2/11/08)
(9 ) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, 10/7/08)
(10) Change timestamp for filename.  Now save SLP under tracer #18 in
     "DAO-FLDS".  Also set unit to 'K' for temperature field.
     (ccc, tai, bmy, 10/13/09)
(11) Now have the option of saving out to HDF5 format.  NOTE: we have to
     bracket HDF-specific code with an #ifdef statement to avoid problems
     if the HDF5 libraries are not installed. (amv, bmy, 12/21/09)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23.5 get_i

Function GET_I returns the absolute longitude index (I), given the relative longitude index (X).

INTERFACE:

```
FUNCTION GET_I( X ) RESULT( I )
```

USES:

```
USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: X   ! Relative longitude index
```

RETURN VALUE:

```
INTEGER             :: I   ! Absolute longitude index
```

REMARKS:

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23.6 init_diag50

Subroutine INIT_DIAG50 allocates and zeroes all module arrays. It also gets values for module variables from "input_mod.f".

INTERFACE:

```
 SUBROUTINE INIT_DIAG50( DO_ND50, N_ND50, TRACERS, IMIN, IMAX,
&                        JMIN,    JMAX,   LMIN,    LMAX, FILE )
```

USES:

```
USE BPCH2_MOD,  ONLY : GET_MODELNAME
USE BPCH2_MOD,  ONLY : GET_HALFPOLAR
USE ERROR_MOD,  ONLY : ALLOC_ERR
USE ERROR_MOD,  ONLY : ERROR_STOP
USE GRID_MOD,   ONLY : GET_XOFFSET
USE GRID_MOD,   ONLY : GET_YOFFSET
USE GRID_MOD,   ONLY : ITS_A_NESTED_GRID
USE TIME_MOD,   ONLY : GET_TAUb
USE TRACER_MOD, ONLY : N_TRACERS

USE CMN_SIZE_MOD
```

INPUT PARAMETERS:

```
! DO_ND50 : Switch to turn on ND50 timeseries diagnostic
! N_ND50  : Number of ND50 read by "input_mod.f"
! TRACERS : Array w/ ND50 tracer #'s read by "input_mod.f"
! IMIN    : Min longitude index read by "input_mod.f"
! IMAX    : Max longitude index read by "input_mod.f"
! JMIN    : Min latitude index read by "input_mod.f"
! JMAX    : Min latitude index read by "input_mod.f"
! LMIN    : Min level index read by "input_mod.f"
! LMAX    : Min level index read by "input_mod.f"
! FILE    : ND50 output file name read by "input_mod.f"
LOGICAL,            INTENT(IN) :: DO_ND50
INTEGER,            INTENT(IN) :: N_ND50, TRACERS(100)
INTEGER,            INTENT(IN) :: IMIN,   IMAX
INTEGER,            INTENT(IN) :: JMIN,   JMAX
INTEGER,            INTENT(IN) :: LMIN,   LMAX
CHARACTER(LEN=255), INTENT(IN) :: FILE
```

REMARKS:

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now get I0 and J0 correctly for nested grid simulations (bmy, 11/9/04)
(2 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
```

```
      value for GEOS or GCAP grids. (bmy, 6/28/05)
(3 ) Now allow ND50_IMIN to be equal to ND50_IMAX and ND50_JMIN to be
      equal to ND50_JMAX.  This will allow us to save out longitude
      or latitude transects.  Now allocate COUNT_CHEM3D array.
      (cdh, phs, 1/24/07)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.23.7 cleanup_diag50

Subroutine CLEANUP_DIAG50 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG50
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now deallocate COUNT_CHEM3D (phs, 1/24/07)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.24 Fortran: Module Interface diag51b_mod

Module DIAG51b_MOD contains variables and routines to generate save timeseries data where the local time is between two user-defined limits. This facilitates comparisons with morning or afternoon-passing satellites such as GOME.

INTERFACE:

```
MODULE DIAG51b_MOD
```

USES:

```
IMPLICIT NONE
#     include "define.h"
PRIVATE
```

PUBLIC DATA MEMBERS:

```
LOGICAL, PUBLIC :: DO_SAVE_DIAG51b   ! On/off switch for ND51b diagnostic
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: CLEANUP_DIAG51b
PUBLIC  :: DIAG51b
PUBLIC  :: INIT_DIAG51b
```

PRIVATE MEMBER FUNCTIONS:

```
   PRIVATE :: ACCUMULATE_DIAG51
   PRIVATE :: GET_LOCAL_TIME
   PRIVATE :: ITS_TIME_FOR_WRITE_DIAG51
   PRIVATE :: WRITE_DIAG51
```

REMARKS:

ND51b tracer numbers:

1 - N_TRACERS	GEOS-CHEM transported tracers	[v/v]
76	OH concentration	[molec/cm3]
77	NO2 concentration	[v/v]
78	PBL heights	[m]
79	PBL heights	[levels]
80	Air density	[molec/cm3]
81	3-D Cloud fractions	[unitless]
82	Column optical depths	[unitless]
83	Cloud top heights	[hPa]
84	Sulfate aerosol optical depth	[unitless]
85	Black carbon aerosol optical depth	[unitless]
86	Organic carbon aerosol optical depth	[unitless]
87	Accumulation mode seasalt optical depth	[unitless]
88	Coarse mode seasalt optical depth	[unitless]
89	Total dust optical depth	[unitless]
90	Total seasalt tracer concentration	[unitless]
91	Pure O3 (not Ox) concentration	[v/v]
92	NO concentration	[v/v]
93	NOy concentration	[v/v]
94	Grid box heights	[m]
95	Relative Humidity	[%]
96	Sea level pressure	[hPa]
97	Zonal wind (a.k.a. U-wind)	[m/s]
98	Meridional wind (a.k.a. V-wind)	[m/s]
99	P(surface) - PTOP	[hPa]
100	Temperature	[K]
101	PAR direct	[hPa]
102	PAR diffuse	[hPa]
103	Daily LAI	[hPa]
104	Temperature at 2m	[K]
105	Isoprene emissions	[atomC/cm2/s]
106	Total Monoterpene emissions	[atomC/cm2/s]
107	Methyl Butanol emissions	[atomC/cm2/s]
108	Alpha-Pinene emissions	[atomC/cm2/s]
109	Beta-Pinene emissions	[atomC/cm2/s]
110	Limonene emissions	[atomC/cm2/s]
111	Sabinene emissions	[atomC/cm2/s]
112	Myrcene emissions	[atomC/cm2/s]
113	3-Carene emissions	[atomC/cm2/s]
114	Ocimene emissions	[atomC/cm2/s]

```
115-121       : size resolved dust optical depth         [unitless   ]
```

REVISION HISTORY:

```
(1 ) Rewritten for clarity (bmy, 7/20/04)
(2 ) Added extra counters for NO, NO2, OH, O3.  Also all diagnostic counter
     arrays are 1-D since they only depend on longitude. (bmy, 10/25/04)
(3 ) Bug fix: Now get I0 and J0 properly for nested grids (bmy, 11/9/04)
(4 ) Now only archive AOD's once per chemistry timestep (bmy, 1/14/05)
(5 ) Now references "pbl_mix_mod.f" (bmy, 2/16/05)
(6 ) Now save cld frac and grid box heights (bmy, 4/20/05)
(7 ) Remove TRCOFFSET since it's always zero  Also now get HALFPOLAR for
     both GCAP and GEOS grids.  (bmy, 6/28/05)
(8 ) Bug fix: do not save SLP if it's not allocated (bmy, 8/2/05)
(9 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(10) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(11) Modified INIT_DIAG51 to save out transects (cdh, bmy, 11/30/06)
(12) Now use 3D timestep counter for full chem in the trop (phs, 1/24/07)
(13) Renumber RH in WRITE_DIAG50 (bmy, 2/11/08)
(14) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, phs, 10/7/08)
(15) Bug fix in GET_LOCAL_TIME (ccc, 12/10/08)
(16) Modified to archive O3, NO, NOy as tracers 89, 90, 91  (tmf, 9/26/07)
(17) Updates in WRITE_DIAG51b (ccc, tai, bmy, 10/13/09)
(18) Updates to AOD output.  Also have the option to write to HDF
     (amv, bmy, 12/21/09)
(19) Added MEGAN species (mpb, bmy, 12/21/09)
(20) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
03 Feb 2011 - S. Kim      - Now do not scale the AOD output
                            (recalculated in RDAER AND DUST_MOD)
```

1.24.1 diag51b

Subroutine DIAG51 generates time series (averages from ! 10am - 12pm LT or 1pm - 4pm LT) for the US grid area. Output is to binary punch files or HDF5 files.

INTERFACE:

```
SUBROUTINE DIAG51b
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Rewritten for clarity (bmy, 7/20/04)
(2 ) Added TAU_W as a local variable (bmy, 9/28/04)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.24.2 get_local_time

Subroutine GET_LOCAL_TIME computes the local time and returns an array of points where the local time is between two user-defined limits.

INTERFACE:

```
SUBROUTINE GET_LOCAL_TIME
```

USES:

```
USE TIME_MOD, ONLY : GET_LOCALTIME
USE TIME_MOD, ONLY : GET_TS_DYN

USE CMN_SIZE_MOD   ! Size parameters
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) The 1d-3 in the computation of XLOCTM is to remove roundoff ambiguity
     if a the local time should fall exactly on an hour boundary.
     (bmy, 11/29/00)
(2 ) Bug fix: XMID(I) should be XMID(II).  Also updated comments.
     (bmy, 7/6/01)
(3 ) Updated comments (rvm, bmy, 2/27/02)
(4 ) Now uses function GET_LOCALTIME of "time_mod.f" (bmy, 3/27/03)
(5 ) Removed reference to CMN (bmy, 7/20/04)
(6 ) Bug fix: LT should be REAL*8 and not INTEGER (ccarouge, 12/10/08)
(7 ) We need to substract TS_DYN to the time to get the local time at
     the beginning of previous time step. (ccc, 8/11/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.24.3 accumulate_diag51

Subroutine ACCUMULATE_DIAG51 accumulates tracers into the Q array.

INTERFACE:

```
SUBROUTINE ACCUMULATE_DIAG51
```

USES:

```
USE DAO_MOD,        ONLY : AD,      AIRDEN, BXHEIGHT, CLDF
USE DAO_MOD,        ONLY : CLDTOPS, OPTD,   RH,       T
USE DAO_MOD,        ONLY : UWND,    VWND,   SLP
! Now included T @ 2m (mpb,2009)
USE DAO_MOD,        ONLY : TS
! Now included PAR direct and diffuse (mpb,2009)
USE DAO_MOD,        ONLY : PARDF, PARDR
```

```
      ! Now included current (MODIS) LAI (mpb,2009)
      USE LAI_MOD,        ONLY : ISOLAI
      USE PBL_MIX_MOD,    ONLY : GET_PBL_TOP_L,    GET_PBL_TOP_m
      USE PRESSURE_MOD,   ONLY : GET_PEDGE
      USE TIME_MOD,       ONLY : GET_ELAPSED_MIN,  GET_TS_CHEM
      USE TIME_MOD,       ONLY : TIMESTAMP_STRING, GET_TS_DYN
      USE TIME_MOD,       ONLY : GET_TS_DIAG,      GET_TS_EMIS
      USE TRACER_MOD,     ONLY : STT, TCVV, ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,     ONLY : N_TRACERS, XNUMOLAIR
      USE TRACERID_MOD,   ONLY : IDTHNO3, IDTHNO4, IDTN2O5, IDTNOX
      USE TRACERID_MOD,   ONLY : IDTPAN,  IDTPMN,  IDTPPN,  IDTOX
      USE TRACERID_MOD,   ONLY : IDTR4N2, IDTSALA, IDTSALC
      USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP

      USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ  ! includes F77_CMN_SIZE
      USE JV_CMN_MOD  ! ODAER, QAA, QAA_AOD
      USE CMN_O3_MOD    ! FRACO3, FRACNO, SAVEO3, SAVENO2, SAVEHO2, FRACNO2
      USE CMN_GCTM_MOD  ! SCALE_HEIGHT
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Rewrote to remove hardwiring and for better efficiency.  Added extra
     diagnostics and updated numbering scheme.  Now scale optical depths
     to 400 nm (which is usually what QAA(2,*) is.  (bmy, 7/20/04)
(2 ) Now reference GET_ELAPSED_MIN and GET_TS_CHEM from "time_mod.f".
     Also now all diagnostic counters are 1-D since they only depend on
     longitude. Now only archive NO, NO2, OH, O3 on every chemistry
     timestep (i.e. only when fullchem is called). (bmy, 10/25/04)
(3 ) Only archive AOD's when it is a chem timestep (bmy, 1/14/05)
(4 ) Remove reference to "CMN".  Also now get PBL heights in meters and
     model layers from GET_PBL_TOP_m and GET_PBL_TOP_L of "pbl_mix_mod.f".
     (bmy, 2/16/05)
(5 ) Now reference CLDF and BXHEIGHT from "dao_mod.f".  Now save 3-D cloud
     fraction as tracer #79 and box height as tracer #93.  Now remove
     references to CLMOSW, CLROSW, and PBL from "dao_mod.f". (bmy, 4/20/05)
(6 ) Remove TRCOFFSET since it's always zero  Also now get HALFPOLAR for
     both GCAP and GEOS grids.  (bmy, 6/28/05)
(7 ) Now do not save SLP data if it is not allocated (bmy, 8/2/05)
(8 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(9 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(10) Now account for time spent in the trop for non-tracers (phs, 1/24/07)
(11) We determine points corresponding to the time window at each timestep.
     But accumulate only when it's time for diagnostic (longest t.s.)
     (ccc, 8/12/09)
(12) Add outputs ("DAO-FLDS" and "BIOGSRCE" categories). Add GOOD_EMIS and
     GOOD_CT_EMIS to manage emission outputs. (ccc, 11/20/09)
(13) Output AOD at 3rd jv_spec.dat row wavelength.  Include all seven dust
```

```
      bin's individual AOD (amv, bmy, 12/21/09)
(12) Added MEGAN species (mpb, bmy, 12/21/09)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
```

1.24.4 its_time_for_write_diag51

Function ITS_TIME_FOR_WRITE_DIAG51 returns TRUE if it's time to write the ND51 bpch file to disk. We test the time at the next dynamic timestep so that we can write to disk properly.

INTERFACE:

```
FUNCTION ITS_TIME_FOR_WRITE_DIAG51( TAU_W ) RESULT( ITS_TIME )
```

USES:

```
USE TIME_MOD,  ONLY : GET_HOUR
USE TIME_MOD,  ONLY : GET_MINUTE
USE TIME_MOD,  ONLY : GET_TAU
USE TIME_MOD,  ONLY : GET_TAUb
USE TIME_MOD,  ONLY : GET_TAUe
USE TIME_MOD,  ONLY : GET_TS_DYN
USE TIME_MOD,  ONLY : GET_TS_DIAG
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
```

OUTPUT PARAMETERS:

```
REAL*8, INTENT(OUT) :: TAU_W   ! TAU at time of disk write
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Added TAU_W so to make sure the timestamp is accurate. (bmy, 9/28/04)
(2 ) Add check with TS_DIAG. (ccc, 7/21/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.24.5 write_diag51

Subroutine WRITE_DIAG51 computes the time-average of quantities between local time limits ND51_HR1 and ND51_HR2 and writes them to a bpch file or HDF5 file. Arrays and counters are also zeroed for the next diagnostic interval.

INTERFACE:

```
SUBROUTINE WRITE_DIAG51( TAU_W )
```

USES:

```
      USE BPCH2_MOD,   ONLY : BPCH2
      USE BPCH2_MOD,   ONLY : OPEN_BPCH2_FOR_WRITE
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE FILE_MOD,    ONLY : IU_ND51b
      USE LOGICAL_MOD, ONLY : LND51b_HDF
      USE TIME_MOD,    ONLY : EXPAND_DATE
      USE TIME_MOD,    ONLY : GET_NYMD_DIAG
      USE TIME_MOD,    ONLY : GET_NHMS
      USE TIME_MOD,    ONLY : GET_TAU
      USE TIME_MOD,    ONLY : TIMESTAMP_STRING
      USE TIME_MOD,    ONLY : GET_TS_DYN
      USE TRACER_MOD,  ONLY : N_TRACERS

#if   defined( USE_HDF5 )
      ! Only include this if we are linking to HDF5 library (bmy, 12/21/09)
      USE HDF_MOD,     ONLY : OPEN_HDF
      USE HDF_MOD,     ONLY : CLOSE_HDF
      USE HDF_MOD,     ONLY : WRITE_HDF
      USE HDF5,        ONLY : HID_T
      INTEGER(HID_T)       :: IU_ND51b_HDF
#endif

      USE CMN_SIZE_MOD   ! Size Parameters
```

INPUT PARAMETERS:

```
      REAL*8, INTENT(IN)  :: TAU_W   ! TAU value at time of disk write
   Arguments as Input:
   ============================================================================
   (1 ) TAU_W (REAL*8) : TAU value at time of writing to disk
   NOTES:
```

REVISION HISTORY:

```
   20 Jul 2004 - R. Yantosca - Initial version
   (1 ) Rewrote to‘ remove hardwiring and for better efficiency.  Added extra
        diagnostics and updated numbering scheme. (bmy, 7/20/04)
   (2 ) Added TAU_W to the arg list.  Now use TAU_W to set TAU0 and TAU0.
        Also now all diagnostic counters are 1-D since they only depend on
        longitude.  Now only archive NO, NO2, OH, O3 on every chemistry
        timestep (i.e. only when fullchem is called).  Also remove reference
        to FIRST. (bmy, 10/25/04)
   (3 ) Now divide tracers 82-87 (i.e. various AOD's) by GOOD_CT_CHEM since
        these are only updated once per chemistry timestep (bmy, 1/14/05)
   (4 ) Now save grid box heights as tracer #93.  Now save 3-D cloud fraction
        as tracer #79 (bmy, 4/20/05)
   (5 ) Remove references to TRCOFFSET because it's always zero (bmy, 6/24/05)
   (6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   (7 ) DIVISOR is now a 3-D array.  Now zero COUNT_CHEM3D.  Now use CASE
```

```
      statement instead of IF statements.  Now zero counter arrays with
      array broadcast assignments. (phs, 1/24/07)
(8 ) RH should be tracer #17 under "TIME-SER" category (bmy, 2/11/08)
(9 ) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, phs, 10/7/08)
(10) Change timestamp used for filename.  Now save SLP under tracer #18 in
     "DAO-FLDS". (ccc, tai, bmy, 10/13/09)
(11) Now have the option of saving out to HDF5 format.  NOTE: we have to
      bracket HDF-specific code with an #ifdef statement to avoid problems
      if the HDF5 libraries are not installed. (amv, bmy, 12/21/09)
(12) Add outputs ("DAO-FLDS" and "BIOGSRCE" categories). Add GOOD_EMIS and
     GOOD_CT_EMIS to manage emission outputs. (ccc, 11/20/09)
(13) Added MEGAN species (mpb, bmy, 12/21/09)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
```

1.24.6 get_i

Function GET_I returns the absolute longitude index (I), given the relative longitude index (X).

INTERFACE:

```
FUNCTION GET_I( X ) RESULT( I )
```

USES:

```
USE CMN_SIZE_MOD   ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: X   ! Relative longitude index
```

RETURN VALUE:

```
INTEGER             :: I   ! Absolute longitude index
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.24.7 init_diag51

Subroutine INIT_DIAG51b allocates and zeroes all module arrays. It also gets values for module variables from "input_mod.f".

INTERFACE:

```
      SUBROUTINE INIT_DIAG51b( DO_ND51, N_ND51, TRACERS, HR_WRITE,
     &                         HR1,     HR2,    IMIN,    IMAX,
     &                         JMIN,    JMAX,   LMIN,    LMAX,  FILE )
```

USES:

```
      USE BPCH2_MOD,  ONLY : GET_MODELNAME
      USE BPCH2_MOD,  ONLY : GET_HALFPOLAR
      USE ERROR_MOD,  ONLY : ALLOC_ERR
      USE ERROR_MOD,  ONLY : ERROR_STOP
      USE GRID_MOD,   ONLY : GET_XOFFSET
      USE GRID_MOD,   ONLY : GET_YOFFSET
      USE GRID_MOD,   ONLY : ITS_A_NESTED_GRID
      USE TIME_MOD,   ONLY : GET_TAUb
      USE TRACER_MOD, ONLY : N_TRACERS

      USE CMN_SIZE_MOD   ! Size parameters
```

INPUT PARAMETERS:

```
      ! DO_ND51 : Switch to turn on ND51 timeseries diagnostic
      ! N_ND51  : Number of ND51 read by "input_mod.f"
      ! TRACERS : Array w/ ND51 tracer #'s read by "input_mod.f"
      ! HR_WRITE: GMT hour of day at which to write bpch file
      ! HR1     : Lower limit of local time averaging bin
      ! HR2     : Upper limit of local time averaging bin
      ! IMIN    : Min longitude index read by "input_mod.f"
      ! IMAX    : Max longitude index read by "input_mod.f"
      ! JMIN    : Min latitude index read by "input_mod.f"
      ! JMAX    : Min latitude index read by "input_mod.f"
      ! LMIN    : Min level index read by "input_mod.f"
      ! LMAX    : Min level index read by "input_mod.f"
      ! FILE    : ND51 output file name read by "input_mod.f"
      LOGICAL,            INTENT(IN) :: DO_ND51
      INTEGER,            INTENT(IN) :: N_ND51, TRACERS(100)
      INTEGER,            INTENT(IN) :: IMIN,   IMAX
      INTEGER,            INTENT(IN) :: JMIN,   JMAX
      INTEGER,            INTENT(IN) :: LMIN,   LMAX
      REAL*8,             INTENT(IN) :: HR1,    HR2
      REAL*8,             INTENT(IN) :: HR_WRITE
      CHARACTER(LEN=255), INTENT(IN) :: FILE
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    (1 ) Diagnostic counter arrays are now only 1-D.  Also add GOOD_CT_CHEM
         which is the counter array of "good" boxes at each chemistry
         timesteps.  Now allocate GOOD_CT_CHEM. (bmy, 10/25/04)
    (2 ) Now get I0 and J0 correctly for nested grid simulations (bmy, 11/9/04)
    (3 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
```

```
      value for GEOS or GCAP grids. (bmy, 6/28/05)
(4 ) Now allow ND51_IMIN to be equal to ND51_IMAX and ND51_JMIN to be
      equal to ND51_JMAX.  This will allow us to save out longitude or
      latitude transects.  Allocate COUNT_CHEM3D. (cdh, bmy, phs, 1/24/07)
(5 ) Allocate GOOD_EMIS and GOOD_CT_EMIS (ccc, 12/12/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.24.8 cleanup_diag51

Subroutine CLEANUP_DIAG51 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG51b
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now deallocate GOOD_CT_CHEM (bmy, 10/25/04)
(2 ) Also deallocate COUNT_CHEM3D (phs, 1/24/07)
(5 ) Also deallocate Allocate GOOD_EMIS and GOOD_CT_EMIS (ccc, 12/12/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.25 Fortran: Module Interface diag56_mod.f

Module DIAG56_MOD contains arrays and routines for archiving the ND56 diagnostic – lightning flash rates.

INTERFACE:

```
MODULE DIAG56_MOD
```

USES:

```
IMPLICIT NONE
#     include "define.h"
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: CLEANUP_DIAG56
PUBLIC :: INIT_DIAG56
PUBLIC :: WRITE_DIAG56
PUBLIC :: ZERO_DIAG56
```

PUBLIC DATA MEMBERS:

```
! Scalars
INTEGER,              PUBLIC :: ND56
INTEGER, PARAMETER,   PUBLIC :: PD56 = 3

! Arrays
REAL*4,  ALLOCATABLE, PUBLIC :: AD56(:,:,:)
```

REVISION HISTORY:

```
11 May 2006 - R. Yantosca - Initial version
(1 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(2 ) Now divide AD56 by the # of A-6 timesteps (ltm, bmy, 3/7/07)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.25.1 zero_diag56

Subroutine ZERO_DIAG03 zeroes the ND03 diagnostic arrays.

INTERFACE:

```
SUBROUTINE ZERO_DIAG56
```

REVISION HISTORY:

```
11 May 2006 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.25.2 write_diag56

Subroutine WRITE_DIAG56 writes the ND03 diagnostic arrays to the binary punch file at the proper time.

INTERFACE:

```
SUBROUTINE WRITE_DIAG56
```

USES:

```
USE BPCH2_MOD,    ONLY : BPCH2, GET_MODELNAME, GET_HALFPOLAR
USE FILE_MOD,     ONLY : IU_BPCH
USE GRID_MOD,     ONLY : GET_XOFFSET, GET_YOFFSET
USE TIME_MOD,     ONLY : GET_CT_A6,   GET_CT_A3
USE TIME_MOD,     ONLY : GET_DIAGb,  GET_DIAGe

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DIAG_MOD     ! TINDEX
```

REMARKS:

```
 # : Field    : Description              : Units          : Scale factor
-----------------------------------------------------------------------
(1 ) LFLASH-$ : Lightning flash rate     : flashes/min/km2 : SCALE_A6
(2 ) LFLASH-$ : Intra-cloud flash rate   : flashes/min/km2 : SCALE_A6
(3 ) LFLASH-$ : Cloud-ground flash rate  : flashes/min/km2 : SCALE_A6
```

REVISION HISTORY:

```
11 May 2006 - R. Yantosca - Initial version
(1 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(2 ) Now scale AD56 by the # of A-6 timesteps (ltm, bmy, 3/7/07)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.25.3 init_diag56

Subroutine INIT_DIAG56 allocates all module arrays, 5/11/06)

INTERFACE:

```
SUBROUTINE INIT_DIAG56
```

USES:

```
USE ERROR_MOD,    ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
11 May 2006 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.25.4 cleanup_diag56

Subroutine CLEANUP_DIAG56 deallocates all module arrays

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG56
```

REVISION HISTORY:

```
11 May 2006 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26 Fortran: Module Interface diag_pl_mod

Module DIAG_PL_MOD contains variables and routines which are used to compute the production and loss of chemical families in the "full chemistry" (NOx-Ox-Hydrocarbon-aerosol) mechanism.

INTERFACE:

```
MODULE DIAG_PL_MOD
```

USES:

```
IMPLICIT NONE
PRIVATE
```

PUBLIC DATA MEMBERS:

```
! Scalars
LOGICAL, PUBLIC              :: DO_SAVE_PL
INTEGER, PUBLIC              :: TAGO3_PL_YEAR

! Arrays
REAL*4,  PUBLIC, ALLOCATABLE :: AD65  (:,:,:,:)
REAL*8,  PUBLIC, ALLOCATABLE :: FAM_PL(:,:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: DO_DIAG_PL
PUBLIC  :: CLEANUP_DIAG_PL
PUBLIC  :: GET_FAM_MWT
PUBLIC  :: GET_FAM_NAME
PUBLIC  :: GET_NFAM
PUBLIC  :: INIT_DIAG_PL
PUBLIC  :: SETJFAM
PUBLIC  :: SETPL
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: DIAG20
PRIVATE :: ITS_TIME_FOR_WRITE20
PRIVATE :: WRITE20
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Add TAUe as a module variable.  Bug fixes: Make sure WRITE20 uses the
     global FILENAME, and also write to disk on the last timestep before
     the end of the simulation. (bmy, 11/15/04)
(2 ) Added routine ITS_TIME_FOR_WRITE20 (bmy, 3/3/05)
(3 ) Added functions GET_NFAM, GET_FAM_MWT, GET_FAM_NAME (bmy, 5/2/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
```

```
(6 ) Bug fix in DIAG20 (phs, 1/22/07)
(7 ) Now use LD65 as the vertical dimension instead of LLTROP or LLTROP_FIX
      in DO_DIAG_PL, DIAG20, and WRITE20 (phs, bmy, 12/4/07)
(8 ) Now make COUNT a 3-D array (phs, 11/18/08)
(9 ) Minor fix in DIAG20 (dbj, bmy, 10/26/09)
16 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.1 setjfam

Subroutine SETJFAM stores info into SMVGEAR arrays for the ND65 prod/loss diagnostic.

INTERFACE:

```
SUBROUTINE SETJFAM( NACTIVE, NINAC )
```

USES:

```
USE CMN_SIZE_MOD     ! Size parameters
USE COMODE_LOOP_MOD     ! SMVGEAR II arrays
```

INPUT/OUTPUT PARAMETERS:

```
INTEGER, INTENT(INOUT) :: NACTIVE   ! # of active chemical species
INTEGER, INTENT(INOUT) :: NINAC     ! # of inactive chemical species
```

REMARKS:

```
At present, the ND65 diagnostic works only with SMVGEAR and not with
KPP.  KPP is generated automatically and lacks the code to keep track of
the production/loss of chemical families. (bmy, 9/16/10)
```

REVISION HISTORY:

```
01 Feb 1999- L. Mickley, I. Bey, R. Yantosca - Initial version
(1 ) Replace NAMESPEC with NAMEGAS for SMVGEAR II.  Added comment header
      and updated comments.  Now references IU_FILE and IOERROR from
      F90 module "file_mod.f".  Now trap I/O errors using routine IOERROR.
      Make DEFMR a parameter for safety's sake.   Need to increment NACTIVE
      for SMVGEAR II or else the last species will be overwritten w/ the
      first ND65 family.  Set NCS = NCSURBAN, since we have defined our
      GEOS-CHEM mechanism in the urban slot of SMVGEAR II.(bmy, 4/21/03)
(2 ) Bundled into "diag65_mod.f" (bmy, 7/20/04)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.2 setpl

Subroutine SETPL flags the reactions and species which contribute to production or loss for a given ND65 prodloss diagnostic family.

INTERFACE:

```
SUBROUTINE SETPL
```

USES:

```
USE ERROR_MOD,   ONLY : ERROR_STOP, GEOS_CHEM_STOP
USE ERROR_MOD,   ONLY : DEBUG_MSG
USE LOGICAL_MOD, ONLY : LPRT

USE CMN_SIZE_MOD
USE COMODE_LOOP_MOD
```

REMARKS:

```
At present, the ND65 diagnostic works only with SMVGEAR and not with
KPP.  KPP is generated automatically and lacks the code to keep track of
the production/loss of chemical families. (bmy, 9/16/10)
```

REVISION HISTORY:

```
01 Feb 1999- L. Mickley, I. Bey, R. Yantosca - Initial version
(1 ) Now references "file_mod.f" and "error_mod.f".  Also now use IOERROR
      to trap I/O errors, and ERROR_STOP to stop the run and deallocate
      all module arrays.  NAMESPEC is now NAMEGAS for SMVGEAR II. Now
      uses F90 declaration syntax.  Set NCS = NCSURBAN for now, since we
      have defined our GEOS-CHEM mechanism in the urban slot of SMVGEAR II
      Updated comments.  (bmy, 5/1/03)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.3 do_diag_pl

Subroutine DO_DIAG_PL saves info on production and loss of families into the FAM_PL diagnostic array.

INTERFACE:

```
SUBROUTINE DO_DIAG_PL
```

USES:

```
USE COMODE_MOD, ONLY : CSPEC, JLOP

USE CMN_SIZE_MOD  ! Size parameters
USE COMODE_LOOP_MOD  ! SMVGEAR II arrays
USE CMN_DIAG_MOD  ! LD65
```

REVISION HISTORY:

```
16 Mar 2000 - I. Bey      - Initial version
(1 ) Now bundled into "prod_loss_diag_mod.f" (bmy, 7/20/04)
(2 ) Now only loop up thru LD65 levels (bmy, 12/4/07)
(3 ) Set FAM_PL to zero in the stratosphere (phs, 11/17/08)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.4 diag20

Subroutine DIAG20 computes production and loss rates of O3, and then calls subroutine WRITE20 to save the these rates to disk. By saving the production and loss rates from a full-chemistry run, a user can use these archived rates to perform a quick O3 chemistry run at a later time.

INTERFACE:

```
SUBROUTINE DIAG20
```

USES:

```
USE COMODE_MOD,    ONLY : JLOP
USE DIRECTORY_MOD, ONLY : O3PL_DIR
USE ERROR_MOD,     ONLY : ERROR_STOP
USE TIME_MOD,      ONLY : EXPAND_DATE,   GET_NYMD
USE TIME_MOD,      ONLY : GET_TAU,       GET_TAUb
USE TIME_MOD,      ONLY : ITS_A_NEW_DAY, TIMESTAMP_STRING
USE TRACER_MOD,    ONLY : STT,           XNUMOL
USE TRACERID_MOD,  ONLY : IDTOX

USE CMN_SIZE_MOD      ! Size parameters
USE CMN_DIAG_MOD      ! LD65
```

REMARKS:

```
DIAG20 assumes that ND65 (P-L diagnostics) have been turned on.
```

REVISION HISTORY:

```
09 Jun 1999 - I. Bey      - Initial version
(1 ) Now bundled into "diag20_mod.f" (bmy, 7/20/04)
(2 ) Now also write to disk when it is the last timestep before the end of
     the run.  Now references GET_TAUE from "time_mod.f". (bmy, 11/15/04)
(3 ) Now call function ITS_TIME_FOR_WRITE20 to determine if the next
     chemistry timestep is the start of a new day.  Remove reference
     to GET_TAUe and GET_TS_CHEM.  Now archive P(Ox) and L(Ox) first
     and then test if we have to save the file to disk. (bmy, 3/3/05)
(4 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(5 ) Now use LLTROP_FIX instead of LLTROP (phs, 1/22/07)
```

```
(6 ) Now use LD65 instead of LLTROP_FIX (phs, bmy, 12/4/07)
(7 ) Now take care of boxes that switch b/w stratospheric and tropospheric
     regimes (phs, 11/17/08)
(8 ) Bug fix: Now just zero arrays w/o loop indices (dbj, bmy, 10/26/09)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.5 write20

Subroutine WRITE20 saves production and loss rates to disk, where they will be later read by subroutine CHEMO3.

INTERFACE:

```
SUBROUTINE WRITE20
```

USES:

```
USE BPCH2_MOD,  ONLY : BPCH2,         GET_HALFPOLAR
USE BPCH2_MOD,  ONLY : GET_MODELNAME, OPEN_BPCH2_FOR_WRITE
USE FILE_MOD,   ONLY : IU_ND20
USE GRID_MOD,   ONLY : GET_XOFFSET,   GET_YOFFSET

USE CMN_SIZE_MOD   ! Size parameters
USE CMN_DIAG_MOD   ! LD65
```

REVISION HISTORY:

```
09 Jun 1999 - I. Bey      - Initial version
(1 ) Now bundled into "diag20_mod.f" (bmy, 7/20/04)
(2 ) Bug fix: remove declaration of FILENAME which masked the global
     declaration (bmy, 11/15/04)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Now only write up to LD65 levels (phs, bmy, 12/4/07)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.6 its_time_for_write20

Function ITS_TIME_FOR_WRITE20 returns TRUE if it's time to write the ND20 ozone P/L rate file to disk. We test the time at the next chemistry timestep so that we can write to disk properly.

INTERFACE:

```
FUNCTION ITS_TIME_FOR_WRITE20( TAU_W ) RESULT( ITS_TIME )
```

USES:

```
      USE TIME_MOD, ONLY : GET_HOUR, GET_MINUTE, GET_TAU
      USE TIME_MOD, ONLY : GET_TAUb, GET_TAUe,   GET_TS_CHEM, GET_TS_DYN
```

INPUT PARAMETERS:

```
      REAL*8,  INTENT(OUT) :: TAU_W      ! TAU value @ time of writing to disk
```

RETURN VALUE:

```
      LOGICAL              :: ITS_TIME   ! =T if its time to write to disk
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.7 get_nfam

Function GET_NFAM returns the number of defined P/L families.

INTERFACE:

```
      FUNCTION GET_NFAM() RESULT( N_FAM )
```

RETURN VALUE:

```
      INTEGER :: N_FAM    ! Number of defined P/L families
```

REVISION HISTORY:

```
    02 May 2005 - R. Yantosca - Initial version
    15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.8 get_fam_name

Function GET_FAM_NAME returns the name of the Nth P/L family.

INTERFACE:

```
      FUNCTION GET_FAM_NAME( N ) RESULT( NAME )
```

USES:

```
      USE ERROR_MOD, ONLY : ERROR_STOP
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: N      ! Family # for desired molecular weight
```

RETURN VALUE:

```
      CHARACTER(LEN=255)   :: NAME   ! Name of Nth P/L family
```

REVISION HISTORY:

```
    02 May 2005 - R. Yantosca - Initial version
    15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.9 get_fam_mwt

Function GET_FAM_MWT returns the molecular weight of the Nth P/L family.

INTERFACE:

```
FUNCTION GET_FAM_MWT( N ) RESULT( MWT )
```

USES:

```
USE CHARPAK_MOD, ONLY : TRANUC
USE ERROR_MOD,   ONLY : ERROR_STOP
USE TRACER_MOD,  ONLY : N_TRACERS, TRACER_MW_KG, TRACER_NAME
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: N     ! Family # for desired molecular weight
```

RETURN VALUE:

```
REAL*8               :: MWT   ! Molecular weight
```

REVISION HISTORY:

```
02 May 2005 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.10 init_diag_pl

Subroutine INIT_DIAG_PL takes values read from the GEOS-Chem input file and saves to module variables w/in "diag_pl_mod.f"

INTERFACE:

```
SUBROUTINE INIT_DIAG_PL( DOPL, SAVEO3, N_FAM, NAME,
&                        TYPE, NMEM,   MEMB,  COEF )
```

USES:

```
USE ERROR_MOD,  ONLY : ALLOC_ERR
USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM

USE CMN_SIZE_MOD   ! Size parameters
USE COMODE_LOOP_MOD   ! LFAMILY, NFAMILIES
USE CMN_DIAG_MOD   ! ND65,    LD65
```

INPUT PARAMETERS:

```
! Turn on P/L diagnostic?
LOGICAL,           INTENT(IN) :: DOPL

! Save out P(Ox), L(Ox) for future tagged Ox simulation?
```

```
LOGICAL,           INTENT(IN) :: SAVEO3

! Number of prod/loss families
INTEGER,           INTENT(IN) :: N_FAM

! Number of members w/in the prod/loss family
INTEGER,           INTENT(IN) :: NMEM(MAXFAM)

! Coefficients for each prod/loss family member
REAL*8,            INTENT(IN) :: COEF(MAXMEM,MAXFAM)

! Prod/loss family name
CHARACTER(LEN=14), INTENT(IN) :: NAME(MAXFAM)

! Prod/loss family type
CHARACTER(LEN=14), INTENT(IN) :: TYPE(MAXFAM)

! Names for each prod/loss family member
CHARACTER(LEN=14), INTENT(IN) :: MEMB(MAXMEM,MAXFAM)
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now allocate arrays up to LD65 levels (phs, bmy, 12/4/07)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.26.11 cleanup_diag_pl

Subroutine CLEANUP_DIAG_PL deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG_PL
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.27 Fortran: Module Interface diag_oh_mod

Module DIAG_OH_MOD contains routines and variables to archive OH mass and air mass concentrations. These are then used to print out the mass-weighted mean OH concentration in 1e5 molec/cm3. This is a metric of how certain chemisry simulations are performing.

INTERFACE:

```
      MODULE DIAG_OH_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_DIAG_OH
      PUBLIC  :: DO_DIAG_OH
      PUBLIC  :: DO_DIAG_OH_CH4
      PUBLIC  :: INIT_DIAG_OH
      PUBLIC  :: PRINT_DIAG_OH
```

REVISION HISTORY:

```
   (1 ) Remove code for obsolete CO-OH simulation (bmy, 6/24/05)
```

1.27.1 do_diag_oh

Subroutine DO_DIAG_OH sums the OH and air mass (from SMVGEAR arrays) for the mean OH concentration diagnostic.

INTERFACE:

```
      SUBROUTINE DO_DIAG_OH
```

USES:

```
      USE COMODE_MOD,   ONLY : AIRDENS, CSPEC, JLOP, T3, VOLUME
      USE TRACERID_MOD, ONLY : IDOH

      USE CMN_SIZE_MOD     ! Size parameters
      USE COMODE_LOOP_MOD     ! NPVERT, NLAT, NLONG
```

REVISION HISTORY:

```
   07 Jul 2004 - R. Yantosca - Initial version
   15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.27.2 do_diag_oh_ch4

Subroutine DO_DIAG_OH_CH4 passes the OH loss, OH mass, and air mass terms from "global_ch4_mod.f" to "diag_oh_mod.f"

INTERFACE:

```
SUBROUTINE DO_DIAG_OH_CH4( I, J, L, XOHMASS, XAIRMASS, XLOSS )
```

USES:

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I          ! Longitude index
INTEGER, INTENT(IN) :: J          ! Latitude index
INTEGER, INTENT(IN) :: L          ! Level index
REAL*8,  INTENT(IN) :: XOHMASS    ! OH Mass  (from global_ch4_mod.f)
REAL*8,  INTENT(IN) :: XAIRMASS   ! Air mass (from global_ch4_mod.f)
REAL*8,  INTENT(IN) :: XLOSS      ! OH loss  (from global_ch4_mod.f)
```

REVISION HISTORY:

```
07 Jul 2004 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.27.3 print_diag_oh

Subroutine PRINT_DIAG_OH prints the mass-weighted OH concentration at the end of a simulation.

INTERFACE:

```
SUBROUTINE PRINT_DIAG_OH
```

USES:

```
USE TRACER_MOD, ONLY : ITS_A_CH4_SIM
```

REVISION HISTORY:

```
21 Oct 2003 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.27.4 init_diag_oh

Subroutine INIT_DIAG_OH initializes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG_OH
```

USES:

```
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE LOGICAL_MOD, ONLY : LCHEM
      USE TRACER_MOD,  ONLY : ITS_A_FULLCHEM_SIM, ITS_A_CH4_SIM

      USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
   07 Jul 2004 - R. Yantosca - Initial version
   (1 ) Remove references to CO-OH simulation and to F77_CMN_DIAG (bmy, 6/24/05)
   15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.27.5 cleanup_diag_oh

Subroutine CLEANUP_DIAG_OH deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_DIAG_OH
```

REVISION HISTORY:

```
   07 Jul 2004 - R. Yantosca - Initial version
   15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.28 Fortran: Module Interface diag_mod

Module DIAG_MOD contains declarations for allocatable arrays for use with GEOS-CHEM diagnostics.

INTERFACE:

```
      MODULE DIAG_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PUBLIC
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_DIAG
```

PUBLIC DATA MEMBERS:

```
      ! For ND01 -- Rn, Pb, Be emissions
      REAL*4,  ALLOCATABLE :: AD01(:,:,:,:)

      ! For ND02 -- Rn, Pb, Be decay
      REAL*4,  ALLOCATABLE :: AD02(:,:,:,:)

      !------------------------------------------
      !! For ND03 -- Kr85 prod/loss
      !REAL*4,  ALLOCATABLE :: AD03(:,:,:,:)
      !------------------------------------------

      ! For ND05 -- Sulfate prod/loss diagnostics
      REAL*4,  ALLOCATABLE :: AD05(:,:,:,:)

      ! For ND06 -- Dust aerosol emission
      REAL*4,  ALLOCATABLE :: AD06(:,:,:)

      ! For ND07 -- Carbon aerosol emission
      REAL*4,  ALLOCATABLE :: AD07(:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_BC(:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_OC(:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_HC(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_SOAGM(:,:,:,:)

#if   defined( APM )
      REAL*4,  ALLOCATABLE :: AD07_OM(:,:)
#endif

      ! For ND08 -- seasalt emission
      REAL*4,  ALLOCATABLE :: AD08(:,:,:)

      ! For ND09 -- HCN / CH3CN simulation
      REAL*4,  ALLOCATABLE :: AD09(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD09_em(:,:,:)

      ! For ND10 -- H2/HD prod, loss, & emiss diagnostics
      REAL*4,  ALLOCATABLE :: AD10(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD10em(:,:,:)

      ! For ND12 -- boundary layer multiplication factor
      REAL*4,  ALLOCATABLE :: AD11(:,:,:)

      ! For ND12 -- boundary layer multiplication factor
      REAL*4,  ALLOCATABLE :: AD12(:,:,:)

      ! For ND13 -- Sulfur emissions
      REAL*4,  ALLOCATABLE :: AD13_DMS(:,:)
      REAL*4,  ALLOCATABLE :: AD13_SO2_ac(:,:,:)
```

```
REAL*4,  ALLOCATABLE :: AD13_SO2_an(:,:,:)
REAL*4,  ALLOCATABLE :: AD13_SO2_bb(:,:)
REAL*4,  ALLOCATABLE :: AD13_SO2_bf(:,:)
REAL*4,  ALLOCATABLE :: AD13_SO2_nv(:,:,:)
REAL*4,  ALLOCATABLE :: AD13_SO2_ev(:,:,:)
REAL*4,  ALLOCATABLE :: AD13_SO2_sh(:,:)
REAL*4,  ALLOCATABLE :: AD13_SO4_an(:,:,:)
REAL*4,  ALLOCATABLE :: AD13_SO4_bf(:,:)
REAL*4,  ALLOCATABLE :: AD13_NH3_an(:,:,:)
REAL*4,  ALLOCATABLE :: AD13_NH3_na(:,:)
REAL*4,  ALLOCATABLE :: AD13_NH3_bb(:,:)
REAL*4,  ALLOCATABLE :: AD13_NH3_bf(:,:)

! For ND14 -- wet convection mass flux diagnostic
REAL*8,  ALLOCATABLE :: CONVFLUP(:,:,:,:)

! For ND15 -- BL mixing mass flux diagnostic
REAL*8,  ALLOCATABLE :: TURBFLUP(:,:,:,:)

! For ND16 -- Fraction of grid box that is precipitating
REAL*4,  ALLOCATABLE :: AD16(:,:,:,:)
INTEGER, ALLOCATABLE :: CT16(:,:,:,:)

! For ND17 -- Fraction of tracer lost to rainout
REAL*4,  ALLOCATABLE :: AD17(:,:,:,:,:)
INTEGER, ALLOCATABLE :: CT17(:,:,:,:)

! For ND18 -- Fraction of tracer lost to washout
REAL*4,  ALLOCATABLE :: AD18(:,:,:,:,:)
INTEGER, ALLOCATABLE :: CT18(:,:,:,:)

! For ND21 -- Optical Depth diagnostic
REAL*4,  ALLOCATABLE :: AD21(:,:,:,:)
REAL*4,  ALLOCATABLE :: AD21_cr(:,:,:)

! For ND22 -- J-value diagnostic
REAL*4,  ALLOCATABLE :: AD22(:,:,:,:)
INTEGER, ALLOCATABLE :: LTJV(:,:)
INTEGER, ALLOCATABLE :: CTJV(:,:)

! For ND23 -- CH3CCl3 lifetime diagnostic
REAL*8,  ALLOCATABLE :: DIAGCHLORO(:,:,:,:)

! For ND24 -- E/W transport mass flux diagnostic
REAL*8,  ALLOCATABLE :: MASSFLEW(:,:,:,:)

! For ND25 -- N/S transport mass flux diagnostic
REAL*8,  ALLOCATABLE :: MASSFLNS(:,:,:,:)
```

```
! For ND26 -- UP/DOWN transport mass flux diagnostic
REAL*8,  ALLOCATABLE :: MASSFLUP(:,:,:,:)

! For ND28 -- Biomass burning diagnostic
REAL*4,  ALLOCATABLE :: AD28(:,:,:)

! For ND29 -- CO source diagnostic
REAL*4,  ALLOCATABLE :: AD29(:,:,:)

! For ND30 -- land / water / ice flags
REAL*4,  ALLOCATABLE :: AD30(:,:)

! For ND31 -- surface pressures
REAL*4,  ALLOCATABLE :: AD31(:,:,:)

! For ND32 -- NOx sources
REAL*4,  ALLOCATABLE :: AD32_ac(:,:,:)
REAL*4,  ALLOCATABLE :: AD32_an(:,:,:)
REAL*4,  ALLOCATABLE :: AD32_bb(:,:)
REAL*4,  ALLOCATABLE :: AD32_bf(:,:)
REAL*4,  ALLOCATABLE :: AD32_fe(:,:)
REAL*4,  ALLOCATABLE :: AD32_li(:,:,:)
REAL*4,  ALLOCATABLE :: AD32_so(:,:)
REAL*4,  ALLOCATABLE :: AD32_ub(:,:)

! For ND33 -- tropopsheric sum of tracer
REAL*4,  ALLOCATABLE :: AD33(:,:,:)

! For ND34 -- biofuel emissions
REAL*4,  ALLOCATABLE :: AD34(:,:,:)

! For ND35 -- 500 mb tracer
REAL*4,  ALLOCATABLE :: AD35(:,:,:)

! For ND36 -- Anthropogenic source diagnostic
REAL*4,  ALLOCATABLE :: AD36(:,:,:)

! For ND37 -- Fraction of tracer scavenged in cloud updrafts
REAL*4,  ALLOCATABLE :: AD37(:,:,:,:)

! For ND38 -- Rainout in moist convection diagnostic
REAL*4,  ALLOCATABLE :: AD38(:,:,:,:)

! For ND39 -- Washout in aerosol wet deposition diagnostic
REAL*4,  ALLOCATABLE :: AD39(:,:,:,:)

! For ND43 -- OH, NO, NO2, HO2 chemical diagnostics
```

```
REAL*4,  ALLOCATABLE :: AD43(:,:,:,:)
INTEGER, ALLOCATABLE :: LTNO(:,:)
INTEGER, ALLOCATABLE :: CTNO(:,:,:)
INTEGER, ALLOCATABLE :: LTOH(:,:)
INTEGER, ALLOCATABLE :: CTOH(:,:,:)
INTEGER, ALLOCATABLE :: LTNO2(:,:)
INTEGER, ALLOCATABLE :: CTNO2(:,:,:)
INTEGER, ALLOCATABLE :: LTHO2(:,:)
INTEGER, ALLOCATABLE :: CTHO2(:,:,:)
INTEGER, ALLOCATABLE :: LTNO3(:,:)
INTEGER, ALLOCATABLE :: CTNO3(:,:,:)
! update for arom (dkh, 06/21/07)
INTEGER, ALLOCATABLE :: CTLBRO2H(:,:,:)
INTEGER, ALLOCATABLE :: CTLBRO2N(:,:,:)
INTEGER, ALLOCATABLE :: CTLTRO2H(:,:,:)
INTEGER, ALLOCATABLE :: CTLTRO2N(:,:,:)
INTEGER, ALLOCATABLE :: CTLXRO2H(:,:,:)
INTEGER, ALLOCATABLE :: CTLXRO2N(:,:,:)
INTEGER, ALLOCATABLE :: LTLBRO2H(:,:)
INTEGER, ALLOCATABLE :: LTLBRO2N(:,:)
INTEGER, ALLOCATABLE :: LTLTRO2H(:,:)
INTEGER, ALLOCATABLE :: LTLTRO2N(:,:)
INTEGER, ALLOCATABLE :: LTLXRO2H(:,:)
INTEGER, ALLOCATABLE :: LTLXRO2N(:,:)

! For ND44 -- Dry deposition fluxes & velocities
REAL*4,  ALLOCATABLE :: AD44(:,:,:,:)

! For ND45 -- Tracer concentration diagnostic
REAL*4,  ALLOCATABLE :: AD45(:,:,:,:)
INTEGER, ALLOCATABLE :: LTOTH(:,:)
INTEGER, ALLOCATABLE :: CTOTH(:,:)
INTEGER, ALLOCATABLE :: CTO3(:,:,:)
INTEGER, ALLOCATABLE :: LTO3(:,:)

! For ND46 -- Tracer concentration diagnostic
REAL*4,  ALLOCATABLE :: AD46(:,:,:)

! For ND47 -- 24-h tracer concentration diagnostic
REAL*4,  ALLOCATABLE :: AD47(:,:,:,:)

! For ND47(O3) / ND65 -- 24-h tracer diagnostic
INTEGER, ALLOCATABLE :: CTO3_24h(:,:,:)

! Dynamically allocatable array -- local only to DIAG50.F
REAL*8,  ALLOCATABLE :: STT_TEMPO2(:,:,:,:)

! For ND52 -- gamma HO2 diagnostic
```

```
      REAL*4,  ALLOCATABLE :: AD52(:,:,:)

      ! For ND54 -- tropopause diagnostics
      REAL*4,  ALLOCATABLE :: AD54(:,:,:)

      ! For ND55 -- tropopause diagnostics
      REAL*4,  ALLOCATABLE :: AD55(:,:,:)

      ! For ND57 -- theta, potential temp (FP 6/2009)
      REAL*4,  ALLOCATABLE :: AD57(:,:,:)

      ! -- for methane simulation diagnostics
      REAL*4,  ALLOCATABLE :: AD19(:,:,:)
      REAL*4,  ALLOCATABLE :: AD58(:,:,:)
      REAL*4,  ALLOCATABLE :: AD60(:,:)

      ! For ND66 -- I-6 fields diagnostic
      REAL*4,  ALLOCATABLE :: AD66(:,:,:,:)

      ! For ND67 -- DAO surface fields diagnostic
      REAL*4,  ALLOCATABLE :: AD67(:,:,:)

      ! For ND68 -- BXHEIGHT, AD, AVGW diagnostic
      REAL*4,  ALLOCATABLE :: AD68(:,:,:,:)

      ! For ND69 -- DXYP diagnostic
      REAL*4,  ALLOCATABLE :: AD69(:,:,:)
```

REVISION HISTORY:

```
30 Nov 1999 - A. Fiore - Initial version
(1 ) DIAG_MOD is written in Fixed-Format F90.
(2 ) Call subroutine CLEANUP at the end of the MAIN program to deallocate
     the memory before the run stops.  It is always good style to free
     any memory we have dynamically allocated when we don't need it
     anymoren
(3 ) Added ND13 arrays for sulfur emissions (bmy, 6/6/00)
(4 ) Moved ND51 arrays to "diag51_mod.f" (bmy, 11/29/00)
(5 ) Added AD34 array for biofuel burning emissions (bmy, 3/15/01)
(6 ) Eliminated old commented-out code (bmy, 4/20/01)
(7 ) Added AD12 array for boundary layer emissions in routine "setemis.f".
     (bdf, bmy, 6/15/01)
(8 ) Added CHEML24, DRYDL24, CTCHDD for archiving daily mean chemical
     and drydep loss in chemo3 and chemo3.f (amf, bmy, 7/2/01)
(9 ) Add ND43 arrays LTNO2, CTNO2, LTHO2, CTHO2 (rvm, bmy, 2/27/02)
(10) Add AD01, AD02 arrays for Rn-Pb-Be simulation (hyl, bmy, 8/7/02)
(11) Add AD05 array for sulfate P-L diagnostic (rjp, bdf, bmy, 9/20/02)
(12) Added subroutine CLEANUP_DIAG...moved code here from "cleanup.f",
```

```
      so that it is internal to "diag_mod.f".  Added arrays AD13_NH3_bb,
      AD13_NH3_bf, AD13_NH3_an for NH3 emissons in ND13.  Deleted obsolete
      allocatable arrays CHEML24, DRYDL24, CTCHDD.  Now also added LTNO3
      and CTNO3 arrays for ND43 diagnostic.  Added AD13_SO2_bf array for
      SO2 biofuel. (bmy, 1/16/03)
(13) Added array AD13_NH3_na for ND13 diagnostic (rjp, bmy, 3/23/03)
(14) Removed P24H and L24H -- these are now defined w/in "tagged_ox_mod.f"
      Also added AD03 array for Kr85 prod/loss diag. (jsw, bmy, 8/20/03)
(15) Added ND06 (dust emission) and ND07 (carbon aerosol emission)
      diagnostic arrays (rjp, tdf, bmy, 4/5/04)
(16) Added AD13_SO2_sh diagnostic array for ND13 (bec, bmy, 5/20/04)
(17) Added AD07_HC diagnostic array for ND07 (rjp, bmy, 7/13/04)
(18) Moved AD65 & FAMPL to "diag65_mod.f" (bmy, 7/20/04)
(19) Added array AD13_SO4_bf (bmy, 11/17/04)!
(20) Added extra arrays for ND03 mercury diagnostics (eck, bmy, 12/7/04)
(21) Added extra ND21 array for crystalline sulfur tracers.  Also remove
      ND03 and ND48 arrays; they are obsolete (bmy, 1/21/05)
(22) Removed AD41 and AFTTOT arrays; they're obsolete (bmy, 2/17/05)
(23) Added AD09, AD09_em arrays for HCN/CH3CN simulation (xyp, bmy, 6/27/05)
(24) Added AD30 array for land/water/ice output (bmy, 8/18/05)
(25) Added AD54 array for time spend in the troposphere (phs, 9/22/06)
(26) Added CTO3 counter. Convert ND43 counter arrays from 2D to 3D, for
      the variable tropopause. (phs, 1/19/07)
(27) Added AD10 and AD10em arrays for ND10 H2-HD-sim diag (phs, 9/18/07)
(28) Added CTO3_24h to account for time in the troposphere for O3 in
      ND47 (phs, 11/17/08)
(29) Added AD52 for Gamma HO2 diagnostic. (jaegle, ccc, 2/26/09)
(30) Updated to save out GLYX production of SOAG in ND07.
     (tmf, 3/6/09)
(31) Add LTO3 for ND45 diag. (ccc, 7/20/09)
(32) Add AD19, AD58, AD60 for CH4 (kjw, 8/18/09)
(33) AD13_NH3_an is 3D now (phs, 10/22/09)
(34) Add counter for aromatics SOA and add AD57 diagnostic for potential
     temperature. (fp, 2/3/10)
26 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.28.1 cleanup_diag

Subroutine CLEANUP_DIAG deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG
```

REVISION HISTORY:

```
13 Dec 2002 - R. Yantosca - Initial version
(1 ) Now also deallocate AD13_NH3_an, AD13_NH3_bb, AD13_NH3_bf arrays
```

```
      for the ND13 diagnostic.  (bmy, 12/13/02)
(2 ) Now also deallocate AD13_NH3_na array for ND13 (rjp, bmy, 3/23/03)
(3 ) Removed P24H and L24H, these are now defined within "tagged_ox_mod.f".
     Now also deallocate AD03 array for Kr85 prod/loss (jsw, bmy, 8/20/03)
(4 ) Now also deallocate AD06 and AD07* arrays (rjp, bdf, bmy, 4/5/04)
(5 ) Now also deallocate AD08 array (rjp, bec, bmy, 4/20/04)
(6 ) Now also deallocaes AD13_SO2_sh array (bec, bmy, 5/20/04)
(7 ) Now also deallocates AD07_HC array (rjp, bmy, 7/13/04)
(8 ) Now also deallocate AD13_SO4_bf array (bmy, 11/17/04)
(9 ) Now deallocate extra arrays for ND03 diagnostics (eck, bmy, 12/7/04)
(10) Now deallocates AD21_cr array.  Remove reference to arrays for ND03
     and ND48 diagnostics, they're obsolete. (cas, sas, bmy, 1/21/05)
(11) Removed AD41 and AFTTOT arrays; they're obsolete (bmy, 2/17/05)
(12) Now also deallocate AD09 and AD09_em (bmy, 6/27/05)
(13) Now deallocate AD30 (bmy, 8/18/05)
(14) Now deallocate CTO3, AD10, AD10em arrays (phs, 9/18/07)
15 Feb 2011 - R. Yantosca - Add modifications for APM microphysics
```

1.29 Fortran: Module Interface dust_mod

Module DUST_MOD contains routines for computing dust aerosol emissions, chemistry, and optical depths.

INTERFACE:

```
      MODULE DUST_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CHEMDUST
      PUBLIC  :: EMISSDUST
      PUBLIC  :: RDUST_ONLINE
      PUBLIC  :: RDUST_OFFLINE
      PUBLIC  :: INIT_DUST
      PUBLIC  :: CLEANUP_DUST
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: DRY_SETTLING
      PRIVATE :: DRY_DEPOSITION
      PRIVATE :: SRC_DUST_DEAD
      PRIVATE :: SRC_DUST_GINOUX
```

REVISION HISTORY:

```
30 Mar 2004 - T. D. Fairlie - Initial version
(1 ) Bug fix in SRC_DUST_DEAD (bmy, 4/14/04)
(2 ) Now references "logical_mod.f", "directory_mod.f", and "tracer_mod.f"
     Added comments. (bmy, 7/2/04)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(5 ) Bug fix in snow height computation (bmy, 11/18/05)
(6 ) Now only do drydep if LDRYD=T (bmy, 5/23/06)
(7 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(8 ) Updated output print statement in SRC_DUST_DEAD (bmy, 1/23/07)
(9 ) Modifications for GEOS-5 (bmy, 1/24/07)
(10) Modified to archive only hydrophilic aerosol/aqueous dust surface area
     (excluding BCPO and OCPO) for aqueous chemistry calculations
     Dust surfaces are considered aqueous only when RH > 35% (tmf, 3/6/09)
(11) Add AOD output for all dust size bins (clh, 5/7/10)
(12) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
03 Sep 2010 - R. Yantosca - Bug fix in SRC_DUST_DEAD
```

1.29.1 chemdust

Subroutine CHEMDUST is the interface between the GEOS-Chem main program and the dust chemistry routines that mostly calculates dust dry deposition.

INTERFACE:

```
SUBROUTINE CHEMDUST
```

USES:

```
USE ERROR_MOD,    ONLY : ERROR_STOP
USE LOGICAL_MOD,  ONLY : LDRYD,   LDUST
USE DRYDEP_MOD,   ONLY : DEPNAME, NUMDEP
USE TRACER_MOD,   ONLY : STT
USE TRACERID_MOD, ONLY : IDTDST1, IDTDST2, IDTDST3, IDTDST4

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
30 Mar 2004 - T. D. Fairlie - Initial version
(1 ) Now references STT from "tracer_mod.f" and LDUST from "logical_mod.f"
     (bmy, 7/20/04)
(5 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(6 ) Now only do dry deposition if LDRYD = T (bmy, 5/23/06)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.2 dry_settling

Subroutine DRY_SETTLING computes the dry settling of dust tracers.

INTERFACE:

```
SUBROUTINE DRY_SETTLING( TC )
```

USES:

```
USE DAO_MOD,      ONLY : T, BXHEIGHT
USE DIAG_MOD,     ONLY : AD44
USE PRESSURE_MOD, ONLY : GET_PCENTER
USE TIME_MOD,     ONLY : GET_TS_CHEM
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE TRACER_MOD,   ONLY : XNUMOL
USE TRACERID_MOD, ONLY : IDTDST1

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_DIAG_MOD       ! ND44
USE CMN_GCTM_MOD       ! g0
```

INPUT/OUTPUT PARAMETERS:

```
REAL*8, INTENT(INOUT) :: TC(IIPAR,JJPAR,LLPAR,NDSTBIN)  ! Dust mass [kg]
```

REVISION HISTORY:

```
30 Mar 2004 - T. D. Fairlie - Initial version
(1 ) Updated comments, cosmetic changes (bmy, 3/30/04)
(2 ) Remove reference to CMN, it's not needed (bmy, 7/20/04)
(3 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.3 dry_deposition

Subroutine DRY_DEPOSITION computes the loss of dust due to dry deposition at the surface using an implicit method.

INTERFACE:

```
SUBROUTINE DRY_DEPOSITION( TC )
```

USES:

```
USE DIAG_MOD,     ONLY : AD44
USE DRYDEP_MOD,   ONLY : DEPSAV
USE TIME_MOD,     ONLY : GET_TS_CHEM
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE TRACER_MOD,   ONLY : XNUMOL
```

```
      USE TRACERID_MOD, ONLY : IDTDST1

      USE CMN_SIZE_MOD       ! Size parameters
      USE CMN_DIAG_MOD       ! ND44
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8, INTENT(INOUT) :: TC(IIPAR,JJPAR,LLPAR,NDSTBIN)  ! Dust mass [kg]
```

REVISION HISTORY:

```
    30 Mar 2004 - T. D. Fairlie - Initial version
    (1 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
    25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.4 emissdust

Subroutine EMISSDUST is the driver routine for the dust emission module. You may call either the GINOUX or the DEAD dust source function.

INTERFACE:

```
      SUBROUTINE EMISSDUST
```

USES:

```
      USE ERROR_MOD,    ONLY : ERROR_STOP, DEBUG_MSG
      USE LOGICAL_MOD,  ONLY : LDEAD, LDUST, LPRT
      USE TRACER_MOD,   ONLY : STT
      USE TRACERID_MOD, ONLY : IDTDST1, IDTDST2, IDTDST3, IDTDST4

      USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
    30 Mar 2004 - T. D. Fairlie - Initial version
    (1 ) Now reference LDEAD, LDUST, LPRT from "logical_mod.f".  Now reference!
         STT from "tracer_mod.f" (bmy, 7/20/04)
    (2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
    25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.5 src_dust_dead

Subroutine SRC_DUST_DEAD is the DEAD model dust emission scheme, alternative to Ginoux scheme. Increments the TC array with emissions from the DEAD model.

INTERFACE:

```
      SUBROUTINE SRC_DUST_DEAD( TC )
```

USES:

```
      USE DAO_MOD,       ONLY : BXHEIGHT,     GWETTOP,   LWI
      USE DAO_MOD,       ONLY : SNOW,         SPHU,      T
      USE DAO_MOD,       ONLY : TS,           UWND,      VWND
      USE DAO_MOD,       ONLY : SNOMAS
      USE DUST_DEAD_MOD, ONLY : GET_TIME_INVARIANT_DATA, GET_ORO
      USE DUST_DEAD_MOD, ONLY : GET_MONTHLY_DATA,        DST_MBL
      USE DIAG_MOD,      ONLY : AD06
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE FILE_MOD,      ONLY : IOERROR
      USE ERROR_MOD,     ONLY : GEOS_CHEM_STOP
      USE GRID_MOD,      ONLY : GET_YMID_R
      USE PRESSURE_MOD,  ONLY : GET_PEDGE,       GET_PCENTER
      USE TIME_MOD,      ONLY : GET_TS_EMIS,     GET_MONTH
      USE TIME_MOD,      ONLY : GET_DAY_OF_YEAR, ITS_A_NEW_MONTH
      USE TRANSFER_MOD,  ONLY : TRANSFER_2D

      USE CMN_SIZE_MOD        ! Size parameters
      USE CMN_DIAG_MOD        ! ND06
      USE CMN_GCTM_MOD        ! g0
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8, INTENT(INOUT) :: TC(IIPAR,JJPAR,LLPAR,NDSTBIN)  ! Dust mass [kg]
```

REMARKS:

```
    Input:
           SRCE_FUNK Source function                                (-)
           for 1: Sand, 2: Silt, 3: Clay
           DUSTDEN   Dust density                                   (kg/m3)
           DUSTREFF  Effective radius                               (um)
           AD        Air mass for each grid box                     (kg)
           NTDT      Time step                                      (s)
           W10M      Velocity at the anemometer level (10meters)    (m/s)
           GWET      Surface wetness                                (-)
                                                                              .
    Parameters used in GEOS-CHEM
                                                                              .
    Longitude: IIPAR
    Latitude : JJPAR
    Levels   : LLPAR  =  20 (GEOS-1), 26 (GEOS-strat), 30 (GEOS-terra)
    Size bins: NDSTBIN  =   4
                                                                              .
    Dust properties used in GOCART
                                                                              .
    Size classes: 01-1, 1-1.8, 1.8-3, 3-6 (um)
```

```
Radius: 0.7, 1.5, 2.5, 4  (um)
Density: 2500, 2650, 2650, 2650 (kg/m3)!
```

REVISION HISTORY:

```
08 Apr 2004 - T. D. Fairlie - Initial version
(1 ) Added OpenMP parallelization, added comments (bmy, 4/8/04)
(2 ) Bug fix: DSRC needs to be held PRIVATE (bmy, 4/14/04)
(3 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Bug fix: It should be SNOW/1d3 not SNOW*1d3 (tdf, bmy, 11/18/05)
(6 ) Updated output statement (bmy, 1/23/07)
(7 ) Use SNOMAS (m H2O) for GEOS-5 (bmy, 1/24/07)
25 Aug 2010 - R. Yantosca - Treat MERRA in the same way as for GEOS-5
25 Aug 2010 - R. Yantosca - Added ProTeX headers
03 Sep 2010 - R. Yantosca - Bug fix, SNOMAS was mislabled in GEOS-5
                            and has units of mm H2O instead of m H2O
                            so we need to convert to m H2O.
```

1.29.6 src_dust_ginoux

Paul GINOUX dust source function. This subroutine updates the surface mixing ratio of dust aerosols for NDSTBIN size bins. The uplifting of dust depends in space on the source function, and in time and space on the soil moisture and surface wind speed (10 meters). Dust is uplifted if the wind speed is greater than a threshold velocity which is calculated with the formula of Marticorena et al. (JGR, v.102, pp 23277-23287, 1997). To run this subroutine you need the source function which can be obtained by contacting Paul Ginoux at ginoux@rondo.gsfc.nasa.gov/ If you are not using GEOS DAS met fields, you will most likely need to adapt the adjusting parameter.

INTERFACE:

```
SUBROUTINE SRC_DUST_GINOUX( TC )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE DAO_MOD,       ONLY : GWETTOP
USE DIAG_MOD,      ONLY : AD06
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE FILE_MOD,      ONLY : IOERROR
USE TIME_MOD,      ONLY : GET_TS_EMIS
USE GRID_MOD,      ONLY : GET_AREA_M2

USE CMN_SIZE_MOD        ! Size parameters
USE CMN_DIAG_MOD        ! ND19, LD13 (for now)
USE CMN_GCTM_MOD        ! g0
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8, INTENT(INOUT) :: TC(IIPAR,JJPAR,LLPAR,NDSTBIN)  ! Dust mass [kg]
```

REMARKS:

```
    Input:
      SRCE_FUNK Source function                                (-)
                for 1: Sand, 2: Silt, 3: Clay
                                                                              .
      DUSTDEN   Dust density                                   (kg/m3)
      DUSTREFF  Effective radius                               (um)
      AD        Air mass for each grid box                     (kg)
      NTDT      Time step                                      (s)
      W10m      Velocity at the anemometer level (10meters)    (m/s)
      GWET      Surface wetness                                (-)
                                                                              .
    Parameters used in GEOS-CHEM
                                                                              .
    Longitude: IIPAR
    Latitude : JJPAR
    Levels   : LLPAR  =  20 (GEOS-1), 26 (GEOS-strat), 30 (GEOS-terra)
    Size bins: NDSTBIN  =   4
                                                                              .
    Dust properties used in GOCART
                                                                              .
    Size classes: 01-1, 1-1.8, 1.8-3, 3-6 (um)
    Radius: 0.7, 1.5, 2.5, 4  (um)
    Density: 2500, 2650, 2650, 2650 (kg/m3)
                                                                              .
    References:
    ============================================================================
    (1 ) Ginoux, P., M. Chin, I. Tegen, J. Prospero, B. Hoben, O. Dubovik,
         and S.-J. Lin, "Sources and distributions of dust aerosols simulated
         with the GOCART model", J. Geophys. Res., 2001
    (2 ) Chin, M., P. Ginoux, S. Kinne, B. Holben, B. Duncan, R. Martin,
         J. Logan, A. Higurashi, and T. Nakajima, "Tropospheric aerosol
         optical thickness from the GOCART model and comparisons with
         satellite and sunphotometers measurements", J. Atmos Sci., 2001.
                                                                              .
    Contact: Paul Ginoux (ginoux@rondo.gsfc.nasa.gov)
```

REVISION HISTORY:

```
    08 Apr 2004 - T. D. Fairlie - Initial version
    (1 ) Added OpenMP parallelization (bmy, 4/8/04)
    (2 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
    25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.7 rdust_online

Subroutine RDUST_ONLINE reads global mineral dust concentrations as determined by P. Ginoux. Calculates dust optical depth at each level for the FAST-J routine "set_prof.f".

INTERFACE:

```
SUBROUTINE RDUST_ONLINE( DUST, WAVELENGTH )
```

USES:

```
USE COMODE_MOD,    ONLY : ERADIUS, IXSAVE, IYSAVE
USE COMODE_MOD,    ONLY : IZSAVE,  JLOP,   TAREA
USE DAO_MOD,       ONLY : BXHEIGHT
USE DIAG_MOD,      ONLY : AD21
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE ERROR_MOD,     ONLY : ERROR_STOP
USE TRANSFER_MOD,  ONLY : TRANSFER_3D
USE COMODE_MOD,    ONLY : WTAREA, WERADIUS
USE DAO_MOD,       ONLY : RH

USE CMN_FJ_MOD,    ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
USE JV_CMN_MOD          ! ODMDUST, QAA, RAA, QAA_AOD (clh)
USE COMODE_LOOP_MOD     ! NTTLOOP

USE CMN_DIAG_MOD        ! ND21, LD21
```

INPUT/OUTPUT PARAMETERS:

```
REAL*8, INTENT(IN)  :: DUST(IIPAR,JJPAR,LLPAR,NDUST)   ! Dust [kg/m3]
INTEGER, INTENT(IN) :: WAVELENGTH
```

REVISION HISTORY:

```
01 Apr 2004 - R. Martin, R. Park - Initial version
(1 ) Bundled into "dust_mod.f" (bmy, 4/1/04)
(2 ) Now references DATA_DIR from "directory_mod.f".  Now parallelize over
     the L-dimension for ND21 diagnostics. (bmy, 7/20/04)
(3 ) Archive only hydrophilic aerosol/aqueous dust surface area
     (excluding BCPO and OCPO), WTAREA and WERADIUS. (tmf, 3/6/09)
03 Feb 2011 - S. Kim.     - Include wavelength argument to determine the
                            wavelength at which the AOD should be computed.
                            This will set the optical properties that are
                            used for the calculation of the AOD. The ND21
                            diagnostic should only be updated when
                            WAVELENGTH = 1. (skim, 02/03/11)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.8 rdust_offline

Subroutine RDUST_OFFLINE reads global mineral dust concentrations as determined by P. Ginoux. Calculates dust optical depth at each level for the FAST-J routine "set_prof.f".

INTERFACE:

```
      SUBROUTINE RDUST_OFFLINE( THISMONTH, THISYEAR, WAVELENGTH )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT, GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0,     READ_BPCH2
      USE COMODE_MOD,    ONLY : ERADIUS, IXSAVE, IYSAVE
      USE COMODE_MOD,    ONLY : IZSAVE,  JLOP,   TAREA
      USE DAO_MOD,       ONLY : BXHEIGHT
      USE DIAG_MOD,      ONLY : AD21
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : ERROR_STOP
      USE TRANSFER_MOD,  ONLY : TRANSFER_3D
      USE COMODE_MOD,    ONLY : WTAREA, WERADIUS
      USE DAO_MOD,       ONLY : RH

#     include "define.h"

      USE CMN_FJ_MOD,    ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
      USE JV_CMN_MOD,    ONLY : ODMDUST, QAA, RAA, RAA_AOD, QAA_AOD
      USE COMODE_LOOP_MOD     ! NTTLOOP
      USE CMN_DIAG_MOD        ! ND21, LD21

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: THISMONTH   ! Current month (1-12)
      INTEGER, INTENT(IN) :: THISYEAR    ! Current year  (YYYY format)
      ! Determine which wavelength to use for optical properties
      INTEGER, INTENT(IN) :: WAVELENGTH
```

REVISION HISTORY:

```
   (1 ) RDUST was patterned after rdaerosol.f (rvm, 9/30/00)
   (2 ) Don't worry about rewinding the binary file...reading from
        binary files is pretty fast.  And it's only done once a month.
   (3 ) Now references punch file utility routines from F90 module
        "bpch2_mod.f".  Also reference variable DATA_DIR from the
        header file "F77_CMN_SETUP". (bmy, 9/30/00)
   (4 ) Now selects proper GEOS-STRAT dust field for 1996 or 1997.
        Also need to pass THISYEAR thru the arg list. (rvm, bmy, 11/21/00)
   (5 ) CONC is now declared as REAL*8 (rvm, bmy, 12/15/00)
   (6 ) Removed obsolete code from 12/15/00 (bmy, 12/21/00)
```

```
(7 ) CONC(IIPAR,JJPAR,LGLOB,NDUST) is now CONC(IIPAR,JJPAR,LLPAR,NDUST).
     Now use routine TRANSFER_3D from "transfer_mod.f" to cast from REAL*4
     to REAL*8 and also to convert from {IJL}GLOB to IIPAR,JJPAR,LLPAR
     space.  Use 3 arguments in call to GET_TAU0.  Updated comments.
     (bmy, 9/26/01)
(8 ) Removed obsolete code from 9/01 (bmy, 10/24/01)
(9 ) Now reference ERADIUS, IXSAVE, IYSAVE, IZSAVE, TAREA from
     "comode_mod.f".  Compute ERADIUS and TAREA for the NDUST dust
     size bins from FAST-J.  Renamed CONC to DUST to avoid conflicts.
     Also reference NTTLOOP from "comode.h".  Also added parallel
     DO-loops.  Also renamed MONTH and YEAR to THISMONTH and THISYEAR
     to avoid conflicts w/ other variables. (bmy, 11/15/01)
(10) Bug fix: Make sure to use 1996 dust data for Dec 1995 for the
     GEOS-STRAT met field dataset.  Set off CASE statement with an
     #if defined( GEOS_STRAT ) block. (rvm, bmy, 1/2/02)
(11) Eliminate obsolete code from 1/02 (bmy, 2/27/02)
(12) Now report dust optical depths in ND21 diagnostic at 400 nm.  Now
     report dust optical depths as one combined diagnostic field instead
     of 7 separate fields.  Now reference JLOP from "comode_mod.f".
     Now save aerosol surface areas as tracer #5 of the ND21 diagnostic.
     (rvm, bmy, 2/28/02)
(13) Remove declaration for TIME, since that is also defined in the
     header file "comode.h" (bmy, 3/20/02)
(14) Now read mineral dust files directly from the DATA_DIR/dust_200203/
     subdirectory (bmy, 4/2/02)
(15) Now reference BXHEIGHT from "dao_mod.f".  Also reference ERROR_STOP
     from "error_mod.f". (bmy, 10/15/02)
(16) Now call READ_BPCH2 with QUIET=TRUE to suppress extra informational
     output from being printed.  Added cosmetic changes. (bmy, 3/14/03)
(17) Since December 1997 dust data does not exist, use November 1997 dust
     data as a proxy. (bnd, bmy, 6/30/03)
(18) Bundled into "dust_mod.f" and renamed to RDUST_OFFLINE. (bmy, 4/1/04)
(19) Now references DATA_DIR from "directory_mod.f".  Now parallelize over
     the L-dimension for ND21 diagnostic. (bmy, 7/20/04)
(20) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(21) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(22) Archive only hydrophilic aerosol/aqueous dust surface area
     (excluding BCPO and OCPO), WTAREA and WERADIUS. (tmf, 3/6/09)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
03 Feb 2011 - S. Kim      - Include third input argument to determine the
                            wavelength at which the AOD should be computed.
                            This will set the optical properties that are
                            used for the calculation of the AOD.  The ND21
                            diagnostic should only be updated when
                            WAVELENGTH = 1.
```

1.29.9 init_dust

Subroutine INIT_DUST allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DUST
```

USES:

```
USE LOGICAL_MOD, ONLY : LDEAD
USE ERROR_MOD,   ONLY : ALLOC_ERR

USE CMN_SIZE_MOD      ! Size parameters
```

REVISION HISTORY:

```
30 Mar 2004 - R. Yantosca - Initial version
(1 ) Now references LDEAD from "logical_mod.f" (bmy, 7/20/04)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.29.10 cleanup_dust

Subroutine CLEANUP_DUST deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DUST
```

REVISION HISTORY:

```
30 Mar 2004 - R. Yantosca - Initial version
25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.30 Fortran: Module Interface emep_mod

Overview

Module EMEP_MOD contains variables and routines to read the EMEP European anthropogenic emission inventory for CO, NOz, and some NMVOCs. The EMEP files come from Marion Auvray and Isabelle Bey at EPFL. (bdf, bmy, amv, phs, 11/1/05, 1/28/09)

References

1. Vestreng, V., and H. Klein (2002), *Emission data reported to UNECE/EMEP: Quality insurance and trend analysis and presentation of Web-Dab*, MSC-W Status Rep. 2002:, 101 pp., Norw. Meteorol. Inst., Oslo, Norway. This paper is on the EMEP web site:

```
http://www.emep.int/mscw/mscw\_publications.html
http://www.emep.int/publ/reports/2002/mscw\_note\_1\_2002.pdf
```

2. Auvray, M., and I. Bey, *Long-Range Transport to Europe: Seasonal Variations and Implications for the European Ozone Budget*, J. Geophys. Res., **110**, D11303, doi: 10.1029/2004JD005503, 2005.

INTERFACE:

```
MODULE EMEP_MOD
```

USES:

```
IMPLICIT NONE
#   include "define.h"
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: EMISS_EMEP
PUBLIC  :: EMISS_EMEP_05x0666
PUBLIC  :: CLEANUP_EMEP
PUBLIC  :: GET_EUROPE_MASK
PUBLIC  :: GET_EMEP_ANTHRO
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: EMEP_SCALE_FUTURE
PRIVATE :: READ_EMEP_UPDATED
PRIVATE :: READ_EMEP_UPDATED_05x0666
PRIVATE :: READ_EUROPE_MASK
PRIVATE :: READ_EUROPE_MASK_05x0666
PRIVATE :: INIT_EMEP
```

REVISION HISTORY:

```
01 Nov 2005 - B. Field, R. Yantosca - Initial version
(1 ) Now only print totals for defined tracers (bmy, 2/6/06)
(2 ) Now modified for IPCC future emissions (swu, bmy, 5/30/06)
(3 ) Now yearly scale factors can be applied (phs, amv, 3/17/08)
(4 ) Now include emep SOx and emep emissions to 2005 (amv, 06/08)
(5 ) Modify to access SHIP emissions from outside (phs, 06/08)
(6 ) Account for monthly variations (amv, 12/9/08)
18 Dec 2009 - Aaron van D - Created routine EMISS_EMEP_05x0666
18 Dec 2009 - Aaron van D - Created routine READ_EMEP_UPDATED_05x0666
18 Dec 2009 - Aaron van D - Created routine READ_EUROPE_MASK_05x0666
11 Jan 2010 - Aaron van D - Max scale year is now 2007, for consistency
11 Jan 2010 - Aaron van D - Extend 1x1 emission files to 2007.  Routine
                            READ_EMEP_UPDATED now mimics routine
```

```
                            READ_EMEP_UPDATED_05x0666.
   26 Jan 2010 - R. Yantosca - Minor bug fix in INIT_EMEP
   31 Aug 2010 - R. Yantosca - Updated comments
   24 Nov 2010 - G. Vinken   - Updated EMEP mask file
```

1.30.1 get_europe_mask

Function GET_EUROPE_MASK returns the value of the EUROPE mask for EMEP emissions at grid box (I,J). MASK=1 if (I,J) is in the European region, or MASK=0 otherwise.

INTERFACE:

```
FUNCTION GET_EUROPE_MASK( I, J ) RESULT( EUROPE )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I        ! Longitude index
INTEGER, INTENT(IN) :: J        ! Latitude  index
```

RETURN VALUE:

```
REAL*8              :: EUROPE   ! Returns the mask value @ (I,J)
```

REVISION HISTORY:

```
01 Nov 2005 - B. Field, R. Yantosca - Initial version
```

1.30.2 get_emep_anthro

Function GET_EMEP_ANTHRO returns the EMEP emission for GEOS-CHEM grid box (I,J) and tracer N.

INTERFACE:

```
FUNCTION GET_EMEP_ANTHRO( I, J, N, KG_S, SHIP ) RESULT( EMEP )
```

USES:

```
USE TRACERID_MOD, ONLY : IDTNOX,  IDTCO,   IDTALK4, IDTMEK
USE TRACERID_MOD, ONLY : IDTALD2, IDTPRPE, IDTC2H6, IDTSO2
USE TRACERID_MOD, ONLY : IDTNH3
USE TRACER_MOD,   ONLY : XNUMOL
USE GRID_MOD,     ONLY : GET_AREA_CM2
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)           :: I       ! Longitude index
INTEGER, INTENT(IN)           :: J       ! Latitude index
INTEGER, INTENT(IN)           :: N       ! Tracer number
LOGICAL, INTENT(IN), OPTIONAL :: KG_S    ! Return emissions in [kg/s]
```

```
      LOGICAL, INTENT(IN), OPTIONAL :: SHIP    ! Return ship emissions
RETURN VALUE:

      REAL*8                        :: EMEP    ! Returns emissions at (I,J)
```

REVISION HISTORY:

```
01 Nov 2005 - B. Field, R. Yantosca - Initial version
(1 ) added SOx, SOx ship and NH3 emissions, plus optional kg/s output
     (amv, 06/2008)
(2 ) Now returns ship emissions if requested (phs, 6/08)
(3 ) Added checks to avoid calling unavailable ship emissions (phs, 6/08)
```

1.30.3 emiss_emep

Subroutine EMISS_EMEP reads the EMEP emission fields at 1x1 resolution and regrids them to the current model resolution.

INTERFACE:

```
      SUBROUTINE EMISS_EMEP
```

USES:

```
      USE BPCH2_MOD,         ONLY : GET_TAU0,     OPEN_BPCH2_FOR_READ
      USE FILE_MOD,          ONLY : IU_FILE,      IOERROR
      USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
      USE LOGICAL_MOD,       ONLY : LFUTURE
      USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1
      USE TIME_MOD,          ONLY : EXPAND_DATE,  GET_YEAR
      USE TIME_MOD,          ONLY : GET_MONTH
      USE SCALE_ANTHRO_MOD, ONLY : GET_ANNUAL_SCALAR

      USE CMN_SIZE_MOD       ! Size parameters
      USE CMN_O3_MOD         ! SCALEYEAR
```

REVISION HISTORY:

```
01 Nov 2005 - B. Field, R. Yantosca - Initial version
(1 ) Modified for IPCC future emissions.  Now references LFUTURE from
      "logical_mod.f". (bmy, 5/30/06)
```

1.30.4 emiss_emep_05x0666

Subroutine EMISS_EMEP reads the EMEP emission fields at 05x0666 resolution and regrids them to the current model resolution.

INTERFACE:

```
SUBROUTINE EMISS_EMEP_05x0666
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,     READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR
USE LOGICAL_MOD,       ONLY : LFUTURE
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_05x0666
USE TIME_MOD,          ONLY : EXPAND_DATE,  GET_YEAR
USE TIME_MOD,          ONLY : GET_MONTH
USE SCALE_ANTHRO_MOD, ONLY : GET_ANNUAL_SCALAR_05x0666_NESTED

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_O3_MOD         ! SCALEYEAR
```

REVISION HISTORY:

```
23 Oct 2006 - A. v. Donkelaar - Initial version, modified from EMISS_EMEP
```

1.30.5 emep_scale_future

Subroutine EMEP_SCALE_FUTURE applies the IPCC future scale factors to the EMEP anthropogenic emissions.

INTERFACE:

```
SUBROUTINE EMEP_SCALE_FUTURE
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_ALK4ff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_C2H6ff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_COff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NOxff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_PRPEff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_TONEff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_VOCff

USE CMN_SIZE_MOD             ! Size parameters
```

REVISION HISTORY:

```
30 May 2006 - S. Wu & R. Yantosca - Initial version
```

1.30.6 total_anthro_Tg

Subroutine TOTAL_ANTHRO_TG prints the amount of EMEP anthropogenic emissions that are emitted each month in Tg or Tg C.

INTERFACE:

```
SUBROUTINE TOTAL_ANTHRO_TG( EMEP_YEAR, EMISS_YEAR, EMEP_MONTH )
```

USES:

```
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE LOGICAL_MOD,  ONLY : LEMEPSHIP
USE TIME_MOD,     ONLY : ITS_A_LEAPYEAR
USE TRACER_MOD,   ONLY : XNUMOL
USE TRACERID_MOD, ONLY : IDTNOX,  IDTCO,   IDTALK4, IDTMEK
USE TRACERID_MOD, ONLY : IDTALD2, IDTPRPE, IDTC2H6, IDTSO2
USE TRACERID_MOD, ONLY : IDTNH3

USE CMN_SIZE_MOD     ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)   :: EMEP_YEAR    ! EMEP base year
INTEGER, INTENT(IN)   :: EMISS_YEAR   ! Current simulated year
INTEGER, INTENT(IN)   :: EMEP_MONTH   ! Current simulated month
```

REVISION HISTORY:

```
10 Nov 2004 - R. Hudman, R. Yantosca - Initial version
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(2 ) Now replace FMOL with TRACER_MW_KG (bmy, 10/25/05)
(3 ) Now only print totals of defined tracers; other totals will be
     printed as zeroes. (bmy, 2/6/06)
(4 ) Now emissions and base year are arguments. Output in Tg/month
     since this is called monthly (phs, 12/9/08)
(5 ) Bug fix, now print out correct monthly EMEP totals (bmy, 1/30/09)
```

1.30.7 read_europe_mask

Subroutine READ_EUROPE_MASK reads and regrids the Europe mask for the EMEP anthropogenic emissions.

INTERFACE:

```
SUBROUTINE READ_EUROPE_MASK
```

USES:

```
USE BPCH2_MOD,      ONLY : READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
18 Oct 2006 - R. Yantosca - Initial version
(1 ) Now read the Europe mask from a disk file instead of defining it as
      a rectangular box (bmy, 10/18/06)
(2 ) Updated the mask file to correspond with the 200911 EMEP emissions
      (gvinken, 11/24/10)
```

1.30.8 read_europe_mask_05x0666

Subroutine READ_EUROPE_MASK reads and regrids the Europe mask for the EMEP anthropogenic emissions.

INTERFACE:

```
SUBROUTINE READ_EUROPE_MASK_05x0666
```

USES:

```
USE BPCH2_MOD,      ONLY : READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR
USE REGRID_1x1_MOD, ONLY : DO_REGRID_05x0666

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
18 Oct 2006 - R. Yantosca - Initial version
(1 ) Now read the Europe mask from a disk file instead of defining it as
      a rectangular box (bmy, 10/18/06)
```

1.30.9 read_emep_updated

Subroutine READ_EMEP_UPDATED reads updated EMEP emissions from the year 1990 including SOx emissions. These are regridded to the simulation resolution. Ship emissions can also be included.

INTERFACE:

```
SUBROUTINE READ_EMEP_UPDATED( TRACER, EMEP_YEAR, ARRAY, wSHIP )
```

USES:

```
USE BPCH2_MOD,      ONLY : READ_BPCH2, GET_TAU0
USE TIME_MOD,       ONLY : EXPAND_DATE, GET_MONTH
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1
USE LOGICAL_MOD,    ONLY : LEMEPSHIP
USE GRID_MOD,       ONLY : GET_AREA_CM2
USE TRACERID_MOD,   ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_O3_MOD         ! SCALEYEAR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: TRACER             ! Tracer number
INTEGER, INTENT(IN)  :: EMEP_YEAR          ! Year of emissions to read
INTEGER, INTENT(IN)  :: wSHIP              ! Use ground, ship, or both?
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: ARRAY(IIPAR,JJPAR)  ! Output array
```

REVISION HISTORY:

```
28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial version
28 Jan 2009 - P. Le Sager - Now account for LEMEPSHIP
29 Oct 2009 - Added multi-species seasonality (amv)
04 Jan 2010 - Extended to 2007, changed input format (amv)
```

1.30.10 read_emep_updated_05x0666

Subroutine READ_EMEP_UPDATED reads updated EMEP emissions from the year 1990 including SOx emissions. These are regridded to the simulation resolution. Ship emissions can also be included.

INTERFACE:

```
SUBROUTINE READ_EMEP_UPDATED_05x0666( TRACER, EMEP_YEAR, ARRAY,
&                   wSHIP )
```

USES:

```
USE BPCH2_MOD,      ONLY : READ_BPCH2, GET_TAU0
USE TIME_MOD,       ONLY : EXPAND_DATE, GET_MONTH
USE DIRECTORY_MOD,  ONLY : DATA_DIR
USE REGRID_1x1_MOD, ONLY : DO_REGRID_05x0666
USE LOGICAL_MOD,    ONLY : LEMEPSHIP
USE TRACERID_MOD,   ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3
USE GRID_MOD,       ONLY : GET_AREA_CM2

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_O3_MOD         ! SCALEYEAR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: TRACER             ! Tracer number
INTEGER, INTENT(IN)  :: EMEP_YEAR          ! Year of emissions to read
INTEGER, INTENT(IN)  :: wSHIP              ! Use ground, ship, or both?
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: ARRAY(IIPAR,JJPAR)  ! Output array
```

REVISION HISTORY:

```
28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial version
28 Jan 2009 - P. Le Sager - Now account for LEMEPSHIP
29 Oct 2009 - Added multi-species seasonality (amv)
```

1.30.11 init_emep

Subroutine INIT_EMEP allocates and zeroes EMEP module arrays, and also creates the mask which defines the European region.

INTERFACE:

```
SUBROUTINE INIT_EMEP
```

USES:

```
! References to F90 modules
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE GRID_MOD,    ONLY : GET_XMID, GET_YMID
USE LOGICAL_MOD, ONLY : LEMEP

USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
01 Nov 2005 - B. Field, R. Yantosca - Initial version
(1 ) Now call READ_EUROPE_MASK to read & regrid EUROPE_MASK from disk
      instead of just defining it as a rectangular box. (bmy, 10/18/06)
26 Jan 2010 - R. Yantosca - Fixed cut-n-paste error.  Now make sure to zero
                            EMEP_CO_SHIP and EMEP_NOx_SHIP.
```

1.30.12 cleanup_emep

Subroutine CLEANUP_EMEP deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_EMEP
```

REVISION HISTORY:

```
1 Nov 2005 - R. Yantosca - Initial Version
```

1.31 Fortran: Module Interface emissions_mod

Module EMISSIONS_MOD is used to call the proper emissions subroutines for the various GEOS-Chem simulations.

INTERFACE:

```
      MODULE EMISSIONS_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: DO_EMISSIONS
  !PUBLIC MEMBER DATA:
      !FP_ISOP (6/2009)
      PUBLIC :: ISOP_SCALING,NOx_SCALING
```

REVISION HISTORY:

```
   11 Feb 2003 - R. Yantosca - Initial version
   (1 ) Now references DEBUG_MSG from "error_mod.f"
   (2 ) Now references "Kr85_mod.f" (jsw, bmy, 8/20/03)
   (3 ) Now references "carbon_mod.f" and "dust_mod.f" (rjp, tdf, bmy, 4/2/04)
   (4 ) Now references "seasalt_mod.f" (rjp, bmy, bec, 4/20/04)
   (5 ) Now references "logical_mod" & "tracer_mod.f" (bmy, 7/20/04)
   (6 ) Now references "epa_nei_mod.f" and "time_mod.f" (bmy, 11/5/04)
   (7 ) Now references "emissions_mod.f" (bmy, 12/7/04)
   (8 ) Now calls EMISSSULFATE if LCRYST=T.  Also read EPA/NEI emissions for
        the offline aerosol simulation. (bmy, 1/11/05)
   (9 ) Remove code for the obsolete CO-OH param simulation (bmy, 6/24/05)
   (10) Now references "co2_mod.f" (pns, bmy, 7/25/05)
   (11) Now references "emep_mod.f" (bdf, bmy, 10/1/05)
   (12) Now references "gfed2_biomass_mod.f" (bmy, 3/30/06)
   (13) Now references "bravo_mod.f" (rjp, kfb, bmy, 6/26/06)
   (14) Now references "edgar_mod.f" (avd, bmy, 7/6/06)
   (15) Now references "streets_anthro_mod.f" (yxw, bmy, 8/18/06)
   (16) Now references "h2_hd_mod.f" (lyj, phs, 9/18/07)
   (17) Now calls EMISSDR for tagged CO simulation (jaf, mak, bmy, 2/14/08)
   (18) Now references "cac_anthro_mod.f" (amv, phs, 03/11/08)
   (19) Now references "vistas_anthro_mod.f" (amv, 12/02/08)
   (20) Bug fixe : add specific calls for Streets for the grid 0.5x0.666.
        (dan, ccc, 3/11/09)
   18 Dec 2009 - Aaron van D - Added emissions for nested grids @ 0.5 x 0.666
   26 Fev 2010 - Fabien P.   - Add scaling for isoprene and Nox emissions
   07 Feb 2011 - R. Yantosca - Now use EPA/NEI99 biofuel emissions when
                               EPA/NEI05 anthro emissions are selected.
```

1.31.1 do_emissions

Subroutine DO_EMISSIONS is the driver routine which calls the appropriate emissions subroutine for the various GEOS-CHEM simulations.

INTERFACE:

```
SUBROUTINE DO_EMISSIONS
```

USES:

```
USE BIOMASS_MOD,            ONLY : COMPUTE_BIOMASS_EMISSIONS
USE ARCTAS_SHIP_EMISS_MOD,  ONLY : EMISS_ARCTAS_SHIP
USE BRAVO_MOD,              ONLY : EMISS_BRAVO
USE C2H6_MOD,               ONLY : EMISSC2H6
USE CAC_ANTHRO_MOD,         ONLY : EMISS_CAC_ANTHRO
USE CAC_ANTHRO_MOD,         ONLY : EMISS_CAC_ANTHRO_05x0666
USE CARBON_MOD,             ONLY : EMISSCARBON
USE CH3I_MOD,               ONLY : EMISSCH3I
USE CO2_MOD,                ONLY : EMISSCO2
USE DUST_MOD,               ONLY : EMISSDUST
USE EDGAR_MOD,              ONLY : EMISS_EDGAR
USE EMEP_MOD,               ONLY : EMISS_EMEP
USE EMEP_MOD,               ONLY : EMISS_EMEP_05x0666
USE EPA_NEI_MOD,            ONLY : EMISS_EPA_NEI
USE ERROR_MOD,              ONLY : DEBUG_MSG
USE GLOBAL_CH4_MOD,         ONLY : EMISSCH4
USE H2_HD_MOD,              ONLY : EMISS_H2_HD
USE HCN_CH3CN_MOD,          ONLY : EMISS_HCN_CH3CN
USE LOGICAL_MOD
USE MERCURY_MOD,            ONLY : EMISSMERCURY
USE NEI2005_ANTHRO_MOD,     ONLY : EMISS_NEI2005_ANTHRO
USE NEI2005_ANTHRO_MOD,     ONLY : EMISS_NEI2005_ANTHRO_05x0666
USE RETRO_MOD,              ONLY : EMISS_RETRO
USE RnPbBe_MOD,             ONLY : EMISSRnPbBe
USE SEASALT_MOD,            ONLY : EMISSSEASALT
USE STREETS_ANTHRO_MOD,     ONLY : EMISS_STREETS_ANTHRO
USE STREETS_ANTHRO_MOD,     ONLY : EMISS_STREETS_ANTHRO_05x0666
USE SULFATE_MOD,            ONLY : EMISSSULFATE
USE TIME_MOD,               ONLY : GET_MONTH,       GET_YEAR
USE TIME_MOD,               ONLY : ITS_A_NEW_MONTH, ITS_A_NEW_YEAR
USE TRACER_MOD
USE TAGGED_CO_MOD,          ONLY : EMISS_TAGGED_CO
USE VISTAS_ANTHRO_MOD,      ONLY : EMISS_VISTAS_ANTHRO
USE ICOADS_SHIP_MOD,        ONLY : EMISS_ICOADS_SHIP !(cklee,7/09/09)

USE CMN_SIZE_MOD                 ! Size parameters
USE CMN_O3_MOD                   ! FSCLYR
```

REVISION HISTORY:

```
(1 ) Now references DEBUG_MSG from "error_mod.f" (bmy, 8/7/03)
(2 ) Now calls Kr85 emissions if NSRCX == 12 (jsw, bmy, 8/20/03)
(3 ) Now calls EMISSCARBON and EMISSDUST for carbon aerosol and dust
```

```
      aerosol chemistry (rjp, tdf, bmy, 4/2/04)
(4 ) Now calls EMISSSEASALT for seasalt emissions (rjp, bec, bmy, 4/20/04)
(5 ) Now use inquiry functions from "tracer_mod.f".  Now references
      "logical_mod.f" (bmy, 7/20/04)
(6 ) Now references ITS_A_NEW_MONTH from "time_mod.f".  Now references
      EMISS_EPA_NEI from "epa_nei_mod.f" (bmy, 11/5/04)
(7 ) Now calls EMISSMERCURY from "mercury_mod.f" (eck, bmy, 12/7/04)
(8 ) Now calls EMISSSULFATE if LCRYST=T.  Also read EPA/NEI emissions for
      the offline sulfate simulation.  Also call EMISS_EPA_NEI for the
      tagged CO simulation. (cas, bmy, stu, 1/10/05).
(9 ) Now call EMISSSEASALT before EMISSSULFATE (bec, bmy, 4/13/05)
(10) Now call EMISS_HCN_CH3CN from "hcn_ch3cn_mod.f".   Also remove all
      references to the obsolete CO-OH param simulation. (xyp, bmy, 6/23/05)
(11) Now call EMISSCO2 from "co2_mod.f" (pns, bmy, 7/25/05)
(12) Now references EMISS_EMEP from "emep_mod.f" (bdf, bmy, 11/1/05)
(13) Now call GFED2_COMPUTE_BIOMASS to read 1x1 biomass emissions and
      regrid to the model resolution once per month. (bmy, 3/30/06)
(14) Now references EMISS_BRAVO from "bravo_mod.f" (rjp, kfb, bmy, 6/26/06)
(15) Now references EMISS_EDGAR from "edgar_mod.f" (avd, bmy, 7/6/06)
(16) Now references EMISS_STREETS_ANTHRO from "streets_anthro_mod.f"
      (yxw, bmy, 8/17/06)
(17) Now calls EMISSDR for tagged CO simulation (jaf, mak, bmy, 2/18/08)
(18) Now references EMISS_CAC_ANTHRO from "cac_anthro_mod.f"
      (amv, phs, 3/11/08)
(19) Now references EMISS_ARCTAS_SHIP from "arctas_ship_emiss_mod.f"
      (phs, 5/12/08)
(20) Now references EMISS_VISTAS_ANTHR from "vistas_anthro_mod.f". Call
      EMEP, and Streets every month (amv, 12/2/08)
(21) Now references EMISS_NEI2005_ANTHRO from "nei2005_anthro_mod.f"
      (amv, 10/19/09)
18 Dec 2009 - Aaron van D - Added emissions for nested grids @ 0.5 x 0.666
08 Feb 2010 - NBIOMAX is now in F77_CMN_SIZE
07 Feb 2011 - R. Yantosca - Use NEI99 biofuels when useing NEI05 anthro
17 Aug 2011 - R. Yantosca - Added call to RETRO anthro emissions
```

1.32 Fortran: Module Interface fjx_acet_mod

Overview

This module contains functions used for the new acetone pressure dependency calculation in JRATET.f introduced in FAST-JX version 6.4 The temperature interpolation factors and the Xsect are different for both acetone photolysis reactions and interdependant. See use in JRATET.f

Reference

Blitz, M. A., D. E. Heard, M. J. Pilling, S. R. Arnold, M. P. Chipperfield 2004: *Pressure and temperature-dependent quantum yields for the photodissociation of acetone between 279 and 327.5 nm*, GRL, **31**, 9, L09104.

INTERFACE:

```
      MODULE FJX_ACET_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: QQ2_F
      PUBLIC :: QQ1_F
      PUBLIC :: TFACA_F
      PUBLIC :: TFAC0_F
      PUBLIC :: TFAC_F
```

AUTHOR:

```
  Original code from Michael Prather.
  Implemented into GEOS-Chem by Claire Carouge (ccarouge@seas.harvard.edu)
```

REVISION HISTORY:

```
  20 Apr 2009 - C. Carouge - Created the module from fastJX64.f code.
```

1.32.1 tfaca_f

Calculates temperature interpolation factors for acetone

INTERFACE:

```
      FUNCTION TFACA_F(TTT, IV)
  !USES
      USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
      USE JV_CMN_MOD
```

INPUT PARAMETERS:

```
      ! Index of the specie in jv_spec.dat (should be between 4 and NJVAL)
      INTEGER :: IV

      ! Temperature in 1 grid box
      REAL*8  :: TTT
  !OUTPUT VALUE:
      ! Temperature interpolation factor
      REAL*8  :: TFACA_F
                                with the "D" double-precision exponent.
```

1.32.2 tfac0_f

Calculates temperature interpolation factors for acetone

INTERFACE:

```
      FUNCTION TFAC0_F(TTT, IV)
```

USES:

```
      USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
      USE JV_CMN_MOD
```

INPUT PARAMETERS:

```
      ! Index of the specie in jv_spec.dat (should be between 4 and NJVAL)
      INTEGER :: IV

      ! Temperature in 1 grid box
      REAL*8  :: TTT
  !OUTPUT VALUE:
      ! Temperature interpolation factor
      REAL*8  :: TFAC0_F
```

1.32.3 tfac_f

Calculates temperature interpolation factors for acetone

INTERFACE:

```
      FUNCTION TFAC_F(TTT, IV)
```

USES:

```
      USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
      USE JV_CMN_MOD
```

INPUT PARAMETERS:

```
      ! Index of the specie in jv_spec.dat (should be between 4 and NJVAL)
      INTEGER :: IV

      ! Temperature in 1 grid box
      REAL*8  :: TTT

  !OUTPUT VALUE:
      ! Temperature interpolation factor
      REAL*8  :: TFAC_F
```

1.32.4 qq2_f

This routine computes the cross-section for acetone.

INTERFACE:

```
FUNCTION QQ2_F(TFAC0, IV, K, TTT)
```

USES:

```
USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
USE JV_CMN_MOD
```

INPUT PARAMETERS:

```
! Index of the specie in jv_spec.dat (should be between 4 and NJVAL)
INTEGER :: IV

! Wavelength
INTEGER :: K

! Temperature in 1 grid box
REAL*8  :: TTT

! Temperature interpolation factor from TFAC0_F function
REAL*8  :: TFAC0
!OUTPUT VALUE:
! Xsect (total abs) for Acetone
REAL*8  :: QQ2_F
!NOTES:
 (1 ) We use IV-3 and not IV because there is no QQQ values for O2, O3
      and O1-D. (ccc, 4/20/19)
```

1.32.5 qq1_f

This routine computes the cross-section for acetone.

INTERFACE:

```
FUNCTION QQ1_F(TFAC, IV, K)
```

USES:

```
USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
USE JV_CMN_MOD
```

INPUT PARAMETERS:

```
! Index of the specie in jv_spec.dat (should be between 4 and NJVAL)
INTEGER :: IV
```

```
      ! Wavelength
      INTEGER :: K

      ! Temperature interpolation factor from TFAC_F function
      REAL*8  :: TFAC
  !OUTPUT VALUE:
      ! Xsect (total abs) for Acetone
      REAL*8  :: QQ1_F
  !NOTES:
   (1 ) We use IV-3 and not IV because there is no QQQ values for O2, O3
        and O1-D. (ccc, 4/20/19)
```

1.33 Fortran: Module Interface gamap_mod

Module GAMAP_MOD contains routines to create GAMAP "tracerinfo.dat" and "diaginfo.dat" files which are customized to each particular GEOS-Chem simulation.

INTERFACE:

```
      MODULE GAMAP_MOD
```

USES:

```
      USE CMN_SIZE_MOD             ! Dimensions of arrays
      USE CMN_DIAG_MOD             ! Diagnostic parameters

      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: DO_GAMAP
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: CREATE_DINFO
      PRIVATE :: CREATE_TINFO
      PRIVATE :: WRITE_TINFO
      PRIVATE :: WRITE_SEPARATOR
      PRIVATE :: INIT_DIAGINFO
      PRIVATE :: INIT_TRACERINFO
      PRIVATE :: INIT_GAMAP
      PRIVATE :: CLEANUP_GAMAP
```

REMARKS:

```
   For more information, please see the GAMAP Online Users' Manual:
    http://acmg.seas.harvard.edu/gamap/doc/index.html
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
(1 ) Minor bug fix for Rn/Pb/Be simulations (bmy, 5/11/05)
(2 ) Added ND09 diagnostic for HCN/CH3CN simulation. (bmy, 6/30/05)
(3 ) Added ND04 diagnostic for CO2 simulation (bmy, 7/25/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Add MBO to ND46 diagnostic (tmf, bmy, 10/20/05)
(6 ) Updated for tagged Hg simulation (cdh, bmy, 4/6/06)
(7 ) Updated for ND56 lightning flash diagnostics (ltm, bmy, 5/5/06)
(8 ) Updated for ND42 SOA concentration diagnostics (dkh, bmy, 5/22/06)
(9 ) Updated for ND36 CH3I simulation diagnostics (bmy, 7/25/06)
(10) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(11) Add routines INIT_DIAGINFO, INIT_TRACERINFO for clarity.  Added new
     entries for biomass burning (ND28) and time in tropopshere (ND54)
     in INIT_DIAGINFO and INIT_TRACERINFO. (phs, bmy, 10/17/06)
(12) Now write GPROD & APROD info to diaginfo.dat, tracerinfo.dat files,
     for the SOA restart files (tmf, havala, bmy, 2/6/07)
(13) Added ND10 diagnostic for H2/HD simulation. (phs, 9/18/07)
(14) Change category name for ND31 diagnostic (bmy, 11/16/07)
(15) Add to tracerinfo.dat file for timeseries and Rn-Pb-Be (bmy, 2/22/08)
(16) Added ND52 diagnostic for gamma HO2 (jaegle 02/26/09)
(17) Add gamap info for dicarbonyl simulation (tmf, 3/10/09)
(18) Add C2H4 in ND46 (ccc, 3/10/09)
(19) Add EFLUX to ND67 (lin, ccc, 5/29/09)
(20) Minor bug fixes (bmy, phs, 10/9/09)
(20) Minor bug fixes (dkh, bmy, 11/19/09)
(21) Include second satellite overpass diagnostic.  Adjust AOD name to 550
     nm from 400 nm.  Add additional dust AOD bins.  Output values to
     hdf_mod. (amv, bmy, 12/1/09)
03 Aug 2010 - R. Yantosca - Added ProTeX headers
03 Aug 2010 - R. Yantosca - Now move the #include "F77_CMN_SIZE" and
                            #include "F77_CMN_DIAG" to the top of module
13 Aug 2010 - R. Yantosca - Added modifications for MERRA
21 Sep 2010 - R. Yantosca - Removed duplicates in INIT_DIAGINFO
21 Oct 2010 - R. Yantosca - Bug fix in INIT_DIAGINFO
09 Dec 2010 - C. Carouge  - Modify MAXTRACER definition to account for
```

1.33.1 do_gamap

Subroutine DO_GAMAP is the driver program for creating the customized GAMAP files "diaginfo.dat" and "tracerinfo.dat".

INTERFACE:

```
SUBROUTINE DO_GAMAP( DIAGINFO, TRACERINFO )
```

USES:

```
USE TIME_MOD,   ONLY : SYSTEM_TIMESTAMP
USE TRACER_MOD, ONLY : GET_SIM_NAME
```

INPUT PARAMETERS:

```
CHARACTER(LEN=255), INTENT(IN) :: DIAGINFO    ! Path of "diaginfo.dat"
CHARACTER(LEN=255), INTENT(IN) :: TRACERINFO  ! Path of "tracerinfo.dat"
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
03 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.33.2 create_dinfo

Subroutine CREATE_DINFO writes information about diagnostic categories to a customized "diaginfo.dat" file. (bmy, 5/3/05)

INTERFACE:

```
SUBROUTINE CREATE_DINFO
```

USES:

```
USE FILE_MOD, ONLY : IOERROR, IU_FILE
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
03 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.33.3 create_tinfo

Subroutine CREATE_TINFO writes information about tracers to a customized tracerinfo.dat" file.

INTERFACE:

```
SUBROUTINE CREATE_TINFO
```

USES:

```
USE FILE_MOD,    ONLY : IOERROR, IU_FILE
USE LOGICAL_MOD, ONLY : LSOA
```

REVISION HISTORY:

```
21 Apr 2005 - R. Yantosca - Initial version
(1 ) Now write out tracers in ug/m3 (dkh, bmy, 5/22/06)
(2 ) Now write out GPROD & APROD info (tmf, havala, bmy, 2/6/07)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.33.4 write_tinfo

Subroutine WRITE_TINFO writes one line to the customized "tracerinfo.dat" file.

INTERFACE:

```
SUBROUTINE WRITE_TINFO( NAME, FNAME, MWT, MOLC, SCALE, UNIT, N )
```

USES:

```
USE FILE_MOD, ONLY : IU_FILE, IOERROR
```

INPUT PARAMETERS:

```
CHARACTER(LEN=*), INTENT(IN) :: NAME    ! GAMAP short tracer name
CHARACTER(LEN=*), INTENT(IN) :: FNAME   ! GAMAP long tracer name
REAL*4,           INTENT(IN) :: MWT     ! Molecular weight [kg/mole]
INTEGER,          INTENT(IN) :: MOLC    ! Moles C/mole tracer (for HC's)
INTEGER,          INTENT(IN) :: N       ! Tracer number
REAL*4,           INTENT(IN) :: SCALE   ! GAMAP scale factor
CHARACTER(LEN=*), INTENT(IN) :: UNIT    ! Unit string
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
03 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.33.5 write_separator

Subroutine WRITE_SEPARATOR writes a separator block to the customized "tracerinfo.dat" file.

INTERFACE:

```
SUBROUTINE WRITE_SEPARATOR( DIAG )
```

USES:

```
USE FILE_MOD, ONLY : IU_FILE, IOERROR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: DIAG   ! GEOS-Chem diagnostic number
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
06 Feb 2007 - R. Yantosca - Added new header for GPROD & APROD info
03 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.33.6 init_diaginfo

Subroutine INIT_DIAGINFO initializes the CATEGORY, DESCRIPT, and OFFSET variables, which are used to define the "diaginfo.dat" file for GAMAP.

INTERFACE:

```
SUBROUTINE INIT_DIAGINFO
```

REVISION HISTORY:

```
17 Oct 1996 - R. Yantosca - Initial version
(1 ) Split this code off from INIT_GAMAP, for clarity.  Now declare biomass
     burning emissions w/ offset of 45000.  Now declare time in the
     troposphere diagnostic with offset of 46000. (phs, bmy, 10/17/06)
(2 ) Now add IJ-GPROD & IJ-APROD w/ offset of SPACING*6, for the SOA
     GPROD & APROD restart file. (tmf, havala, bmy, 2/6/07)
(3 ) Now declare H2-HD sources w/ offset of 48000. Now declare H2-HD
     production/loss w/ offset of 47000. (phs, 9/18/07)
(4 ) Change diagnostic category for ND31 diagnostic from "PS-PTOP"
     to "PEDGE-$" (bmy, 11/16/07)
(5 ) Add categories CH4-LOSS, CH4-EMISS and WET-FRAC (kjw, 8/18/09)
(6 ) Add potential temperature category. (fp, 2/26/10)
21 May 2010 - C. Carouge  - Add diagnostic for mercury simulation
03 Aug 2010 - R. Yantosca - Added ProTeX headers
21 Sep 2010 - R. Yantosca - Remove duplicate definitions of CV-FLX-$,
                            TURBMC-$, EW-FLX-$, NS-FLX-$, UP-FLX-$
21 Oct 2010 - R. Yantosca - Bug fix: MC-FRC-$ should have an offset of
                            SPACING*3 since it has units of kg/s.
```

1.33.7 init_tracerinfo

Subroutine INIT_TRACERINFO initializes the NAME, FNAME, MWT, MOLC, INDEX, MOLC, UNIT arrays which are used to define the "tracerinfo.dat" file.

INTERFACE:

```
SUBROUTINE INIT_TRACERINFO
```

USES:

```
USE DIAG03_MOD,   ONLY : ND03, PD03, PD03_PL
USE DIAG04_MOD,   ONLY : ND04
USE DIAG41_MOD,   ONLY : ND41
USE DIAG42_MOD,   ONLY : ND42
USE DIAG48_MOD,   ONLY : DO_SAVE_DIAG48
USE DIAG49_MOD,   ONLY : DO_SAVE_DIAG49
USE DIAG50_MOD,   ONLY : DO_SAVE_DIAG50
```

```
      USE DIAG51_MOD,   ONLY : DO_SAVE_DIAG51
      USE DIAG51b_MOD,  ONLY : DO_SAVE_DIAG51b
      USE DIAG56_MOD,   ONLY : ND56
      USE DIAG_PL_MOD,  ONLY : DO_SAVE_PL,  GET_NFAM
      USE DIAG_PL_MOD,  ONLY : GET_FAM_MWT, GET_FAM_NAME
      USE DRYDEP_MOD,   ONLY : DEPNAME,     NUMDEP,    NTRAIND
      USE LOGICAL_MOD,  ONLY : LSOA
      USE TRACER_MOD,   ONLY : ITS_A_CO2_SIM,    ITS_A_H2HD_SIM
      USE TRACER_MOD,   ONLY : ITS_A_CH3I_SIM,   ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,   ONLY : ITS_A_HCN_SIM,    ITS_A_MERCURY_SIM
      USE TRACER_MOD,   ONLY : ITS_A_RnPbBe_SIM, ITS_A_TAGOX_SIM
      USE TRACER_MOD,   ONLY : N_TRACERS,        TRACER_COEFF
      USE TRACER_MOD,   ONLY : TRACER_MW_KG,     TRACER_NAME
      USE TRACERID_MOD, ONLY : IDTBCPI, IDTOCPI, IDTALPH, IDTLIMO
      USE TRACERID_MOD, ONLY : IDTSOA1, IDTSOA2, IDTSOA3, NEMANTHRO
      !(hotp, 7/31/08)
      USE TRACERID_MOD, ONLY : IDTSOA4, IDTSOAM, IDTSOAG, IDTSOA5
      USE TRACERID_MOD, ONLY : IDTGLYX, IDTMGLY, IDTC2H4, IDTC2H2
      USE TRACERID_MOD, ONLY : IDTGLYC, IDTHAC
      USE WETSCAV_MOD,  ONLY : GET_WETDEP_IDWETD, GET_WETDEP_NSOL
      !(FP, 6/2009) To remove hard-wired for biomass burning
      USE TRACERID_MOD, ONLY : IDBNOX,  IDBCO,   IDBALK4, IDBACET
      USE TRACERID_MOD, ONLY : IDBMEK,  IDBALD2, IDBPRPE, IDBC3H8
      USE TRACERID_MOD, ONLY : IDBCH2O, IDBC2H6
      USE TRACERID_MOD, ONLY : IDBSO2,  IDBNH3
      USE TRACERID_MOD, ONLY : IDBBC,   IDBOC
      USE TRACERID_MOD, ONLY : IDBXYLE, IDBBENZ, IDBTOLU
      USE TRACERID_MOD, ONLY : IDBGLYX, IDBMGLY, IDBC2H4, IDBC2H2
      USE TRACERID_MOD, ONLY : IDBGLYC, IDBHAC
      USE TRACERID_MOD, ONLY : IDTNOX,  IDTCO,   IDTALK4, IDTACET
      USE TRACERID_MOD, ONLY : IDTMEK,  IDTALD2, IDTPRPE, IDTC3H8
      USE TRACERID_MOD, ONLY : IDTCH2O, IDTC2H6
      USE TRACERID_MOD, ONLY : IDTSO2,  IDTNH3
      USE TRACERID_MOD, ONLY : IDTBCPI,   IDTOCPI
      USE TRACERID_MOD, ONLY : IDTXYLE, IDTBENZ, IDTTOLU
      USE TRACERID_MOD, ONLY : N_Hg_CATS  !CDH for snowpack
```

REVISION HISTORY:

```
      17 Oct 1996 - R. Yantosca & P. Le Sager - Initial version
      (1 ) Split this code off from INIT_GAMAP, for clarity.  Also now declare
           biomass burning emissions w/ offset of 45000.  Bug fix: write out
           26 tracers for ND48, ND49, ND50, ND51 timeseries.  Also define
           ND54 diagnostic with offset of 46000. (bmy, 10/17/06)
      (2 ) Modifications for H2/HD in ND10, ND44 diagnostics (phs, 9/18/07)
      (3 ) Now write out PBLDEPTH diagnostic information to "tracerinfo.dat" if
           any of ND41, ND48, ND49, ND50, ND51 are turned on.  Also set the
           unit to "kg/s" for the Rn-Pb-Be ND44 drydep diag. (cdh, bmy, 2/22/08)
```

```
(4 ) Added C2H4 in ND46 (ccc, 2/2/09)
(5 ) Add EFLUX to ND67 (lin, ccc, 5/29/08)
(6 ) Bug fix in ND28: ALD2 should have 2 carbons, not 3.  Also bug fix
     in ND66 to print out the name of ZMMU correctly. (dbm, bmy, 10/9/09)
(7 ) Previous bug fix was erroneous; now corrected (dkh, bmy, 11/19/09)
(8 ) Include second satellite overpass diagnostic.  Adjust AOD name to 550
     nm from 400 nm.  Add additional dust AOD bins (amv, bmy, 12/18/09)
20 Jul 2010 - C. Carouge  - Modifications to ND03 for mercury.
03 Aug 2010 - R. Yantosca - Added ProTeX headers
13 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
02 Sep 2010 - R. Yantosca - In ND28: Omit SOA tracers if LSOA = .FALSE.
12 Nov 2010 - R. Yantosca - Need to save out surface pressure line to
                            tracerinfo.dat for the timeseries diagnostics
```

1.33.8 init_gamap

Subroutine INIT_GAMAP allocates and initializes all module variables.

INTERFACE:

```
SUBROUTINE INIT_GAMAP( DIAGINFO, TRACERINFO )
```

USES:

```
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE TIME_MOD,    ONLY : EXPAND_DATE, GET_NHMSb, GET_NYMDb
USE LOGICAL_MOD, ONLY : LND50_HDF,   LND51_HDF, LND51b_HDF
USE HDF_MOD,     ONLY : INIT_HDF
USE HDF_MOD,     ONLY : HDFCATEGORY
USE HDF_MOD,     ONLY : HDFDESCRIPT
USE HDF_MOD,     ONLY : HDFNAME
USE HDF_MOD,     ONLY : HDFFNAME
USE HDF_MOD,     ONLY : HDFUNIT
USE HDF_MOD,     ONLY : HDFMOLC
USE HDF_MOD,     ONLY : HDFMWT
USE HDF_MOD,     ONLY : HDFSCALE
```

INPUT PARAMETERS:

```
CHARACTER(LEN=255), INTENT(IN) :: DIAGINFO    ! Path for "diaginfo.dat"
CHARACTER(LEN=255), INTENT(IN) :: TRACERINFO  ! Path for "tracerinfo.dat"
```

REVISION HISTORY:

```
22 Apr 2005 - R. Yantosca - Initial version
(1 ) Now add proper UNIT & SCALE for Rn/Pb/Be simulations (bmy, 5/11/05)
(2 ) Added HCN & CH3CN source & sink info for ND09 (bmy, 6/27/05)
(3 ) Bug fix: removed duplicate category names.  Updated for CO2-SRCE
     diagnostic.  Now references ND04 from "diag04_mod.f.
```

```
      (pns, bmy, 7/25/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Now save MBO as tracer #5 for ND46 (tmf, bmy, 10/20/05)
(6 ) Now add categories CV-FLX-$, TURBMC-$, EW-FLX-$, NS-FLX-$, UP-FLX-$
      which had been inadvertently omitted.  Also add OCEAN-HG category.
      Rewrote do loop and case statement to add new diagnostics to ND03.
      Now make units of Hg tracers "pptv", not "ppbv".  Now remove
      restriction on printing out cloud mass flux in GEOS-4 for the ND66
      diagnostic.  Added new sea salt category. (cdh, eck, bmy, 4/6/06)
(7 ) Now references ND56 from "diag56_mod.f" (ltm, bmy, 5/5/06)
(8 ) Now references ND42 from "diag42_mod.f".  Also updated for extra SOA
      tracers in ND07 diagnostic. (dkh, bmy, 5/22/06)
(9 ) Updated ND36 for CH3I simulation (bmy, 7/25/06)
(10) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(11) Split into INIT_DIAGINFO, INIT_TRACERINFO for clarity (bmy, 9/28/06)
(12) Save output to HDF_MOD (amv, bmy, 12/18/09)
03 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.33.9 cleanup_gamap

Subroutine CLEANUP_GAMAP deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_GAMAP
```

REVISION HISTORY:

```
25 Apr 2005 - R. Yantosca - Initial version
03 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.34 Fortran: Module Interface gfed3_biomass_mod

Module GFED3_BIOMASS_MOD contains routines and variables used in the wet scavenging of tracer in cloud updrafts, rainout, and washout.

INTERFACE:

```
MODULE GFED3_BIOMASS_MOD
```

USES:

```
IMPLICIT NONE
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: GFED3_COMPUTE_BIOMASS
      PUBLIC  :: CLEANUP_GFED3_BIOMASS
      PUBLIC  :: GFED3_IS_NEW
   PRIVATE MEMBER FUNCTIONS:
      PRIVATE :: CHECK_GFED3
      PRIVATE :: GFED3_AVAILABLE
      PRIVATE :: GFED3_SCALE_FUTURE
      PRIVATE :: GFED3_TOTAL_Tg
      PRIVATE :: INIT_GFED3_BIOMASS
      PRIVATE :: REARRANGE_BIOM
```

REMARKS:

```
    Monthly/8-day/3-hr emissions of DM are read from disk and then
    multiplied by the appropriate emission factors to produce biomass
    burning emissions on a "generic" 1x1 grid.  The emissions are then
    regridded to the current GEOS-Chem or GCAP grid (1x1, 2x25, or 4x5).
                                                                             .
    If several gfed3 options are switched on, the smaller period
    product is used: 3-hr before 8-day before monthly.
                                                                             .
    GFED3 biomass burning emissions are computed for the following gas-phase
    and aerosol-phase species:
                                                                             .
       (1 ) NOx  [  molec/cm2/s]     (13) BC   [atoms C/cm2/s]
       (2 ) CO   [  molec/cm2/s]     (14) OC   [atoms C/cm2/s]
       (3 ) ALK4 [atoms C/cm2/s]     (15) GLYX [  molec/cm2/s]
       (4 ) ACET [atoms C/cm2/s]     (16) MGLY [  molec/cm2/s]
       (5 ) MEK  [atoms C/cm2/s]     (17) BENZ [atoms C/cm2/s]
       (6 ) ALD2 [atoms C/cm2/s]     (18) TOLU [atoms C/cm2/s]
       (7 ) PRPE [atoms C/cm2/s]     (19) XYLE [atoms C/cm2/s]
       (8 ) C3H8 [atoms C/cm2/s]     (20) C2H4 [atoms C/cm2/s]
       (9 ) CH2O [  molec/cm2/s]     (21) C2H2 [atoms C/cm2/s]
       (10) C2H6 [atoms C/cm2/s]     (22) GLYC [  molec/cm2/s]
       (11) SO2  [  molec/cm2/s]     (23) HAC  [  molec/cm2/s]
       (12) NH3  [  molec/cm2/s]     (24) CO2  [  molec/cm2/s]
                                                                             .
    References:
    ============================================================================
    (1 ) Original GFED3 database from Guido van der Werf
          http://www.falw.vu/~gwerf/GFED/GFED3/emissions/
    (2 ) Giglio, L., Randerson, J. T., van der Werf, G. R., Kasibhatla, P. S.,
         Collatz, G. J., Morton, D. C., and DeFries, R. S.: Assessing
         variability and long-term trends in burned area by merging multiple
         satellite fire products, Biogeosciences, 7, 1171-1186,
         doi:10.5194/bg-7-1171-2010, 2010.
    (3 ) van der Werf, G. R., Randerson, J. T., Giglio, L., Collatz, G. J.,
         Mu, M., Kasibhatla, P. S., Morton, D. C., DeFries, R. S., Jin, Y.,
         and van Leeuwen, T. T.: Global fire emissions and the contribution of
```

```
deforestation, savanna, forest, agricultural, and peat fires
(19972009), Atmos. Chem. Phys., 10, 11707-11735,
doi:10.5194/acp-10-11707-2010, 2010.
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.1 gfed3_is_new

Function GFED3_IS_NEW returns TRUE if GFED3 emissions have been updated.

INTERFACE:

```
FUNCTION GFED3_IS_NEW( ) RESULT( IS_UPDATED )
```

RETURN VALUE:

```
LOGICAL :: IS_UPDATED    ! =T if GFED3 is updated; =F otherwise
```

REMARKS:

```
Called from carbon_mod.f and sulfate_mod.f
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.2 check_gfed3

Subroutine CHECK_GFED3 checks if we entered a new GFED period since last emission timestep (ie, last call). The result depends on the emissions time step, and the GFED time period used, as well as MMDDHH at beginning of the GEOS-Chem run

INTERFACE:

```
SUBROUTINE CHECK_GFED3( DOY, HH )
```

USES:

```
USE LOGICAL_MOD, ONLY : LGFED3BB
USE LOGICAL_MOD, ONLY : L8DAYBB3
USE LOGICAL_MOD, ONLY : L3HRBB3
USE LOGICAL_MOD, ONLY : LSYNOPBB3
USE TIME_MOD,    ONLY : ITS_A_NEW_MONTH
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: DOY   ! Day of year (0-365 or 0-366 leap years)
INTEGER, INTENT(IN) :: HH    ! Hour of day (0-23)
```

REMARKS:

```
The routine computes the DOY (resp. HOUR) at start of the 8-day (resp.
3-hour) period we are in, if the 8-day (resp. 3-hr or synoptic) GFED3
option is on. Result is compared to previous value to indicate if new
data should be read.
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.3 gfed3_available

Function GFED3_AVAILABLE checks an input YYYY year and MM month against the available data dates. If the requested YYYY and MM lie outside of the valid range of dates, then GFED3_AVAILABLE will return the last valid YYYY and MM.

INTERFACE:

```
SUBROUTINE GFED3_AVAILABLE( YYYY, YMIN, YMAX, MM, MMIN, MMAX )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)              :: YMIN, YMAX   ! Min & max years
INTEGER, INTENT(IN),    OPTIONAL :: MMIN, MMAX   ! Min & max months
```

INPUT/OUTPUT PARAMETERS:

```
INTEGER, INTENT(INOUT)           :: YYYY         ! Year of GFED3 data
INTEGER, INTENT(INOUT), OPTIONAL :: MM           ! Month of GFED3 data
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.4 gfed3_compute_biomass

Subroutine GFED3_COMPUTE_BIOMASS computes the monthly GFED3 biomass burning emissions for a given year and month.

INTERFACE:

```
SUBROUTINE GFED3_COMPUTE_BIOMASS( THIS_YYYY, THIS_MM, BIOM_OUT )
```

USES:

```
      USE BPCH2_MOD,      ONLY : READ_BPCH2
      USE BPCH2_MOD,      ONLY : GET_TAU0
      USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
      USE JULDAY_MOD,     ONLY : JULDAY
      USE JULDAY_MOD,     ONLY : CALDATE
      USE LOGICAL_MOD,    ONLY : LFUTURE
      USE LOGICAL_MOD,    ONLY : L8DAYBB3
      USE LOGICAL_MOD,    ONLY : L3HRBB3
      USE LOGICAL_MOD,    ONLY : LSYNOPBB3
      USE LOGICAL_MOD,    ONLY : LGFED3BB
      USE TIME_MOD,       ONLY : EXPAND_DATE
      USE TIME_MOD,       ONLY : TIMESTAMP_STRING
      USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1
      USE REGRID_1x1_MOD, ONLY : DO_REGRID_G2G_1x1
      USE TIME_MOD,       ONLY : GET_DAY
      USE TIME_MOD,       ONLY : GET_HOUR
      USE TIME_MOD,       ONLY : GET_DAY_OF_YEAR
      USE TIME_MOD,       ONLY : ITS_A_LEAPYEAR

      USE CMN_SIZE_MOD                                          ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: THIS_YYYY                         ! Current year
      INTEGER, INTENT(IN)  :: THIS_MM                           ! Current month
```

OUTPUT PARAMETERS:

```
      REAL*8,  INTENT(OUT) :: BIOM_OUT(IIPAR,JJPAR,NBIOMAX)  ! BB emissions
                                                              ! [molec/cm2/s]
```

REMARKS:

```
    This routine has to be called on EVERY emissions-timestep if you use one
    of the GFED3 options.
```

REVISION HISTORY:

```
    07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
    07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.5 gfed3_scale_future

Subroutine GFED3_SCALE_FUTURE applies the IPCC future emissions scale factors to the GFED3 biomass burning emisisons in order to compute the future emissions of biomass burning for NOx, CO, and VOC's.

INTERFACE:

```
SUBROUTINE GFED3_SCALE_FUTURE( BB )
```

USES:

```
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_BCbb
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_CObb
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_NH3bb
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_NOxbb
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_OCbb
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_SO2bb
USE FUTURE_EMISSIONS_MOD,   ONLY : GET_FUTURE_SCALE_VOCbb
USE TRACER_MOD,             ONLY : ITS_A_CO2_SIM
USE TRACERID_MOD,           ONLY : IDBNOx,  IDBCO,   IDBSO2
USE TRACERID_MOD,           ONLY : IDBNH3,  IDBBC,   IDBOC

USE CMN_SIZE_MOD                 ! Size parameters
```

OUTPUT PARAMETERS:

```
!  Array w/ biomass burning emisisons [molec/cm2]
REAL*8, INTENT(INOUT) :: BB(IIPAR,JJPAR,N_SPEC)
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.6 gfed3_total_Tg

Subroutine GFED3_TOTAL_Tg prints the amount of biomass burning emissions that are emitted each month/8-day/3-hr in Tg or Tg C.

INTERFACE:

```
SUBROUTINE GFED3_TOTAL_Tg( YYYY, MM )
```

USES:

```
USE GRID_MOD,    ONLY : GET_AREA_CM2

USE CMN_SIZE_MOD              ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: YYYY   ! Current year
INTEGER, INTENT(IN) :: MM     ! Current month
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.7 init_gfed3_biomass

Subroutine INIT_GFED3_BIOMASS allocates all module arrays. It also reads the emission factors at the start of a GEOS-Chem simulation.

INTERFACE:

```
SUBROUTINE INIT_GFED3_BIOMASS
```

USES:

```
USE BPCH2_MOD,     ONLY : READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR_1x1
USE ERROR_MOD,     ONLY : ALLOC_ERR
USE FILE_MOD,      ONLY : IOERROR
USE FILE_MOD,      ONLY : IU_FILE
USE LOGICAL_MOD,   ONLY : LDICARB
USE TRACERID_MOD,  ONLY : IDBNOx,  IDBCO,   IDBALK4
USE TRACERID_MOD,  ONLY : IDBACET, IDBMEK,  IDBALD2
USE TRACERID_MOD,  ONLY : IDBPRPE, IDBC3H8, IDBCH2O
USE TRACERID_MOD,  ONLY : IDBC2H6, IDBBC,   IDBOC
USE TRACERID_MOD,  ONLY : IDBSO2,  IDBNH3,  IDBCO2
USE TRACERID_MOD,  ONLY : IDBGLYX, IDBMGLY, IDBBENZ
USE TRACERID_MOD,  ONLY : IDBTOLU, IDBXYLE, IDBC2H4
USE TRACERID_MOD,  ONLY : IDBC2H2, IDBGLYC, IDBHAC

USE CMN_SIZE_MOD        ! Size parameters
```

REVISION HISTORY:

```
07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.8

Subroutine REARRANGE_BIOM takes GFED3 emissions (which have their own, unique ID numbers and associates them with the IDBxxxs of tracerid_mod.F.

INTERFACE:

```
SUBROUTINE REARRANGE_BIOM( BIOM_OUT, BIOM_OUTM )
```

USES:

```
USE CMN_SIZE_MOD     ! Size parameters
```

INPUT PARAMETERS:

```
REAL*8, INTENT(IN)  :: BIOM_OUT (IIPAR,JJPAR,N_SPEC)
```

OUTPUT PARAMETERS:

```
      REAL*8, INTENT(OUT) :: BIOM_OUTM(IIPAR,JJPAR,NBIOMAX) !+1 from CO2
```

REVISION HISTORY:

```
    07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
    07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.34.9 cleanup_gfed3_biomass

Subroutine CLEANUP_GFED3_BIOMASS deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_GFED3_BIOMASS
```

REVISION HISTORY:

```
    07 Sep 2011 - P. Kasibhatla - Initial version, based on GFED2
    07 Sep 2011 - R. Yantosca   - Added ProTeX headers
```

1.35 Fortran: Module Interface global_Br_mod

Module GLOBAL_Br_MOD contains variables and routines for reading the global monthly mean Br concentration from disk.

INTERFACE:

```
      MODULE GLOBAL_Br_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      ! Array to store global monthly mean BR field
      REAL*8, PUBLIC, ALLOCATABLE :: BR_TROP(:,:,:)
      REAL*8, PUBLIC, ALLOCATABLE :: BR_STRAT(:,:,:)
      REAL*8, PUBLIC, ALLOCATABLE :: BR_MERGE(:,:,:)

      ! Array to store global monthly mean BrO field
      REAL*8, PUBLIC, ALLOCATABLE :: BRO_TROP(:,:,:)
      REAL*8, PUBLIC, ALLOCATABLE :: BRO_STRAT(:,:,:)
      REAL*8, PUBLIC, ALLOCATABLE :: BRO_MERGE(:,:,:)

      ! Array to store global monthly J-BrO field
      REAL*8, PUBLIC, ALLOCATABLE :: J_BRO(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
! Remove obsolete routine
!PUBLIC :: GET_GLOBAL_Br_NEW
PUBLIC :: GET_GLOBAL_Br
PUBLIC :: INIT_GLOBAL_Br
PUBLIC :: CLEANUP_GLOBAL_Br
```

REVISION HISTORY:

```
05 Jul 2006 - C. Holmes   - Copied from "global_oh_mod.f"
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.35.1 get_global_Br

Subroutine GET_GLOBAL_Br reads global Br from binary punch files stored in the /data/ctm/GEOS_MEAN directory. This Br data is needed as oxidant for mercury chemistry.

INTERFACE:

```
! Rename to GET_GLOBAL_Br
!SUBROUTINE GET_GLOBAL_Br_NEW( THISMONTH )
SUBROUTINE GET_GLOBAL_Br( THISMONTH )
```

USES:

```
!USE LOGICAL_MOD,    ONLY : LVARTROP     ! Comment this out for now
USE BPCH2_MOD,      ONLY : GET_NAME_EXT
USE BPCH2_MOD,      ONLY : GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0
USE BPCH2_MOD,      ONLY : READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR ! cdh
USE TRANSFER_MOD,   ONLY : TRANSFER_3D
USE TRANSFER_MOD,   ONLY : TRANSFER_3D_TROP
USE TROPOPAUSE_MOD, ONLY : GET_TPAUSE_LEVEL

USE CMN_SIZE_MOD                ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: THISMONTH   ! Current month
```

REMARKS:

```
THIS IS A NEW VERSION OF THIS SUBROUTINE WHICH COMBINES Br CONCENTRATIONS
FROM MULTIPLE DATA SOURCES
```

REVISION HISTORY:

```
05 Jul 2006 - C. Holmes   - Copied from "global_oh_mod.f"
(1 ) GET_GLOBAL_BR assumes that we are reading global BR data that occupies
      all CTM levels.  Contact Bob Yantosca (bmy@io.harvard.edu) for IDL
      regridding code which will produce the appropriate BR files.
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.35.2 init_global_Br

Subroutine INIT_GLOBAL_Br allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_GLOBAL_Br
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
05 Jul 2006 - C. Holmes   - Copied from "global_oh_mod.f"
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.35.3 cleanup_global_Br

Subroutine CLEANUP_GLOBAL_Br deallocates module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_GLOBAL_Br
```

REVISION HISTORY:

```
05 Jul 2006 - C. Holmes   - Copied from "global_oh_mod.f"
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.36 Fortran: Module Interface global_NO3_mod

Module GLOBAL_NO3_MOD contains variables and routines for reading the global monthly mean NO3 concentration from disk. These are needed for the offline sulfate/aerosol simulation.

INTERFACE:

```
      MODULE GLOBAL_NO3_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      ! Array to store global monthly mean OH field
      REAL*8, PUBLIC, ALLOCATABLE :: NO3(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: GET_GLOBAL_NO3
      PUBLIC  :: CLEANUP_GLOBAL_NO3
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: INIT_GLOBAL_NO3
```

REVISION HISTORY:

```
    15 Oct 2002 - R. Yantosca - Initial version
    (1 ) Adapted from "global_oh_mod.f" (bmy, 10/3/02)
    (2 ) Minor bug fix in FORMAT statements (bmy, 3/23/03)
    (3 ) Cosmetic changes (bmy, 3/27/03)
    (4 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
    (5 ) Now suppress output from READ_BPCH2 with QUIET=T (bmy, 1/14/05)
    (6 ) Now read from "sulfate_sim_200508/offline" directory (bmy, 8/1/05)
    (7 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
    (8 ) Bug fix: now zero ARRAY (phs, 1/22/07)
    01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.36.1 get_global_NO3

Subroutine GET_GLOBAL_NO3 reads monthly mean NO3 data fields. These are needed for simulations such as offline sulfate/aerosol.

INTERFACE:

```
      SUBROUTINE GET_GLOBAL_NO3( THISMONTH )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT
      USE BPCH2_MOD,     ONLY : GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0
      USE BPCH2_MOD,     ONLY : READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE TRANSFER_MOD,  ONLY : TRANSFER_3D_TROP

      USE CMN_SIZE_MOD                 ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: THISMONTH   ! Current month
```

REVISION HISTORY:

```
15 Oct 2002 - R. Yantosca - Initial version
(1 ) Minor bug fix in FORMAT statements (bmy, 3/23/03)
(2 ) Cosmetic changes (bmy, 3/27/03)
(3 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(4 ) Now suppress output from READ_BPCH2 with QUIET=T (bmy, 1/14/05)
(5 ) GEOS-3 & GEOS-4 data comes from model runs w/ 30 levels.  Also now
     read from "sulfate_sim_200508/offline" directory.  Also now read
     up to LLTROP levels.  Now reference TRANSFER_3D_TROP from
     "transfer_mod.f". (bmy, 8/1/05)
(5 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(6 ) Now zero local variable ARRAY (phs, 1/22/07)
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.36.2 init_global_NO3

Subroutine INIT_GLOBAL_NO3 allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_GLOBAL_NO3
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
15 Oct 2002 - R. Yantosca - Initial version
(1 ) Now references ALLOC_ERR from "error_mod.f" (bmy, 10/15/02)
(2 ) Now allocate NO3 array up to LLTROP levels (bmy, 8/1/05)
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.36.3 cleanup_global_no3

Subroutine CLEANUP_GLOBAL_NO3 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_GLOBAL_NO3
```

REVISION HISTORY:

```
15 Oct 2002 - R. Yantosca - Initial version
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.37 Fortran: Module Interface global_NOx_mod

Module GLOBAL_NOx_MOD contains variables and routines for reading the global monthly mean NOx concentration from disk.

INTERFACE:

```
      MODULE GLOBAL_NOX_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      ! Array to store global monthly mean BNOX field
      REAL*8, PUBLIC, ALLOCATABLE :: BNOX(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_GLOBAL_NOx
      PUBLIC :: GET_GLOBAL_NOx
      PUBLIC :: INIT_GLOBAL_NOx
```

REVISION HISTORY:

```
28 Jul 2000 - R. Yantosca - Initial version
(1 ) Updated comments, made cosmetic changes (bmy, 6/13/01)
(2 ) Updated comments (bmy, 9/4/01)
(3 ) Now regrid BNOX array from 48L to 30L for GEOS-3 if necessary.
     (bmy, 1/14/02)
(4 ) Eliminated obsolete code from 1/02 (bmy, 2/27/02)
(5 ) Now divide module header into MODULE PRIVATE, MODULE VARIABLES, and
     MODULE ROUTINES sections.  Updated comments (bmy, 5/28/02)
(6 ) Now references "error_mod.f" (bmy, 10/15/02)
(7 ) Minor bug fix in FORMAT statements (bmy, 3/23/03)
(8 ) Cosmetic changes to improve output (bmy, 3/27/03)
(9 ) Now references "directory_mod.f" and "unix_cmds_mod.f" (bmy, 7/20/04)
(10) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.37.1 get_global_nox

Subroutine GET_GLOBAL_NOx reads global NOx from binary punch files from a full chemistry run. This NOx data is needed to calculate the CO yield from isoprene oxidation.

INTERFACE:

```
SUBROUTINE GET_GLOBAL_NOx( THISMONTH )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0
USE BPCH2_MOD,     ONLY : READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE DIRECTORY_MOD, ONLY : TEMP_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_3D
USE UNIX_CMDS_MOD, ONLY : REDIRECT
USE UNIX_CMDS_MOD, ONLY : UNZIP_CMD
USE UNIX_CMDS_MOD, ONLY : ZIP_SUFFIX

USE CMN_SIZE_MOD                 ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: THISMONTH   ! Current month
```

REVISION HISTORY:

```
28 Jul 2000 - R. Yantosca - Initial version
(1 ) Now use version of GET_TAU0 with 3 arguments.  Now call READ_BPCH2
     with IIPAR,JJPAR,LGLOB.  Call TRANSFER_3D to cast from REAL*4 to
     REAL*8 and to regrid to 30 levels for GEOS-3 (if necessary).  ARRAY
     should now be of size (IIPAR,JJPAR,LGLOB). (bmy, 1/14/02)
(2 ) Eliminated obsolete code from 1/02 (bmy, 2/27/02)
(3 ) Bug fix in FORMAT statement: replace missing commas.  Also make sure
     to define FILENAME before printing it (bmy, 4/28/03)
(4 ) Now references TEMP_DIR, DATA_DIR from "directory_mod.f".  Also
     references Unix unzipping commands from "unix_cmds_mod.f".
     (bmy, 7/20/04)
(5 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.37.2 init_global_NOx

Subroutine INIT_GLOBAL_NOx allocates and zeroes all module arrays.

INTERFACE:

```
      SUBROUTINE INIT_GLOBAL_NOX
```

USES:

```
      USE ERROR_MOD, ONLY : ALLOC_ERR

      USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
    28 Jul 2000 - R. Yantosca - Initial version
    (1 ) BNOX now needs to be sized (IIPAR,JJPAR,LLPAR) (bmy, 1/14/02)
    (2 ) Eliminated obsolete code from 1/02 (bmy, 2/27/02)
    (3 ) Now references ALLOC_ERR from "error_mod.f" (bmy, 10/15/02)
    01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.37.3 cleanup_global_nox

Subroutine CLEANUP_GLOBAL_NOx deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_GLOBAL_NOX
```

REVISION HISTORY:

```
    28 Jul 2000 - R. Yantosca - Initial version
    01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.38 Fortran: Module Interface global_o1d_mod

Module GLOBAL_O1D_MOD contains variables and routines for reading the global monthly mean O1D stratospheric concentration from disk. This is used in the H2/HD simulation. The O1D fields were obtained from Gabriele Curci GEOS-Chem simulation in the stratosphere (v5.03).

INTERFACE:

```
      MODULE GLOBAL_O1D_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
! Array to store global monthly mean O1D field
REAL*8, PUBLIC, ALLOCATABLE :: O1D(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: CLEANUP_GLOBAL_O1D
PUBLIC :: GET_GLOBAL_O1D
PUBLIC :: INIT_GLOBAL_O1D
```

REVISION HISTORY:

```
18 Sep 2007 - H. U. Price, P. Le Sager - Initial version
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.38.1 get_global_O1D

Subroutine GET_GLOBAL_O1D reads global O1D from binary punch files stored in the /data/ctm/GEOS_MEAN directory. This O1D data is needed for the H2/HD mechanisms in Tagged H2.

INTERFACE:

```
SUBROUTINE GET_GLOBAL_O1D( THISMONTH )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0
USE BPCH2_MOD,     ONLY : READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_3D

USE CMN_SIZE_MOD                  ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: THISMONTH   ! Current month
```

REVISION HISTORY:

```
18 Sep 2007 - H. U. Price, P. Le Sager - Initial version
(1 ) GET_GLOBAL_O1D assumes that we are reading global O1D data that
      occupies all CTM levels.  Contact Bob Yantosca (bmy@io.harvard.edu)
      for IDL regridding code which will produce the appropriate O1D files.
(2 ) ARRAY should now be of size (IIPAR,JJPAR,LGLOB). (bmy, 1/11/02)
(3 ) Now point to new O1D files in the ??? subdirectory.
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.38.2 init_global_o1d

Subroutine INIT_GLOBAL_O1D allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_GLOBAL_O1D
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
18 Sep 2007 - H. U. Price, P. Le Sager - Initial version
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.38.3 cleanup_global_O1D

Subroutine CLEANUP_GLOBAL_O1D deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_GLOBAL_O1D
```

REVISION HISTORY:

```
18 Sep 2007 - H. U. Price, P. Le Sager - Initial version
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.39 Fortran: Module Interface global_o3_mod

Module GLOBAL_O3_MOD contains variables and routines for reading the global monthly mean O3 concentration from disk. These are needed for the offline sulfate/aerosol simulation.

INTERFACE:

```
MODULE GLOBAL_O3_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC              :: CLEANUP_GLOBAL_O3
      PUBLIC              :: GET_GLOBAL_O3
```

PUBLIC DATA MEMBERS:

```
      PUBLIC              :: O3
      REAL*8, ALLOCATABLE :: O3(:,:,:)        ! Global monthly mean OH field
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE             :: INIT_GLOBAL_O3
```

REVISION HISTORY:

```
   (1 ) Now references "directory_mod.f" (bmy, 7/20/04)
   (2 ) Now reads O3 data from "sulfate_sim_200508/offline" dir (bmy, 8/30/05)
   (3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   (4 ) Bug fixes in GET_GLOBAL_O3 (bmy, 12/1/05)
   (5 ) Now reads O3 from MERGE files, which include stratospheric O3 from
        COMBO, for GEOS-3 and GEOS-4 met fields (phs, 1/19/07)
   (6 ) Bug fix in GET_GLOBAL_O3 (bmy, 1/14/09)
   13 Aug 2010 - R. Yantosca - Added modifications for MERRA
   13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.39.1 get_global_o3

Subroutine GET_GLOBAL_O3 reads monthly mean O3 data fields. These are needed for simulations such as offline sulfate/aerosol.

INTERFACE:

```
      SUBROUTINE GET_GLOBAL_O3( THISMONTH )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT, GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0,     READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE TRANSFER_MOD,  ONLY : TRANSFER_3D

      USE CMN_SIZE_MOD                      ! Size parameters
      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: THISMONTH       ! Current month
```

REVISION HISTORY:

```
23 Mar 2003 - R. Yantosca - Initial version
(1 ) Minor bug fix in FORMAT statements (bmy, 3/23/03)
(2 ) Cosmetic changes (bmy, 3/27/03)
(3 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(4 ) Now reads O3 data from "sulfate_sim_200508/offline" dir (bmy, 8/30/05)
(5 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(6 ) Tracer number for O3 is now 51.  Also need to call TRANSFER_3D_TROP
      since the new O3 data file only goes up to LLTROP. (bmy, 11/18/05)
(7 ) Modified to include stratospheric O3 -- Requires access to new
      MERGE.O3* files. (phs, 1/19/07)
(8 ) Renamed GRID30LEV to GRIDREDUCED (bmy, 2/7/07)
(9 ) Bug fix: don't call TRANSFER_3D if you use GRIDREDUCED (bmy, 1/14/09)
13 Aug 2010 - R. Yantosca - Rewrote logic more cleanly
13 Aug 2010 - R. Yantosca - Treat MERRA in same way as GEOS-5
08 Dec 2009 - R. Yantosca - Added ProTeX headers
19 Aug 2010 - R. Yantosca - Removed hardwiring of data directory
```

1.39.2 init_global_o3

Subroutine INIT_GLOBAL_O3 allocates the O3 module array.

INTERFACE:

```
SUBROUTINE INIT_GLOBAL_O3
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
13 Jul 2004 - R. Yantosca - Initial version
(1 ) Now references ALLOC_ERR from "error_mod.f" (bmy, 7/13/04)
(2 ) Now dimension O3 with LLTROP (bmy, 12/1/05)
(3 ) Now dimension O3 with LLPAR (phs, 1/19/07)
13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.39.3 cleanup_global_o3

Subroutine CLEANUP_GLOBAL_O3 deallocates the O3 array.

INTERFACE:

```
SUBROUTINE CLEANUP_GLOBAL_O3
```

REVISION HISTORY:

```
13 Jul 2004 - R. Yantosca - Initial version
13 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.40 Fortran: Module Interface global_oh_mod

Module GLOBAL_OH_MOD contains variables and routines for reading the global monthly mean OH concentration from disk.

INTERFACE:

```
      MODULE GLOBAL_OH_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      ! Array to store global monthly mean OH field [molec/cm3]
      REAL*8, PUBLIC, ALLOCATABLE :: OH(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_GLOBAL_OH
      PUBLIC :: GET_GLOBAL_OH
      PUBLIC :: INIT_GLOBAL_OH
```

REVISION HISTORY:

```
28 Jul 2000 - R. Yantosca - Initial version
(1 ) Updated comments (bmy, 9/4/01)
(2 ) Now use routines from "transfer_mod.f" to regrid OH to 30 levels
      for reduced GEOS-3 grid.  Also size OH array properly. (bmy, 1/14/02)
(3 ) Eliminate obsolete code from 11/01 (bmy, 2/27/02)
(4 ) Now divide module header into MODULE PRIVATE, MODULE VARIABLES, and
      MODULE ROUTINES sections.  Updated comments (bmy, 5/28/02)
(5 ) Now use updated OH fields (bmy, 10/2/02)
(6 ) Now references "error_mod.f" (bmy, 10/15/02)
(7 ) Minor bug fixes in FORMAT statements (bmy, 3/23/03)
(8 ) Cosmetic changes to simplify output (bmy, 3/27/03)
(9 ) Bug fix: OH should be (IIPAR,JJPAR,LLPAR) (bmy, 5/4/04)
(10) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.40.1 get_global_oh

Subroutine GET_GLOBAL_OH reads global OH from binary punch files stored in the /data/ctm/GEOS_MEAN directory. This OH data is needed as oxidant for various offline chemistry mechanisms.

INTERFACE:

```
SUBROUTINE GET_GLOBAL_OH( THISMONTH )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0
USE BPCH2_MOD,     ONLY : READ_BPCH2
USE DIRECTORY_MOD, ONLY : OH_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_3D
USE DAO_MOD,       ONLY : AIRDEN_FULLGRID, AIRDEN, AIRQNT_FULLGRID

USE CMN_SIZE_MOD                  ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: THISMONTH   ! Current month
```

REVISION HISTORY:

```
28 Jul 2000 - R. Yantosca - Initial version
(1 ) GET_GLOBAL_OH assumes that we are reading global OH data that occupies
     all CTM levels.  Contact Bob Yantosca (bmy@io.harvard.edu) for IDL
     regridding code which will produce the appropriate OH files.
(2 ) Now use version of GET_TAU0 with 3 arguments.  Now call READ_BPCH2
     with IIPAR,JJPAR,LGLOB.  Call TRANSFER_3D to cast from REAL*4 to
     REAL*8 and to regrid to 30 levels for GEOS-3 (if necessary).
     ARRAY should now be of size (IIPAR,JJPAR,LGLOB). (bmy, 1/11/02)
(3 ) Now point to new OH files in the v4-26 subdirectory.  Also eliminated
     obsolete code from 11/01. (bmy, 2/27/02)
(4 ) Now point to OH files in the v4-33 subdirectory. (bmy, 10/2/02)
(5 ) Replace missing commas in the FORMAT statement (bmy, 3/23/03)
(6 ) Cosmetic changes to simplify output (bmy, 3/27/03)
(7 ) Add Mat's OH as an option.  Also read bpch file quietly (bmy, 5/4/04)
(8 ) Now use OH_DIR from "directory_mod.f" (bmy, 7/20/04)
(9 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.40.2 init_global_oh

Subroutine INIT_GLOBAL_OH allocates and zeroes all module arrays.

INTERFACE:

```
      SUBROUTINE INIT_GLOBAL_OH
```

USES:

```
      USE ERROR_MOD, ONLY : ALLOC_ERR

      USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
    28 Jul 2000 - R. Yantosca - Initial version
    (1 ) OH array now needs to be sized (IIPAR,JJPAR,LGLOB) (bmy, 1/14/02)
    (2 ) Also eliminated obsolete code from 11/01 (bmy, 2/27/02)
    (3 ) Now references ALLOC_ERR from "error_mod.f" (bmy, 10/15/02)
    (4 ) OH should be (IIPAR,JJPAR,LLPAR): avoid subscript errors (bmy, 5/4/04)
    01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.40.3 cleanup_global_oh

Subroutine CLEANUP_GLOBAL_OH deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_GLOBAL_OH
```

REVISION HISTORY:

```
    28 Jul 2000 - R. Yantosca - Initial version
    01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.41 Fortran: Module Interface

Module H2_HD_MOD contains variables and routines used for the geographically tagged H2-HD simulation.

INTERFACE:

```
      MODULE H2_HD_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: CHEM_H2_HD
PUBLIC  :: CLEANUP_H2_HD
PUBLIC  :: EMISS_H2_HD
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: INIT_H2_HD
PRIVATE :: READ_OCEAN_H2
PRIVATE :: READ_H2YIELD
```

REVISION HISTORY:

```
18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
07 Sep 2011 - P. Kasibhatla - Modified to include GFED3 (psk, 1/5/11)
```

1.41.1 emiss_h2_hd

Subroutine EMISS_H2_HD reads in emissions for the H2/HD simulation.

INTERFACE:

```
SUBROUTINE EMISS_H2_HD
```

USES:

```
USE BIOFUEL_MOD,   ONLY : BIOFUEL,     BIOFUEL_BURN
! IDBCO moved to tracerid_mod by FP (hotp 7/31/09)
USE BIOMASS_MOD,   ONLY : BIOMASS!,     IDBCO
USE DAO_MOD,       ONLY : SUNCOS,      BXHEIGHT
USE DIAG_MOD,      ONLY : AD29,        AD46,          AD10em
USE GEIA_MOD,      ONLY : GET_IHOUR,   GET_DAY_INDEX, READ_GEIA
USE GEIA_MOD,      ONLY : READ_LIQCO2, READ_TOTCO2,   READ_TODX
USE GRID_MOD,      ONLY : GET_XOFFSET, GET_YOFFSET,   GET_AREA_CM2
USE LOGICAL_MOD,      ONLY : LANTHRO,     LGFED2BB, LGFED3BB
USE LOGICAL_MOD,      ONLY : LBIOMASS,    LBIOFUEL,      LNEI99
USE LOGICAL_MOD,      ONLY : LSTREETS,    LEDGAR,        LBRAVO
USE MEGANUT_MOD,      ONLY : XLTMMP
USE TRACERID_MOD,  ONLY : IDBCO
USE TIME_MOD,         ONLY : GET_MONTH,   GET_TAU
USE TIME_MOD,         ONLY : GET_YEAR,    GET_TS_EMIS
USE TRACER_MOD,       ONLY : STT
USE TRACERID_MOD,     ONLY : IDBFCO,      IDTH2,         IDTHD
USE TAGGED_CO_MOD,    ONLY : INIT_TAGGED_CO,  READ_ACETONE, EMACET
USE SCALE_ANTHRO_MOD, ONLY : GET_ANNUAL_SCALAR

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_O3_MOD       ! FSCALYR, SCNR89, TODH, EMISTCO
USE CMN_DIAG_MOD     ! Diagnostic arrays & switches
```

REVISION HISTORY:

```
18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
(1 ) Now references GET_ANNUAL_SCALAR (phs, 3/11/08)
(2 ) Move XLTMMP to module MEGANUT_MOD (ccc, 11/20/09)
(3 ) IDBCO is in TRACERID_MOD now (hotp 7/31/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.41.2 chem_h2_hd

Subroutine CHEM_H2_HD performs H2 and HD chemistry. Chemical production is by oxidation of BVOC and CH4. Loss is via reaction with OH and uptake by soils. In the stratosphere, H2 is also lost by reaction with O(1D). For HD, we include the fractionation from photochemical oxidation (162 permil), and loss by OH and soil uptake.

INTERFACE:

```
SUBROUTINE CHEM_H2_HD
```

USES:

```
USE DAO_MOD,         ONLY : AD, AIRVOL, T
USE DIAG_MOD,        ONLY : AD10
USE ERROR_MOD,       ONLY : CHECK_VALUE
USE GLOBAL_OH_MOD,   ONLY : GET_GLOBAL_OH,   OH
USE GLOBAL_O1D_MOD, ONLY : GET_GLOBAL_O1D, O1D
USE GLOBAL_NOX_MOD, ONLY : GET_GLOBAL_NOX,  BNOX
USE GRID_MOD,        ONLY : GET_YMID, GET_AREA_M2, GET_AREA_CM2
USE PRESSURE_MOD,    ONLY : GET_PCENTER, GET_PEDGE
USE TIME_MOD,        ONLY : GET_TS_CHEM,     GET_MONTH, GET_YEAR
USE TIME_MOD,        ONLY : ITS_A_NEW_MONTH, ITS_A_NEW_YEAR
USE DRYDEP_MOD,      ONLY : DEPSAV
USE TRACER_MOD,      ONLY : N_TRACERS,       STT
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_STRAT
USE TRACERID_MOD,    ONLY : IDTH2, IDTHD
USE TAGGED_CO_MOD,   ONLY : GET_ALPHA_ISOP,    READ_PCO_LCO_STRAT
USE TAGGED_CO_MOD,   ONLY : GET_PCO_LCO_STRAT

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DIAG_MOD     ! ND65
USE CMN_DEP_MOD      ! FRCLND
```

REVISION HISTORY:

```
18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.41.3 read_ocean_h2

Subroutine READ_OCEAN_H2 reads in oceanic H2 emissions from nitrogen fixation.

INTERFACE:

```
SUBROUTINE READ_OCEAN_H2( THISMONTH )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,     READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE TRANSFER_MOD,  ONLY : TRANSFER_2D

USE CMN_SIZE_MOD  ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: THISMONTH   ! Current month
```

REMARKS:

```
Ocean H2 emissions are based on the N2 oceanic fixation rates
determined by Curtis Deutsch (University of Washington) by
assimilating observed nutrient distributions in the oceans:
"Spatial coupling of nitrogen inputs and losses in the ocean",
Deutsch et al., Nature 445, 163-167 (2007).

The oceanic N2 fixation rates are read in and then scaled to
obtain a total ocean H2 source of 6 TgH2/yr. This source is
assumed to be constant and does not vary annually.
```

REVISION HISTORY:

```
18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.41.4 read_h2yield

Subroutine READ_H2YIELD reads in the relative H2/CO yield from photochemical production. This has been archived monthly (PH2/PCO using the PRODLOSS diagnostic and turning H2 on as an active species) from a full chemistry simulation at 4x5, v7-03-03, year 2001, GEOS-3 met fields.

INTERFACE:

```
SUBROUTINE READ_H2YIELD( THISMONTH )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT, GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0,     READ_BPCH2
      USE TRANSFER_MOD,  ONLY : TRANSFER_3D
      USE DIRECTORY_MOD, ONLY : DATA_DIR
       USE GRID_MOD,      ONLY : GET_YMID

      USE CMN_SIZE_MOD                 ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: THISMONTH   ! Current month
```

REVISION HISTORY:

```
    18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.41.5 init_h2_hd

Subroutine INIT_H2_HD allocates memory to module arrays.

INTERFACE:

```
      SUBROUTINE INIT_H2_HD
```

USES:

```
      USE ERROR_MOD, ONLY : ALLOC_ERR

      USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
    18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.41.6 cleanup_h2_hd

Subroutine CLEANUP_H2_HD deallocates memory from previously allocated module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_H2_HD
```

REVISION HISTORY:

```
    18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.42 Fortran: Module Interface icoads_ship_mod

Module ICOADS_SHIP_MOD contains variables and routines to read the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) ship emissions. Base year is 2002.

INTERFACE:

```
      MODULE ICOADS_SHIP_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_ICOADS_SHIP
      PUBLIC  :: EMISS_ICOADS_SHIP
      PUBLIC  :: GET_ICOADS_SHIP
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: ICOADS_SCALE_FUTURE
      PRIVATE :: INIT_ICOADS_SHIP
      PRIVATE :: TOTAL_ICOADS_SHIP_TG
```

REMARKS:

```
Source: ICOADS Emissions data for NOx, SOx, and CO were downloaded from
http://coast.cms.udel.edu/GlobalShipEmissions/Inventories/
Reference: Wang, C., J. J. Corbett, and J. Firestone, \emph{Improving
Spatial representation of Global Ship Emissions Inventories},
Environ. Sci. Technol., 42, (1), 193-199, 2008.
```

REVISION HISTORY:

```
21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.42.1 get_icoads_ship

Function GET_ICOADS_SHIP returns the ICOADS ship emissions for GEOS-Chem grid box (I,J) and tracer N. Emissions can be returned in units of [kg/s] or [molec/cm2/s].

INTERFACE:

```
      FUNCTION GET_ICOADS_SHIP( I,    J,     N,
     &                          MOLEC_CM2_S, KG_S ) RESULT( VALUE )
```

USES:

```
USE TRACER_MOD,   ONLY : XNUMOL
USE TRACERID_MOD, ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3
USE TIME_MOD,     ONLY : GET_YEAR, GET_MONTH
```

INPUT PARAMETERS:

```
! Longitude, latitude, and tracer indices
INTEGER, INTENT(IN)           :: I, J, N

! OPTIONAL -- return emissions in [molec/cm2/s]
LOGICAL, INTENT(IN), OPTIONAL :: MOLEC_CM2_S

! OPTIONAL -- return emissions in [kg/s]
LOGICAL, INTENT(IN), OPTIONAL :: KG_S
```

RETURN VALUE:

```
! Emissions output
REAL*8                        :: VALUE
```

REVISION HISTORY:

```
21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.42.2 emiss_icoads_ship

Subroutine EMISS_ICOADS_SHIP reads the ICOADS emission fields at 1x1 resolution and regrids them to the current model resolution.

INTERFACE:

```
SUBROUTINE EMISS_ICOADS_SHIP
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
USE LOGICAL_MOD,       ONLY : LFUTURE
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1
USE TIME_MOD,          ONLY : GET_YEAR,      GET_MONTH
USE SCALE_ANTHRO_MOD,  ONLY : GET_ANNUAL_SCALAR_1x1

USE CMN_SIZE_MOD          ! Size parameters
USE CMN_O3_MOD            ! FSCALYR
```

REVISION HISTORY:

```
21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.42.3 icoads_scale_future

applies the IPCC future scale factors

INTERFACE:

```
SUBROUTINE ICOADS_SCALE_FUTURE
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_COff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NOxff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_SO2ff

USE CMN_SIZE_MOD             ! Size parameters
```

REVISION HISTORY:

```
21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.42.4 total_icoads_ship_Tg

Subroutine TOTAL_ICOADS_SHIP_TG prints the totals for ship emissions of NOx, CO, and SO2.

INTERFACE:

```
SUBROUTINE TOTAL_ICOADS_SHIP_TG( MONTH )
```

USES:

```
USE CMN_SIZE_MOD            ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: MONTH   ! Month of data to compute totals
```

REVISION HISTORY:

```
21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.42.5 init_icoads_ship

Subroutine INIT_ICOADS_SHIP allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_ICOADS_SHIP
```

USES:

```
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE GRID_MOD,    ONLY : GET_AREA_CM2
      USE LOGICAL_MOD, ONLY : LICOADSSHIP

      USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
   21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.42.6 cleanup_icoads_ship

Subroutine CLEANUP_ICOADS_SHIP deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_ICOADS_SHIP
```

REVISION HISTORY:

```
   21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version
```

1.43 Fortran: Module Interface input_mod

Module INPUT_MOD contains routines that read the GEOS-Chem input file at the start of the run and pass the information to several other GEOS-Chem F90 modules.

INTERFACE:

```
      MODULE INPUT_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: READ_INPUT_FILE
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: READ_ONE_LINE
      PRIVATE :: SPLIT_ONE_LINE
      PRIVATE :: READ_SIMULATION_MENU
      PRIVATE :: READ_TRACER_MENU
      PRIVATE :: READ_AEROSOL_MENU
```

```
  PRIVATE :: READ_EMISSIONS_MENU
  PRIVATE :: READ_FUTURE_MENU
  PRIVATE :: READ_CHEMISTRY_MENU
  PRIVATE :: READ_TRANSPORT_MENU
  PRIVATE :: READ_CONVECTION_MENU
  PRIVATE :: READ_DEPOSITION_MENU
  PRIVATE :: READ_OUTPUT_MENU
  PRIVATE :: READ_DIAGNOSTIC_MENU
  PRIVATE :: SET_TINDEX
  PRIVATE :: READ_ND49_MENU
  PRIVATE :: READ_ND50_MENU
  PRIVATE :: READ_ND51_MENU
  PRIVATE :: READ_ND51b_MENU
  PRIVATE :: READ_PROD_LOSS_MENU
  PRIVATE :: READ_UNIX_CMDS_MENU
  PRIVATE :: READ_NESTED_GRID_MENU
  PRIVATE :: READ_ARCHIVED_OH_MENU
  PRIVATE :: READ_O3PL_MENU
  PRIVATE :: READ_BENCHMARK_MENU
  PRIVATE :: READ_CH4_MENU
  PRIVATE :: VALIDATE_DIRECTORIES
  PRIVATE :: CHECK_DIRECTORY
  PRIVATE :: CHECK_TIME_STEPS
  PRIVATE :: IS_LAST_DAY_GOOD
  PRIVATE :: INIT_INPUT
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now references LSOA in READ_AEROSOL_MENU (bmy, 9/28/04)
(2 ) Fixed error checks and assign LSPLIT for tagged Hg.  Also now
     refernces LAVHRRLAI from "logical_mod.f" (eck, bmy, 12/20/04)
(3 ) Updated for crystalline/aqueous aerosol tracers.  Also moved routine
     IS_LAST_DAY_GOOD here from "main.f".  Also now references
     "ocean_mercury_mod.f".  Also now open the bpch file for output in
     READ_DIAGNOSTIC_MENU instead of in "main.f".  (cas, sas, bmy, 2/3/05)
(4 ) Now references "diag03_mod.f" and "diag41_mod.f".  Fixed minor
     bugs.  Now references FILE_EXISTS from "file_mod.f".  Updated
     comments. (bmy, 3/28/05)
(5 ) Now modified for GEOS-5 and GCAP met fields.  Also now set LSPLIT
     correctly for HCN/CH3CN simulation. (swu, xyp, bmy, 6/30/05)
(6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(7 ) Now read LMEGAN switch for MEGAN biogenics.  Now read variable
     DATA_DIR_1x1 for 1x1 emissions files, etc.  Now reference XNUMOL and
     XNUMOLAIR from "tracer_mod.f" (tmf, bmy, 10/25/05)
(8 ) Now read LEMEP switch for EMEP emissions (bdf, bmy, 11/1/05)
(9 ) Now added MERCURY MENU section.  Also fixed bug in READ_ND48_MENU.
     (eck, cdh, bmy, 3/6/06)
```

```
(10) Now read LGFED2BB switch for GFED2 biomass emissions (bmy, 4/5/06)
(11) Bug fix for GCAP in IS_LAST_DAY_GOOD.  Also now read LCTH, LMFLUX,
     LPRECON in READ_EMISSIONS_MENU. (bmy, 5/10/06)
(12) Updated for ND42 SOA concentration diagnostic (dkh, bmy, 5/22/06)
(13) Modified for future emissions (swu, bmy, 6/1/06)
(14) Modified for BRAVO emissions (rjp, kfb, bmy, 6/26/06)
(15) Remove support for GEOS-1 and GEOS-STRAT met fields.  Also modified
     for David Streets' emissions. (bmy, 8/17/06)
(16) Modified for variable tropopause.  Also set dimension of ND28 diag
     for GFED2 or default biomass burning.  Now read if Time Spent in
     Troposphere is wanted (phs, bmy, 10/17/06)
(17) Now modified for OTD-LIS local redistribution.  Remove references
     to GEOS-1 and GEOS-STRAT run dirs. (bmy, 11/5/07)
(18) New error traps for OTD-LIS scaling, dependent on met field type.
     Bug fix, create string variables for ERROR_STOP.  Bug fix: use ND52
     in call to SET_TINDEX in READ_DIAGNOSTIC_MENU. (ltm, bmy, 2/11/08)
(19) Bug fix: use (0,0) in call to INIT_TRANSFER (phs, 6/17/08)
(20) Minor fix in READ_TRANSPORT_MENU (cdh, bmy, 7/7/08)
(21) Fixed typo READ_EMISSIONS_MENU for GEOS-3 (bmy, 10/30/08)
(22) Set upper limit on dynamic timestep for 0.5 x 0.666 nested
     grids (yxw, bmy, dan, 11/6/08)
(23) Now read LCAC switch for CAC emissions (amv, 1/09/2008)
(24) Move the call to NDXX_SETUP (phs, 11/18/08)
(25) Minor bug fix in READ_DIAGNOSTIC_MENU (tmf, 2/10/09)
(26) Add LMEGANMONO switch in emission menu (ccc, 3/2/09)
(27) Add LDICARB switch in aerosol menu (ccc, tmf, 3/10/09)
(28) Now read LCOOKE in aerosol menu (phs, 5/18/09)
(29) Add CH4_MENU in input.geos (kjw, 8/18/09)
(30) Corrected typos in CHECK_TIME_STEPS (bmy, 8/21/09)
(31) Now read LLINOZ in READ_SIMULATION_MENU (dbm, bmy, 10/16/09)
(32) Remove reference to obsolete embedded chemistry stuff (bmy, 2/25/10)
(33) Remove depreciated lightning options (ltm, bmy, 1/24/11)
25 Aug 2010 - R. Yantosca - Added modifications for MERRA
27 Aug 2010 - R. Yantosca - Added ProTeX headers
29 Jul 2011 - R. Yantosca - Bug fix in READ_EMISSIONS_MENU for nested NA
16 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
07 Sep 2011 - P. Kasibhatla - Modified to include GFED3
```

1.43.1 read_input_file

Subroutine READ_INPUT_FILE is the driver program for reading the GEOS-Chem input file "input.geos" from disk.

INTERFACE:

```
SUBROUTINE READ_INPUT_FILE
```

USES:

```
USE CHARPAK_MOD, ONLY : STRREPL
USE FILE_MOD,    ONLY : IU_GEOS, IOERROR
USE GAMAP_MOD,   ONLY : DO_GAMAP
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now call DO_GAMAP from "gamap_mod.f" to create "diaginfo.dat" and
     "tracerinfo.dat" files after all diagnostic menus have been read in
(2 ) Now call NDXX_setup from this routine (phs, 11/18/08)
(3 ) Now call READ_ND51b_MENU (amv, bmy, 12/18/09)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.2 read_one_line

Subroutine READ_ONE_LINE reads a line from the input file. If the global variable VERBOSE is set, the line will be printed to stdout. READ_ONE_LINE can trap an unexpected EOF if LOCATION is passed. Otherwise, it will pass a logical flag back to the calling routine, where the error trapping will be done.

INTERFACE:

```
FUNCTION READ_ONE_LINE( EOF, LOCATION ) RESULT( LINE )
```

USES:

```
USE FILE_MOD, ONLY : IU_GEOS, IOERROR
```

INPUT PARAMETERS:

```
CHARACTER(LEN=*), INTENT(IN), OPTIONAL :: LOCATION    ! Msg to display
```

OUTPUT PARAMETERS:

```
LOGICAL,          INTENT(OUT)          :: EOF         ! Denotes EOF
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.3 split_one_line

Subroutine SPLIT_ONE_LINE reads a line from the input file (via routine READ_ONE_LINE), and separates it into substrings.

SPLIT_ONE_LINE also checks to see if the number of substrings found is equal to the number of substrings that we expected to find. However, if you don't know a-priori how many substrings to expect a-priori, you can skip the error check.

INTERFACE:

```
SUBROUTINE SPLIT_ONE_LINE( SUBSTRS, N_SUBSTRS, N_EXP, LOCATION )
```

USES:

```
USE CHARPAK_MOD, ONLY: STRSPLIT
```

INPUT PARAMETERS:

```
! Number of substrings we expect to find
INTEGER,            INTENT(IN)  :: N_EXP

! Name of routine that called SPLIT_ONE_LINE
CHARACTER(LEN=*),   INTENT(IN)  :: LOCATION
```

OUTPUT PARAMETERS:

```
! Array of substrings (separated by " ")
CHARACTER(LEN=255), INTENT(OUT) :: SUBSTRS(MAXDIM)

! Number of substrings actually found
INTEGER,            INTENT(OUT) :: N_SUBSTRS
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.4 read_simulation_menu

Subroutine READ_SIMULATION_MENU reads the SIMULATION MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_SIMULATION_MENU
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR,    DATA_DIR_1x1, GCAP_DIR
USE DIRECTORY_MOD, ONLY : GEOS_3_DIR,  GEOS_4_DIR,   GEOS_5_DIR
USE DIRECTORY_MOD, ONLY : MERRA_DIR
USE DIRECTORY_MOD, ONLY : RUN_DIR
USE DIRECTORY_MOD, ONLY : TEMP_DIR
USE GRID_MOD,      ONLY : SET_XOFFSET, SET_YOFFSET,  COMPUTE_GRID
USE LOGICAL_MOD,   ONLY : LSVGLB,      LUNZIP,       LWAIT
USE LOGICAL_MOD,   ONLY : LVARTROP,    LLINOZ
USE RESTART_MOD,   ONLY : SET_RESTART
USE TIME_MOD,      ONLY : SET_BEGIN_TIME,   SET_END_TIME
USE TIME_MOD,      ONLY : SET_CURRENT_TIME, SET_DIAGb
USE TIME_MOD,      ONLY : SET_NDIAGTIME,    GET_TAU
USE TRANSFER_MOD,  ONLY : INIT_TRANSFER
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Bug fix: Read LSVGLB w/ the * format and not w/ '(a)'. (bmy, 2/23/05)
(2 ) Now read GEOS_5_DIR and GCAP_DIR from input.geos (swu, bmy, 5/25/05)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Now references DATA_DIR_1x1 for 1x1 emissions files (bmy, 10/24/05)
(5 ) Now read switch for using variable tropopause or not (phs, 9/14/06)
(6 ) Remove references to GEOS-1 and GEOS-STRAT run dirs.  Now calls
     INIT_TRANSFER (bmy, 11/5/07)
(7 ) Fix typo in "print to screen" section  (phs, 6/1/08)
(8 ) Call INIT_TRANSFER w/ (0,0) instead of (I0,J0) (phs, 6/17/08)
(10) Now read LLINOZ switch from input.geos file (dbm, bmy, 10/16/09)
13 Aug 2010 - R. Yantosca - Now read MERRA_DIR
19 Aug 2010 - R. Yantosca - Set LUNZIP=F for MERRA met fields.
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.5 read_tracer_menu

Subroutine READ_TRACER_MENU reads the TRACER MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_TRACER_MENU
```

USES:

```
USE CHARPAK_MOD,  ONLY : ISDIGIT
USE BIOFUEL_MOD,  ONLY : SET_BFTRACE
USE BIOMASS_MOD,  ONLY : SET_BIOTRCE
USE ERROR_MOD,    ONLY : ALLOC_ERR, ERROR_STOP
USE LOGICAL_MOD,  ONLY : LSPLIT
USE TRACER_MOD,   ONLY : ID_EMITTED,     ID_TRACER
USE TRACER_MOD,   ONLY : SIM_TYPE,       N_TRACERS
USE TRACER_MOD,   ONLY : TCVV,           TRACER_COEFF
USE TRACER_MOD,   ONLY : TRACER_CONST,   TRACER_MW_G
USE TRACER_MOD,   ONLY : TRACER_MW_KG,   TRACER_N_CONST
USE TRACER_MOD,   ONLY : TRACER_NAME,    INIT_TRACER
USE TRACER_MOD,   ONLY : XNUMOL,         XNUMOLAIR
USE TRACER_MOD,   ONLY : ITS_A_FULLCHEM_SIM
USE TRACER_MOD,   ONLY : ITS_A_HCN_SIM
USE TRACER_MOD,   ONLY : ITS_A_MERCURY_SIM
USE TRACERID_MOD, ONLY : TRACERID

USE CMN_SIZE_MOD       ! Size parameters
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now set LSPLIT correctly for Tagged Hg simulation (eck, bmy, 12/13/04)
(2 ) Now initialize ocean mercury module (sas, bmy, 1/20/05)
(3 ) Now set LSPLIT correctly for Tagged HCN/CH3CN sim (xyp, bmy, 6/30/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Now reference XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(6 ) Now move call to INIT_OCEAN_MERCURY to READ_MERCURY_MENU (bmy, 2/24/06)
(7 ) Now do not call SET_BIOTRCE anymore; it's obsolete (bmy, 4/5/06)
(8 ) Add SET_BIOTRCE to initialize IDBxxxs. (fp, 2/26/10)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.6 read_aerosol_menu

Subroutine READ_AEROSOL_MENU reads the AEROSOL MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_AEROSOL_MENU
```

USES:

```
USE ERROR_MOD,    ONLY : ERROR_STOP
USE LOGICAL_MOD,  ONLY : LSULF, LCARB, LSOA
USE LOGICAL_MOD,  ONLY : LDUST, LDEAD, LSSALT, LCRYST
USE LOGICAL_MOD,  ONLY : LDICARB
USE TRACER_MOD,   ONLY : N_TRACERS
USE TRACER_MOD,   ONLY : SALA_REDGE_um,      SALC_REDGE_um
USE TRACER_MOD,   ONLY : ITS_AN_AEROSOL_SIM, ITS_A_FULLCHEM_SIM
USE TRACERID_MOD, ONLY : IDTDMS,   IDTSO2,   IDTSO4,  IDTSO4s
USE TRACERID_MOD, ONLY : IDTMSA,   IDTNH3,   IDTNH4,  IDTNITs
USE TRACERID_MOD, ONLY : IDTAS,    IDTAHS,   IDTLET,  IDTNH4aq
USE TRACERID_MOD, ONLY : IDTSO4aq, IDTBCPO,  IDTBCPI, IDTOCPO
USE TRACERID_MOD, ONLY : IDTOCPI,  IDTALPH,  IDTLIMO, IDTALCO
USE TRACERID_MOD, ONLY : IDTSOG1,  IDTSOG2,  IDTSOG3, IDTSOG4
USE TRACERID_MOD, ONLY : IDTSOA1,  IDTSOA2,  IDTSOA3, IDTSOA4
USE TRACERID_MOD, ONLY : IDTDST1,  IDTDST2,  IDTDST3, IDTDST4
USE TRACERID_MOD, ONLY : IDTSALA,  IDTSALC
USE TRACERID_MOD, ONLY : IDTSOAG,  IDTSOAM,  IDTSOA5
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now reference LSOA (bmy, 9/28/04)
(2 ) Now stop run if LSOA=T and SOA tracers are undefined (bmy, 11/19/04)
(3 ) Now reference LCRYST from "logical_mod.f".  Also now check to make
     prevent aerosol tracers from being undefined if the corresponding
```

```
      logical switch is set. (cas, bmy, 1/14/05)
(4 ) Now also require LSSALT=T when LSULF=T, since we now compute the
      production of SO4 and NIT w/in the seasalt aerosol (bec, bmy, 4/13/05)
(5 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(6 ) Now update error check for SOG4, SOA4 (dkh, bmy, 6/1/06)
(7 ) Add LDICARB switch to cancel SOG condensation onto OC aerosols.
    (ccc, tmf, 3/10/09)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.7 read_emissions_menu

Subroutine READ_EMISSIONS_MENU reads the EMISSIONS MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_EMISSIONS_MENU
```

USES:

```
USE ERROR_MOD,   ONLY : ERROR_STOP
USE LOGICAL_MOD, ONLY : LAIRNOX,    LANTHRO,   LAVHRRLAI, LBBSEA
USE LOGICAL_MOD, ONLY : LBIOFUEL,   LBIOGENIC, LBIOMASS,  LBIONOX
USE LOGICAL_MOD, ONLY : LCOOKE
USE LOGICAL_MOD, ONLY : LEMIS,      LFOSSIL,   LLIGHTNOX, LMONOT
USE LOGICAL_MOD, ONLY : LNEI99,     LSHIPSO2,  LSOILNOX,  LTOMSAI
USE LOGICAL_MOD, ONLY : LWOODCO,    LMEGAN,    LMEGANMONO,LEMEP
USE LOGICAL_MOD, ONLY : LFERTILIZERNOX
USE LOGICAL_MOD, ONLY : LOTDLOC
USE LOGICAL_MOD, ONLY : LBRAVO,    LEDGAR
USE LOGICAL_MOD, ONLY : LEDGARNOx,  LEDGARCO,  LEDGARSOx
USE LOGICAL_MOD, ONLY : LEDGARSHIP, LSTREETS,  LCAC,      LVISTAS
USE LOGICAL_MOD, ONLY : LARCSHIP,   LEMEPSHIP, LICARTT,   LGFED2BB
USE LOGICAL_MOD, ONLY : LGFED3BB
USE LOGICAL_MOD, ONLY : LICOADSSHIP,LNEI05
USE LOGICAL_MOD, ONLY : L8DAYBB,    L3HRBB,    LSYNOPBB
USE LOGICAL_MOD, ONLY : L8DAYBB3,   L3HRBB3,   LSYNOPBB3
USE TRACER_MOD,  ONLY : ITS_A_FULLCHEM_SIM
USE LOGICAL_MOD, ONLY : LMODISLAI , LPECCA  !(mpb,2009)
USE EMISSIONS_MOD, ONLY : ISOP_SCALING
USE EMISSIONS_MOD, ONLY : NOx_SCALING
USE LOGICAL_MOD, ONLY : LRETRO  !(wfr, 3/8/11)


USE CMN_SIZE_MOD      ! Size parameters
USE CMN_O3_MOD        ! FSCALYR
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now read LNEI99 -- switch for EPA/NEI99 emissions (bmy, 11/5/04)
(2 ) Now read LAVHRRLAI-switch for using AVHRR-derived LAI (bmy, 12/20/04)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Now read LMEGAN -- switch for MEGAN biogenics (tmf, bmy, 10/20/05)
(5 ) Now read LEMEP -- switch for EMEP emissions (bdf, bmy, 11/1/05)
(6 ) Now read LGFED2BB -- switch for GFED2 biomass emissions (bmy, 4/5/06)
(7 ) Now read LOTDLIS, LCTH, LMFLUX, LPRECON for lightning options
     (bmy, 5/10/06)
(8 ) Now read LBRAVO for BRAVO Mexican emissions (rjp, kfb, bmy, 6/26/06)
(9 ) Now read LEDGAR for EDGAR emissions (avd, bmy, 7/11/06)
(10) Now read LSTREETS for David Streets' emissions (bmy, 8/17/06)
(11) Kludge: Reset LMFLUX or LPRECON to LCTH, as the MFLUX and PRECON
     lightning schemes have not yet been implemented.  Rename LOTDLIS
     to LOTDREG.  Also read LOTDLOC for the OTD-LIS local redistribution
     of lightning flashes (cf B. Sauvage).  Make sure LOTDREG and
     LOTDLOC are not both turned on at the same time. (bmy, 1/31/07)
(12) Add LOTDSCALE to the list of LNOx options (ltm, bmy, 9/24/07)
(13) Add new error traps for OTD-LIS options, dependent on met field type
     (ltm, bmy, 11/29/07)
(14) Bug fix, create string variables for ERROR_STOP (bmy, 1/24/08)
(15) Now read LCAC for CAC emissions (amv, 1/09/2008)
(16) Now read LEDGARSHIP, LARCSHIP and LEMEPSHIP (phs, 12/5/08)
(17) Fixed typo in message for GEOS-3 (bmy, 10/30/08)
(18) Now read LVISTAS (amv, 12/2/08)
(19) Now read L8DAYBB, L3HRBB and LSYNOPBB for GFED2 8-days and 3hr
     emissions, and LICARTT for corrected EPA (phs, yc, 12/17/08)
(20) Add a specific switch for MEGAN emissions for monoterpenes and MBO
     (ccc, 2/2/09)
(21) Now read LICOADSSHIP (cklee, 6/30/09)
(22) Bug fix: for now, if LEMEPSHIP is turned on but LEMEP is turned off,
     just turn off LEMEPSHIP and print a warning msg. (mak, bmy, 10/18/09)
(23) Now accounts for NEI2005 (amv, phs, 10/9/09)
(24) Included optional flag for using MODIS LAI data (mpb,2009).
(25) Included optional flag for using PCEEA model (mpb, 2009)
(26) Now force settings for EU, NA, CC nested grids (amv, bmy, 12/18/09)
(27) Now force MEGAN to use MODIS LAI (ccarouge, bmy, 2/24/10)
(28) Add separate switch for NOx fertilizer. (fp, 2/29/10)
(29) Add scaling for isoprene and NOx emissions. (fp, 2/29/10)
(30) Remove depreciated lightning options. (ltm, 1/25,11)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
27 Aug 2010 - R. Yantosca - Added warning msg for MERRA
29 Jul 2011 - L. Zhang    - Fix bug that turns off CAC/BRAVO emissions
                            inadvertently during nested NA simulations
07 Sep 2011 - P. Kasibhatla - Add modifications for GFED3
```

1.43.8 read_co2_sim_menu

Subroutine READ_CO2_SIM_MENU reads the CO2 SIM MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_CO2_SIM_MENU
```

USES:

```
USE ERROR_MOD,   ONLY : ERROR_STOP
USE LOGICAL_MOD, ONLY : LANTHRO, LFOSSIL
USE LOGICAL_MOD, ONLY : LGENFF, LANNFF, LMONFF, LSTREETS
USE LOGICAL_MOD, ONLY : LSEASBB, LGFED2BB, L8DAYBB, LBIOFUEL
USE LOGICAL_MOD, ONLY : LGFED3BB, L8DAYBB3
USE LOGICAL_MOD, ONLY : LBIODAILY, LBIODIURNAL
USE LOGICAL_MOD, ONLY : LBIONETORIG, LBIONETCLIM
USE LOGICAL_MOD, ONLY : LOCN1997, LOCN2009ANN, LOCN2009MON
USE LOGICAL_MOD, ONLY : LFFBKGRD
USE LOGICAL_MOD, ONLY : LSHIPEDG, LSHIPICO, LPLANE
USE LOGICAL_MOD, ONLY : LBIOSPHTAG, LFOSSILTAG
USE LOGICAL_MOD, ONLY : LSHIPTAG, LPLANETAG
USE LOGICAL_MOD, ONLY : LSHIPSCALE, LPLANESCALE
USE LOGICAL_MOD, ONLY : LCHEMCO2
USE TRACER_MOD,  ONLY : ITS_A_CO2_SIM

USE CMN_SIZE_MOD      ! Size parameters
USE CMN_O3_MOD        ! FSCALYR
```

REVISION HISTORY:

```
02 Mar 2009 - R. Nassar   - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
07 Sep 2011 - P. Kasibhatla - Modified for GFED3
```

1.43.9 read_future_menu

Subroutine READ_FUTURE_MENU reads the FUTURE MENU section of the GEOS-Chem input file; this defines IPCC future emissions options.

INTERFACE:

```
SUBROUTINE READ_FUTURE_MENU
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : DO_FUTURE_EMISSIONS
USE LOGICAL_MOD,          ONLY : LFUTURE
```

```
#     include "define.h"             ! C-preprocessor switches
```

REVISION HISTORY:

```
01 Jun 2006 - S. Wu       - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.10 read_chemistry_menu

Subroutine READ_CHEMISTRY_MENU reads the CHEMISTRY MENU section of the GEOS-Chem input file.

INTERFACE:

```
      SUBROUTINE READ_CHEMISTRY_MENU
```

USES:

```
      USE ERROR_MOD,   ONLY : ERROR_STOP
      USE LOGICAL_MOD, ONLY : LCHEM
      USE LOGICAL_MOD, ONLY : LSVCSPEC, LKPP
      USE TIME_MOD,    ONLY : SET_CT_CHEM
      USE TRACER_MOD,  ONLY : N_TRACERS

      USE CMN_SIZE_MOD      ! Size parameters
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1) added optional test on KPPTRACER (phs, 6/17/09)
(2) Remove reference to obsolete embedded chemistry stuff in "CMN"
    (bmy, 2/25/10)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.11 read_transport_menu

Subroutine READ_TRANSPORT_MENU reads the TRANSPORT MENU section of the GEOS-Chem input file.

INTERFACE:

```
      SUBROUTINE READ_TRANSPORT_MENU
```

USES:

```
USE ERROR_MOD,     ONLY : ERROR_STOP
USE LOGICAL_MOD,   ONLY : LTRAN,               LUPBD
USE LOGICAL_MOD,   ONLY : LMFCT,               LFILL
USE TRACER_MOD,    ONLY : ITS_A_FULLCHEM_SIM, ITS_A_TAGOX_SIM
USE TRANSPORT_MOD, ONLY : SET_TRANSPORT
USE UPBDFLX_MOD,   ONLY : INIT_UPBDFLX
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now define MAX_DYN for 1 x 1.25 grid (bmy, 12/1/04)
(2 ) Update text in error message (bmy, 2/23/05)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Don't stop run if TS_DYN > MAX_DYN but transport is turned off
     (cdh, bmy, 7/7/08)
(5 ) Set MAX_DYN for the 0.5 x 0.666 nested grid (yxw, dan, bmy, 11/6/08)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.12 read_convection_menu

Subroutine READ_CONVECTION_MENU reads the CONVECTION MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_CONVECTION_MENU
```

USES:

```
USE ERROR_MOD,   ONLY : ERROR_STOP
USE LOGICAL_MOD, ONLY : LCONV, LTURB
USE LOGICAL_MOD, ONLY : LNLPBL        ! (Lin, 03/31/09)
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Add option for new non-local PBL scheme. And a check on GEOS-5,
     LNLPBL turned to false if GEOS-5 is not used (lin, ccc 5/13/09)
27 Aug 2010 - R. Yantosca - Now allow non-local PBL for MERRA met data
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.13 read_deposition_menu

Subroutine READ_DEPOSITION_MENU reads the DEPOSITION MENU section of the GEOS-Chem input file.

INTERFACE:

```
      SUBROUTINE READ_DEPOSITION_MENU
```

USES:

```
      USE ERROR_MOD,   ONLY : ERROR_STOP
      USE DRYDEP_MOD,  ONLY : INIT_DRYDEP
      USE LOGICAL_MOD, ONLY : LCONV,              LDRYD
      USE LOGICAL_MOD, ONLY : LWETD,              LSPLIT
      USE TRACER_MOD,  ONLY : ITS_A_C2H6_SIM,     ITS_A_CH3I_SIM
      USE TRACER_MOD,  ONLY : ITS_A_CH4_SIM,      ITS_A_HCN_SIM
      USE TRACER_MOD,  ONLY : ITS_A_MERCURY_SIM, ITS_A_TAGCO_SIM
      USE TRACER_MOD,  ONLY : ITS_A_TAGOX_SIM
      USE WETSCAV_MOD, ONLY : WETDEPID
#if   defined( APM )
      USE APM_WETS_MOD, ONLY : WETDEPBINID
#endif
```

REVISION HISTORY:

```
   20 Jul 2004 - R. Yantosca - Initial version
   (1 ) Now print an informational message for tagged Hg (bmy, 12/15/04)
   (2 ) We need to call WETDEPID for both wetdep and cloud convection
        since this sets up the list of soluble tracers (bmy, 3/1/05)
   (3 ) Remove references to obsolete CO_OH simulation (bmy, 6/24/05)
   (4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   27 Aug 2010 - R. Yantosca - Added ProTeX headers
   16 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.43.14 read_gamap_menu

Subroutine READ_GAMAP_MENU reads the GAMAP MENU section of the GEOS-Chem input file.

INTERFACE:

```
      SUBROUTINE READ_GAMAP_MENU
```

REVISION HISTORY:

```
   25 Apr 2005 - R. Yantosca - Initial version
   27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.15 read_output_menu

Subroutine READ_OUTPUT_MENU reads the OUTPUT MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_OUTPUT_MENU
```

USES:

```
USE FILE_MOD, ONLY : IU_GEOS, IOERROR

USE CMN_SIZE_MOD   ! Size parameters
USE CMN_DIAG_MOD   ! NJDAY
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.16 read_diagnostic_menu

Subroutine READ_DIAGNOSTIC_MENU reads the DIAGNOSTIC MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_DIAGNOSTIC_MENU
```

USES:

```
USE BIOFUEL_MOD,  ONLY : NBFTRACE
USE BPCH2_MOD,    ONLY : OPEN_BPCH2_FOR_WRITE
USE DIAG03_MOD,   ONLY : ND03,      PD03,      INIT_DIAG03
USE DIAG04_MOD,   ONLY : ND04,      PD04,      INIT_DIAG04
USE DIAG41_MOD,   ONLY : ND41,      PD41,      INIT_DIAG41
USE DIAG42_MOD,   ONLY : ND42,      PD42,      INIT_DIAG42
USE DIAG56_MOD,   ONLY : ND56,      PD56,      INIT_DIAG56
USE DIAG_OH_MOD,  ONLY : INIT_DIAG_OH
USE DRYDEP_MOD,   ONLY : NUMDEP
USE ERROR_MOD,    ONLY : ERROR_STOP
USE FILE_MOD,     ONLY : IU_BPCH
USE LOGICAL_MOD,  ONLY : LBIOMASS,  LBIOFUEL,  LCARB, LCONV
USE LOGICAL_MOD,  ONLY : LDRYD,     LDUST,     LPRT,  LSULF
USE LOGICAL_MOD,  ONLY : LSSALT,    LTURB,     LWETD, LGFED2BB
USE LOGICAL_MOD,  ONLY : LGFED3BB
USE TIME_MOD,     ONLY : GET_NYMDb, GET_NHMSb, EXPAND_DATE
USE TRACER_MOD,   ONLY : N_TRACERS
USE TRACER_MOD,   ONLY : ITS_A_CO2_SIM,        ITS_A_FULLCHEM_SIM
USE TRACER_MOD,   ONLY : ITS_A_MERCURY_SIM,    ITS_A_RnPbBe_SIM
USE TRACER_MOD,   ONLY : ITS_A_TAGOX_SIM,      ITS_A_CH3I_SIM
USE TRACER_MOD,   ONLY : SALA_REDGE_um,        ITS_A_CH4_SIM
USE TRACERID_MOD, ONLY : NEMANTHRO
USE WETSCAV_MOD,  ONLY : GET_WETDEP_NMAX
```

```
      USE CMN_SIZE_MOD       ! Size parameters
      USE CMN_DIAG_MOD       ! NDxx flags
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    (1 ) Now reference IU_BPCH from "file_mod.f" and OPEN_BPCH2_FOR_WRITE
         from "bpch2_mod.f".  Now opens the bpch file for output here
         instead of w/in "main.f" (bmy, 2/3/05)
    (2 ) Now references "diag03_mod.f" and "diag41_mod.f".  Now turn off ND38
         when both LWETD=F and LCONV=F.  Now calls EXPAND_DATE to replace
         YYYYMMDD and HHMMSS tokens in the bpch file name with the actual
         starting date & time of the run. (bmy, 3/25/05)
    (3 ) Now get diag info for ND09 for HCN/CH3CN sim (bmy, 6/27/05)
    (4 ) Now references "diag04_mod.f" (bmy, 7/26/05)
    (5 ) Now make sure all USE statements are USE, ONLY.  Also remove reference
         to DIAG_MOD, it's not needed. (bmy, 10/3/05)
    (6 ) Now remove reference to NBIOTRCE; Replace w/ NBIOMAX. (bmy, 4/5/06)
    (7 ) Now reference ND56, PD56, INIT_DIAG56 from "diag56_mod.f"
         (bmy, 5/10/06)
    (8 ) Now reference ND42, PD42, INIT_DIAG42 from "diag42_mod.f"
         (dkh, bmy, 5/22/06)
    (9 ) Now set max dimension for GFED2 or default biomass (bmy, 9/22/06)
    (10) Bug fix: Should use ND52 in call to SET_TINDEX (cdh, bmy, 2/11/08)
    (11) Remove call to NDXX_SETUP; this is now called in READ_INPUT_FILE.
         (phs, 11/18/08)
    (12) Now set TINDEX with PD45=NNPAR+1 tracers instead of N_TRACERS.
         (tmf, 2/10/09)
    (13) NBIOMAX now in F77_CMN_SIZE (fp, 6/2009)
    27 Aug 2010 - R. Yantosca - Added ProTeX headers
    26 May 2011 - R. Yantosca - For ND17, ND18, ND37, ND38, ND39, we need to
                                set N_TMP = N_TRACERS, or else wetdep tracers
                                with indices higher than #32 won't print out.
```

1.43.17 set_tindex

Subroutine SET_TINDEX sets the TINDEX and TMAX arrays, which determine how many tracers to print to the punch file.

INTERFACE:

```
      SUBROUTINE SET_TINDEX( N_DIAG, L_DIAG, SUBSTRS, N, NMAX )
```

USES:

```
      USE CMN_SIZE_MOD                          ! Size parameters
      USE CMN_DIAG_MOD                          ! TMAX, TINDEX
```

INPUT PARAMETERS:

```
INTEGER,            INTENT(IN) :: N_DIAG      ! GEOS-Chem diagnostic #
INTEGER,            INTENT(IN) :: N           ! # of valid substrs passed
INTEGER,            INTENT(IN) :: NMAX        ! Max # of tracers allowed
INTEGER,            INTENT(IN) :: L_DIAG      ! # of levels to save
CHARACTER(LEN=255), INTENT(IN) :: SUBSTRS(N)  ! Substrs passed from
                                              !  READ_DIAGNOSTIC_MENU
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Bug fix: now do not drop the last tracer number if "all" is not
      explicitly specified (tmf, bmy, 11/15/04)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.18 read_planeflight_menu

Subroutine READ_PLANEFLIGHT_MENU reads the PLANEFLIGHT MENU section of the GEOS-Chem input file. This turns on the ND40 flight track diagnostic.

INTERFACE:

```
SUBROUTINE READ_PLANEFLIGHT_MENU
```

USES:

```
USE ERROR_MOD,       ONLY : ERROR_STOP
USE PLANEFLIGHT_MOD, ONLY : SET_PLANEFLIGHT

USE CMN_SIZE_MOD          ! MAXFAM
USE CMN_DIAG_MOD          ! ND40
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.19 read_nd48_menu

Subroutine READ_ND48_MENU reads the ND48 MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_ND48_MENU
```

USES:

```
USE DIAG48_MOD, ONLY : INIT_DIAG48, ND48_MAX_STATIONS
USE ERROR_MOD,  ONLY : ERROR_STOP
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Bug fix: ND48 stations should now be read correctly. (bmy, 3/6/06)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.20 read_nd49_menu

Subroutine READ_ND49_MENU reads the ND49 MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_ND49_MENU
```

USES:

```
USE DIAG49_MOD, ONLY : INIT_DIAG49
USE ERROR_MOD,  ONLY : ERROR_STOP

USE CMN_SIZE_MOD     ! Size parameters
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.21 read_nd50_menu

Subroutine READ_ND50_MENU reads the ND50 MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_ND50_MENU
```

USES:

```
USE DIAG50_MOD,  ONLY : INIT_DIAG50
USE ERROR_MOD,   ONLY : ERROR_STOP
USE LOGICAL_MOD, ONLY : LND50_HDF
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now include option to save ND51 diagnostic to HDF5 file format
      (amv, bmy, 12/21/09)
(2 ) Increase tracer number to 121. (ccc, 4/20/10)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.22 read_nd51_menu

Subroutine READ_ND51_MENU reads the ND51 MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_ND51_MENU
```

USES:

```
USE DIAG51_MOD,  ONLY : INIT_DIAG51
USE ERROR_MOD,   ONLY : ERROR_STOP
USE LOGICAL_MOD, ONLY : LND51_HDF

USE CMN_SIZE_MOD      ! Size parameters
USE CMN_DIAG_MOD      ! NDxx flags
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now include option to save ND51 diagnostic to HDF5 file format
      (amv, bmy, 12/21/09)
(2 ) Increase # of tracers to 121 (ccc, 4/20/10)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.23 read_nd51b_menu

Subroutine READ_ND51b_MENU reads the ND51 MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_ND51b_MENU
```

USES:

```
USE DIAG51b_MOD, ONLY : INIT_DIAG51b
USE ERROR_MOD,   ONLY : ERROR_STOP
USE LOGICAL_MOD, ONLY : LND51b_HDF
```

```
      USE CMN_SIZE_MOD      ! Size parameters
      USE CMN_DIAG_MOD      ! NDxx flags
```

REVISION HISTORY:

```
21 Dec 2009 - Aaron van D - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.24 read_prod_loss_menu

Subroutine READ_PROD_LOSS_MENU reads the PROD AND LOSS MENU section of the GEOS-Chem input file

INTERFACE:

```
      SUBROUTINE READ_PROD_LOSS_MENU
```

USES:

```
      USE CHARPAK_MOD, ONLY : ISDIGIT,         STRSPLIT
      USE DIAG_PL_MOD, ONLY : INIT_DIAG_PL
      USE ERROR_MOD,   ONLY : ERROR_STOP
      USE TRACER_MOD,  ONLY : N_TRACERS,       ITS_A_TAGCO_SIM
      USE TRACER_MOD,  ONLY : ITS_A_TAGOX_SIM, ITS_AN_AEROSOL_SIM
      USE LOGICAL_MOD, ONLY : LKPP

      USE CMN_SIZE_MOD      ! MAXFAM
      USE CMN_DIAG_MOD      ! ND65
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Bug fixes.  Only error check # of prod/loss families for TagOx and
      TagCO runs if DO_SAVE_PL=T.  Also turn off this diagnostic for
      the offline aerosol run. (bmy, 10/29/04)
(2 ) Add error trap is P/L families are asked when using KPP. (ccc, 3/10/10)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.25 read_unix_cmds_menu

Subroutine READ_UNIX_CMDS_MENU reads the UNIX CMDS MENU section of the GEOS-Chem input file.

INTERFACE:

```
      SUBROUTINE READ_UNIX_CMDS_MENU
```

USES:

```
USE CHARPAK_MOD,   ONLY : STRSQUEEZE
USE UNIX_CMDS_MOD, ONLY : BACKGROUND, REDIRECT,  REMOVE_CMD
USE UNIX_CMDS_MOD, ONLY : SEPARATOR,  SPACE,     UNZIP_CMD
USE UNIX_CMDS_MOD, ONLY : WILD_CARD,  ZIP_SUFFIX
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.26 read_nested_grid_menu

Subroutine READ_NESTED_GRID_MENU reads the NESTED GRID MENU section of the GEOS-CHEM input file.

INTERFACE:

```
SUBROUTINE READ_NESTED_GRID_MENU
```

USES:

```
USE DIRECTORY_MOD, ONLY : TPBC_DIR
USE DIRECTORY_MOD, ONLY : TPBC_DIR_NA, TPBC_DIR_EU
USE DIRECTORY_MOD, ONLY : TPBC_DIR_CH
USE LOGICAL_MOD,   ONLY : LWINDO, LWINDO2x25
USE LOGICAL_MOD,   ONLY : LWINDO_NA, LWINDO_EU, LWINDO_CH
USE LOGICAL_MOD,   ONLY : LWINDO_CU
USE TPCORE_BC_MOD, ONLY : INIT_TPCORE_BC
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now give user the option of saving out nested grid boundary conditions
      at 2 x 2.5 resolution for the EU, CH, or NA grids (amv, bmy, 12/18/09)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.27 read_benchmark_menu

Subroutine READ_BENCHMARK_MENU reads the BENCHMARK MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_BENCHMARK_MENU
```

USES:

```
USE BENCHMARK_MOD, ONLY : INITIAL_FILE, FINAL_FILE
USE LOGICAL_MOD,   ONLY : LSTDRUN
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.28 read_archived_oh_menu

Subroutine READ_ARCHIVED_OH_MENU reads the ARCHIVED OH MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_ARCHIVED_OH_MENU
```

USES:

```
USE DIRECTORY_MOD, ONLY : OH_DIR
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.29 read_o3pl_menu

Subroutine READ_O3PL_MENU reads the O3 P/L MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_O3PL_MENU
```

USES:

```
USE DIRECTORY_MOD, ONLY : O3PL_DIR
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.30 read_mercury_menu

Subroutine READ_MERCURY_MENU reads the BENCHMARK MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_MERCURY_MENU
```

USES:

```
! References to F90 modules
USE LOGICAL_MOD,       ONLY : LDYNOCEAN, LPREINDHG, LGTMM
USE MERCURY_MOD,       ONLY : INIT_MERCURY
USE OCEAN_MERCURY_MOD, ONLY : INIT_OCEAN_MERCURY
USE DEPO_MERCURY_MOD,  ONLY : INIT_DEPO_MERCURY
USE LAND_MERCURY_MOD,  ONLY : INIT_LAND_MERCURY
USE TRACER_MOD,        ONLY : ITS_A_MERCURY_SIM
```

REVISION HISTORY:

```
24 Feb 2006 - R. Yantosca - Initial version
( 1) Update for Chris Holmes's mercury version. (ccc, 5/6/10)
( 2) Add options to use GTMM for mercury soil emissions (ccc, 9/16/09)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.31 read_ch4_menu

Subroutine READ_CH4_MENU reads the CH4 MENU section of the GEOS-Chem input file; this defines emissions options for CH4 tagged simulations.

INTERFACE:

```
SUBROUTINE READ_CH4_MENU
```

USES:

```
! References to F90 modules
USE LOGICAL_MOD, ONLY : LGAO,    LCOL,    LLIV,   LWAST
USE LOGICAL_MOD, ONLY : LBFCH4,  LBMCH4,  LWETL,  LRICE
USE LOGICAL_MOD, ONLY : LOTANT,  LSOABS,  LOTNAT
USE LOGICAL_MOD, ONLY : LCH4BUD

#     include "define.h"             ! C-preprocessor switches
```

REVISION HISTORY:

```
03 Aug 2009 - K. Wecht, C. Pickett-Heaps - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.32 read_apm_menu

Subroutine READ_APM_MENU reads the APM MENU section of the GEOS-Chem input file.

INTERFACE:

```
SUBROUTINE READ_APM_MENU
```

USES:

```
USE ERROR_MOD,     ONLY : ERROR_STOP
USE APM_INIT_MOD,  ONLY : APMTRACER_MW_G
USE APM_INIT_MOD,  ONLY : APMTRACER_MW_Kg
USE APM_INIT_MOD,  ONLY : IFNUCL
USE APM_INIT_MOD,  ONLY : FEO
USE APM_INIT_MOD,  ONLY : LAPM
USE TRACER_MOD,    ONLY : N_APMTRA
USE TRACER_MOD,    ONLY : N_TRACERS
USE TRACER_MOD,    ONLY : TCVV
USE TRACER_MOD,    ONLY : XNUMOL
```

REMARKS:

```
This subroutine is only compiled when you build GEOS-Chem with the
APM=yes makefile option.
```

REVISION HISTORY:

```
30 Sep 2008 - G. Luo, F. Yu - Initial version
16 Feb 2011 - R. Yantosca - Added ProTeX headers
```

1.43.33 validate_directories

Subroutine VALIDATE_DIRECTORIES makes sure that each of the directories that we have read from the GEOS-Chem input file are valid. Also, trailing separator characters will be added.

INTERFACE:

```
SUBROUTINE VALIDATE_DIRECTORIES
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR,    DATA_DIR_1x1, GCAP_DIR
USE DIRECTORY_MOD, ONLY : GEOS_1_DIR,  GEOS_S_DIR,   GEOS_3_DIR
USE DIRECTORY_MOD, ONLY : GEOS_4_DIR,  GEOS_5_DIR,   O3PL_DIR
USE DIRECTORY_MOD, ONLY : OH_DIR,      RUN_DIR,      TEMP_DIR
USE DIRECTORY_MOD, ONLY : TPBC_DIR,    TPBC_DIR_NA,  MERRA_DIR
USE DIRECTORY_MOD, ONLY : TPBC_DIR_EU, TPBC_DIR_CH
USE GRID_MOD,      ONLY : ITS_A_NESTED_GRID
```

```
      USE LOGICAL_MOD,   ONLY : LWINDO_CU,   LUNZIP
      USE LOGICAL_MOD,   ONLY : LWINDO_NA,   LWINDO_EU,    LWINDO_CH
      USE TIME_MOD,      ONLY : EXPAND_DATE, GET_NYMDb,    GET_NYMDe

#     include "define.h"
```

REVISION HISTORY:

```
   20 Jul 2004 - R. Yantosca - Initial version
   (1 ) Now make sure all USE statements are USE, ONLY.  Now also validate
        GCAP and GEOS-5 directories. (bmy, 10/3/05)
   (2 ) Now references DATA_DIR_1x1 from directory_mod.f (bmy, 10/24/05)
   (3 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
   (4 ) Now check TPBC_DIR_NA, TPBC_DIR_CH, TPBC_DIR_EU (amv, bmy, 12/18/09)
   27 Aug 2010 - R. Yantosca - Added ProTeX headers
   27 Aug 2010 - R. Yantosca - Now check MERRA directory
```

1.43.34 check_directory

Subroutine CHECK_DIRECTORY makes sure that the given directory is valid. Also a trailing slash character will be added if necessary.

INTERFACE:

```
      SUBROUTINE CHECK_DIRECTORY( DIR )
```

USES:

```
      ! References to F90 modules
      USE ERROR_MOD,     ONLY : ERROR_STOP
      USE FILE_MOD,      ONLY : FILE_EXISTS
      USE UNIX_CMDS_MOD, ONLY : SEPARATOR

#     include "define.h"                        ! C-preprocessor flags
```

INPUT PARAMETERS:

```
      CHARACTER(LEN=*), INTENT(INOUT) :: DIR    ! Directory to be checked
```

REVISION HISTORY:

```
   20 Mar 2003 - R. Yantosca - Initial version
   (1 ) Now references FILE_EXISTS from "file_mod.f" (bmy, 3/23/05)
   27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.35 check_time_steps

Subroutine CHECK_TIME_STEPS computes the smallest dynamic time step for the model, based on which operation are turned on. This is called from routine READ_INPUT_FILE, after all of the timesteps and logical flags have been read from "input.geos".

INTERFACE:

```
SUBROUTINE CHECK_TIME_STEPS
```

USES:

```
USE LOGICAL_MOD, ONLY : LCONV, LCHEM, LDRYD
USE LOGICAL_MOD, ONLY : LEMIS, LTRAN, LTURB
USE TIME_MOD,    ONLY : SET_TIMESTEPS
USE ERROR_MOD,   ONLY : GEOS_CHEM_STOP
USE TRACER_MOD,  ONLY : ITS_A_CH4_SIM
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(2 ) Add TS_DIAG, the largest time steps used for diagnostics.
     And test that all time steps are multiple of the smallest one.
     (ccc, 5/13/09)
(3 ) Corrected typos -99999 instead of -999999 (phs, bmy, 8/21/09)
(4 ) Now compute TS_SUN_2 which is 1/2 of the chemistry timestep (or
     smallest timestep if LCHEM=LEMIS=LDRYD=F).  This is used to compute
     SUNCOS at the midpoint of the timestep instead of the beginning.
     (bmy, 4/27/10)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
07 Oct 2011 - R. Yantosca - Add extra error checks for centralizing
                            chemistry timestep algorithm
07 Oct 2011 - R. Yantosca - Remove TS_SUN_2 from call to SET_TIMESTEPS
```

1.43.36 is_last_day_good

Suborutine IS_LAST_DAY_GOOD tests to see if there is output scheduled on the last day of the run.

INTERFACE:

```
SUBROUTINE IS_LAST_DAY_GOOD
```

USES:

```
USE ERROR_MOD,  ONLY : ERROR_STOP
USE JULDAY_MOD, ONLY : JULDAY
USE TIME_MOD,   ONLY : GET_NYMDe, ITS_A_LEAPYEAR, YMD_EXTRACT
```

```
USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DIAG_MOD     ! NJDAY
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Moved to "input_mod.f" from "main.f" (bmy, 1/11/05)
(2 ) Now call ITS_A_LEAPYEAR with FORCE=.TRUE. to always return whether
     the year Y would be a leap year, regardless of met field type.
     (swu, bmy, 4/24/06)
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.43.37 init_input

Subroutine INIT_INPUT initializes all variables from "directory_mod.f" and "logical_mod.f" for safety's sake.

INTERFACE:

```
SUBROUTINE INIT_INPUT
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR,   GEOS_1_DIR, GEOS_S_DIR
USE DIRECTORY_MOD, ONLY : GEOS_3_DIR, GEOS_4_DIR, TEMP_DIR
USE DIRECTORY_MOD, ONLY : RUN_DIR,    OH_DIR,     O3PL_DIR
USE DIRECTORY_MOD, ONLY : TPBC_DIR,   DATA_DIR_1x1
USE LOGICAL_MOD,   ONLY : LATEQ,      LAVHRRLAI,  LCARB
USE LOGICAL_MOD,   ONLY : LDEAD,      LDUST,      LSULF
USE LOGICAL_MOD,   ONLY : LSOA,       LSSALT,     LCHEM
USE LOGICAL_MOD,   ONLY : LCONV,      LDBUG
USE LOGICAL_MOD,   ONLY : LDIAG,      LPRT,       LSTDRUN
USE LOGICAL_MOD,   ONLY : LDRYD,      LAIRNOX,    LANTHRO
USE LOGICAL_MOD,   ONLY : LBIONOX,    LBIOMASS,   LBIOFUEL
USE LOGICAL_MOD,   ONLY : LBIOGENIC,  LBBSEA,     LEMIS
USE LOGICAL_MOD,   ONLY : LFFNOX,     LFOSSIL,    LLIGHTNOX
USE LOGICAL_MOD,   ONLY : LMONOT,     LNEI99,     LSHIPSO2
USE LOGICAL_MOD,   ONLY : LSOILNOX,   LTOMSAI,    LWOODCO
USE LOGICAL_MOD,   ONLY : LFILL,      LMFCT,      LTRAN
USE LOGICAL_MOD,   ONLY : LTPFV,      LUPBD,      LWINDO
USE LOGICAL_MOD,   ONLY : LUNZIP,     LWAIT,      LTURB
USE LOGICAL_MOD,   ONLY : LSVGLB,     LSPLIT,     LWETD
USE LOGICAL_MOD,   ONLY : LMEGAN,     LMEGANMONO, LDYNOCEAN
USE LOGICAL_MOD,   ONLY : LGFED2BB,   LFUTURE,    LEDGAR
USE LOGICAL_MOD,   ONLY : LGFED3BB
USE LOGICAL_MOD,   ONLY : LEDGARNOx,  LEDGARCO,   LEDGARSHIP
```

```
      USE LOGICAL_MOD,   ONLY : LEDGARSOx,  LVARTROP
      USE LOGICAL_MOD,   ONLY : LOTDLOC
      USE LOGICAL_MOD,   ONLY : LEMEP
      USE LOGICAL_MOD,   ONLY : LNEI05,     LPREINDHG
      USE LOGICAL_MOD,   ONLY : LSVCSPEC
      USE LOGICAL_MOD,   ONLY : LLINOZ
      USE LOGICAL_MOD,   ONLY : LMODISLAI,   LPECCA
      USE LOGICAL_MOD,   ONLY : LGENFF,      LANNFF,      LMONFF
      USE LOGICAL_MOD,   ONLY : LSEASBB,     LBIODAILY,   LBIODIURNAL
      USE LOGICAL_MOD,   ONLY : LBIONETORIG, LBIONETCLIM
      USE LOGICAL_MOD,   ONLY : LOCN1997,    LOCN2009ANN, LOCN2009MON
      USE LOGICAL_MOD,   ONLY : LFFBKGRD
      USE LOGICAL_MOD,   ONLY : LBIOSPHTAG,  LFOSSILTAG
      USE LOGICAL_MOD,   ONLY : LSHIPEDG,    LSHIPICO,    LPLANE
      USE LOGICAL_MOD,   ONLY : LSHIPSCALE,  LPLANESCALE
      USE LOGICAL_MOD,   ONLY : LSHIPTAG,    LPLANETAG
      USE LOGICAL_MOD,   ONLY : LCHEMCO2
      USE LOGICAL_MOD,   ONLY : LRETRO   !(wfr, 3/8/11)
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now also initialize LNEI99 from "logical_mod.f" (bmy, 11/5/04)
(2 ) Now also initialize LAVHRRLAI from "logical_mod.f" (bmy, 12/20/04)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Now also initialize LMEGAN switch (tmf, bmy, 10/20/05)
(5 ) Now also initialize LEMEP, LGFED2BB switches and DATA_DIR_1x1
     directory (bmy, 4/5/06)
(6 ) Now also intitialize LFUTURE (swu, bmy, 6/1/06)
(7 ) Now reference the EDGAR logical switches from "logical_mod.f"
     (avd, bmy, 7/11/06)
(8 ) Now initialize the LVARTROP switch (phs, 9/14/06)
(9 ) Now initialize LOTDREG, LOTDLOC, LCTH, LMFLUX, LPRECON (bmy, 1/31/07)
(10) Now initialize LOTDSCALE (ltm, bmy, 9/24/07)
(11) Add MEGAN Monoterpenes switch (ccc, 2/2/09)
16 Oct 2009 - R. Yantosca - Now initialize LLINOZ
19 Nov 2009 - C. Carouge  - Initialize LMODISLAI and LPECCA
01 Dec 2009 - C. Carouge  - Initialize LNEI05
27 Aug 2010 - R. Yantosca - Added ProTeX headers
07 Sep 2011 - P. Kasibhatla - Modified for GFED3
```

1.44 Fortran: Module Interface isoropiaii_mod

Module ISOROPIAII_MOD contains the routines that provide the interface between ISORROPIA II and GEOS-Chem.

The actual ISORROPIA II code which performs Na-SO4-NH3-NO3-Cl-(Ca-K-Mg) aerosol thermodynamic equilibrium is in `isoropiaIIcode.f`.

INTERFACE:

```
      MODULE ISOROPIAII_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_ISOROPIAII
      PUBLIC  :: DO_ISOROPIAII
      PUBLIC  :: GET_GNO3
      PUBLIC  :: GET_ISRINFO
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: GET_HNO3
      PRIVATE :: INIT_ISOROPIAII
      PRIVATE :: SAFELOG10
      PRIVATE :: SET_HNO3
```

REMARKS:

```
    Original Author:
    *** COPYRIGHT 1996-2006, UNIVERSITY OF MIAMI, CARNEGIE MELLON UNIVERSITY,
    *** GEORGIA INSTITUTE OF TECHNOLOGY
    *** WRITTEN BY ATHANASIOS NENES
    *** UPDATED BY CHRISTOS FOUNTOUKIS
                                                                             .
    Original v1.3 isoropia implementation into GEOS-Chem by
    Becky Alexander and Bob Yantosca (bec, bmy, 4/12/05, 11/2/05)
                                                                             .
    For Ca,K,Mg = 0, ISOROPIA II performs exactly like ISOROPIAv1.7
    Ca, K, Mg, Na from dust is not currently considered
                                                                             .
    To implement ISOROPIA II into GEOS-Chem:
      * cleanup_isoropiaII needs to be called from cleanup.f
      * DO_ISOROPIA needs to be replaced with DO_ISOROPIAII in chemistry_mod.f
      * Change ISOROPIA to ISOROPIAII in sulfate_mod.f
      * add isoropiaII_mod.f, isoropiaIIcode.f, and irspia.inc to Makefile
                                                                             .
    ISOROPIA II implementation notes by Havala O.T. Pye:
    (1) The original isoropia code from T.Nenes is left as unmodified as
         possible. Original isoropia code can be found in isoropiaIIcode.f
         and common blocks can be found in isrpia.inc. For future upgrades
```

```
      to isoropia, replace isrpia.inc and isoropiaIIcode.f with the new
      version of isoropia and modify the call to ISOROPIA in this module.
      Please let the original author know of any changes made to ISOROPIA.
(2) As of Nov 2007, routines using non-zero Ca, K, and Mg do not always
      conserve mass. Ca, K, and Mg are set to zero.

NOTE: ISORROPIA is Greek for "equilibrium", in case you were wondering.
```

REVISION HISTORY:

```
06 Jul 2007 - H. O. T. Pye - Initial version
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
21 Apr 2010 - R. Yantosca  - Bug fix in DO_ISOROPIAII for offline aerosol
16 Feb 2011 - R. Yantosca  - Add modifications for APM from G. Luo
```

1.44.1 do_isoropiaii

Subroutine DO_ISOROPIAII is the interface between the GEOS-Chem model and the aerosol thermodynamical equilibrium routine ISORROPIA II.

INTERFACE:

```
      SUBROUTINE DO_ISOROPIAII
```

USES:

```
      USE DAO_MOD,          ONLY : AIRVOL, RH, T
      USE ERROR_MOD,        ONLY : DEBUG_MSG,       ERROR_STOP
      USE ERROR_MOD,        ONLY : SAFE_DIV
      USE GLOBAL_HNO3_MOD, ONLY : GET_GLOBAL_HNO3
      USE LOGICAL_MOD,      ONLY : LPRT
      USE TIME_MOD,         ONLY : GET_MONTH,       ITS_A_NEW_MONTH
      USE TRACER_MOD
      USE TRACERID_MOD,     ONLY : IDTHNO3, IDTNIT, IDTNH4, IDTNH3
      USE TRACERID_MOD,     ONLY : IDTSALA, IDTSO4
      USE TROPOPAUSE_MOD,   ONLY : ITS_IN_THE_STRAT
#if   defined( APM )
      USE APM_INIT_MOD,     ONLY : NSO4
      USE APM_INIT_MOD,     ONLY : IDTSO4BIN1,IDTCTSEA
      USE APM_INIT_MOD,     ONLY : IDTCTBCOC, IDTCTDST,IDTCTSO4
#endif

      USE CMN_SIZE_MOD        ! Size parameters
```

REMARKS:

```
Original isoropia v1.3 implmentation: (rjp, bec, bmy, 12/17/01, 8/22/05)
```

REVISION HISTORY:

```
24 Aug 2007 - H. O. T. Pye - Initial version, in ISORROPIA II
18 Dec 2009 - H. O. T. Pye - Added division checks
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
21 Apr 2010 - E. Sofen     - Prevent out-of-bounds errors for offline
                             aerosol simulations where HNO3 is undefined
23 Jul 2010 - R. Yantosca  - Bug fix: corrected typo in ND42 diag section
```

1.44.2 safelog10

Calculates the LOG (base 10) of a number X. Returns a minimum value if X is too small, in order to avoid NaN or Infinity problems.

INTERFACE:

```
FUNCTION SAFELOG10( X ) RESULT ( SAFLOG )
```

INPUT PARAMETERS:

```
REAL*8, INTENT(IN) :: X        ! Argument for LOG10 function
```

RETURN VALUE:

```
REAL*8             :: SAFLOG   ! LOG10 output --
```

REVISION HISTORY:

```
11 Aug 2009 - H. O. T. Pye - Initial version, in ISORROPIA II
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.44.3 get_isrinfo

Subroutine GET_ISRINFO returns information related to aerosol pH.

INTERFACE:

```
FUNCTION GET_ISRINFO( I, J, L, N ) RESULT ( RETURNVALUE )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I   ! GEOS-Chem longitude index
INTEGER, INTENT(IN) :: J   ! GEOS-Chem latitude index
INTEGER, INTENT(IN) :: L   ! GEOS-Chem level index
INTEGER, INTENT(IN) :: N   ! Flag for which information is desired
```

RETURN VALUE:

```
REAL*8              :: RETURNVALUE
```

REVISION HISTORY:

```
11 Aug 2009 - H. O. T. Pye - Initial version
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.44.4 get_hno3

Subroutine GET_HNO3 allows the HNO3 concentrations to evolve with time, but relaxes back to the monthly mean concentrations every 3 hours.

INTERFACE:

```
FUNCTION GET_HNO3( I, J, L ) RESULT ( HNO3_UGM3 )
```

USES:

```
USE GLOBAL_HNO3_MOD, ONLY : GET_HNO3_UGM3
USE TIME_MOD,        ONLY : GET_ELAPSED_MIN
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I  ! GEOS-Chem longitude index
INTEGER, INTENT(IN) :: J  ! GEOS-Chem latitude index
INTEGER, INTENT(IN) :: L  ! GEOS-Chem level index
```

REVISION HISTORY:

```
16 Dec 2002 - R. Yantosca  - Initial version, in ISORROPIA I
24 Mar 2003 - R. Yantosca  - Now use function GET_ELAPSED_MIN() from the
                             new "time_mod.f" to get the elapsed minutes
                             since the start of run.
06 Jul 2007 - H. O. T. Pye - Initial version, in ISORROPIA II
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.44.5 set_hno3

Subroutine SET_HNO3 stores the modified HNO3 value back into the HNO3_sav array for the next timestep.

INTERFACE:

```
SUBROUTINE SET_HNO3( I, J, L, HNO3_UGM3 )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I           ! GEOS-Chem longitude index
INTEGER, INTENT(IN) :: J           ! GEOS-Chem longitude index
INTEGER, INTENT(IN) :: L           ! GEOS-Chem longitude index
REAL*8,  INTENT(IN) :: HNO3_UGM3   ! HNO3 concentration [ug/m3]
```

REVISION HISTORY:

```
16 Dec 2002 - R. Yantosca  - Initial version, in ISORROPIA I
06 Jul 2007 - H. O. T. Pye - Initial version, in ISORROPIA II
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.44.6 get_gno3

Function GET_GNO3 returns the gas-phase HNO3 [v/v] for calculation of sea-salt chemistry in sulfate_mod (SEASALT_CHEM).

INTERFACE:

```
SUBROUTINE GET_GNO3( I, J, L, HNO3_kg )
```

USES:

```
USE DAO_MOD, ONLY : AIRVOL, AD
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: I       ! GEOS-Chem longitude index
INTEGER, INTENT(IN)  :: J       ! GEOS-Chem latitude index
INTEGER, INTENT(IN)  :: L       ! GEOS-Chem level index
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: HNO3_kg ! Gas-phase HNO3 [kg]
```

REVISION HISTORY:

```
15 Apr 2005 - B. Alexander - Initial version, in ISORROPIA I
06 Jul 2007 - H. O. T. Pye - Initial version, in ISORROPIA II
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.44.7 init_isoropiaII

Subroutine INIT_ISOROPIAII initializes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_ISOROPIAII
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
06 Jul 2007 - H. O. T. Pye - Initial version
29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.44.8 cleanup_isoropiaII

Subroutine CLEANUP_ISOROPIAII deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_ISOROPIAII
```

REVISION HISTORY:

```
   06 Jul 2007 - H. O. T. Pye - Initial version
   29 Jan 2010 - R. Yantosca  - Added ProTeX headers
```

1.45 Fortran: Module Interface land_mercury_mod

Module LAND_MERCURY_MOD contains variables and routines for the land emissions for the GEOS-Chem mercury simulation.

INTERFACE:

```
      MODULE LAND_MERCURY_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: BIOMASSHG
      PUBLIC :: VEGEMIS
      PUBLIC :: SOILEMIS
      PUBLIC :: LAND_MERCURY_FLUX
      PUBLIC :: GTMM_DR
      PUBLIC :: SNOWPACK_MERCURY_FLUX
      PUBLIC :: INIT_LAND_MERCURY
      PUBLIC :: CLEANUP_LAND_MERCURY
```

REVISION HISTORY:

```
   02 Jun 2010 - N. E. Selin, C. Carouge - Initial version
   02 Jun 2010 - C. Carouge  - Group all land emissions routine for mercury
                               into this new module.
   13 Aug 2010 - R. Yantosca - Added modifications for MERRA
   25 Aug 2010 - R. Yantosca - Treat MERRA in same way as GEOS-5
   30 Aug 2010 - R. Yantosca - Added more ProTeX headers
   12 Apr 2011 - J. Fisher   - Add missing code from Holmes 2010
```

1.45.1 land_mercury_flux

Subroutine LAND_MERCURY_FLUX calculates emissions of Hg(0) from prompt recycling of previously deposited mercury to land, in [kg/s].

INTERFACE:

```
SUBROUTINE LAND_MERCURY_FLUX( LFLUX, LHGSNOW )
```

USES:

```
USE TRACERID_MOD,     ONLY : ID_Hg0,          N_Hg_CATS
USE LOGICAL_MOD,      ONLY : LSPLIT
USE TIME_MOD,         ONLY : GET_TS_EMIS
USE DAO_MOD,          ONLY : SNOW, SNOMAS
USE DEPO_MERCURY_MOD, ONLY : WD_HGP, WD_HG2, DD_HGP, DD_HG2
USE DAO_MOD,          ONLY : IS_ICE, IS_LAND
USE DAO_MOD,          ONLY : FRSNO, FRSEAICE, FRLANDIC, FRLAND

USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

```
LOGICAL, INTENT(IN)  :: LHGSNOW                     ! Use Hg0 from snow?
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: LFLUX(IIPAR,JJPAR,N_Hg_CATS) ! Hg0 flux [kg/s]
```

REVISION HISTORY:

```
30 Aug 2010 - N. E. Selin, C. Holmes, B. Corbitt - Initial version
(1 ) Now uses SNOWMAS from DAO_MOD for compatibility with GEOS-5.
     (eds 7/30/08)
(2 ) Now includes REEMFRAC in parallelization; previous versions may have
     overwritten variable. (cdh, eds 7/30/08)
(3 ) Now also reemit Hg(0) from ice surfaces, including sea ice
     (cdh, 8/19/08)
13 Aug 2010 - R. Yantosca - Add modifications for MERRA
25 Aug 2010 - R. Yantosca - Treat MERRA in same way as GEOS-5
26 Apr 2011 - J. Fisher   - Use MERRA land fraction information
12 Apr 2011 - J. Fisher   - Add missing code from Holmes 2010
```

1.45.2 biomasshg

Subroutine BIOMASSHG is the subroutine for Hg(0) emissions from biomass burning. These emissions are active only for present day simulations and not for preindustrial simulations.

INTERFACE:

```
SUBROUTINE BIOMASSHG( EHg0_bb )
```

USES:

```
USE BIOMASS_MOD,  ONLY : BIOMASS
USE TRACERID_MOD, ONLY : IDBCO
USE LOGICAL_MOD,  ONLY : LBIOMASS, LPREINDHG
USE TIME_MOD,     ONLY : GET_TS_EMIS
USE GRID_MOD,     ONLY : GET_AREA_CM2

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DIAG_MOD     ! Diagnostic arrays & switches
```

OUTPUT PARAMETERS:

```
REAL*8, DIMENSION(:,:),INTENT(OUT) :: EHg0_bb
```

REMARKS:

```
Emissions are based on an inventory of CO emissions from biomass burning
(Duncan et al. J Geophys Res 2003), multiplied by a Hg/CO ratio in BB
plumes from Franz Slemr (Poster, EGU 2006).

Slemr surveyed emission factors from measurements worldwide. Although his
best estimate was 1.5e-7 mol Hg/ mol CO, we chose the highest value
(2.1e-7 mol Hg/ mol CO) in the range because the simulations shown in
Selin et al. (GBC 2008) required large Hg(0) emissions to sustain
reasonable atmospheric Hg(0) concentrations. (eck, 11/13/2008)
```

REVISION HISTORY:

```
30 Jul 2008 - N. E. Selin, C. Holmes, B. Corbitt - Initial version
12 Apr 2011 - J. Fisher   - Add missing code from Holmes 2010
```

1.45.3 vegemis

Subroutine VEGEMIS is the subroutine for Hg(0) emissions from vegetation by evapotranspiration.

INTERFACE:

```
! Bug fix: VEGEMIS shouldn't be tied to GCAP emissions
! (jaf, eds, 4/1/11)
SUBROUTINE VEGEMIS( LVEGEMIS, EHg0_dist, EHg0_vg )
```

USES:

```
USE DAO_MOD,        ONLY: RADSWG, IS_LAND
USE TIME_MOD,       ONLY: GET_MONTH, ITS_A_NEW_MONTH
USE TIME_MOD,       ONLY: GET_TS_EMIS
USE GRID_MOD,       ONLY: GET_AREA_M2

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DEP_MOD      ! FRCLND
```

INPUT PARAMETERS:

```
! Bug fix: VEGEMIS shouldn't be tied to GCAP emissions
! (jaf, eds, 4/1/11)
!LOGICAL,                INTENT(IN)  :: LGCAPEMIS
LOGICAL,                INTENT(IN)  :: LVEGEMIS
REAL*8, DIMENSION(:,:), INTENT(IN)  :: EHg0_dist
```

OUTPUT PARAMETERS:

```
REAL*8, DIMENSION(:,:), INTENT(OUT) :: EHg0_vg
```

REMARKS:

```
 Vegetation emissions are proportional to the evapotranspiration rate and the
 soil water mercury content. We assume a constant concentration of mercury
 in soil matter, based on the preindustrial and present-day simulations
 described in Selin et al. (GBC 2008) and in SOILEMIS subroutine. From the
 soil matter Hg concentration, we calculate a soil water Hg concentration in
 equilibrium (Allison and Allison, 2005).
 NASA provides a climatology of evapotranspiration based on a water budget
 model (Mintz and Walker, 1993).
Calculate vegetation emissions following Xu et al (1999)
   Fc = Ec Cw
   Fc is Hg0 flux (ng m-2 s-1)
   Ec is canopy transpiration (m s-1)
   Cw is conc of Hg0 in surface soil water (ng m-3)
Calculate Cw from the Allison and Allison (2005) equilibrium formula
   Cw = Cs / Kd
   Cs is the concentration of Hg is surface soil solids, ng/g
   Kd is the equilibrium constant = [sorbed]/[dissolved]
      log Kd = 3.8 L/kg -> Kd = 6310 L /kg = 6.31D-3 m3/g
We assume a global mean Cs = 45 ng/g for the preindustrial period. In
iterative simulations we redistribute this according to the deposition
pattern while maintining the global mean. The scaling factor, EHg0_dist,
also accounts for the anthropogenic enhancement of soil Hg in the present
day.
```

REVISION HISTORY:

```
 30 Aug 2010 - N. Eckley, C. Holmes, B. Corbitt - Initial version
```

1.45.4 soilemis

Subroutine SOILEMIS is the subroutine for Hg(0) emissions from soils.

INTERFACE:

```
SUBROUTINE SOILEMIS( EHg0_dist, EHg0_so )
```

USES:

```
USE LAI_MOD,  ONLY : ISOLAI, MISOLAI, PMISOLAI, DAYS_BTW_M
USE DAO_MOD,  ONLY : RADSWG, SUNCOS, TS, IS_LAND
USE TIME_MOD, ONLY : GET_MONTH, ITS_A_NEW_MONTH
USE TIME_MOD, ONLY : GET_TS_EMIS
USE GRID_MOD, ONLY : GET_AREA_M2
USE DAO_MOD,  ONLY : SNOW, SNOMAS
USE DAO_MOD,  ONLY : FRSNO, FRLAND

USE CMN_SIZE_MOD     ! Size parameters
USE CMN_DEP_MOD      ! FRCLND
```

INPUT PARAMETERS:

```
REAL*8, DIMENSION(:,:), INTENT(IN) :: EHg0_dist
```

OUTPUT PARAMETERS:

```
REAL*8, DIMENSION(:,:), INTENT(OUT):: EHg0_so
```

REMARKS:

```
Soil emissions are a function of solar radiation at ground level
(accounting for attenuation by leaf canopy) and surface temperature.
The radiation dependence from Zhang et al. (2000) is multiplied by the
temperature dependence from Poissant and Casimir (1998).
Finally, this emission factor is multiplied by the soil mercury
concentration and scaled to meet the global emission total.
Comments on soil Hg concentration:
----------------------------------
We chose the preindustrial value of 45 ng Hg /g dry soil as the mean of
the range quoted in Selin et al. (GBC 2008): 20-70 ng/g (Andersson, 1967;
Shacklette et al., 1971; Richardson et al., 2003; Frescholtz and Gustin,
2004). Present-day soil concentrations are thought to be 15% greater than
preindustrial (Mason and Sheu 2002), but such a difference is much less
than the range of concentrations found today, so not well constrained.
We calculate the present-day soil Hg distribution by adding a global mean
6.75 ng/g (=0.15 * 45 ng/g) according to present-day Hg deposition.
(eck, 11/13/08)
```

REVISION HISTORY:

```
30 Aug 2010 - N. Eckley, B. Corbitt - Initial version
(1 ) Added comments. (cdh, eds, 7/30/08)
(2 ) Now include light attenuation by the canopy after sunset. Emissions
     change by < 1% in high-emission areas  (cdh, 8/13/2008)
(3 ) Removed FRCLND for consistency with other Hg emissions (cdh, 8/19/08)
2 June 2010 - C. Carouge  - Solve
13 Aug 2010 - R. Yantosca - Added modifications for MERRA
25 Aug 2010 - R. Yantosca - Treat MERRA in same way as GEOS-5
26 Apr 2011 - J. Fisher   - Use MERRA land fraction information
12 Apr 2011 - J. Fisher   - Bug fixes, add missing code from Holmes 2010
```

1.45.5 read_nasa_transp

Subroutine READ_NASA_TRANSP reads monthly average transpiration [m/s] from NASA: for input into the vegetation emissions.

INTERFACE:

```
SUBROUTINE READ_NASA_TRANSP
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_TAU0,   READ_BPCH2
USE BPCH2_MOD,      ONLY : GET_RES_EXT
USE DIRECTORY_MOD,  ONLY : DATA_DIR
USE TIME_MOD,       ONLY : GET_MONTH,  ITS_A_NEW_MONTH
USE TRANSFER_MOD,   ONLY : TRANSFER_2D

USE CMN_SIZE_MOD       ! Size parameters
```

REMARKS:

```
Data source:
 http://gcmd.nasa.gov/records/GCMD_MINTZ_WALKER_SOIL_AND_EVAPO.html
References:
-----------
Mintz, Y and G.K. Walker (1993). "Global fields of soil moisture
 and land surface evapotranspiration derived from observed
 precipitation and surface air temperature." J. Appl. Meteorol. 32 (8),
1305-1334.
```

REVISION HISTORY:

```
15 Sep 2006 - N. E. Selin - Initial version
30 Aug 2010 - R. Yantosca - Added ProTeX headers
```

1.45.6 snowpack_mercury_flux

Subroutine SNOWPACK_MERCURY_FLUX calculates emission of Hg(0) from snow and ice.

INTERFACE:

```
SUBROUTINE SNOWPACK_MERCURY_FLUX( FLUX, LHGSNOW )
```

USES:

```
USE TRACERID_MOD,     ONLY : N_Hg_CATS
USE TIME_MOD,         ONLY : GET_TS_EMIS
USE DAO_MOD,          ONLY : T, SUNCOS
USE DEPO_MERCURY_MOD, ONLY : SNOW_HG

USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

```
LOGICAL, INTENT(IN)   :: LHGSNOW                      ! Use Hg from snow?
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT)  :: FLUX(IIPAR,JJPAR,N_Hg_CATS)  ! Hg0 flux [kg/s]
```

REMARKS:

```
Emissions are a linear function of Hg mass stored in the snowpack. The
Hg lifetime in snow is assumed to be 180 d when T< 270K and 7 d when T>270K
   E = k * SNOW_HG     : k = 6D-8 if T<270K, 1.6D-6 otherwise
These time constants reflect the time scales of emission observed in the
Arctic and in field studies. Holmes et al 2010
```

REVISION HISTORY:

```
15 Sep 2009 - C. Holmes, S. Carouge - Initial version
30 Aug 2010 - R. Yantosca - Added ProTex headers
12 Apr 2011 - J. Fisher   - Add missing code from Holmes 2010
```

1.45.7 gtmm_dr

GTMM_DR is a driver to call GTMM from GEOS-Chem.

INTERFACE:

```
SUBROUTINE GTMM_DR( Hg0gtm )
```

USES:

```
USE BPCH2_MOD
USE DAO_MOD,           ONLY : IS_LAND
USE FILE_MOD,          ONLY : IU_FILE, IOERROR
USE TIME_MOD,          ONLY : EXPAND_DATE, YMD_EXTRACT
USE TIME_MOD,          ONLY : GET_NYMD, GET_NHMS
USE DIRECTORY_MOD,     ONLY : DATA_DIR
USE DEPO_MERCURY_MOD,  ONLY : CHECK_DIMENSIONS
USE DEPO_MERCURY_MOD,  ONLY : WD_Hg2, WD_HgP, DD_HgP, DD_Hg2
USE DEPO_MERCURY_MOD,  ONLY : READ_GTMM_RESTART

USE CMN_SIZE_MOD          ! Size parameters
```

INPUT PARAMETERS:

```
! Emission of Hg0 calculated by GTMM for the month [kg/s]
REAL*8, INTENT(OUT)   :: Hg0gtm(IIPAR, JJPAR)
```

REVISION HISTORY:

```
15 Sep 2009 - C. Carouge  - Initial version
```

1.45.8 init_land_mercury

Subroutine INIT_LAND_MERCURY allocates and zeroes all module arrays.

INTERFACE:

```
      SUBROUTINE INIT_LAND_MERCURY
```

USES:

```
      USE ERROR_MOD,    ONLY : ALLOC_ERR
      USE TRACERID_MOD, ONLY : N_Hg_CATS

      USE CMN_SIZE_MOD     ! Size parameters
```

REVISION HISTORY:

```
    14 Sep 2009 - C. Carouge  - Initial version
```

1.45.9 cleanup_land_mercury

Subroutine CLEANUP_LAND_MERCURY deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_LAND_MERCURY
```

REVISION HISTORY:

```
    14 Sep 2009 - C. Carouge  - Initial version
```

1.46 Fortran: Module Interface lightning_nox_mod

Module LIGHTNING_NOx_MOD contains variables and routines for emitting NOx from lightning into the atmosphere. Original code comes from the old GISS-II CTM's of Yuhang Wang, Gerry Gardner, & Larry Horowitz.

INTERFACE:

```
      MODULE LIGHTNING_NOx_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: LIGHTNING
PUBLIC  :: EMLIGHTNING
PUBLIC  :: CLEANUP_LIGHTNING_NOX
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: LIGHTDIST
PRIVATE :: FLASHES_CTH
PRIVATE :: GET_IC_CG_RATIO
PRIVATE :: READ_LOCAL_REDIST
PRIVATE :: GET_OTD_LIS_SCALE
PRIVATE :: INIT_LIGHTNING_NOX
```

PUBLIC DATA MEMBERS:

```
! Lightning NOx emissions [molec/cm3/s]
REAL*8, ALLOCATABLE, PUBLIC :: EMIS_LI_NOx(:,:,:)
```

REMARKS:

```
%%% NOTE: MFLUX and PRECON methods are now deprecated (ltm, bmy, 7/9/09)
                                                                             .
References:
============================================================================
(1 ) Price & Rind (1992), JGR, vol. 97, 9919-9933.
(2 ) Price & Rind (1994), M. Weather Rev, vol. 122, 1930-1939.
(3 ) Allen & Pickering (2002), JGR, 107, D23, 4711, doi:10.1029/2002JD002066
(4 ) Hudman et al (2007), JGR, 112, D12S05, doi:10.1029/2006JD007912
(5 ) Sauvage et al, 2007, ACP,
     http://www.atmos-chem-phys.net/7/815/2007/acp-7-815-2007.pdf
(6 ) Ott et al., (2010), JGR
(7 ) Allen et al., (2010), JGR
(8 ) Murray et al., (2011), in prep.
```

REVISION HISTORY:

```
14 Apr 2004 - L. Murray, R. Hudman - Initial version
(1 ) Based on "lightning_nox_mod.f", but updated for near-land formulation
     and for CTH, MFLUX, PRECON parameterizations (ltm, bmy, 5/10/06)
(2 ) Now move computation of IC/CG flash ratio out of routines FLASHES_CTH,
     FLASHES_MFLUX, FLASHES_PRECON, and into routine GET_IC_CG_RATIO.
     Added a fix in LIGHTDIST for pathological grid boxes.  Set E_IC_CG=1
     according to Allen & Pickering [2002].  Rename OTDSCALE array to
     OTD_REG_REDIST, and also add OTD_LOC_REDIST array.  Now scale
     lightning to 6 Tg N/yr for both 2x25 and 4x5.  Rename routine
     GET_OTD_LIS_REDIST to GET_REGIONAL_REDIST.  Add similar routine
     GET_LOCAL_REDIST.  Removed GET_OTD_LOCp AL_REDIST.  Bug fix: divide
     A_M2 by 1d6 to get A_KM2. (rch, ltm, bmy, 2/22/07)
(3 ) Rewritten for separate treatment of LNOx emissions at tropics &
```

```
      midlatitudes, based on Hudman et al 2007.  Removed obsolete
      variable E_IC_CG. (rch, ltm, bmy, 3/27/07)
(4 ) Changes implemented in this version (ltm, bmy, 10/3/07)
      * Revert to not classifying near-land as land
      * Eliminate NOx emisisons per path length entirely
      * Scale tropics to 260 mol/fl constraint from Randall Martin's
         4.4 Tg and OTD-LIS avg ann flash rate
      * Remove top-down scaling (remove the three functions)
      * Allow option of mid-level scaling to match global avg ann flash
         rate between G-C and OTD-LIS 11-year climatology (new function)
      * Local Redist now a la Murray et al, 2007 in preparation (monthly)
      * Replace GEMISNOX (from F77_CMN_NOX) with module variable EMIS_LI_NOx
(5 ) Added MFLUX, PRECON redistribution options (ltm, bmy, 11/29/07)
(6 ) Updated OTD/LIS scaling for GEOS-5 to get more realistic totals
      (ltm, bmy, 2/20/08)
(7 ) Now add the proper scale factors for the GEOS-5 0.5 x 0.666 grid
      and the GEOS-3 1x1 nested N. America grid in routine
      GET_OTD_LIS_SCALE. (yxw, dan, ltm, bmy, 11/14/08)
(8 ) Added quick fix for GEOS-5 reprocessed met fields (ltm, bmy, 2/18/09)
(9 ) Added quick fix for GEOS-5 years 2004, 2005, 2008 (ltm, bmy, 4/29/09)
(10) Updated OTD/LIS scaling for GEOS-5 reprocessed data (ltm, bmy, 7/10/09)
(11) Updated for GEOS-4 1 x 1.25 grid (lok, ltm, bmy, 1/13/10)
(12) Reprocessed for CLDTOPS calculation error; Updated Ott vertical
      profiles; Removal of depreciated options, e.g., MFLUX and PRECON;
      GEOS5 5.1.0 vs. 5.2.0 special treatment; MERRA; Other changes.
      Please see PDF on wiki page for full description of lightning
      changes to v9-01-01. (ltm, 1/25/11)
13 Aug 2010 - R. Yantosca - Add modifications for MERRA
10 Nov 2010 - L. Murray   - Updated OTD/LIS local scaling for MERRA 4x5
10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.1 lightning

Subroutine LIGHTNING uses Price & Rind's formulation for computing NOx emission from lightning (with various updates).

INTERFACE:

```
SUBROUTINE LIGHTNING
```

USES:

```
USE DAO_MOD,      ONLY : BXHEIGHT,  CLDTOPS,    PRECON,   T, ZMMU
USE DIAG56_MOD,   ONLY : AD56,      ND56
USE GRID_MOD,     ONLY : GET_YMID,  GET_XMID,   GET_AREA_M2
USE LOGICAL_MOD,  ONLY : LOTDLOC
USE PRESSURE_MOD, ONLY : GET_PEDGE, GET_PCENTER
USE TIME_MOD,     ONLY : GET_MONTH, GET_YEAR
```

```
      USE CMN_SIZE_MOD     ! Size parameters
      USE CMN_GCTM_MOD     ! Physical constants
```

REMARKS:

```
    Output Lightning NOX [molec/cm3/s] is stored in the EMIS_NOX_LI array.
```

REVISION HISTORY:

```
    10 May 2006 - L. Murray - Initial version
    (1 ) Now recompute the cold cloud thickness according to updated formula
         from Lee Murray.  Rearranged argument lists to routines FLASHES_CTH,
         FLASHES_MFLUX, FLASHES_PRECON.  Now call READ_REGIONAL_REDIST and
         READ_LOCAL_REDIST. Updated comments accordingly.  Now apply
         FLASH_SCALE to scale the total lightning NOx to 6 Tg N/yr.  Now apply
         OTD/LIS regional or local redistribution (cf. B. Sauvage) to the ND56
         diagnostic. lightning redistribution to the ND56 diag.  Renamed
         REGSCALE variable to REDIST.  Bug fix: divide A_M2 by 1d6 to get
         A_KM2. (rch, ltm, bmy, 2/14/07)
    (2 ) Rewritten for separate treatment of LNOx emissions at tropics &
         midlatitudes (rch, ltm, bmy, 3/27/07)
    (3 ) Remove path-length algorithm.  Renamed from LIGHTNING_NL to LIGHTNING.
         Other improvements. (ltm, bmy, 9/24/07)
    (4 ) Remove depreciated options; Update to new Ott et al vertical profiles;
         Reprocessed for bug in CLDTOPS calculation. See PDF on wiki for
         full description of changes for v9-01-01. (ltm, bmy, 1/25,11)
    10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.2 lightdist

Subroutine LIGHTDIST reads in the CDF used to partition the column lightning NOx into the GEOS-Chem vertical layers.

INTERFACE:

```
      SUBROUTINE LIGHTDIST( I, J, LTOP, H0, XLAT, TOTAL, VERTPROF )
```

USES:

```
      USE DAO_MOD,       ONLY : BXHEIGHT, IS_ICE,  IS_LAND
      USE DAO_MOD,       ONLY : IS_NEAR,  IS_WATER
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : GEOS_CHEM_STOP
      USE FILE_MOD,      ONLY : IU_FILE,  IOERROR
      USE GRID_MOD,      ONLY : GET_YMID
      USE TIME_MOD,      ONLY : GET_MONTH

      USE CMN_SIZE_MOD                       ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: I                ! Longitude index
INTEGER, INTENT(IN)  :: J                ! Latitude index
INTEGER, INTENT(IN)  :: LTOP             ! Level of conv cloud top
REAL*8,  INTENT(IN)  :: H0               ! Conv cloud top height [m]
REAL*8,  INTENT(IN)  :: XLAT             ! Latitude value [degrees]
REAL*8,  INTENT(IN)  :: TOTAL            ! Column Total # of LNOx molec
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: VERTPROF(LLPAR)  ! Vertical profile of LNOx
```

REMARKS:

References:

```
============================================================================
(1 ) Pickering et al., JGR 103, 31,203 - 31,316, 1998.
(2 ) Ott et al., JGR, 2010
(3 ) Allen et al., JGR, 2010
```

REVISION HISTORY:

```
18 Sep 2002 - M. Evans - Initial version (based on Yuhang Wang's code)
(1 ) Use functions IS_LAND and IS_WATER to determine if the given grid
     box is over land or water.  These functions work for all DAO met
     field data sets. (bmy, 4/2/02)
(2 ) Renamed M2 to LTOP and THEIGHT to H0 for consistency w/ variable names
     w/in "lightning.f".  Now read the "light_dist.dat.geos3" file for
     GEOS-3 directly from the DATA_DIR/lightning_NOx_200203/ subdirectory.
     Now read the "light_dist.dat" file for GEOS-1, GEOS-STRAT directly
     from the DATA_DIR/lightning_NOx_200203/ subdirectory.  Added
     descriptive comment header.  Now trap I/O errors across all
     platforms with subroutine "ioerror.f".  Updated comments, cosmetic
     changes.  Redimension FRAC(NNLIGHT) to FRAC(LLPAR). (bmy, 4/2/02)
(3 ) Deleted obsolete code from April 2002.  Now reference IU_FILE and
     IOERROR from "file_mod.f".  Now use IU_FILE instead of IUNIT as the
     file unit number. (bmy, 6/27/02)
(4 ) Now reference BXHEIGHT from "dao_mod.f" (bmy, 9/18/02)
(5 ) Bug fix: add GEOS_4 to the #if block (bmy, 3/4/04)
(6 ) Now bundled into "lightning_mod.f".  CDF's are now read w/in
     routine INIT_LIGHTNING to allow parallelization (bmy, 4/14/04)
(7 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(8 ) Now uses near-land formulation (ltm, bmy, 5/10/06)
(9 ) Added extra safety check for pathological boxes (bmy, 12/11/06)
(10) Remove the near-land formulation, except for PRECON (ltm, bmy, 9/24/07)
(11) Now use the Ott et al. [2010] profiles, and apply consistently with
     GMI model [Allen et al., 2010] (ltm, bmy, 1/25/11).
10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.3 flashes_cth

Subroutine FLASHES_CTH determines the rate of lightning flashes per minute based on the height of convective cloud tops, and the intra-cloud to cloud-ground strike ratio.

INTERFACE:

```
      SUBROUTINE FLASHES_CTH( I, J, HEIGHT, FLASHRATE )
```

USES:

```
#     include "define.h"

      USE DAO_MOD, ONLY : IS_ICE
      USE DAO_MOD, ONLY : IS_LAND
      USE DAO_MOD, ONLY : IS_WATER
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: I           ! Longitude index
      INTEGER, INTENT(IN)  :: J           ! Latitude index
      REAL*8,  INTENT(IN)  :: HEIGHT      ! Height of conv cloud top [m]
```

OUTPUT PARAMETERS:

```
      REAL*8,  INTENT(OUT) :: FLASHRATE   ! Lightning flash rate [flashes/min]
```

REVISION HISTORY:

```
   10 May 2006 - L. Murray - Initial version
   (1  ) Subroutine renamed from FLASHES (ltm, bmy, 5/10/06)
   (2  ) Remove CCTHICK, IC_CG_RATIO as arguments.  Remove computation of
         IC_CG_RATIO and move that to GET_IC_CG_RATIO. (ltm, bmy, 12/11/06)
   (3  ) Remove the near-land formulation (i.e. use function IS_LAND
         instead of IS_NEAR).(ltm, bmy, 9/24/07)
   10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.4 get_ic_cg_ratio

Function GET_IC_CG_RATIO calculates the Intra-Cloud (IC) and Cloud-to-Ground (CG) lightning flash ratio based on the method of Price and Rind 1993, which is calculated from the cold-cloud depth (CCTHICK).

INTERFACE:

```
      FUNCTION GET_IC_CG_RATIO( CCTHICK ) RESULT( IC_CG_RATIO )
```

INPUT PARAMETERS:

```
      REAL*8,  INTENT(IN)  :: CCTHICK       ! Cold cloud thickness [m]
```

RETURN VALUE:

```
      REAL*8               :: IC_CG_RATIO   ! Intra-cloud/cloud-ground ratio
```

REVISION HISTORY:

```
    11 Dec 2006 - R. Yantosca - Initial version
    (1 ) Split off from FLASHES_CTH, FLASHES_MFLUX, FLASHES_PRECON into this
         separate function (ltm, bmy, 12/11/06)
    (2 ) Bug fix for XLF compiler (morin, bmy, 7/8/09)
    10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.5 read_local_redist

Subroutine READ_LOCAL_REDIST reads in seasonal factors in order to redistribute GEOS-Chem flash rates according the "local redistribution" method of Bastien Sauvage. This helps to make sure that the lightning flashes occur according to the distribution of observed convection.

INTERFACE:

```
      SUBROUTINE READ_LOCAL_REDIST( MONTH )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT
      USE BPCH2_MOD,     ONLY : GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0
      USE BPCH2_MOD,     ONLY : READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : ALLOC_ERR
      USE TIME_MOD,      ONLY : GET_TAU
      USE TRANSFER_MOD,  ONLY : TRANSFER_2D

      USE CMN_SIZE_MOD               ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)    :: MONTH   ! Current month
```

REVISION HISTORY:

```
    26 Jan 2007 - B. Sauvage - Initial version
    (1 ) Change from seasonal to monthly.  Rename all filenames from "v2"
         to "v3". (ltm, bmy, 9/24/07)
    (2 ) Change all filenames from "v2" to "v3".  Also now read from the
         directory lightning_NOx_200709. (ltm, bmy, 9/24/07)
    (3 ) Added "quick fix" for reprocessed GEOS-5 met fields to be used when
         the IN_CLOUD_OD switch is turned on. (ltm, bmy, 2/18/09)
    (4 ) Now read from lightning_NOx_200907 directory for GEOS-4 and
         GEOS-5 CTH parameterizations.  Updated OTD/LIS for GEOS-5 based on
```

```
      4+ years of data; removed temporary fixes. (ltm, bmy, 7/10/09)
(5 ) Remove depreciated options and update to v5 of redist files in
     new data directory. Special handling for GEOS5.1.0 and 5.2.0 added.
     (ltm, bmy, 1/25/11)
10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.6 emlightning

Subroutine EMLIGHTNING converts lightning emissions to [molec/cm3/s] and stores them in the GEMISNOX array, which gets passed to SMVGEAR.

INTERFACE:

```
SUBROUTINE EMLIGHTNING( I, J )
```

USES:

```
USE DAO_MOD,  ONLY : BXHEIGHT
USE DIAG_MOD, ONLY : AD32_li

USE CMN_SIZE_MOD         ! Size parameters
USE CMN_DIAG_MOD         ! ND32
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I   ! Longitude index
INTEGER, INTENT(IN) :: J   ! Latitude index
```

REVISION HISTORY:

```
09 Oct 1997 - R. Yantosca - Initial version
(1 ) Remove IOFF, JOFF from the argument list.  Also remove references
     to header files "F77_CMN_O3" and "comtrid.h" (bmy, 3/16/00)
(2 ) Now use allocatable array for ND32 diagnostic (bmy, 3/16/00)
(3 ) Now reference BXHEIGHT from "dao_mod.f".  Updated comments, cosmetic
     changes.  Replace LCONVM with the parameter LLCONVM. (bmy, 9/18/02)
(4 ) Removed obsolete reference to "CMN".  Now bundled into
     "lightning_mod.f" (bmy, 4/14/04)
(5 ) Renamed from EMLIGHTNING_NL to EMLIGHTNING.  Now replace GEMISNOX
     (from F77_CMN_NOX) with module variable EMIS_LI_NOx. (ltm, bmy, 10/3/07)
10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.7 get_otd_lis_scale

Function GET_OTD_LIS_SCALE returns a met-field dependent scale factor which is to be applied to the lightning flash rate to bring the annual average flash rate to match that of the OTD-LIS climatology (45.9 flashes/sec). Computed by running the model over

the 11-year OTD-LIS campaign window and comparing the average flash rates, or as many years as are available.

INTERFACE:

```
      FUNCTION GET_OTD_LIS_SCALE() RESULT( BETA )
```

USES:

```
#     include "define.h"

      USE BPCH2_MOD,   ONLY : GET_TAU0
      USE ERROR_MOD,   ONLY : GEOS_CHEM_STOP
      USE TIME_MOD,    ONLY : GET_TAU
```

RETURN VALUE:

```
      REAL*8 :: BETA    ! Scale factor
```

REMARKS:

REVISION HISTORY:

```
   24 Sep 2007 - L. Murray - Initial version
   (1 ) Added MFLUX, PRECON scaling for GEOS-4.  Also write messages for met
        field types/grids where scaling is not defined. (ltm, bmy, 11/29/07)
   (2 ) Now use different divisor for local redist (ltm, bmy, 2/20/08)
   (3 ) Now compute the proper scale factor for GEOS-5 0.5 x 0.666 grids
        and the GEOS-3 1x1 nested NA grid (yxw, dan, ltm, bmy, 11/14/08)
   (4 ) Added "quick fix" for reprocessed GEOS-5 met fields to be used when
        the IN_CLOUD_OD switch is turned on. (ltm, bmy, 2/18/09)
   (5 ) Added "quick fix" for 2004, 2005, 2008 OTD/LIS (ltm, bmy, 4/29/09)
   (6 ) Updated scale factors for GEOS-5 based on 4+ years of data.  Remove
        temporary fixes. (bmy, 7/10/09)
   (7 ) Modification for GEOS-4 1 x 1.25 grid (lok, ltm, bmy, 1/13/10)
   (8 ) Reprocessed for error in CLDTOPS field; Updated for GEOS
        5.1.0 vs. 5.2.0; MERRA added; (ltm, bmy, 1/25/11)
   10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.8 init_lightning_NOx

Subroutine INIT_LIGHTNING_NOx allocates all module arrays. It also reads the lightning CDF data from disk before the first lightning timestep.

INTERFACE:

```
      SUBROUTINE INIT_LIGHTNING_NOx
```

USES:

```
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : ALLOC_ERR
      USE FILE_MOD,      ONLY : IOERROR
      USE FILE_MOD,      ONLY : IU_FILE
      USE GRID_MOD,      ONLY : GET_YEDGE
      USE GRID_MOD,      ONLY : GET_AREA_M2
      USE LOGICAL_MOD,   ONLY : LOTDLOC

      USE CMN_SIZE_MOD      ! Size parameters
```

REVISION HISTORY:

```
14 Apr 2004 - R. Yantosca - Initial version
(1 ) Now reference DATA_DIR from "directory_mod.f"
(2 ) Now call GET_MET_FIELD_SCALE to initialize the scale factor for
     each met field type and grid resolution (bmy, 8/25/05)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Now get the box area at 30N for MFLUX, PRECON (lth, bmy, 5/10/06)
(5 ) Rename OTDSCALE to OTD_REG_REDIST.  Also add similar array
     OTD_LOC_REDIST.  Now call GET_FLASH_SCALE_CTH, GET_FLASH_SCALE_MFLUX,
     GET_FLASH_SCALE_PRECON depending on the type of lightning param used.
     Updated comments.  (ltm, bmy, 1/31/07)
(6 ) Removed near-land stuff.  Renamed from INIT_LIGHTNING_NOX_NL to
     INIT_LIGHTNING_NOX.  Now allocate EMIS_LI_NOx. (ltm, bmy, 10/3/07)
(7 ) Also update location of PDF file to lightning_NOx_200709 directory.
     (bmy, 1/24/08)
(8 ) Read in new Ott profiles from lightning_NOx_201101. Remove
     depreciated options. (ltm, bmy, 1/25/11)
10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.46.9 cleanup_lightning_NOx

Subroutine CLEANUP_LIGHTNING_NOx deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_LIGHTNING_NOx
```

REVISION HISTORY:

```
14 Apr 2004 - R. Yantosca - Initial version
(1 ) Now deallocates OTDSCALE (ltm, bmy, 5/10/06)
(2 ) Rename OTDSCALE to OTD_REG_REDIST.  Now deallocate OTD_LOC_REDIST.
     (bmy, 1/31/07)
(3 ) Renamed from CLEANUP_LIGHTNING_NOX_NL to CLEANUP_LIGHTNING_NOX.
     Now deallocate EMIS_LI_NOx. (ltm, bmy, 10/3/07)
(4 ) Remove depreciated options. (ltm, bmy, 1/25/11)
10 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.47 Fortran: Module Interface linoz_mod

Module LINOZ_MOD contains routines to perform the Linoz stratospheric ozone chemistry.

INTERFACE:

```
      MODULE LINOZ_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

DEFINED PARAMETERS:

```
      INTEGER, PARAMETER  :: NFIELDS_LINOZ = 7   ! # of Linoz fields
      INTEGER, PARAMETER  :: NLEVELS_LINOZ = 25  ! # of levels in Linoz fields
      INTEGER, PARAMETER  :: NLAT_LINOZ    = 18  ! # latitudes in Linoz fields
      INTEGER, PARAMETER  :: NMONTHS_LINOZ = 12  ! # of months in Linoz fields
  !PRIVATE DATA MEMBERS:
      REAL*8, ALLOCATABLE :: TPARM(:,:,:,:)
      REAL*8, ALLOCATABLE :: TLSTT(:,:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_LINOZ
      PUBLIC  :: DO_LINOZ
      PUBLIC  :: LINOZ_READ
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: INIT_LINOZ
      PRIVATE :: LINOZ_CHEM3
      PRIVATE :: LINOZ_STRATL
      PRIVATE :: LINOZ_STRT2M
      PRIVATE :: LINOZ_SOMLFQ
      PRIVATE :: LINOZ_INTPL
      PRIVATE :: STRAT_INIT
```

REMARKS:

```
   Dylan Jones (dbj@atmosp.physics.utoronto.ca) wrote:

     Testing this code [in v8-02-04] was more difficult that I thought.
     I began by trying to compare the output of v8-02-04 with our previous
     runs with v8-02-01.  I accounted for the changes in the transport_mod.f
     and I tried to undo the changes in when the diagnostics are archived in
     v8-02-04, but I was still getting large differences between v8-02-04
     and v8-02-01. I finally gave up on this since I may have made a mistake
```

```
    in reverting to the old way of doing the diagnostics in v8-02-04.  In
    the end I took the new linoz code from v8-02-04 and used it in v8-02-01.
    I ran two GEOS-5 full chemistry simulations for 2007 and the output
    were consistent over the full year.

    I think that it is safe to release [Linoz in v8-02-04].  However, we
    should acknowledge that it was [only] tested in v8-02-01, since I was
    not able to assess the quality of the output in v8-02-04.
REVISION HISTORY:
 23 Mar 2000 - P. Cameron-Smith    - Initial version adapted heavily
                                     from McLinden's original file.
 24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
 28 May 2009 - D. Jones            - Further modifications
 18 Nov 2009 - D. Jones            - Further modifications
```

1.47.1 do_linoz

Subroutine DO_LINOZ is the main driver for the Linoz stratospheric Ozone chemistry package.

INTERFACE:

```
      SUBROUTINE DO_LINOZ
```

USES:

```
      USE TIME_MOD

      USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
    24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
```

1.47.2 linoz_chem3

Subroutine LINOZ_CHEM3 applies linearized chemistry based on tables from PRATMO model using climatological T, O3, time of year

INTERFACE:

```
      SUBROUTINE LINOZ_CHEM3( DTCHEM )
```

USES:

```
      USE DAO_MOD
      USE GRID_MOD,       ONLY : GET_AREA_CM2
      USE TRACER_MOD
```

```
      USE TRACERID_MOD
      USE TROPOPAUSE_MOD, ONLY : GET_TPAUSE_LEVEL
      USE TROPOPAUSE_MOD, ONLY : GET_MAX_TPAUSE_LEVEL
      USE PRESSURE_MOD,   ONLY : GET_PEDGE
      USE PRESSURE_MOD,   ONLY : GET_PCENTER

      USE CMN_SIZE_MOD
      USE CMN_MOD
```

INPUT PARAMETERS:

```
      REAL*8, INTENT(IN) :: DTCHEM    ! Time step [seconds]
```

REVISION HISTORY:

```
    24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
    18 Nov 2009 - D. Jones            - For now, set tagged stratospheric
                                        tracer to total O3 in the overworld
                                        to avoid issues with spin ups
    08 Feb 2010 - R. Yantosca         - Deleted obsolete local variables
    22 Oct 2010 - R. Yantosca         - Added OMP parallel loop
```

1.47.3 linoz_stratl

Subroutine LINOZ_STRATL performs a monthly fixup of chemistry parameters for the Linoz stratospheric ozone chemistry.

INTERFACE:

```
      SUBROUTINE LINOZ_STRATL
```

USES:

```
      USE GRID_MOD,       ONLY : GET_YMID
      USE TIME_MOD,       ONLY : GET_MONTH
      USE PRESSURE_MOD

      USE CMN_SIZE_MOD
      USE CMN_MOD
```

REVISION HISTORY:

```
    24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
```

1.47.4 linoz_strt2m

Subroutine LINOZ_STRT2M sets up a std z* atmosphere: p = 1000 * 10**(-z*/16 km).

INTERFACE:

```
SUBROUTINE LINOZ_STRT2M(STRTX,NX,STRT0L,STRT1L,STRT2L,P0L,NSTRT)
```

USES:

```
USE CMN_SIZE_MOD
```

DEFINED PARAMETERS:

```
! Parameter (ncbox=25)
! Now use nlevels_linoz for all routines. {PJC}
INTEGER, PARAMETER   :: NL = NLEVELS_LINOZ+5
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: NX
INTEGER, INTENT(IN)  :: NSTRT
REAL*8,  INTENT(IN)  :: STRTX(NLEVELS_LINOZ)
REAL*8,  INTENT(IN)  :: P0L(LLPAR+1)
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: STRT0L(LLPAR+1)
REAL*8,  INTENT(OUT) :: STRT1L(LLPAR+1)
REAL*8,  INTENT(OUT) :: STRT2L(LLPAR+1)
```

REVISION HISTORY:

```
24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
```

1.47.5 linoz_somlfq

subroutine LINOZ_SOMLFQ calculates loss freq moments from a set of loss frequencies at std z*, given a CTM model interval pressure range: P1 ¿ P2 (decreasing up)

INTERFACE:

```
SUBROUTINE LINOZ_SOMLFQ(P1,P2,F0,F1,F2,PS,F,NL)
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: NL
REAL*8,  INTENT(IN)  :: F(NL)
REAL*8,  INTENT(IN)  :: PS(NL+1)
REAL*8,  INTENT(OUT) :: P1
REAL*8,  INTENT(OUT) :: P2
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: F0
REAL*8,  INTENT(OUT) :: F1
REAL*8,  INTENT(OUT) :: F2
REMARKS:
```

```
The pressure levels BETWEEN z* values are:
     PS(i) > PS(i+1) bounds z*(i)

NL:  z* levels, ==> PS(NL+1) = 0  (extrapolate chemical loss to top)
     Z1 = 16.D0*LOG10(1000.D0/P1)
     Z2 = 16.D0*LOG10(1000.D0/P2)

The MOMENTS for a square-wave or 'bar': F(x)=f0  b<=x<=c, =0.0 else
     S0 =   f0 (x)                      [from x=b to x=c]
     S1 = 3 f0 (x^2 - x)                [from x=b to x=c]
     S2 = 5 f0 (2x^3 - 3x^2 + x)        [from x=b to x=c]
```

REVISION HISTORY:

```
24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
```

1.47.6 linoz_read

Subroutine LINOZ_READ reads the input data file for the Linoz stratospheric ozone chemistry.

INTERFACE:

```
SUBROUTINE LINOZ_READ
```

USES:

```
USE FILE_MOD,      ONLY : IU_FILE        ! Logical unit #
USE FILE_MOD,      ONLY : IOERROR        ! I/O error subroutine
USE DIRECTORY_MOD, ONLY : DATA_DIR_1x1   ! Data directory path

USE CMN_SIZE_MOD
```

REMARKS:

```
LINOZ_READ is called from "main.f" at the start of the simulation.
LINOZ_READ will also call INIT_LINOZ to initialize the arrays.
```

REVISION HISTORY:

```
24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
16 Oct 2009 - R. Yantosca         - Now use IU_FILE instead of IU_LINOZ
16 Oct 2009 - R. Yantosca         - Read file from DATA_DIR_1x1
```

1.47.7 linoz_intpl

Subroutine LINOZ_INTPL does some kind of interpolation.

INTERFACE:

```
SUBROUTINE LINOZ_INTPL(KE,IE,ND,NE,XI,XN,YI,YN)
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: KE
INTEGER, INTENT(IN)  :: IE
INTEGER, INTENT(IN)  :: ND
INTEGER, INTENT(IN)  :: NE
REAL*8,  INTENT(IN)  :: XI(IE)
REAL*8,  INTENT(IN)  :: XN(ND)
REAL*8,  INTENT(IN)  :: YI(KE,IE)
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: YN(KE,ND)
```

REVISION HISTORY:

```
24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
```

1.47.8 strat_init

Subroutine STRAT_INIT copies the ozone computed by the Linoz stratospheric chemistry algorithm back into the GEOS-Chem tracer array.

INTERFACE:

```
SUBROUTINE STRAT_INIT
```

USES:

```
USE TRACERID_MOD
USE TRACER_MOD

USE CMN_SIZE_MOD
USE CMN_MOD
```

REVISION HISTORY:

```
24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem
```

1.47.9 init_linoz

Subroutine INIT_LINOZ allocates and zeroes the module arrays used in the Linoz stratospheric ozone algorithm.

INTERFACE:

```
SUBROUTINE INIT_LINOZ
```

USES:

```
      USE ERROR_MOD, ONLY : ALLOC_ERR

      USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
    16 Oct 2009 - R. Yantosca - Initial version
```

1.47.10 cleanup_linoz

Subroutine CLEANUP_LINOZ deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_LINOZ
```

REVISION HISTORY:

```
    16 Oct 2009 - R. Yantosca - Initial version
```

1.48 Fortran: Module Interface logical_mod.f

Module LOGICAL_MOD contains all of the logical switches used by GEOS-Chem.

INTERFACE:

```
      MODULE LOGICAL_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
    05 Nov 2004 - R. Yantosca - Added LNEI99 switch to toggle EPA/NEI emissions
    20 Dec 2004 - R. Yantosca - Added LAVHRRLAI switch for AVHRR LAI fields
    20 Oct 2005 - T-M Fu.     - Added LMEGAN switch for MEGAN biogenics
    01 Nov 2005 - B. Field    - Added LEMEP switch
    26 Feb 2006 - R. Yantosca - Added LDYNOCEAN switch for online ocean Hg model
    05 Apr 2006 - R. Yantosca - Added LGFED2BB switch for GFED2 BIOMASS BURNING
    05 May 2006 - L. Murray   - Added LCTH, LMFLUX, LPRECON for lightning
    30 May 2006 - S. Wu       - Added LFUTURE
    26 Jun 2006 - R. Park     - Added LBRAVO
    06 Jul 2006 - Aaron van D.- Added LEDGAR, LEDGARNOx, LEDGARCO, LEDGARSHIP,
                                LEDGARSOx switches for EDGAR emissions
    17 Aug 2006 - R. Yantosca - Added LSTREETS for David Streets' emissions
```

```
21 Aug 2006 - P. Le Sager - Added LVARTROP for variable tropopause
31 Jan 2007 - L. Murray   - Added LOTDREG, LOTDLOC for regional or local
                            OTD-LIS redistribution of lightning flashes
31 Jan 2007 - L. Murray   - Added LOTDSCALE
08 Mar 2008 - Aaron van D.- Added LCAC, LARCSHIP, LEMEPSHIP
24 Nov 2008 - Aaron van D.- Added LVISTAS
16 Oct 2009 - Y. Chen     - Added L8DAYBB, L3HRBB and LSYNOPBB for
                            8-day and 3-hr GFED BB emissions
26 Jan 2009 - P. Le Sager - Added LICARTT to account for Hudman
                            corrections to EPA/NEI99
12 Feb 2009 - D. Henze    - Added LSVCSPEC
10 Mar 2009 - T-M Fu      - Added LMEGANMONO
10 Mar 2009 - T-M Fu      - Added LDICARB
29 May 2009 - J. Lin      - Add LNLPBL, LARPBLH and LDEPBCK (non-local PBL)
18 May 2009 - P. Le Sager - Added LCOOKE
28 May 2009 - P. Le Sager - Added LKPP
16 Oct 2009 - C. Lee      - Added LICOADSSHIP
18 Aug 2009 - K. Wecht    - Added switches for CH4 emissions & budget
16 Oct 2009 - R. Yantosca - Added LLINOZ switch for Linoz O3 strat chem
16 Oct 2009 - R. Yantosca - Added ProTeX header
30 Oct 2009 - Aaron van D - Added LNEI2005
19 Nov 2009 - M. Barkley  - Added LMODISLAI and LPECCA
18 Dec 2009 - Aaron van D - Added HDF5 logical switches
18 Dec 2009 - Aaron van D - Added logicals for NA, EU, CH, CU nested grids
18 Dec 2009 - Aaron van D - Added logical for 2 x 2.5 TPCORE BC's
29 Jan 2009 - F. Paulot   - Added LFERTILIZERNOX.
26 Feb 2010 - R. Yantosca - Remove obsolete LEMBED flag
18 May 2010 - R. Nassar   - Add logical flags for CO2 offline simulation
20 Jul 2010 - C. Carouge  - Add LPREINDHG and LGTMM for updated mercury.
24 Jan 2011 - L. Murray   - Remove LOTDREG, LCTH, LMFLUX, LPRECON,
                             and LOTDSCALE for lightning
07 Sep 2011 - P. Kasibhatla - Modified to include GFED3
```

1.49 Fortran: Module Interface megan_mod

Module MEGAN_MOD contains variables and routines specifying the algorithms that control the MEGAN inventory of biogenic emissions.

References:

- Guenther, A., et al., *A global model of natural volatile organic compound emissions*, J.Geophys. Res., **100**, 8873-8892, 1995.
- Wang, Y., D. J. Jacob, and J. A. Logan, *Global simulation of tropospheric O3-Nox-hydrocarbon chemistry: 1. Model formulation*, J. Geophys. Res., **103**, D9, 10713-10726, 1998.

- Guenther, A., B. Baugh, G. Brasseur, J. Greenberg, P. Harley, L. Klinger, D. Serca, and L. Vierling, *Isoprene emission estimates and uncertanties for the Central African EXPRESSO study domain*, J. Geophys. Res., **104**, 30,625-30,639, 1999.
- Guenther, A. C., T. Pierce, B. Lamb, P. Harley, and R. Fall, *Natural emissions of non-methane volatile organic compounds, carbon monoxide, and oxides of nitrogen from North America*, Atmos. Environ., **34**, 2205-2230, 2000.
- Guenther, A., and C. Wiedinmyer, *User's guide to Model of Emissions of Gases and Aerosols from Nature*. http://cdp.ucar.edu. (Nov. 3, 2004)
- Guenther, A., *AEF for methyl butenol*, personal commucation. (Nov, 2004)

INTERFACE:

```
      MODULE MEGAN_MOD
```

USES:

```
      USE ERROR_MOD, ONLY : ERROR_STOP

      USE CMN_SIZE_MOD                                ! Size parameters
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

DEFINED PARAMETERS:

```
      ! Scalars
#if   defined( MERRA )
      INTEGER, PARAMETER  :: DAY_DIM        = 24       ! # of 1-hr periods/day
#else
      INTEGER, PARAMETER  :: DAY_DIM        = 8        ! # of 3-hr periods/day
#endif
      INTEGER, PARAMETER  :: NUM_DAYS       = 10       ! # of days to avg
      REAL*8,  PARAMETER  :: WM2_TO_UMOLM2S = 4.766d0  ! W/m2 -> umol/m2/s

      ! Some conversions factors (mpb,2009)
      REAL*8, PARAMETER   :: D2RAD =  3.14159d0 /   180.0d0  ! Deg -> Radians
      REAL*8, PARAMETER   :: RAD2D =    180.0d0 / 3.14159d0  ! Radians -> Deg
      REAL*8, PARAMETER   :: PI    =  3.14159d0              ! PI
```

PRIVATE TYPES:

```
      ! Past light & temperature conditions (mpb,2009)
      ! (1) Temperature at 2m (TS):
      REAL*8, ALLOCATABLE :: T_DAILY(:,:)       ! Daily averaged sfc temp
      REAL*8, ALLOCATABLE :: T_DAY(:,:,:)       ! Holds 1 day of sfc temp data
      REAL*8, ALLOCATABLE :: T_15(:,:,:)        ! Holds 15 days of daily avg T
      REAL*8, ALLOCATABLE :: T_15_AVG(:,:)      ! Sfc temp avg'd over NUM_DAYS
```

```
! (2) PAR Direct:
REAL*8, ALLOCATABLE :: PARDR_DAILY(:,:)   ! Average daily PARDR
REAL*8, ALLOCATABLE :: PARDR_DAY(:,:,:)   ! Holds 1 day of PARDR data
REAL*8, ALLOCATABLE :: PARDR_15(:,:,:)    ! 10 days of daily avg'd PARDR
REAL*8, ALLOCATABLE :: PARDR_15_AVG(:,:)  ! PARDR averaged over NUM_DAYS

! (3) PAR Diffuse:
REAL*8, ALLOCATABLE :: PARDF_DAILY(:,:)   ! Average daily PARDR
REAL*8, ALLOCATABLE :: PARDF_DAY(:,:,:)   ! Holds 1-day of PARDR data
REAL*8, ALLOCATABLE :: PARDF_15(:,:,:)    ! 10 days of daily avg'd PARDR
REAL*8, ALLOCATABLE :: PARDF_15_AVG(:,:)  ! PARDF averaged over NUM_DAYS

! Annual emission factor arrays (mpb,2009)
REAL*8, ALLOCATABLE :: AEF_ISOP(:,:)      ! Isoprene
REAL*8, ALLOCATABLE :: AEF_MONOT(:,:)     ! Total monoterpenes
REAL*8, ALLOCATABLE :: AEF_MBO(:,:)       ! Methyl butenol
REAL*8, ALLOCATABLE :: AEF_OVOC(:,:)      ! Other biogenic VOC's
REAL*8, ALLOCATABLE :: AEF_APINE(:,:)     ! Alpha-pinene
REAL*8, ALLOCATABLE :: AEF_BPINE(:,:)     ! Beta-pinene
REAL*8, ALLOCATABLE :: AEF_LIMON(:,:)     ! Limonene
REAL*8, ALLOCATABLE :: AEF_SABIN(:,:)     ! Sabine
REAL*8, ALLOCATABLE :: AEF_MYRCN(:,:)     ! Myrcene
REAL*8, ALLOCATABLE :: AEF_CAREN(:,:)     ! 3-Carene
REAL*8, ALLOCATABLE :: AEF_OCIMN(:,:)     ! Ocimene
! bug fix: causes issues in parallel (hotp 3/10/10)
!REAL*8, ALLOCATABLE :: AEF_SPARE(:,:)     ! Temp array for monoterp's

! Path to MEGAN emission factors
CHARACTER(LEN=20)   :: MEGAN_SUBDIR = 'MEGAN_200909/'
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: ACTIVITY_FACTORS
PUBLIC  :: CLEANUP_MEGAN
PUBLIC  :: GET_EMISOP_MEGAN
PUBLIC  :: GET_EMMBO_MEGAN
PUBLIC  :: GET_EMMONOG_MEGAN
PUBLIC  :: GET_EMMONOT_MEGAN
PUBLIC  :: GET_AEF
PUBLIC  :: GET_AEF_05x0666
PUBLIC  :: INIT_MEGAN
PUBLIC  :: UPDATE_T_DAY
PUBLIC  :: UPDATE_T_15_AVG
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: GET_GAMMA_LAI
PRIVATE :: GET_GAMMA_LEAF_AGE
PRIVATE :: GET_GAMMA_P
```

```
PRIVATE :: GET_GAMMA_T_ISOP
PRIVATE :: GET_GAMMA_T_NISOP
PRIVATE :: GET_GAMMA_P_PECCA
PRIVATE :: SOLAR_ANGLE
```

REVISION HISTORY:

```
(1 ) Original code (biogen_em_mod.f) by Dorian Abbot (6/2003).  Updated to
     latest algorithm and modified for the standard code by May Fu
     (11/2004).
(2 ) All emission are currently calculated using TS from DAO met field.
     TS is the surface air temperature, which should be carefully
     distinguished from TSKIN. (tmf, 11/20/2004)
(3 ) In GEOS4, the TS used here are the T2M in the A3 files, read in
     'a3_read_mod.f'.
(4 ) Bug fix: change #if block to also cover GCAP met fields (bmy, 12/6/05)
(5 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(6 ) Bug fix: Skip Feb 29th if GCAP in INIT_MEGAN (phs, 9/18/07)
(7 ) Added routine GET_AEF_05x0666 to read hi-res AEF data for the GEOS-5
     0.5 x 0.666 nested grid simulations (yxw, dan, bmy, 11/6/08)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
09 Mar 2010 - R. Yantosca - Minor bug fix in GET_EMMONOT_MEGAN
17 Mar 2010 - H. Pye      - AEF_SPARE must be a scalar local variable
                            in GET_EMMONOT_MEGAN for parallelization.
20 Aug 2010 - R. Yantosca - Move F77_CMN_SIZE to top of module
20 Aug 2010 - R. Yantosca - Now set DAY_DIM = 24 for MERRA, since the
                            surface temperature is now an hourly field.
01 Sep 2010 - R. Yantosca - Bug fix in INIT_MEGAN: now only read in
                            NUM_DAYS (instead of 15) days of sfc temp data
```

1.49.1 get_emisop_megan

Subroutine GET_EMISOP_MEGAN computes isoprene emissions in units of [atoms C/box] using the MEGAN inventory.

INTERFACE:

```
FUNCTION GET_EMISOP_MEGAN( I,  J,     SUNCOS,
&                          TS, Q_DIR, Q_DIFF, XNUMOL )
&         RESULT( EMISOP )
```

USES:

```
USE LAI_MOD,     ONLY : ISOLAI, MISOLAI, PMISOLAI, DAYS_BTW_M
USE LOGICAL_MOD, ONLY : LPECCA
```

INPUT PARAMETERS:

```
! Arguments
INTEGER, INTENT(IN) :: I, J    ! GEOS-Chem lon & lat indices
REAL*8,  INTENT(IN) :: SUNCOS  ! Solar zenith angle [unitless]
REAL*8,  INTENT(IN) :: TS      ! Surface temperature [K]
REAL*8,  INTENT(IN) :: Q_DIR   ! Flux of direct PAR above canopy [W/m2]
REAL*8,  INTENT(IN) :: Q_DIFF  ! Flux of diffuse PAR above canopy [W/m2]
REAL*8,  INTENT(IN) :: XNUMOL  ! Number of atoms C / kg C
```

RETURN VALUE:

```
REAL*8              :: EMISOP  ! Isoprene emissions [atoms C/box]
```

REMARKS:

```
References (see above for full citations):
=============================================================================
(1 ) Guenther et al, 1995, 1999, 2000, 2004, 2006
(2 ) Wang,    et al, 1998
(3 ) Guenther et al, 2007, MEGAN v2.1 User mannual
```

REVISION HISTORY:

```
(1 ) Original code by Dorian Abbot (9/2003).  Updated to the latest
     algorithm and modified for the standard code by May Fu (11/20/04)
(2 ) All MEGAN biogenic emission are currently calculated using TS from DAO
     met field. TS is the surface air temperature, which should be
     carefully distinguished from TSKIN. (tmf, 11/20/04)
(3 ) Restructing of function & implementation of activity factors (mpb,2009)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.2 get_emmbo_megan

Subroutine GET_EMMBO_MEGAN computes methylbutenol emissions in units of [atoms C/box] using the MEGAN inventory.

INTERFACE:

```
FUNCTION GET_EMMBO_MEGAN( I,  J,      SUNCOS,
&                         TS, Q_DIR,  Q_DIFF, XNUMOL )
&         RESULT( EMMBO )
```

USES:

```
USE LAI_MOD,     ONLY : ISOLAI, MISOLAI, PMISOLAI, DAYS_BTW_M
USE LOGICAL_MOD, ONLY : LPECCA
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I, J    ! GEOS-Chem lon & lat indices
      REAL*8,  INTENT(IN) :: SUNCOS  ! Solar zenith angle [unitless]
      REAL*8,  INTENT(IN) :: TS      ! Surface temperature [K]
      REAL*8,  INTENT(IN) :: Q_DIR   ! Flux of direct PAR above canopy [W/m2]
      REAL*8,  INTENT(IN) :: Q_DIFF  ! Flux of diffuse PAR above canopy [W/m2]
      REAL*8,  INTENT(IN) :: XNUMOL  ! Number of atoms C / kg C
```

RETURN VALUE:

```
      REAL*8              :: EMMBO   ! Methylbutenol emissions [atoms C/box]
```

REMARKS:

```
References (see above for full citations):
==============================================================================
(1 ) Guenther et al, 1995, 1999, 2000, 2004, 2006
(2 ) Wang,    et al, 1998
(3 ) Guenther et al, 2007, MEGAN v2.1 User mannual
```

REVISION HISTORY:

```
(1 ) Original code by Dorian Abbot (9/2003).  Updated to the latest
     algorithm and modified for the standard code by May Fu (11/20/04)
(2 ) All MEGAN biogenic emission are currently calculated using TS from DAO
     met field. TS is the surface air temperature, which should be
     carefully distinguished from TSKIN. (tmf, 11/20/04)
(3 ) Restructing of function & implementation of activity factors (mpb,2009)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.3 get_emmonog_megan

Subroutine GET_EMMONOG_MEGAN computes generic ('G') monoterpene emissions for individual monoterpene species in units of [atoms C/box] using the new v2.1 MEGAN inventory emission factor maps.

INTERFACE:

```
      FUNCTION GET_EMMONOG_MEGAN( I,     J,      SUNCOS, TS,
     &                            Q_DIR, Q_DIFF, XNUMOL, MONO_SPECIES )
     &            RESULT( EMMONOT )
```

USES:

```
      USE LAI_MOD,     ONLY : ISOLAI, MISOLAI, PMISOLAI, DAYS_BTW_M
      USE LOGICAL_MOD, ONLY : LPECCA
```

INPUT PARAMETERS:

```
INTEGER,          INTENT(IN) :: I, J          ! Lon & lat indices
REAL*8,           INTENT(IN) :: SUNCOS        ! Cos(solar zenith angle)
REAL*8,           INTENT(IN) :: TS            ! Surface temperature [K]
REAL*8,           INTENT(IN) :: Q_DIR         ! Direct PAR [W/m2]
REAL*8,           INTENT(IN) :: Q_DIFF        ! Diffuse PAR [W/m2]
REAL*8,           INTENT(IN) :: XNUMOL        ! Number of atoms C / kg C
CHARACTER(LEN=5), INTENT(IN) :: MONO_SPECIES  ! Monoterpene species name
```

RETURN VALUE:

```
REAL*8                       :: EMMONOT       ! Emissions [atoms C/box]
```

REMARKS:

```
References (see above for full citations):
=============================================================================
(1 ) Guenther et al, 1995, 1999, 2004, 2006
(2 ) Guenther et al, 2007, MEGAN v2.1 User Manual
```

REVISION HISTORY:

```
(1 ) Written by Michael Barkley (2008), based on old monoterpene code by
     dsa,tmf.
(2 ) Uses gamma factors instead of exchange factors, this includes
      calling of a new temperature algorithm which use a beta factor.
      (mpb,2008)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.4 get_emmonot_megan

Subroutine GET_EMMONOT_MEGAN computes the total monoterpene emissions in units of [atoms C/box] using the MEGAN v2.1 inventory.

INTERFACE:

```
FUNCTION GET_EMMONOT_MEGAN( I,  J,     SUNCOS,
&                           TS, Q_DIR, Q_DIFF, XNUMOL )
&            RESULT( EMMONOT )
```

USES:

```
USE LAI_MOD,    ONLY : ISOLAI, MISOLAI, PMISOLAI, DAYS_BTW_M
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I, J      ! Lon & lat indices
REAL*8,  INTENT(IN) :: SUNCOS    ! Cos( solar zenith angle )
REAL*8,  INTENT(IN) :: TS        ! Local surface air temperature [K]
REAL*8,  INTENT(IN) :: Q_DIR     ! Direct PAR above canopy [W/m2]
REAL*8,  INTENT(IN) :: Q_DIFF    ! Diffuse PAR above canopy [W/m2]
REAL*8,  INTENT(IN) :: XNUMOL    ! Number of atoms C / kg C
```

RETURN VALUE:

```
REAL*8              :: EMMONOT   ! Monoterpene emissions [atoms C/box]
```

REMARKS:

```
References (see above for full citations):
=============================================================================
(1 ) Guenther et al, 1995, 1999, 2000, 2006
(2 ) Guenther et al, 2007, MEGAN v2.1 User Manual
```

REVISION HISTORY:

```
(1 ) Original code by Michael Barkley (mpb,2009).
17 Dec 2009 - R. Yantosca - Added ProTeX headers
09 Mar 2010 - H.O.T. Pye  - Change order of arguments in call to
                            routine GET_EMMONOG_MEGAN
```

1.49.5 activity_factors

Subroutine ACTIVITY_FACTORS computes the gamma activity factors which adjust the emission factors to the current weather and vegetation conditions. Here they are calculated by (default) for isoprene.

INTERFACE:

```
SUBROUTINE ACTIVITY_FACTORS( I,              J,       TS,
&                            SUNCOS,         Q_DIR,   Q_DIFF,
&                            XNUMOL,         SPECIES, GAMMA_LAI,
&                            GAMMA_LEAF_AGE, GAMMA_P, GAMMA_T,
&                            GAMMA_SM )
```

USES:

```
USE LAI_MOD,     ONLY : ISOLAI, MISOLAI, PMISOLAI, DAYS_BTW_M
USE LOGICAL_MOD, ONLY : LPECCA
```

INPUT PARAMETERS:

```
INTEGER,          INTENT(IN)   :: I, J     ! Lon & lat indices
REAL*8,           INTENT(IN)   :: SUNCOS   ! Cos( solar zenith angle )
REAL*8,           INTENT(IN)   :: TS       ! Surface air temperature [K]
REAL*8,           INTENT(IN)   :: XNUMOL   ! Number of atoms C / kg C
REAL*8,           INTENT(IN)   :: Q_DIR    ! Direct PAR [W/m2]
REAL*8,           INTENT(IN)   :: Q_DIFF   ! Diffuse PAR [W/m2]
CHARACTER(LEN=4), INTENT(IN)   :: SPECIES  ! Species (ISOP,MONO,MBOT)
```

OUTPUT PARAMETERS:

```
! GAMMA factors for:
REAL*8,           INTENT(OUT)  :: GAMMA_LAI       ! LAI
REAL*8,           INTENT(OUT)  :: GAMMA_LEAF_AGE  ! Leaf age
REAL*8,           INTENT(OUT)  :: GAMMA_P         ! Light
REAL*8,           INTENT(OUT)  :: GAMMA_T         ! Temperature
REAL*8,           INTENT(OUT)  :: GAMMA_SM        ! Soil moisture
```

REVISION HISTORY:

```
(1 ) Original code written by Michael Barkley (mpb,2009).
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.6 get_gamma_p_pecca

Computes the PECCA gamma activity factor with sensitivity to LIGHT.

INTERFACE:

```
 FUNCTION GET_GAMMA_P_PECCA( I , J , Q_DIR_2, Q_DIFF_2 ,
&                            PARDR_AVG_SIM ,  PARDF_AVG_SIM  )
&              RESULT( GAMMA_P_PECCA )
```

USES:

```
USE TIME_MOD,   ONLY : GET_DAY_OF_YEAR
USE TIME_MOD,   ONLY : GET_LOCALTIME
USE GRID_MOD,   ONLY : GET_YMID

USE CMN_GCTM_MOD   ! Physical constants (why?!)
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I,  J             ! Lon & lat indices
REAL*8,  INTENT(IN) :: PARDR_AVG_SIM     ! Average direct PAR [W/m2]
REAL*8,  INTENT(IN) :: PARDF_AVG_SIM     ! Average diffuse PAR [W/m2]
REAL*8,  INTENT(IN) :: Q_DIR_2           ! Direct PAR [umol/m2/s]
REAL*8,  INTENT(IN) :: Q_DIFF_2          ! Diffuse PAR [umol/m2/s]
```

RETURN VALUE:

```
REAL*8              :: GAMMA_P_PECCA     ! GAMMA factor for light
```

REMARKS:

```
References (see above for full citations):
==========================================================================
(1 ) Guenther et al, 2006
(2 ) Guenther et al, 2007, MEGAN v2.1 user guide
```

REVISION HISTORY:

```
(1 ) Here PAR*_AVG_SIM is the average light conditions over the simulation
     period. I've set this = 10 days to be consistent with temperature & as
     outlined in Guenther et al, 2006. (mpb,2009)
(2 ) Code was taken & adapted directly from the MEGAN v2.1 source code.
     (mpb,2009)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.7 solar_angle

Function SOLAR_ANGLE computes the local solar angle for a given day of year, latitude and longitude (or local time). Called from routine GAMMA_P_PECCA.

INTERFACE:

```
FUNCTION SOLAR_ANGLE( DOY, SHOUR, LAT ) RESULT( SINbeta )
```

USES:

INPUT PARAMETERS:

```
! Arguments
INTEGER, INTENT(IN) :: DOY       ! Day of year
REAL*8,  INTENT(IN) :: SHOUR     ! Local time
REAL*8,  INTENT(IN) :: LAT       ! Latitude
```

RETURN VALUE:

```
REAL*8              :: SINbeta   ! Sin of the local solar angle
```

REMARKS:

```
References (see above for full citations):
(1 ) Guenther et al, 2006
(2 ) Guenther et al, MEGAN v2.1 user mannual 2007-09
```

REVISION HISTORY:

```
(1 ) This code was taken directly from the MEGAN v2.1 source code.(mpb,2009)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.8 get_gamma_t_isop

Function GET_GAMMA_T_ISOP computes the temperature sensitivity for ISOPRENE ONLY.

INTERFACE:

```
FUNCTION GET_GAMMA_T_ISOP( T, PT_15, PT_1 ) RESULT( GAMMA_T )
```

INPUT PARAMETERS:

```
! Current leaf temperature, the surface air temperature field (TS)
! is assumed equivalent to the leaf temperature over forests.
REAL*8,  INTENT(IN) :: T


! Average leaf temperature over the past 15 days
REAL*8,  INTENT(IN) :: PT_15

! Average leaf temperature over the past arbitray day(s).
! This is not used at present (but might be soon!).
REAL*8,  INTENT(IN) :: PT_1
```

RETURN VALUE:

```
! GAMMA factor for temperature (isoprene only)
REAL*8              :: GAMMA_T
```

REMARKS:

```
References (see above for full citations):
=============================================================================
(1 ) Guenther et al, 1995
(2 ) Guenther et al, 2006
(3 ) Guenther et al, MEGAN v2.1 user mannual 2007-08
```

REVISION HISTORY:

```
(1 ) Includes the latest MEGAN v2.1 temperature algorithm (mpb, 2009).
     Note, this temp-dependence is the same for the PECCA & hybrid models.
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.9 get_gamma_t_nisop

Function GET_GAMMA_T_NISOP computes the temperature activity factor (GAMMA_T) for BVOCs OTHER than isoprene. Called from routines GET_EMMONOG_MEGAN and GET_EMMBO_MEGAN.

INTERFACE:

```
FUNCTION GET_GAMMA_T_NISOP( T, BETA ) RESULT( GAMMA_T )
```

INPUT PARAMETERS:

```
      ! Current leaf temperature [K], the surface air temperature field (TS)
      ! is assumed equivalent to the leaf temperature over forests.
      REAL*8, INTENT(IN) :: T

      ! Temperature factor per species (from MEGAN user manual).
      ! Beta = 0.09 for MBO and for monoterpene species (APINE, BPINE, LIMON,
      ! SABIN, MYRCN, CAREN, OCIMN). Pass as an argument in case this changes.
      REAL*8, INTENT(IN) :: BETA
```

RETURN VALUE:

```
      REAL*8             :: GAMMA_T  !
```

REMARKS:

```
   GAMMA_T =  exp[BETA*(T-Ts)]

                                                                              .
              where BETA   = temperature dependent parameter
                    Ts     = standard temperature (normally 303K, 30C)
                                                                              .
   References (see above for full citations):
   ============================================================================
   (1 ) Guenther et al, 2006
   (2 ) Guenther et al, MEGAN user mannual 2007-08
```

REVISION HISTORY:

```
   (1 ) Original code by Michael Barkley (2009).
        Note: If T = Ts  (i.e. standard conditions) then GAMMA_T = 1
   17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.10 get_gamma_p

Function GET_GAMMA_P computes the gamma activity factor with sensitivity to LIGHT (aka 'PAR'). Called by the functions ! GET_EMISOP_MEGAN, GET_EMMBO_MEGAN, and GET_EMMONOG_MEGAN.

INTERFACE:

```
      FUNCTION GET_GAMMA_P( LAI, SUNCOS1, Q_DIR_2, Q_DIFF_2 )
     &              RESULT( GAMMA_P )
```

USES:

```
      USE CMN_GCTM_MOD   ! Physical constants
```

INPUT PARAMETERS:

```
      REAL*8,  INTENT(IN) :: LAI        ! Cumulative leaf area index
      REAL*8,  INTENT(IN) :: SUNCOS1    ! Cosine of solar zenith angle
      REAL*8,  INTENT(IN) :: Q_DIR_2    ! Direct PAR above canopy [umol/m2/s]
      REAL*8,  INTENT(IN) :: Q_DIFF_2   ! Diffuse PAR above canopy [umol/m2/s]
```

RETURN VALUE:

```
      REAL*8              :: GAMMA_P    ! Gamma activity factor w/r/t light
```

REMARKS:

```
    *** REVAMPED FUNCTION ***

                                                                             .
    C_PPFD: Effect of increasing PPFD up to a saturation point, where emission
            level off, based on Eq 4abc from Guenther et al. (1999)
            In addition, a 5 layered canopy model based on Eqs 12-16
            from Guenther et al. (1995) is included to correct for light
            attenuation in the canopy.

                                                                             .
    References (see above for full citations):
    ============================================================================
    (1 ) Guenther et al, 1995
    (2 ) Wang     et al, 1998
    (3 ) Guenther et al, 1999
    (5 ) Guenther et al, 2004
```

REVISION HISTORY:

```
    (1 ) Original code by Dorian Abbot and by May Fu.
    (2 ) This code was extracted from the previous GET_HEA_TL function.
         (mpb,2009)
    17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.11 get_gamma_leaf_age

Function GET_GAMMA_LEAF_AGE computes the gamma exchange activity factor which is sensitive to leaf age (= GAMMA_LEAF_AGE). Called from GET_EMISOP_MEGAN, GET_EMMBO_MEGAN, and GET_EMMONOG_MEGAN.

INTERFACE:

```
      FUNCTION GET_GAMMA_LEAF_AGE( CMLAI, PMLAI, T, SPECIES, TT )
     &            RESULT( GAMMA_LEAF_AGE )
```

INPUT PARAMETERS:

```
      REAL*8,           INTENT(IN) :: T        ! Number of days between
                                               !  current and previous LAI.
      REAL*8,           INTENT(IN) :: CMLAI    ! Current month's LAI [cm2/cm2]
      REAL*8,           INTENT(IN) :: PMLAI    ! Previous months LAI [cm2/cm2]
      CHARACTER(LEN=4), INTENT(IN) :: SPECIES  ! BVOC species name
      REAL*8,           INTENT(IN) :: TT       ! Daily average temperature [K]
```

RETURN VALUE:

```
      REAL*8                         :: GAMMA_LEAF_AGE   ! Activity factor
```

REMARKS:

```
References (see above for full citations):
=============================================================================
(3 ) Guenther et al, 2006
(5 ) Guenther et al, MEGAN user mannual 2007-08
```

REVISION HISTORY:

```
(1 ) Original code by Dorian Abbot (9/2003). Modified for the standard
     code by May Fu (11/2004)
(2 ) Update to publically released (as of 11/2004) MEGAN algorithm and
     modified for the standard code by May Fu (11/2004).
(3 ) Algorithm is based on the latest User's Guide (tmf, 11/19/04)
(4 ) Renamed & now includes specific relative emission activity factors for
     each BVOC based on MEGAN v2.1 algorithm (mpb,2008)
(5 ) Now calculate TI (number of days after budbreak required to induce
     iso. em.) and TM (number of days after budbreak required to reach
     peak iso. em. rates) using the daily average temperature, instead
     of using fixed values (mpb,2008)
     NOTE: Can create 20% increases in tropics (Guenther et al 2006)
(6 ) Implemented change for the calculation of FGRO if ( CMLAI > PMLAI ),
     i.e. if LAI has increased with time, and used new values for
     all foilage fractions if ( CMLAI = PMLAI ). Also removed TG variable
     as not now needed. (mpb,2000)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.12 get_gamma_lai

Function GET_GAMMA_LAI computes the gamma exchange activity factor which is sensitive to leaf area (= GAMMA_LAI). Called from GET_EMISOP_MEGAN, GET_EMMBO_MEGAN, and GET_EMMONOG_MEGAN.

INTERFACE:

```
      FUNCTION GET_GAMMA_LAI( CMLAI ) RESULT( GAMMA_LAI )
```

INPUT PARAMETERS:

```
      REAL*8, INTENT(IN)  :: CMLAI       ! Current month's LAI [cm2/cm2]
```

RETURN VALUE:

```
      REAL*8              :: GAMMA_LAI
```

REMARKS:

```
References (see above for full citations):
============================================================================
(1 ) Guenther et al, 2006
(2 ) Guenther et al, MEGAN user mannual 2007-08
```

REVISION HISTORY:

```
(1 ) Original code by Dorian Abbot (9/2003).  Modified for the standard
     code by May Fu (11/2004)
(2 ) Update to publically released (as of 11/2004) MEGAN algorithm and
     modified for the standard code by May Fu (11/2004).
(3 ) Algorithm is based on the latest MEGAN v2.1 User's Guide (mpb,2009)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.13 get_aef

Subroutine GET_AEF reads Annual Emission Factor for all biogenic VOC species from disk. Called from GET_AEF is called from "main.f".

INTERFACE:

```
SUBROUTINE GET_AEF
```

USES:

```
! References to F90 modules
USE BPCH2_MOD,      ONLY : GET_RES_EXT, READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1
USE TIME_MOD,       ONLY : GET_TS_EMIS
USE GRID_MOD,       ONLY : GET_AREA_M2
```

REMARKS:

```
Reference: (5 ) Guenther et al, 2004
```

REVISION HISTORY:

```
(1 ) Original code by Dorian Abbot (9/2003).  Modified for the standard
     code by May Fu (11/2004)
(2 ) AEF detailed in the latest MEGAN User's Guide (tmf, 11/19/04)
(3 ) Bug fix (tmf, 11/30/04)
(4 ) Now reads 1x1 files and regrids to current resolution (bmy, 10/24/05)
(5 ) Uses new v2.1 emission factors maps for isoprene, MBO and 7 monoterpene
     species, download in 2009. (mpb,2009)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.14 get_aef_05x0666

Subroutine GET_AEF_05x0666 reads Annual Emission Factor for all biogenic VOC species from disk. Called from "main.f". Specially constructed to read 0.5 x 0.666 nested grid data for the GEOS-5 nested grid simulations.

INTERFACE:

```
SUBROUTINE GET_AEF_05x0666
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_RES_EXT, READ_BPCH2
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_05x0666
USE TIME_MOD,       ONLY : GET_TS_EMIS
USE GRID_MOD,       ONLY : GET_AREA_M2
USE DIRECTORY_MOD,  ONLY : DATA_DIR
```

REMARKS:

```
Reference: (5 ) Guenther et al, 2004
```

REVISION HISTORY:

```
(1) Specially constructed to read 0.5 x 0.666 nested grid data for the
    GEOS-5 nested grid simulations. (yxw, dan, bmy, 11/6/08)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.15 update_t_day

Subroutine UPDATE_T_DAY must be called every time the A-3 fields are updated. Each 3h TS value for each gridbox is moved up one spot in the matrix and the current value is put in the last spot.

INTERFACE:

```
SUBROUTINE UPDATE_T_DAY
```

USES:

```
USE MEGANUT_MOD     ! We use all functions from the module
```

REVISION HISTORY:

```
(1 ) All MEGAN biogenic emission are currently calculated using TS from DAO
     met field. TS is the surface air temperature, which should be
     carefully distinguished from TSKIN. (tmf, 11/20/04)
(2 ) In GEOS4, TS are originally T2M in the A3 files, read in
     'a3_read_mod.f'.
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.16 update_t_15_avg

Subroutine UPDATE_T_15_AVG should be called at the beginning of each day. It loops through the gridboxes doing the following:

1. Average T_DAY over the 8 TS values during the day.
2. Push the daily average TS values through T_15, throwing out the oldest and putting the newest (the T_DAY average) in the last spot
3. Get T_15_AVG by averaging T_15 over the 15 day period.

INTERFACE:

```
      SUBROUTINE UPDATE_T_15_AVG
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
#     include "define.h"
```

REVISION HISTORY:

```
   01 Oct 1995 - M. Prather  - Initial version
   (1 ) All MEGAN biogenic emission are currently calculated using TS from DAO
        met field. TS is the surface air temperature, which should be
        carefully distinguished from TSKIN. (tmf, 11/20/04)
   (2 ) In GEOS4, TS are originally T2M in the A3 files, read in
        'a3_read_mod.f'.
   17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.49.17 init_megan

Subroutine INIT_MEGAN allocates and initializes all module arrays.

INTERFACE:

```
      SUBROUTINE INIT_MEGAN
```

USES:

```
      USE A3_READ_MOD
      USE MERRA_A1_MOD
      USE FILE_MOD,    ONLY : IU_A3
      USE JULDAY_MOD,  ONLY : CALDATE
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE LAI_MOD,     ONLY : INIT_LAI
      USE LOGICAL_MOD, ONLY : LUNZIP
      USE TIME_MOD,    ONLY : GET_FIRST_A3_TIME, GET_JD
      USE TIME_MOD,    ONLY : ITS_A_LEAPYEAR,    YMD_EXTRACT
```

REVISION HISTORY:

```
(1 ) Change the logic in the #if block for G4AHEAD. (bmy, 12/6/05)
(2 ) Bug fix: skip Feb 29th if GCAP (phs, 9/18/07)
(3 ) Now call GET_AEF_05x0666 for GEOS-5 nested grids (yxw,dan,bmy, 11/6/08)
17 Dec 2009 - R. Yantosca - Added ProTeX headers
26 Aug 2010 - R. Yantosca - Now reference merra_a1_mod.f
01 Sep 2010 - R. Yantosca - Now read in NUM_DAYS of sfc temp data (this had
                            been hardwired to 15 days previously)
07 Feb 2011 - R. Yantosca - Fix typos: make sure to zero out the proper
                            PARDF_* and PARDR_* arrays after allocation
```

1.49.18 cleanup_megan

Subroutine CLEANUP_MEGAN deallocates all allocated arrays at the end of a GEOS-Chem model run.

INTERFACE:

```
      SUBROUTINE CLEANUP_MEGAN
```

REVISION HISTORY:

```
17 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.50 Fortran: Module Interface meganut_mod

Module MEGANUT_MOD contains functions used by MEGAN.

INTERFACE:

```
      MODULE MEGANUT_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: XLTMMP
      PUBLIC :: XLPARDF
      PUBLIC :: XLPARDR
  !REVISION HISTORY
   20 Nov 2009 - C. Carouge - Create the module with xltmmp, xlpardf and
                              xlpardr functions.
```

1.50.1 xltmmp

Function XLTMMP passes the value of the DAO meterological field TS(IIPAR,JJPAR) back to the calling subroutine. This preserves the functionality of the H/G/I CTM function XLTMMP. XLTMMP is written in Fixed-Form Fortran 90. I, J are the long/lat indices of the grid box. IJLOOP is passed in order to maintain compatibility with the H/G/I subroutines, but is not used.

INTERFACE:

```
      FUNCTION XLTMMP( I, J, IJLOOP ) RESULT( VALUE )
```

USES:

```
      USE DAO_MOD, ONLY : TS

      USE CMN_SIZE_MOD
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)           :: I, J
      INTEGER, INTENT(IN), OPTIONAL :: IJLOOP
```

RETURN VALUE:

```
      REAL*8                        :: VALUE
```

REVISION HISTORY:

```
                              Use C-preprocessor #include statement to
                              include F77_CMN_SIZE, which has IIPAR, JJPAR,
                              LLPAR, IIPAR, JJPAR, LGLOB.
   23 Jun 2000 - R. Yantosca - Now reference TS from "dao_mod.f" instead of
                              from common block header file "F77_CMN_TS".
   31 Aug 2000 - R. Yantosca - Eliminated obsolete code from 6/23/00
   26 Sep 2001 - R. Yantosca - Now declare XLTMMP as REAL*8 w/in program body.
                              Also updated comments.
   24 Oct 2001 - R. Yantosca - Remove obsolete commented out code from 9/01
   20 Jul 2004 - R. Yantosca - IJLOOP is now not declared optional...this
                              facilitates compiling with -C on Altix
   04 Aug 2005 - R. Yantosca - Now make IJLOOP an optional argument; it's only
                              kept for backwards compatibility w/ older code
 ------------------------------------------------------------------------------
 BOC
      VALUE = TS(I,J)

      END FUNCTION XLTMMP
 EOC
 ------------------------------------------------------------------------------
           Harvard University Atmospheric Chemistry Modeling Group            !
 ------------------------------------------------------------------------------
```

```
%////////////////////////////////////////////////////////////

\mbox{}\hrulefill\


  \subsubsection{xlpardr }


  Function XLPARDR passes the value of the DAO meterological
    field PARDR(IIPAR,JJPAR) back to the calling subroutine.  This preserves
    the functionality of the H/G/I CTM function PARDR.  I, J are the long/lat
    indices of the grid box. IJLOOP is passed in order to maintain compatibility
    with the H/G/I subroutines, but is not used.
  \\
  \\{\bf INTERFACE:}
\begin{verbatim}       FUNCTION XLPARDR( I, J, IJLOOP ) RESULT( VALUE )
   !USES
       USE DAO_MOD, ONLY : PARDR

       USE CMN_SIZE_MOD
   !INPUT PARAMETERS
       INTEGER, INTENT(IN)           :: I, J
       INTEGER, INTENT(IN), OPTIONAL :: IJLOOP
```

RETURN VALUE:

```
       REAL*8                        :: VALUE
   !REVISION HISTORY
   20 Nov 2009 - M. Barkley - Original version
```

1.50.2 xlpardf

Function XLPARDF passes the value of the DAO meterological field PARDF(IIPAR,JJPAR) back to the calling subroutine. This preserves the functionality of the H/G/I CTM function PARDF. I, J are the long/lat indices of the grid box. IJLOOP is passed in order to maintain compatibility with the H/G/I subroutines, but is not used.

INTERFACE:

```
       FUNCTION XLPARDF( I, J, IJLOOP ) RESULT( VALUE )
   !USES
       USE DAO_MOD, ONLY : PARDF

       USE CMN_SIZE_MOD
   !INPUT PARAMETERS
       INTEGER, INTENT(IN)           :: I, J
       INTEGER, INTENT(IN), OPTIONAL :: IJLOOP
```

RETURN VALUE:

```
       REAL*8                          :: VALUE

   !REVISION HISTORY
    20 Nov 2009 - M. Barkley - Original version
  !EOP
  ------------------------------------------------------------------------------
  BOC
       VALUE = PARDF(I,J)

       END FUNCTION XLPARDF
  EOC
       END MODULE MEGANUT_MOD
\markboth{Left}{Source File: merra\_a1\_mod.F,  Date: Thu Nov 17 16:07:15 EST 2011
}


  ------------------------------------------------------------------------------
            Harvard University Atmospheric Chemistry Modeling Group            !
  ------------------------------------------------------------------------------
%//////////////////////////////////////////////////////////////

\mbox{}\hrulefill\


  \subsection{Fortran:  Module Interface merra\_a1\_mod }


  Module MERRA\_A1\_MOD contains subroutines for reading the
    1-hour time averaged (aka "A1") fields from the MERRA data archive.
  \\
  \\{\bf INTERFACE:}
\begin{verbatim}       MODULE MERRA_A1_MOD
```

USES:

```
       IMPLICIT NONE
 #     include "define.h"
       PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
       PUBLIC  :: GET_MERRA_A1_FIELDS
       PUBLIC  :: OPEN_MERRA_A1_FIELDS
```

PRIVATE MEMBER FUNCTIONS:

```
       PRIVATE :: A1_CHECK
       PRIVATE :: DO_OPEN_A1
       PRIVATE :: READ_A1
```

REMARKS:

```
Don't bother with the file unzipping anymore.
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
```

1.50.3 do_open_a1

Function DO_OPEN_A1 returns TRUE if is time to open the A1 met field file or FALSE otherwise. This prevents us from opening a file which has already been opened.

INTERFACE:

```
FUNCTION DO_OPEN_A1( NYMD, NHMS, RESET ) RESULT( DO_OPEN )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)           :: NYMD     ! YYYYMMDD and hhmmss to test
INTEGER, INTENT(IN)           :: NHMS     !  if it's time to open file
LOGICAL, INTENT(IN), OPTIONAL :: RESET    ! Reset the
```

RETURN VALUE:

```
LOGICAL                       :: DO_OPEN  ! =T if it's time to open file
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
21 Sep 2010 - R. Yantosca - Add RESET via the argument list to reset
                            the FIRST flag if so desired.
```

1.50.4 open_merra_a1_fields

Subroutine OPEN_MERRA_A1_FIELDS opens the A1 met fields file for date NYMD and time NHMS.

INTERFACE:

```
SUBROUTINE OPEN_MERRA_A1_FIELDS( NYMD, NHMS, RESET )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE DIRECTORY_MOD, ONLY : MERRA_DIR
USE ERROR_MOD,     ONLY : ERROR_STOP
USE FILE_MOD,      ONLY : FILE_EXISTS
USE FILE_MOD,      ONLY : IU_A1
USE FILE_MOD,      ONLY : IOERROR
USE TIME_MOD,      ONLY : EXPAND_DATE
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)           :: NYMD    ! YYYYMMDD date
INTEGER, INTENT(IN)           :: NHMS    ! hhmmss time
LOGICAL, INTENT(IN), OPTIONAL :: RESET   ! Reset first-time A1 flag?
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
```

1.50.5 get_merra_a1_fields

Subroutine GET_MERRA_A1_FIELDS is a wrapper for routine READ_A1.

INTERFACE:

```
SUBROUTINE GET_MERRA_A1_FIELDS( NYMD, NHMS )
```

USES:

```
USE DAO_MOD, ONLY : ALBD,     CLDFRC,   EFLUX,    EVAP
USE DAO_MOD, ONLY : FRSEAICE, FRSNO,    GRN,      GWETROOT
USE DAO_MOD, ONLY : GWETTOP,  HFLUX,    LAI,      LWI
USE DAO_MOD, ONLY : PARDF,    PARDR,    PBL,      PREANV
USE DAO_MOD, ONLY : PREACC,   PRECON,   PRELSC,   PRECSNO
USE DAO_MOD, ONLY : RADLWG,   RADSWG,   SEAICE00, SEAICE10
USE DAO_MOD, ONLY : SEAICE20, SEAICE30, SEAICE40, SEAICE50
USE DAO_MOD, ONLY : SEAICE60, SEAICE70, SEAICE80, SEAICE90
USE DAO_MOD, ONLY : SLP,      SNODP,    SNOMAS,   TROPP
USE DAO_MOD, ONLY : TS,       TSKIN,    U10M,     USTAR
USE DAO_MOD, ONLY : V10M,     Z0

USE CMN_SIZE_MOD            ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD
INTEGER, INTENT(IN) :: NHMS   !  and hhmmss of data to read from disk
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
25 Aug 2010 - R. Yantosca - Now pass LWI down to READ_A1
```

1.50.6 read_a1

Subroutine READ_A1 reads MERRA 1-hour time averaged ("A1") met fields from disk.

INTERFACE:

```
 SUBROUTINE READ_A1( NYMD,     NHMS,
&                    ALBEDO,   CLDTOT,   EFLUX,    EVAP,
&                    FRSEAICE, FRSNO,    GRN,      GWETROOT,
&                    GWETTOP,  HFLUX,    LAI,      LWGNT,
&                    LWI,      PARDF,    PARDR,    PBLH,
&                    PRECANV,  PRECTOT,  PRECCON,  PRECLSC,
&                    PRECSNO,  SEAICE00, SEAICE10, SEAICE20,
&                    SEAICE30, SEAICE40, SEAICE50, SEAICE60,
&                    SEAICE70, SEAICE80, SEAICE90, SLP,
&                    SNODP,    SNOMAS,   SWGNT,    TROPPT,
&                    T2M,      TS,       U10M,     USTAR,
&                    V10M,     Z0M                          )
```

USES:

```
USE DIAG_MOD,     ONLY : AD67
USE FILE_MOD,     ONLY : IOERROR
USE FILE_MOD,     ONLY : IU_A1
USE TIME_MOD,     ONLY : SET_CT_A1
USE TIME_MOD,     ONLY : TIMESTAMP_STRING
USE TRANSFER_MOD, ONLY : TRANSFER_2D
USE TRANSFER_MOD, ONLY : TRANSFER_TO_1D

USE CMN_SIZE_MOD                          ! Size parameters
USE CMN_DIAG_MOD                          ! ND67 flag
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: NYMD                ! YYYYMMDD and hhmmss
INTEGER, INTENT(IN)  :: NHMS                !  of data to read
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: ALBEDO  (IIPAR,JJPAR)  ! Sfc albedo [unitless]
REAL*8,  INTENT(OUT) :: CLDTOT  (IIPAR,JJPAR)  ! Column cld fraction
REAL*8,  INTENT(OUT) :: EFLUX   (IIPAR,JJPAR)  ! Latent heat flux [W/m2]
REAL*8,  INTENT(OUT) :: EVAP    (IIPAR,JJPAR)  ! Surface evap [kg/m2/s]
REAL*8,  INTENT(OUT) :: FRSEAICE(IIPAR,JJPAR)  ! Sfc sea ice fraction
REAL*8,  INTENT(OUT) :: FRSNO   (IIPAR,JJPAR)  ! Sfc snow fraction
REAL*8,  INTENT(OUT) :: GRN     (IIPAR,JJPAR)  ! Greenness fraction
REAL*8,  INTENT(OUT) :: GWETROOT(IIPAR,JJPAR)  ! Root soil wetness [frac]
REAL*8,  INTENT(OUT) :: GWETTOP (IIPAR,JJPAR)  ! Topsoil wetness [frac]
REAL*8,  INTENT(OUT) :: HFLUX   (IIPAR,JJPAR)  ! Sensible H-flux [W/m2]
REAL*8,  INTENT(OUT) :: LAI     (IIPAR,JJPAR)  ! Leaf area index [m2/m2]
REAL*8,  INTENT(OUT) :: LWI     (IIPAR,JJPAR)  ! Leaf area index [m2/m2]
```

```
REAL*8,  INTENT(OUT) :: LWGNT   (IIPAR,JJPAR)  ! Net LW rad @ sfc [W/m2]
REAL*8,  INTENT(OUT) :: PARDF   (IIPAR,JJPAR)  ! Diffuse PAR [W/m2]
REAL*8,  INTENT(OUT) :: PARDR   (IIPAR,JJPAR)  ! Direct PAR [W/m2]
REAL*8,  INTENT(OUT) :: PBLH    (IIPAR,JJPAR)  ! PBL height [m]
REAL*8,  INTENT(OUT) :: PRECANV (IIPAR,JJPAR)  ! Anv prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECTOT (IIPAR,JJPAR)  ! Tot prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECCON (IIPAR,JJPAR)  ! CV prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECLSC (IIPAR,JJPAR)  ! LS prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECSNO (IIPAR,JJPAR)  ! Snow precip [kg/m2/s]
REAL*8,  INTENT(OUT) :: SEAICE00(IIPAR,JJPAR)  ! Sea ice coverage 00-10%
REAL*8,  INTENT(OUT) :: SEAICE10(IIPAR,JJPAR)  ! Sea ice coverage 10-20%
REAL*8,  INTENT(OUT) :: SEAICE20(IIPAR,JJPAR)  ! Sea ice coverage 20-30%
REAL*8,  INTENT(OUT) :: SEAICE30(IIPAR,JJPAR)  ! Sea ice coverage 30-40%
REAL*8,  INTENT(OUT) :: SEAICE40(IIPAR,JJPAR)  ! Sea ice coverage 40-50%
REAL*8,  INTENT(OUT) :: SEAICE50(IIPAR,JJPAR)  ! Sea ice coverage 50-60%
REAL*8,  INTENT(OUT) :: SEAICE60(IIPAR,JJPAR)  ! Sea ice coverage 60-70%
REAL*8,  INTENT(OUT) :: SEAICE70(IIPAR,JJPAR)  ! Sea ice coverage 70-80%
REAL*8,  INTENT(OUT) :: SEAICE80(IIPAR,JJPAR)  ! Sea ice coverage 80-90%
REAL*8,  INTENT(OUT) :: SEAICE90(IIPAR,JJPAR)  ! Sea ice coverage 90-100%
REAL*8,  INTENT(OUT) :: SLP     (IIPAR,JJPAR)  ! Sea level pressure [hPa]
REAL*8,  INTENT(OUT) :: SNODP   (IIPAR,JJPAR)  ! Snow depth [m]
REAL*8,  INTENT(OUT) :: SNOMAS  (IIPAR,JJPAR)  ! Snow mass [kg/m2]
REAL*8,  INTENT(OUT) :: SWGNT   (IIPAR,JJPAR)  ! SW rad @ sfc [W/m2]
REAL*8,  INTENT(OUT) :: TROPPT  (IIPAR,JJPAR)  ! T'pause pressure [hPa]
REAL*8,  INTENT(OUT) :: T2M     (IIPAR,JJPAR)  ! T @ 2m height [K]
REAL*8,  INTENT(OUT) :: TS      (IIPAR,JJPAR)  ! Sfc skin T [K]
REAL*8,  INTENT(OUT) :: U10M    (IIPAR,JJPAR)  ! U-wind @ 10m [m/s]
REAL*8,  INTENT(OUT) :: USTAR   (IIPAR,JJPAR)  ! Friction velocity [m/s]
REAL*8,  INTENT(OUT) :: V10M    (IIPAR,JJPAR)  ! V-wind @ 10m [m/s]
REAL*8,  INTENT(OUT) :: Z0M     (IIPAR,JJPAR)  ! Roughness height [m]
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
25 Aug 2010 - R. Yantosca - Now read LWI (land/water/ice) from disk
15 Aug 2011 - R. Yantosca - Now save SWGDN in 2nd slot of ND67 diagnostic
25 Mar 2011 - R. Yantosca - Bug fix: make local SWGDN array for ND67 diag
```

1.50.7 a1_check

Subroutine A1_CHECK prints an error message if not all of the A-3 met fields are found. The run is also terminated.

INTERFACE:

```
SUBROUTINE A1_CHECK( NFOUND, N_A1 )
```

USES:

```
      USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: NFOUND   ! Number of met fields read in from disk
      INTEGER, INTENT(IN) :: N_A1     ! Number of expected met fields
```

REVISION HISTORY:

```
    19 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
```

1.51 Fortran: Module Interface merra_a3_mod

Module MERRA_A3_MOD contains subroutines for reading the 3-hour time averaged (aka "A3") fields from the MERRA data archive.

INTERFACE:

```
      MODULE MERRA_A3_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: GET_MERRA_A3_FIELDS
      PUBLIC  :: OPEN_MERRA_A3_FIELDS
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: A3_CHECK
      PRIVATE :: DO_OPEN_A3
      PRIVATE :: READ_A3
```

REMARKS:

```
    Don't bother with the file unzipping anymore.
```

REVISION HISTORY:

```
    19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.51.1 do_open_a3

unction DO_OPEN_A3 returns TRUE if is time to open the A3 met field file or FALSE otherwise. This prevents us from opening a file which has already been opened.

INTERFACE:

```
FUNCTION DO_OPEN_A3( NYMD, NHMS ) RESULT( DO_OPEN )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD      ! YYYYMMDD and hhmmss to be tested
INTEGER, INTENT(IN) :: NHMS      !  to see if it's time to open A3 file
```

RETURN VALUE:

```
LOGICAL             :: DO_OPEN   ! = T if it is time to open the file
```

REVISION HISTORY:

```
20 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
```

1.51.2 open_merra_a3_fields

Subroutine OPEN_MERRA_A3_FIELDS opens the A3 met fields file for date NYMD and time NHMS.

INTERFACE:

```
SUBROUTINE OPEN_MERRA_A3_FIELDS( NYMD, NHMS )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE DIRECTORY_MOD, ONLY : MERRA_DIR
USE ERROR_MOD,     ONLY : ERROR_STOP
USE FILE_MOD,      ONLY : FILE_EXISTS
USE FILE_MOD,      ONLY : IU_A3
USE FILE_MOD,      ONLY : IOERROR
USE TIME_MOD,      ONLY : EXPAND_DATE

USE CMN_SIZE_MOD      ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD and
INTEGER, INTENT(IN) :: NHMS   !  hhmmss to test for A3 file open
```

REVISION HISTORY:

```
20 Aug 2010 - R. Yantosca - Initial version, based on a6_read_mod.f
```

1.51.3 get_merra_a3_fields

Subroutine GET_MERRA_A3_FIELDS is a wrapper for routine READ_A3.

INTERFACE:

```
SUBROUTINE GET_MERRA_A3_FIELDS( NYMD, NHMS )
```

USES:

```
USE DAO_MOD, ONLY : CLDF,    CLDTOPS,  CMFMC,    DQRCU
USE DAO_MOD, ONLY : DQRLSAN, DQIDTMST, DQLDTMST, DQVDTMST
USE DAO_MOD, ONLY : DTRAIN,  MOISTQ,   OPTDEP,   PFICU
USE DAO_MOD, ONLY : PFILSAN, PFLCU,    PFLLSAN,  QI
USE DAO_MOD, ONLY : QL,      SPHU,     REEVAPCN, REEVAPLS
USE DAO_MOD, ONLY : T,       TAUCLI,   TAUCLW,   UWND
USE DAO_MOD, ONLY : VWND

USE CMN_SIZE_MOD            ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD and
INTEGER, INTENT(IN) :: NHMS   !  hhmmss of desired data fields
```

REVISION HISTORY:

```
20 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
```

1.51.4 read_a3

Subroutine READ_A3 reads the MERRA 3-hour time-averaged (aka "A3") met fields from disk.

INTERFACE:

```
 SUBROUTINE READ_A3( NYMD,     NHMS,
&                    CLOUD,    CLDTOPS,  CMFMC,    DQRCU,
&                    DQRLSAN,  DQIDTMST, DQLDTMST, DQVDTMST,
&                    DTRAIN,   MOISTQ,   OPTDEPTH, PFICU,
&                    PFILSAN,  PFLCU,    PFLLSAN,  QI,
&                    QL,       QV,       REEVAPCN, REEVAPLS,
&                    T,        TAUCLI,   TAUCLW,   U,
&                    V                                     )
```

USES:

```
USE DIAG_MOD,     ONLY : AD66
USE DIAG_MOD,     ONLY : AD67
USE FILE_MOD,     ONLY : IOERROR
```

```
      USE FILE_MOD,     ONLY : IU_A3
      USE TIME_MOD,     ONLY : SET_CT_A3
      USE TIME_MOD,     ONLY : TIMESTAMP_STRING
      USE TRANSFER_MOD, ONLY : TRANSFER_A6
      USE TRANSFER_MOD, ONLY : TRANSFER_3D_Lp1
      USE TRANSFER_MOD, ONLY : TRANSFER_3D
      USE TRANSFER_MOD, ONLY : TRANSFER_G5_PLE

      USE CMN_SIZE_MOD                                  ! Size parameters
      USE CMN_DIAG_MOD                                  ! ND66, LD66, ND67
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: NYMD                        ! YYYYMMDD & hhmmss
      INTEGER, INTENT(IN)  :: NHMS                        !  of desired data
```

OUTPUT PARAMETERS:

```
      ! Fields dimensioed as (I,J)
      INTEGER, INTENT(OUT) :: CLDTOPS (IIPAR,JJPAR       )

      ! Fields dimensioned as (I,J,L)
      REAL*8,  INTENT(OUT) :: CMFMC   (IIPAR,JJPAR,LLPAR+1)
      REAL*8,  INTENT(OUT) :: DQRCU   (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: DQRLSAN (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: DQIDTMST(IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: DQLDTMST(IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: DQVDTMST(IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: DTRAIN  (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: PFICU   (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: PFILSAN (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: PFLCU   (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: PFLLSAN (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: QI      (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: QL      (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: QV      (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: REEVAPCN(IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: REEVAPLS(IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: T       (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: TAUCLI  (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: TAUCLW  (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: U       (IIPAR,JJPAR,LLPAR  )
      REAL*8,  INTENT(OUT) :: V       (IIPAR,JJPAR,LLPAR  )

      ! Fields dimensioned as (L,I,J)
      REAL*8,  INTENT(OUT) :: CLOUD   (LLPAR,IIPAR,JJPAR  )
      REAL*8,  INTENT(OUT) :: MOISTQ  (LLPAR,IIPAR,JJPAR  )
      REAL*8,  INTENT(OUT) :: OPTDEPTH(LLPAR,IIPAR,JJPAR  )
```

REVISION HISTORY:

```
20 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f
20 Aug 2010 - R. Yantosca - Now save CLDTOPS to ND67 diagnostic
```

1.51.5 a3_check

Subroutine A3_CHECK prints an error message if not all of the A-6 met fields are found. The run is also terminated.

INTERFACE:

```
SUBROUTINE A3_CHECK( NFOUND, N_A3 )
```

USES:

```
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NFOUND   ! # of fields found in file
INTEGER, INTENT(IN) :: N_A3     ! # of expected fields
```

REVISION HISTORY:

```
20 Aug 2010 - R. Yantosca - Initial version, based on a6_read_mod.f
```

1.52 Fortran: Module Interface merra_cn_mod

Module MERRA_CN_MOD contains subroutines for reading the constant (aka "CN") fields from the MERRA data archive.

INTERFACE:

```
MODULE MERRA_CN_MOD
```

USES:

```
USE CMN_SIZE_MOD             ! Size parameters
USE CMN_DIAG_MOD             ! NDxx flags
USE CMN_GCTM_MOD             ! g0

IMPLICIT NONE
#     include "define.h"

PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: GET_MERRA_CN_FIELDS
PUBLIC  :: OPEN_MERRA_CN_FIELDS
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: CN_CHECK
PRIVATE :: READ_CN
```

REMARKS:

```
Don't bother with the file unzipping anymore.
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
20 Aug 2010 - R. Yantosca - Moved include files to top of module
```

1.52.1 open_merra_cn_fields

Subroutine OPEN_MERRA_CN_FIELDS opens the MERRA "CN" met fields file for date NYMD and time NHMS.

INTERFACE:

```
SUBROUTINE OPEN_MERRA_CN_FIELDS( NYMD, NHMS )
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_RES_EXT
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE DIRECTORY_MOD, ONLY : MERRA_DIR
USE ERROR_MOD,     ONLY : ERROR_STOP
USE FILE_MOD,      ONLY : FILE_EXISTS
USE FILE_MOD,      ONLY : IU_CN
USE FILE_MOD,      ONLY : IOERROR
USE TIME_MOD,      ONLY : EXPAND_DATE
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD date
INTEGER, INTENT(IN) :: NHMS   ! hhmmss time
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.52.2 get_merra_cn_fields

Subroutine GET_MERRA_CN_FIELDS is a wrapper for routine READ_CN.

INTERFACE:

```
SUBROUTINE GET_MERRA_CN_FIELDS( NYMD, NHMS )
```

USES:

```
USE DAO_MOD, ONLY : FRLAKE     ! Fraction of grid box that is lake
USE DAO_MOD, ONLY : FRLAND     ! Fraction of grid box that is land
USE DAO_MOD, ONLY : FRLANDIC   ! Fraction of grid box that is land ice
USE DAO_MOD, ONLY : FROCEAN    ! Fraction of grid box that is ocean
USE DAO_MOD, ONLY : PHIS       ! Surface geopotential height
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD    ! YYYYMMDD date
INTEGER, INTENT(IN) :: NHMS    !  and hhmmss time of desired data
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.52.3 read_cn

Subroutine READ_CN reads the MERRA CN (constant) fields from disk.

INTERFACE:

```
SUBROUTINE READ_CN( NYMD,   NHMS,
&                   FRLAKE, FRLAND, FRLANDIC, FROCEAN, PHIS )
```

USES:

```
USE DIAG_MOD,     ONLY : AD67
USE FILE_MOD,     ONLY : IOERROR
USE FILE_MOD,     ONLY : IU_CN
USE TIME_MOD,     ONLY : TIMESTAMP_STRING
USE TRANSFER_MOD, ONLY : TRANSFER_2D
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: NYMD   ! YYYYMMDD and
INTEGER, INTENT(IN)  :: NHMS   !  hhmmss time of desired data
```

OUTPUT PARAMETERS:

```
! Fraction of grid box covered by lakes [unitless]
REAL*8,  INTENT(OUT) :: FRLAKE  (IIPAR,JJPAR)

! Fraction of grid box covered by land ice [unitless]
REAL*8,  INTENT(OUT) :: FRLAND  (IIPAR,JJPAR)

! Fraction of grid box covered by land ice [unitless]
REAL*8,  INTENT(OUT) :: FRLANDIC(IIPAR,JJPAR)

! Fraction of grid box covered by ocean [unitless]
REAL*8,  INTENT(OUT) :: FROCEAN (IIPAR,JJPAR)

! Surface geopotential height [m2/s2]
REAL*8,  INTENT(OUT) :: PHIS    (IIPAR,JJPAR)
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.52.4 cn_check

Subroutine CN_CHECK prints an error message if not all of the CN met fields are found. The run is also terminated.

INTERFACE:

```
SUBROUTINE CN_CHECK( NFOUND, N_CN )
```

USES:

```
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NFOUND   ! Number of met fields read in from disk
INTEGER, INTENT(IN) :: N_CN     ! Number of expected met fields
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.53 Fortran: Module Interface merra_i6_mod

Module MERRA_I6_MOD contains subroutines for reading the 6-hour instantaneous (aka "I6") fields from the MERRA data archive.

INTERFACE:

```
MODULE MERRA_I6_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: GET_MERRA_I6_FIELDS_1
      PUBLIC  :: GET_MERRA_I6_FIELDS_2
      PUBLIC  :: OPEN_MERRA_I6_FIELDS
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: I6_CHECK
      PRIVATE :: READ_I6
```

REMARKS:

Don't bother with the file unzipping anymore.

REVISION HISTORY:

19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f

---

1.53.1 open_merra_i6_fields

Subroutine OPEN_MERRA_I6_FIELDS opens the MERRA "I6" met fields file for date NYMD and time NHMS.

INTERFACE:

```
      SUBROUTINE OPEN_MERRA_I6_FIELDS( NYMD, NHMS )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_RES_EXT
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE DIRECTORY_MOD, ONLY : MERRA_DIR
      USE ERROR_MOD,     ONLY : ERROR_STOP
      USE FILE_MOD,      ONLY : FILE_EXISTS
      USE FILE_MOD,      ONLY : IU_I6
      USE FILE_MOD,      ONLY : IOERROR
      USE TIME_MOD,      ONLY : EXPAND_DATE
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD date
      INTEGER, INTENT(IN) :: NHMS   ! hhmmss time
```

REVISION HISTORY:

19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f

---

1.53.2 get_merra_i6_fields_1

Subroutine GET_MERRA_I6_FIELDS_1 is a wrapper for routine READ_I6. It reads the initial data at the start of a GEOS-Chem simulation.

INTERFACE:

```
SUBROUTINE GET_MERRA_I6_FIELDS_1( NYMD, NHMS )
```

USES:

```
USE DAO_MOD, ONLY : PS1       ! Surface pressure  [hPa]
USE DAO_MOD, ONLY : RH1       ! Relative humidity [fraction]
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD date
INTEGER, INTENT(IN) :: NHMS   !  and hhmmss time of desired data
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.53.3 get_merra_i6_fields_2

Subroutine GET_MERRA_I6_FIELDS_2 is a wrapper for routine READ_I6. It reads the data every 6 hours during a GEOS-Chem simulation.

INTERFACE:

```
SUBROUTINE GET_MERRA_I6_FIELDS_2( NYMD, NHMS )
```

USES:

```
USE DAO_MOD, ONLY : PS2       ! Surface pressure  [hPa]
USE DAO_MOD, ONLY : RH2       ! Relative humidity [fraction]
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD   ! YYYYMMDD date
INTEGER, INTENT(IN) :: NHMS   !  and hhmmss time of desired data
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.53.4 read_i6

Subroutine READ_I6 reads GEOS-Chem I-6 (instantaneous 6-hour) met fields from disk.

INTERFACE:

```
SUBROUTINE READ_I6( NYMD, NHMS, PS, RH )
```

USES:

```
USE FILE_MOD,     ONLY : IOERROR
USE FILE_MOD,     ONLY : IU_I6
USE TIME_MOD,     ONLY : SET_CT_I6
USE TIME_MOD,     ONLY : TIMESTAMP_STRING
USE TRANSFER_MOD, ONLY : TRANSFER_2D
USE TRANSFER_MOD, ONLY : TRANSFER_3D

USE CMN_SIZE_MOD                              ! Size parameters
USE CMN_DIAG_MOD                              ! NDxx flags
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: NYMD                    ! YYYYMMDD and hhmmss
INTEGER, INTENT(IN)  :: NHMS                    !  time of desired data
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT) :: PS(IIPAR,JJPAR      )  ! Surface pressure [hPa]
REAL*8,  INTENT(OUT) :: RH(IIPAR,JJPAR,LLPAR)  ! Rel. humidity [unitless]
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.53.5 i6_check

Subroutine I6_CHECK prints an error message if not all of the I6 met fields are found. The run is also terminated.

INTERFACE:

```
SUBROUTINE I6_CHECK( NFOUND, N_I6 )
```

USES:

```
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NFOUND   ! Number of met fields read in from disk
INTEGER, INTENT(IN) :: N_I6     ! Number of expected met fields
```

REVISION HISTORY:

```
19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f
```

1.54 Fortran: Module Interface nei2005_anthro_mod

Module NEI2005_ANTHRO_MOD contains variables and routines to read the NEI2005 anthropogenic emissions.

INTERFACE:

```
      MODULE NEI2005_ANTHRO_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      REAL*8, PUBLIC, ALLOCATABLE :: USA_MASK(:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_NEI2005_ANTHRO
      PUBLIC  :: EMISS_NEI2005_ANTHRO
      PUBLIC  :: EMISS_NEI2005_ANTHRO_05x0666
      PUBLIC  :: GET_NEI2005_ANTHRO
      !-------------------------------------
      ! Leave for future use (bmy, 12/3/09)
      !PUBLIC  :: GET_NEI2005_MASK
      !-------------------------------------
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: NEI2005_SCALE_FUTURE
      PRIVATE :: INIT_NEI2005_ANTHRO
      PRIVATE :: TOTAL_ANTHRO_TG
      PRIVATE :: READ_NEI2005_MASK
      PRIVATE :: GET_NEI99_SEASON
      PRIVATE :: GET_NEI99_SEASON_05x0666
      PRIVATE :: GET_VISTAS_SEASON
      PRIVATE :: GET_VISTAS_SEASON_05x0666
      PRIVATE :: GET_NEI99_WKSCALE
      PRIVATE :: GET_NEI99_WKSCALE_05x0666
```

REMARKS:

```
(1) NIT is available in the data file but not read here (it is not
    emitted in GEOS-Chem).
(2) The algorithms in routines EMISS_NEI2005_ANTHRO and
    EMISS_NEI2005_ANTHRO_05x0666 may cause the code to die
    when running offline simulations.  We will add a fix later.
```

REVISION HISTORY:

```
07 Oct 2009 - A. van Donkelaar - initial version
20 Oct 2009 - P. Le Sager - added handling of VOC & masks
02 Nov 2009 - A. van Donkelaar - added seasonality, weekday factors
02 Dec 2009 - R. Yantosca - Added GET_NEI2005_MASK function
02 Dec 2009 - R. Yantosca - Updated comments etc.
10 Dec 2009 - D. Millet - Fix scaling, which is by ozone season
11 Dec 2009 - L. Zhang, A. Van Donkelaar - Add seasonality for NH3
21 Dec 2009 - R. Yantosca - Added support for 0.5 x 0.666 nested grids
13 Aug 2010 - R. Yantosca - Add modifications for MERRA (treat like GEOS-5)
27 Jul 2011 - R. Yantosca - Removed typo in EMISS_NEI2005_ANTHRO_05x0666
```

1.54.1 get_nei2005_anthro

Function GET_NEI2005_ANTHRO returns the NEI2005 emission for GEOS-Chem grid box (I,J,L) and tracer N. Emissions can be returned in units of [kg/s] or [molec/cm2/s].

INTERFACE:

```
      FUNCTION GET_NEI2005_ANTHRO( I,    J,     L, N, WEEKDAY,
     &                         MOLEC_CM2_S, KG_S ) RESULT( VALUE )
```

USES:

```
      USE TRACER_MOD,   ONLY : XNUMOL
      USE TRACERID_MOD, ONLY : IDTACET, IDTALK4, IDTC2H6, IDTC3H8
      USE TRACERID_MOD, ONLY : IDTALD2, IDTCH2O, IDTPRPE, IDTMEK
      USE TRACERID_MOD, ONLY : IDTNOx,  IDTCO,   IDTSO2,  IDTNH3
      USE TRACERID_MOD, ONLY : IDTSO4
```

INPUT PARAMETERS:

```
      ! Longitude, latitude, and tracer indices
      INTEGER, INTENT(IN)           :: I, J, L, N

      ! OPTIONAL -- return emissions in [molec/cm2/s]
      LOGICAL, INTENT(IN), OPTIONAL :: WEEKDAY, MOLEC_CM2_S

      ! OPTIONAL -- return emissions in [kg/s] or [kg C/s]
      LOGICAL, INTENT(IN), OPTIONAL :: KG_S
```

RETURN VALUE:

```
      ! Emissions output
      REAL*8                        :: VALUE
```

REVISION HISTORY:

```
     7 Oct 2009 - A. van Donkelaar - initial version
```

1.54.2 emiss_nei2005_anthro

Subroutine EMISS_NEI2005_ANTHRO reads the NEI2005 emission fields at 1x1 resolution and regrids them to the current model resolution.

INTERFACE:

```
SUBROUTINE EMISS_NEI2005_ANTHRO
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
USE LOGICAL_MOD,       ONLY : LFUTURE
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1
USE TIME_MOD,          ONLY : GET_YEAR, GET_MONTH
USE SCALE_ANTHRO_MOD,  ONLY : GET_ANNUAL_SCALAR_1x1
USE TRACERID_MOD, ONLY : IDTACET, IDTALK4, IDTC2H6, IDTC3H8
USE TRACERID_MOD, ONLY : IDTALD2, IDTCH2O, IDTPRPE, IDTMEK
USE TRACERID_MOD, ONLY : IDTNOx,  IDTCO,   IDTSO2,  IDTNH3
USE TRACERID_MOD, ONLY : IDTSO4,  IDTOCPI, IDTBCPI

USE CMN_SIZE_MOD          ! Size parameters
USE CMN_O3_MOD            ! FSCALYR
```

REVISION HISTORY:

```
07 Oct 2009 - A. van Donkelaar - initial version
20 Oct 2009 - P. Le Sager - added VOC, account for mask to get better total
12 Jul 2010 - R. Yantosca - Now point to NEI2005_201007 directory, to read
                            in updated files (by Aaron van Donkelaar) to
                            fix a problem in the VOC emissions.
13 Aug 2010 - R. Yantosca - Treat MERRA like GEOS-5
```

1.54.3 emiss_nei2005_anthro_05x0666

Subroutine EMISS_NEI2005_ANTHRO reads the NEI2005 emission fields at 1/2 x 2.3 resolution

INTERFACE:

```
SUBROUTINE EMISS_NEI2005_ANTHRO_05x0666
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR
USE LOGICAL_MOD,       ONLY : LFUTURE
USE TIME_MOD,          ONLY : GET_YEAR, GET_MONTH
USE SCALE_ANTHRO_MOD,  ONLY : GET_ANNUAL_SCALAR_05x0666_NESTED
```

```
      USE TRACERID_MOD, ONLY : IDTACET, IDTALK4, IDTC2H6, IDTC3H8
      USE TRACERID_MOD, ONLY : IDTALD2, IDTCH2O, IDTPRPE, IDTMEK
      USE TRACERID_MOD, ONLY : IDTNOx,  IDTCO,   IDTSO2,  IDTNH3
      USE TRACERID_MOD, ONLY : IDTSO4,  IDTOCPI, IDTBCPI

      USE CMN_SIZE_MOD          ! Size parameters
      USE CMN_O3_MOD            ! FSCALYR
```

REVISION HISTORY:

```
   03 Nov 2009 - A. van Donkelaar - initial version
   12 Jul 2010 - R. Yantosca - Now point to NEI2005_201007 directory, to read
                               in updated files (by Aaron van Donkelaar) to
                               fix a problem in the VOC emissions.
   13 Aug 2010 - R. Yantosca - Treat MERRA like GEOS-5 (leave for future use)
   27 Jul 2011 - R. Yantosca - Fixed typo: now *really* point to the NEI2005
                               data directory NEI2005_101007/
```

1.54.4 get_nei99_season

Subroutine GET_NEI99_SEASON returns monthly scale factors from EPA 1999

INTERFACE:

```
      SUBROUTINE GET_NEI99_SEASON( TRACER, AS )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_TAU0,    READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR_1x1
      USE TIME_MOD,      ONLY : GET_MONTH
      USE TRACERID_MOD,  ONLY : IDTACET, IDTALK4, IDTC2H6, IDTC3H8
      USE TRACERID_MOD,  ONLY : IDTALD2, IDTCH2O, IDTPRPE, IDTMEK
      USE TRACERID_MOD,  ONLY : IDTNOx,  IDTCO,   IDTSO2,  IDTNH3
      USE TRACERID_MOD,  ONLY : IDTSO4

      USE CMN_SIZE_MOD                         ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)    :: TRACER   ! Tracer number
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*4,  INTENT(OUT)   :: AS(I1x1,J1x1,5)  ! Scale factor array
```

REVISION HISTORY:

```
   30 Oct 2009 - A. van Donkelaar - Initial Version
    3 Nov 2009 - P. Le Sager      - update handling of boxes w/ zero emissions
   10 Dec 2009 - D. Millet        - Now scale to August, not an annual average
   11 Dec 2009 - L. Zhang, A. van Donkelaar - Add seasonality for NH3
```

1.54.5 get_nei99_season_05x0666

Subroutine GET_NEI_SEASON returns monthly scale factors from EPA 1999, for the 0.5 x 0.666 nested grids.

INTERFACE:

```
SUBROUTINE GET_NEI99_SEASON_05x0666( TRACER, AS )
```

USES:

```
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1

USE CMN_SIZE_MOD                          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)       :: TRACER   ! Tracer number
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJPAR,5)  ! Scale factor array
```

REVISION HISTORY:

```
30 Oct 2009 - A. van Donkelaar - Initial Version
```

1.54.6 get_vistas_season

Subroutine GET_VISTAS_SEASON returns monthly scale factors to account for monthly variations in NOx emissions on 1x1 resolution grid (amv, 11/02/09)

INTERFACE:

```
SUBROUTINE GET_VISTAS_SEASON( AS )
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
USE TIME_MOD,          ONLY : GET_MONTH,     GET_YEAR

USE CMN_SIZE_MOD                          ! Size parameters
USE CMN_O3_MOD            ! FSCALYR
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(I1x1,J1x1,5)  ! Scale factor array
```

REVISION HISTORY:

```
30 Oct 2009 - A. van Donkelaar - Initial Version
 3 Nov 2009 - P. Le Sager      - update handling of boxes w/ zero emissions
10 Dec 2009 - D. Millet        - Now scale to August, not an annual average
```

1.54.7 get_vistas_season_05x0666

Subroutine GET_VISTAS_SEASON_05x0666 returns monthly scale factors to account for monthly variations in NOx emissions for the 0.5 x 0.666 nested grids. (amv, 11/02/09)

INTERFACE:

```
SUBROUTINE GET_VISTAS_SEASON_05x0666( AS )
```

USES:

```
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1

USE CMN_SIZE_MOD                          ! Size parameters
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJPAR,5)  ! Scale factor array
```

REVISION HISTORY:

```
03 Nov 2009 - A. van Donkelaar - Initial Version
```

1.54.8 get_nei99_wkscale

Subroutine GET_NEI99_WKSCALE returns the scale factors to convert weekday to weekend emissions based on the NEI99.

INTERFACE:

```
SUBROUTINE GET_NEI99_WKSCALE( TRACER, AS )
```

USES:

```
USE BPCH2_MOD,         ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,     ONLY : DATA_DIR_1x1
USE TIME_MOD,          ONLY : GET_MONTH
USE TRACERID_MOD, ONLY : IDTACET, IDTALK4, IDTC2H6, IDTC3H8
USE TRACERID_MOD, ONLY : IDTALD2, IDTCH2O, IDTPRPE, IDTMEK
USE TRACERID_MOD, ONLY : IDTNOx,  IDTCO,   IDTSO2,  IDTNH3
USE TRACERID_MOD, ONLY : IDTSO4

USE CMN_SIZE_MOD                          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)       :: TRACER   ! Tracer number
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(I1x1,J1x1,5)  ! Scale factor array
```

REVISION HISTORY:

```
30 Oct 2009 - A. van Donkelaar - Initial Version
 3 Nov 2009 - P. Le Sager - update handling of boxes w/ zero emissions
```

1.54.9 get_nei99_wkscale_05x0666

Subroutine GET_NEI99_WKSCALE_05x0666 returns the scale factors (for 0.5 x 0.666 nested grids) to convert weekday to weekend emissions based on the NEI99.

INTERFACE:

```
SUBROUTINE GET_NEI99_WKSCALE_05x0666( TRACER, AS )
```

USES:

```
USE REGRID_1x1_MOD,    ONLY : DO_REGRID_1x1

USE CMN_SIZE_MOD                          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)       :: TRACER   ! Tracer number
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJPAR,5)  ! Scale factor array
```

REVISION HISTORY:

```
30 Oct 2009 - A. van Donkelaar - Initial Version
```

1.54.10 read_nei2005_mask

Subroutine READ_NEI2005_MASK reads the mask for NEI data

INTERFACE:

```
SUBROUTINE READ_NEI2005_MASK
```

USES:

```
! Reference to F90 modules
USE BPCH2_MOD,      ONLY : GET_NAME_EXT_2D, GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0,        READ_BPCH2
USE LOGICAL_MOD,    ONLY : LCAC,            LBRAVO
USE DIRECTORY_MOD,  ONLY : DATA_DIR_1x1
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1
USE TRANSFER_MOD,   ONLY : TRANSFER_2D

USE CMN_SIZE_MOD        ! Size parameters
```

REMARKS:

```
temporary mask: same as EPA 99
```

REVISION HISTORY:

```
20 Oct 2009 - P. Le Sager - init
26 Oct 2009 - P. Le Sager - new masks
```

1.54.11 nei2005_scale_future

Subroutine NEI2005_SCALE_FUTURE applies the IPCC future scale factors to the NEI2005 anthropogenic emissions.

INTERFACE:

```
SUBROUTINE NEI2005_SCALE_FUTURE
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_COff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NH3an
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NOxff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_SO2ff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_OCff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_BCff

USE CMN_SIZE_MOD             ! Size parameters
```

REMARKS:

```
VOC are not scaled, however scale factors are available (see
 epa_nei_mod.f for procedure)
```

REVISION HISTORY:

```
 7 Oct 2009 - A. van Donkelaar - initial version
20 Oct 2009 - P. Le Sager - set L OpenMP private, put L loop first
```

1.54.12 total_anthro_Tg

Subroutine TOTAL_ANTHRO_TG prints the totals for the anthropogenic emissions of NOx, CO, SO2 and NH3.

INTERFACE:

```
SUBROUTINE TOTAL_ANTHRO_TG( YEAR )
```

USES:

```
USE CMN_SIZE_MOD            ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: YEAR   ! Year of data to compute totals
```

REVISION HISTORY:

```
7 Oct 2009 - A. van Donkelaar - initial version
```

1.54.13 init_nei2005_anthro

Subroutine INIT_NEI2005_ANTHRO allocates and zeroes all module arrays.

INTERFACE:

```
      SUBROUTINE INIT_NEI2005_ANTHRO
```

USES:

```
      USE ERROR_MOD,   ONLY : ALLOC_ERR
      USE GRID_MOD,    ONLY : GET_AREA_CM2
      USE LOGICAL_MOD, ONLY : LNEI05

      USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

1.54.14 cleanup_nei2005_anthro

Subroutine CLEANUP_NEI2005_ANTHRO deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_NEI2005_ANTHRO
```

REVISION HISTORY:

1.55 Fortran: Module Interface optdepth_mod

Module OPTDEPTH_MOD contains routines to return optical depths and update the ND21 diagnostic.

INTERFACE:

```
      MODULE OPTDEPTH_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
INTERFACE OPTDEPTH
   MODULE PROCEDURE OD_GEOS3_GEOS4
END INTERFACE

PUBLIC  :: OPTDEPTH
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: OD_GEOS3_GEOS4
```

REVISION HISTORY:

```
15 Aug 2001 - R. Yantosca - Initial version
(1 ) Now add parallel DO-loops (bmy, 8/15/01)
(2 ) Removed obsolete code from 9/01 (bmy, 10/24/01)
(3 ) Now divide module header into MODULE PRIVATE, MODULE VARIABLES, and
     MODULE ROUTINES sections.  Also add MODULE INTERFACES section,
     since we have an interface here. (bmy, 5/28/02)
(4 ) Renamed OD_GEOS2_GEOS_3 to OD_GEOS3_GEOS4.  (bmy, 4/20/05)
(5 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
14 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.55.1 od_geos3_geos4

Subroutine OD_GEOS3_GEOS4 copies the DAO grid box optical depth from the OPTDEP met field array into the OPTD array. Diagnostics are also archived.

INTERFACE:

```
SUBROUTINE OD_GEOS3_GEOS4( NVERT, CLDF, OPTDEP, OPTD )
```

USES:

```
USE DIAG_MOD, ONLY: AD21

USE CMN_SIZE_MOD   ! Size parameters
USE CMN_DIAG_MOD   ! ND21
```

INPUT PARAMETERS:

```
! Number of levels for which optical depth is desired
INTEGER, INTENT(IN)  :: NVERT

! 3/D cloud fraction from met fields  [unitless]
REAL*8,  INTENT(IN)  :: CLDF  (LLPAR,IIPAR,JJPAR)

! Optical depths from met fields [unitless]
REAL*8,  INTENT(IN)  :: OPTDEP(LLPAR,IIPAR,JJPAR)
```

OUTPUT PARAMETERS:

```
      ! Optical depth output array [unitless]
      REAL*8,  INTENT(OUT) :: OPTD  (LLPAR,IIPAR,JJPAR)
```

REMARKS:

```
The optical depths in the GEOS-5 met field archives are in-cloud optical
depths instead of grid-box optical depths (as was reported in the file
specification documents erroneously).

Also, the name "OD_GEOS3_GEOS4" is historical.  Once upon a time this was
used to denote the difference between the optical depths in GEOS-3 and
GEOS-4 (which come directly from the met fields) and GEOS-1 and GEOS-STRAT
(which were computed as functions of temperature).  The GEOS-5 and MERRA
optical depths are also provided in the met field archive, so the
algorithms in this routine are also equally applicable.
```

REVISION HISTORY:

```
15 Aug 2001 - R. Yantosca - Initial version
(1 ) Now parallelize I-J DO loops (bmy, 8/15/01)
(2 ) Renamed to OD_GEOS3_GEOS4.  Also now saves CLDF in AD21(I,J,L,2)
     for the ND21 diagnostic (bmy, 4/20/05)
14 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.56 Fortran: Module Interface Pjc_Pfix_Mod

Module Pjc_Pfix_Mod contains routines which implements the Philip Cameron-Smith pressure fixer for the new fvDAS transport scheme. (bdf, bmy, 5/8/03, 10/27/03)

INTERFACE:

```
      MODULE Pjc_Pfix_Mod
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: Do_Pjc_Pfix
      PUBLIC  :: Cleanup_Pjc_Pfix
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: Calc_Pressure
      PRIVATE :: Calc_Advection_Factors
      PRIVATE :: Adjust_Press
      PRIVATE :: Init_Press_Fix
      PRIVATE :: Do_Press_Fix_LLNL
```

```
PRIVATE :: Average_Press_Poles
PRIVATE :: Convert_Winds
PRIVATE :: Calc_Horiz_Mass_Flux
PRIVATE :: Calc_Divergence
PRIVATE :: Set_Press_Terms
PRIVATE :: Do_Divergence_Pole_Sum
PRIVATE :: Xpavg
PRIVATE :: Init_Pjc_Pfix
```

AUTHOR:

```
Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)
Brendan Field and Bob Yantosca (5/8/03)
Modified for new GMI TPCORE by Claire Carouge (ccarouge@seas.harvard.edu)
```

REVISION HISTORY:

```
(1 ) Bug fix for Linux/PGI compiler in routines ADJUST_PRESS and
     INIT_PRESS_FIX. (bmy, 6/23/03)
(2 ) Now make P1, P2 true surface pressure in DO_PJC_PFIX (bmy, 10/27/03)
```

1.56.1 Do_Pjc_Pfix

Subroutine Do_Pjc_Pfix is the driver routine for the Philip Cameron-Smith pressure fixer for the fvDAS transport scheme. (bdf, bmy, 5/8/03, 3/5/07)

We assume that the winds are on the A-GRID, since this is the input that the fvDAS transport scheme takes. (bdf, bmy, 5/8/03)

INTERFACE:

```
SUBROUTINE Do_Pjc_Pfix( D_DYN, P1, P2, UWND, VWND, XMASS, YMASS )
```

USES:

```
USE CMN_SIZE_MOD    ! Size parameters
USE CMN_GCTM_MOD    ! Physical constants
```

INPUT PARAMETERS:

```
! Dynamic timestep [s]
REAL*8,  INTENT(IN)  :: D_DYN

! True PSurface at middle of dynamic timestep [hPa]
REAL*8,  INTENT(IN)  :: P1(IIPAR,JJPAR)

! True PSurface at end    of dynamic timestep [hPa]
REAL*8,  INTENT(IN)  :: P2(IIPAR,JJPAR)
```

```
! Zonal (E-W) wind [m/s]
REAL*8,  INTENT(IN)  :: UWND(IIPAR,JJPAR,LLPAR)

! Meridional (N-S) wind [m/s]
REAL*8,  INTENT(IN)  :: VWND(IIPAR,JJPAR,LLPAR)
```

OUTPUT PARAMETERS:

```
! E-W mass fluxes [mixing ratio]
REAL*8,  INTENT(OUT) :: XMASS(IIPAR,JJPAR,LLPAR)

! N-S mass fluxes [mixing ratio]
REAL*8,  INTENT(OUT) :: YMASS(IIPAR,JJPAR,LLPAR)
```

AUTHOR:

Brendan Field and Bob Yantosca (5/8/03)

REMARKS:

(1) Now P1 and P2 are "true" surface pressures, and not PS-PTOP. If using this P-fixer w/ GEOS-3 winds, pass true surface pressure to this routine. (bmy, 10/27/03)
(2) Now define P2_TMP array for passing to ADJUST_PRESS (yxw, bmy, 3/5/07)

REVISION HISTORY:

02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers. Declare all REAL variables as REAL*8.

1.56.2 Calc_Pressure

Subroutine Calc_Pressure recalculates the new surface pressure from the adjusted air masses XMASS and YMASS. This is useful for debugging purposes. (bdf, bmy, 5/8/03)

INTERFACE:

```
SUBROUTINE Calc_Pressure( XMASS, YMASS, RGW_FV, PS_NOW, PS_AFTER )
```

USES:

```
USE CMN_SIZE_MOD  ! Size parameters
USE CMN_MOD       ! STT, NTRACE, LPRT, LWINDO
```

INPUT PARAMETERS:

```
! E-W mass flux from pressure fixer
REAL*8, INTENT(IN)  :: XMASS(IIPAR,JJPAR,LLPAR)

! N-S mass flux from pressure fixer
REAL*8, INTENT(IN)  :: YMASS(IIPAR,JJPAR,LLPAR)
```

```
! Surface pressure - PTOP at current time
REAL*8, INTENT(IN)  :: PS_NOW(IIPAR,JJPAR)

! 1 / ( SINE(J+1) - SINE(J) ) -- latitude factor
REAL*8, INTENT(IN)  :: RGW_FV(JJPAR)
```

OUTPUT PARAMETERS:

```
! Surface pressure - PTOP adjusted by P-fixer
REAL*8, INTENT(OUT) :: PS_AFTER(IIPAR,JJPAR)
```

AUTHOR:

Brendan Field and Bob Yantosca (5/8/03)

REVISION HISTORY:

02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
Declare all REAL variables as REAL*8.

1.56.3 Calc_Advection_Factors

Subroutine Calc_Advection_Factors calculates the relative area of each grid box, and the geometrical factors used by this modified version of TPCORE. These geomoetrical DO assume that the space is regularly gridded, but do not assume any link between the surface area and the linear dimensions.

INTERFACE:

```
SUBROUTINE Calc_Advection_Factors
&  (mcor, rel_area, geofac, geofac_pc)
```

USES:

```
USE CMN_SIZE_MOD   ! Size parameters
USE CMN_GCTM_MOD   ! Physical constants
```

INPUT PARAMETERS:

```
! Area of grid box (m^2)
REAL*8, INTENT(IN)  :: mcor(i1_gl :i2_gl, ju1_gl:j2_gl)
```

OUTPUT PARAMETERS:

```
! relative surface area of grid box (fraction)
REAL*8, INTENT(OUT) :: rel_area(i1_gl :i2_gl, ju1_gl:j2_gl)

! Geometrical factor for meridional advection; geofac uses
! correct spherical geometry, and replaces acosp as the
! meridional geometrical factor in tpcore
REAL*8, INTENT(OUT) :: geofac(ju1_gl:j2_gl)

! Special geometrical factor (geofac) for Polar cap
REAL*8, INTENT(OUT) :: geofac_pc
```

AUTHOR:

```
Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)
```

REMARKS:

```
Now reference PI from "F77_CMN_GCTM" for consistency.  Also force
double-precision with the "D" exponent. (bmy, 5/6/03)
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.4 Adjust_Press

Subroutine Adjust_Press initializes and calls the pressure fixer code.

INTERFACE:

```
 SUBROUTINE Adjust_Press
&  (metdata_name_org, do_timinterp_winds, new_met_rec,
&   met_grid_type, advec_consrv_opt, pmet2_opt, press_fix_opt,
&   tdt, geofac_pc, geofac, cose, cosp, rel_area, dap, dbk,
&   pctm1, pctm2, pmet2, uu, vv, xmass, ymass)
```

INPUT PARAMETERS:

```
! First  part of metdata_name, e.g., "NCAR"
CHARACTER(LEN=*) :: metdata_name_org

! Time interpolate wind fields?
LOGICAL :: do_timinterp_winds

! New met record?
LOGICAL :: new_met_rec

! Met grid type, A or C
INTEGER :: met_grid_type

! Advection_conserve option
INTEGER :: advec_consrv_opt

! pmet2 option
INTEGER :: pmet2_opt

! pressure fixer option
INTEGER :: press_fix_opt
```

```
! Model time step [s]
REAL*8  :: tdt

! Special geometrical factor (geofac) for Polar cap
REAL*8  :: geofac_pc

! Geometrical factor for meridional advection; geofac uses
! correct spherical geometry, and replaces acosp as the
! meridional geometrical factor in tpcore
REAL*8  :: geofac  (ju1_gl:j2_gl)

! Cosines of grid box edges and centers
REAL*8  :: cose    (ju1_gl:j2_gl)
REAL*8  :: cosp    (ju1_gl:j2_gl)

! Pressure difference across layer from (ai * pt) term [hPa]
REAL*8  :: dap     (k1:k2)

! Difference in bi across layer - the dSigma term
REAL*8  :: dbk     (k1:k2)

! Relative surface area of grid box (fraction)
REAL*8  :: rel_area( i1_gl:i2_gl,   ju1_gl:j2_gl)

! Metfield surface pressure at t1+tdt [hPa]
REAL*8  :: pmet2(ilo_gl:ihi_gl, julo_gl:jhi_gl)

! CTM surface pressure at t1 [hPa]
REAL*8  :: pctm1(ilo_gl:ihi_gl, julo_gl:jhi_gl)

! CTM surface pressure at t1+tdt [hPa]
REAL*8  :: pctm2(ilo_gl:ihi_gl, julo_gl:jhi_gl)

! Wind velocity, x direction at t1+tdt/2 [m/s]
REAL*8  :: uu(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)

! Wind velocity, y direction at t1+tdt/2 [m/s]
REAL*8  :: vv(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)
```

INPUT/OUTPUT PARAMETERS:

```
! Horizontal mass flux in E-W direction [hPa]
REAL*8  :: xmass(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)

! Horizontal mass flux in N-S direction [hPa]
REAL*8  :: ymass(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)
```

AUTHOR:

Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.5 Init_Press_Fix

Subroutine Init_Press_Fix initializes the pressure fixer.

INTERFACE:

```
 SUBROUTINE Init_Press_Fix
&  (metdata_name_org, met_grid_type, tdt, geofac_pc, geofac,
&   cose, cosp, dap, dbk, dps, dps_ctm, rel_area, pctm1, pmet2,
&   uu, vv, xmass, ymass)
```

INPUT PARAMETERS:

```
 ! Model Time step [s]
 REAL*8 :: tdt

 ! First part of metdata_name, e.g., "NCAR"
 CHARACTER(LEN=*) :: metdata_name_org

 ! Met grid type, A or C
 INTEGER          :: met_grid_type

 ! Special geometrical factor (geofac) for Polar cap
 REAL*8           :: geofac_pc

 ! Cosine of grid box edges and centers
 REAL*8           :: cose(ju1_gl:j2_gl)
 REAL*8           :: cosp(ju1_gl:j2_gl)

 ! Geometrical factor for meridional advection; geofac uses
 ! correct spherical geometry, and replaces acosp as the
 ! meridional geometrical factor in tpcore
 REAL*8           :: geofac(ju1_gl:j2_gl)

 ! Pressure difference across layer from (ai * pt) term [hPa]
 REAL*8           :: dap(k1:k2)

 ! Difference in bi across layer - the dSigma term
 REAL*8           :: dbk(k1:k2)

 ! relative surface area of grid box (fraction)
```

```
REAL*8           :: rel_area( i1_gl:i2_gl, ju1_gl:j2_gl)

! Metfield surface pressure at t1 [hPa]
REAL*8           :: pmet2(ilo_gl:ihi_gl, julo_gl:jhi_gl)

! CTM surface pressure at t1 [hPa]
REAL*8           :: pctm1(ilo_gl:ihi_gl, julo_gl:jhi_gl)

! CTM surface pressure at t1+tdt [hPa]
REAL*8           :: pctm2(ilo_gl:ihi_gl, julo_gl:jhi_gl)

! Wind velocity, x direction at t1+tdt/2 [m/s]
REAL*8           :: uu(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)

! Wind velocity, y direction at t1+tdt/2 [m/s]
REAL*8           :: vv(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)
```

OUTPUT PARAMETERS:

```
! Horizontal mass flux in E-W direction [hPa]
REAL*8  :: xmass(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)

! Horizontal mass flux in N-S direction [hPa]
REAL*8  :: ymass(ilo_gl:ihi_gl, julo_gl:jhi_gl, k1_gl:k2_gl)

! Change of surface pressure from met field pressure [hPa]
REAL*8  :: dps(i1_gl:i2_gl, ju1_gl:j2_gl)

! CTM surface pressure tendency [hPa]
REAL*8  :: dps_ctm(i1_gl:i2_gl, ju1_gl:j2_gl)
```

AUTHOR:

Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.6 Do_Press_Fix_Llnl

Subroutine Do_Press_Fix_Llnl fixes the mass fluxes to match the met field pressure tendency.

INTERFACE:

```
  SUBROUTINE Do_Press_Fix_Llnl
 &  (geofac_pc, geofac, dbk, dps, dps_ctm, rel_area,
 &   xmass, ymass, xmass_fixed, ymass_fixed)
```

INPUT PARAMETERS:

```
! Special geometrical factor (geofac) for Polar cap
REAL*8, INTENT(IN)   :: geofac_pc

! Geometrical factor for meridional advection; geofac uses
! correct spherical geometry, and replaces acosp as the
!  meridional geometrical factor in tpcore
REAL*8, INTENT(IN)   :: geofac(ju1_gl:j2_gl)

! Difference in bi across layer - the dSigma term
REAL*8, INTENT(IN)   :: dbk(k1:k2)

! Change of surface pressure from met field pressure [hPa]
REAL*8, INTENT(IN)   :: dps(i1:i2, ju1:j2)

! Relative surface area of grid box (fraction)
REAL*8, INTENT(IN)   :: rel_area(i1:i2, ju1:j2)

! Horizontal mass fluxes in E-W and N-S directions [hPa]
REAL*8, INTENT(IN)   :: xmass(ilo:ihi, julo:jhi, k1:k2)
REAL*8, INTENT(IN)   :: ymass(ilo:ihi, julo:jhi, k1:k2)
```

OUTPUT PARAMETERS:

```
! Sum over vertical of dpi calculated from original mass fluxes [hPa]
REAL*8,  INTENT(OUT) :: dps_ctm(i1:i2, ju1:j2)

! Horizontal mass flux in E-W and N-S directions after fixing [hPa]
REAL*8,  INTENT(OUT) :: xmass_fixed(ilo:ihi, julo:jhi, k1:k2)
REAL*8,  INTENT(OUT) :: ymass_fixed(ilo:ihi, julo:jhi, k1:k2)
```

AUTHOR:

```
Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.7 Average_Press_Poles

Subroutine Average_Press_Poles averages pressure at the Poles when the Polar cap is enlarged. It makes the last two latitudes equal.

INTERFACE:

```
 SUBROUTINE Average_Press_Poles
&  (rel_area, press)
```

INPUT PARAMETERS:

```
! Relative surface area of grid box (fraction)
REAL*8, INTENT(IN)    :: rel_area(i1:i2, ju1:j2)
```

OUTPUT PARAMETERS:

```
! Surface pressure [hPa]
REAL*8, INTENT(INOUT) :: press   (ilo:ihi, julo:jhi)
```

AUTHOR:

```
Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.8 Convert_Winds

Subroutine Convert_Winds converts winds on A or C grid to Courant # on C grid.

INTERFACE:

```
  SUBROUTINE Convert_Winds
 &  (igd, tdt, cosp, crx, cry, uu, vv)
```

USES:

```
USE CMN_SIZE_MOD ! Size parameters
USE CMN_GCTM_MOD ! Re, PI
```

INPUT PARAMETERS:

```
! A or C grid
INTEGER, INTENT(IN)  :: igd

! Model time step [s]
REAL*8,  INTENT(IN)  :: tdt

! Cosine of grid box centers
REAL*8,  INTENT(IN)  :: cosp(ju1_gl:j2_gl)

! Wind velocity in E-W (UU) and N-S (VV) directions at t1+tdt/2 [m/s]
REAL*8,  INTENT(IN)  :: uu  (ilo:ihi, julo:jhi, k1:k2)
REAL*8,  INTENT(IN)  :: vv  (ilo:ihi, julo:jhi, k1:k2)
```

OUTPUT PARAMETERS:

```
! Courant number in E-W (CRX) and N-S (CRY) directions
REAL*8,  INTENT(OUT) :: crx (ilo:ihi, julo:jhi, k1:k2)
REAL*8,  INTENT(OUT) :: cry (ilo:ihi, julo:jhi, k1:k2)
```

AUTHOR:

Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)

REMARKS:

Use GEOS-CHEM physical constants Re, PI to be consistent with other usage everywhere (bmy, 5/5/03)

REVISION HISTORY:

02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers. Declare all REAL variables as REAL*8.

1.56.9 Calc_Horiz_Mass_Flux

Subroutine Calc_Horiz_Mass_Flux calculates the horizontal mass flux for non-GISS met data.

INTERFACE:

```
SUBROUTINE Calc_Horiz_Mass_Flux
&  (cose, delpm, uu, vv, xmass, ymass, tdt, cosp)
```

USES:

```
USE CMN_SIZE_MOD ! Size parameters
USE CMN_GCTM_MOD ! Re, Pi
```

INPUT PARAMETERS:

```
! Timestep [s]
REAL*8, INTENT(IN)   :: tdt

! Cosine of grid box edges
REAL*8, INTENT(IN)   :: cose (ju1_gl:j2_gl)

! Cosine of grid box centers
REAL*8, INTENT(IN)   :: cosp (ju1_gl:j2_gl)

! Pressure thickness, the pseudo-density in a
! hdrostatic system  at t1+tdt/2 (approximate) [hPa]
REAL*8, INTENT(IN)   :: delpm(ilo:ihi, julo:jhi, k1:k2)

! E-W (UU) and N-S (VV) winds [m/s]
REAL*8, INTENT(IN)   :: uu  (ilo:ihi, julo:jhi, k1:k2)
REAL*8, INTENT(IN)   :: vv  (ilo:ihi, julo:jhi, k1:k2)
```

OUTPUT PARAMETERS:

```
! Horizontal mass flux in E-W and N-S directions [hPa]
REAL*8, INTENT(OUT)  :: xmass(ilo:ihi, julo:jhi, k1:k2)
REAL*8, INTENT(OUT)  :: ymass(ilo:ihi, julo:jhi, k1:k2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REMARKS:

```
Use GEOS-CHEM physical constants Re, PI to be consistent with other
usage everywhere (bmy, 5/5/03)
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.10 Calc_Divergence

Subroutine Calc_Divergence calculates the divergence.

INTERFACE:

```
  SUBROUTINE Calc_Divergence
 &  (do_reduction, geofac_pc, geofac, dpi, xmass, ymass)
```

INPUT PARAMETERS:

```
! Set to F if called on Master; set to T if called by Slaves
! (NOTE: this doesn't seem to be used!)
LOGICAL, INTENT(IN)    :: do_reduction

! Special geometrical factor (geofac) for Polar cap
REAL*8,  INTENT(IN)    :: geofac_pc

! geometrical factor for meridional advection; geofac uses
! correct spherical geometry, and replaces acosp as the
! meridional geometrical factor in tpcore
REAL*8,  INTENT(IN)    :: geofac(ju1_gl:j2_gl)

! horizontal mass fluxes in E-W and N-S directions [hPa]
REAL*8,  INTENT(IN)    :: xmass (ilo:ihi, julo:jhi, k1:k2)
REAL*8,  INTENT(IN)    :: ymass (ilo:ihi, julo:jhi, k1:k2)
```

INPUT/OUTPUT PARAMETERS:

```
! Divergence at a grid point; used to calculate vertical motion [hPa]
REAL*8,  INTENT(INOUT) :: dpi   (i1:i2, ju1:j2, k1:k2)
```

AUTHOR:

Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.
```

1.56.11 Set_Press_Terms

Subroutine Set_Press_Terms sets the pressure terms.

INTERFACE:

```
SUBROUTINE Set_Press_Terms
&  (dap, dbk, pres1, pres2, delp1, delpm, pu)
```

INPUT PARAMETERS:

```
! Pressure difference across layer from (ai * pt) term [hPa]
REAL*8, INTENT(IN)  :: dap  (k1:k2)

! Difference in bi across layer - the dSigma term
REAL*8, INTENT(IN)  :: dbk  (k1:k2)

! Surface pressure at t1 [hPa]
REAL*8, INTENT(IN)  :: pres1(ilo:ihi, julo:jhi)

! Surface pressure at t1+tdt [hPa]
REAL*8, INTENT(IN)  :: pres2(ilo:ihi, julo:jhi)
```

OUTPUT PARAMETERS:

```
! Pressure thickness, the psudo-density in a
! hydrostatic system at t1 [hPa]
REAL*8, INTENT(OUT) :: delp1(ilo:ihi, julo:jhi, k1:k2)

! Pressure thickness, the psudo-density in a
! hydrostatic system at t1+tdt/2 (approximate)  [hPa]
REAL*8, INTENT(OUT) :: delpm(ilo:ihi, julo:jhi, k1:k2)

! Pressure at edges in "u" [hPa]
REAL*8, INTENT(OUT) :: pu   (ilo:ihi, julo:jhi, k1:k2)
```

AUTHOR:

Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)

REVISION HISTORY:

02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
Declare all REAL variables as REAL*8.

1.56.12 Do_Divergence_Pole_Sum

Do_Divergence_Pole_Sum sets the divergence at the Poles.

INTERFACE:

```
SUBROUTINE Do_Divergence_Pole_Sum
&  (do_reduction, geofac_pc, dpi, ymass)
```

INPUT PARAMETERS:

```
! Set to T if called on Master; set to F if called by Slaves
! (NOTE: This does not seem to be used!)
LOGICAL :: do_reduction

! Special geometrical factor (geofac) for Polar cap
REAL*8  :: geofac_pc

! horizontal mass flux in N-S direction [hPa]
REAL*8  :: ymass(ilo:ihi, julo:jhi, k1:k2)
```

OUTPUT PARAMETERS:

```
! Divergence at a grid point; used to calculate vertical motion [hPa]
REAL*8  :: dpi  ( i1:i2,   ju1:j2,  k1:k2)
```

AUTHOR:

Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)

REVISION HISTORY:

02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
Declare all REAL variables as REAL*8.

1.56.13 Xpavg

!description: Subroutine Xpavg replaces each element of a vector with the average of the entire array. (bmy, 5/7/03)

INTERFACE:

```
SUBROUTINE Xpavg( P, IM )
```

USES:

```
! References to F90 modules
USE ERROR_MOD, ONLY : ERROR_STOP
```

INPUT PARAMETERS:

```
! Dimension of P
INTEGER, INTENT(IN)    :: IM
```

INPUT/OUTPUT PARAMETERS:

```
! 1-D vector to be averaged
REAL*8,  INTENT(INOUT) :: P(IM)
```

AUTHOR:

```
Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Now make all REAL variables REAL*8.
```

1.56.14 Init_Pjc_Pfix

Subroutine Init_Pjc_Pfix allocates and initializes module arrays and variables. GMI dimension variables will be used for compatibility with the Phil Cameron-Smith P-fixer. (bdf, bmy, 5/8/03)

INTERFACE:

```
SUBROUTINE Init_Pjc_Pfix
```

USES:

```
! References to F90 modules
USE GRID_MOD,     ONLY : GET_AREA_M2, GET_YMID_R
USE ERROR_MOD,    ONLY : ALLOC_ERR,   ERROR_STOP
USE PRESSURE_MOD, ONLY : GET_AP,      GET_BP

USE CMN_SIZE_MOD  ! Size parameters
USE CMN_GCTM_MOD  ! Re, PI, etc...
```

AUTHOR:

```
Brendan Field and Bob Yantosca (5/8/03)
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
```

1.56.15 Cleanup_Pjc_Pfix

Subroutine Cleanup_Pjc_Pfix deallocates all module arrays (bmy, 5/8/03)

INTERFACE:

```
      SUBROUTINE Cleanup_Pjc_Pfix
```

REVISION HISTORY:

```
02 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
```

1.57 Fortran: Module Interface planeflight_mod

Module PLANEFLIGHT_MOD contains variables and routines which are used to "fly" a plane through the GEOS-Chem model simulation. This is useful for comparing model results with aircraft observations.

INTERFACE:

```
      MODULE PLANEFLIGHT_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: ARCHIVE_RXNS_FOR_PF
      PUBLIC  :: CLEANUP_PLANEFLIGHT
      PUBLIC  :: PLANEFLIGHT
      PUBLIC  :: SETUP_PLANEFLIGHT
      PUBLIC  :: SET_PLANEFLIGHT
```

PRIVATE MEMBER FUNCTIONS:

```
  PRIVATE :: AN_SETUP
  PRIVATE :: INIT_PLANEFLIGHT
  PRIVATE :: NOY_SETUP
  PRIVATE :: READ_VARIABLES
  PRIVATE :: READ_POINTS
  PRIVATE :: RO2_SETUP
  PRIVATE :: TEST_VALID
  PRIVATE :: WRITE_VARS_TO_FILE
```

REMARKS:

The quantities that are saved to disk by the planeflight diagnostic were requested by GEOS-Chem users. If you would like to save out a new quantity, then you will have to make your own modifications in this module.

REVISION HISTORY:

(1) Now references "pressure_mod.f" (dsa, bdf, bmy, 8/21/02)
(2) Now reference AD from "dao_mod.f". Now also references "error_mod.f". (bmy, 10/15/02)
(3) Bug fix: replace missing commas in FORMAT statement (bmy, 3/23/03)
(4) Now references "time_mod.f". (bmy, 3/27/03)
(5) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
(6) Bug fix: use NAMEGAS instead of NAMESPEC (lyj, bmy, 7/9/03)
(7) Bug fix: avoid referencing JLOP for non-SMVGEAR runs (bmy, 7/18/03)
(8) Bug fix: Use T instead of T3 for GMAO temperature. Also replace NAMESPEC w/ NAMEGAS in RO2_SETUP. Now locate reordered rxn numbers for SMVGEAR II.(tdf, mje, bmy, 8/1/03)
(9) Now print out N2O5 hydrolysis rxn as a special case. Also rename output file. (bmy, 8/8/03)
(10) Changed "DAO" to "GMAO" for met field variable names. Now can save aerosol optical depths. Bug fix in TEST_VALID. (bmy, 4/23/03)
(11) Now references "tracer_mod.f" (bmy, 7/20/04)
(12) Bug fix in READ_VARIABLES (1/7/05)
(13) Modified the plane flight diagnostic so that it writes output files for each day where flight track files are defined. (bmy, 3/24/05)
(14) Minor bug fix in ARCHIVE_RXNS_FOR_PF (bmy, 5/20/05)
(15) Now split AOD's into column AOD's and AOD's below plane. Also scale AOD's to 400nm. (bmy, 10/25/05)
(16) Bug fixes in READ_VARIABLES (bmy, 10/16/06)
(17) Bug fix in PLANEFLIGHT (cdh, bmy, 12/12/06)
(18) Bug fix in RO2_SETUP (tmf, bmy, 4/23/07)
(19) Set very small values to zero. (tmf, 1/7/09)
(20) Add new RO2 species according to 'globchem.dat' (tmf, 1/7/09)
(21) Make sure we have 3 spaces in the exponential format (phs, 7/13/09)
(22) Output the grid cell indexes (kjw, 8/18/09)
(23) Add AN and NOy species. (fp, 3/10/10)
(24) Now scale AODs to wavelength specified in jv_spec_aod.dat(clh, 5/14/09)
29 Jul 2011 - R. Yantosca - Now also archive MERRA SEAICExx fields
29 Jul 2011 - R. Yantosca - Added ProTeX headers

1.57.1 setup_planeflight

Subroutine SETUP_PLANEFLIGHT reads information from the input file in order to initialize the planeflight diagnostic. Also calls INIT_PLANEFLIGHT to allocate and zero module arrays.

INTERFACE:

```
SUBROUTINE SETUP_PLANEFLIGHT
```

USES:

```
USE FILE_MOD,   ONLY : FILE_EXISTS
USE FILE_MOD,   ONLY : IOERROR
USE FILE_MOD,   ONLY : IU_FILE
USE FILE_MOD,   ONLY : IU_PLANE
USE TIME_MOD,   ONLY : EXPAND_DATE
USE TIME_MOD,   ONLY : GET_NYMD
USE TIME_MOD,   ONLY : GET_NHMS
USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM
```

REMARKS:

```
For SMVGEAR or KPP simulations, the call to SETUP_PLANEFLIGHT is made from
routine "chemdr.f", after the "chem.dat" file is read.  This is necessary
since we have to reference the SMVGEAR rxn rate and species numbers.

For offline simulations, the call to SETUP_PLANEFLIGHT can be made
at the start of the GEOS-Chem run (in "ndxx_setup.f" or similar routine).
```

REVISION HISTORY:

```
30 Jul 2002 - M. Evans    - Initial version
(1 ) Rename from "plane.dat" to "plane.log", since "*.dat" implies an input
     file name. (bmy, 8/8/03)
(2 ) Add fancy output string (bmy, 4/26/04)
(3 ) Now references GET_NYMD, GET_NHMS, and EXPAND_DATE from "time_mod.f".
     Now also replaces date & time tokens in the filenames. (bmy, 7/20/04)
(4 ) Now references FILE_EXISTS from "file_mod.f".  Modified so that we
     check if a flight track file exists on each day.  Open file for
     output on each day and write header. (bmy, 3/25/05)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.2 read_variables

Subroutine READ_VARIABLES reads the list of variables (SMVGEAR/KPP chemical species, SMVGEAR/KPP rxn rates, GMAO met fields, or GEOS-Chem tracers) to be

printed out and sorts the information into the appropriate module variables.

INTERFACE:

```
SUBROUTINE READ_VARIABLES
```

USES:

```
USE ERROR_MOD,  ONLY : GEOS_CHEM_STOP
USE FILE_MOD,   ONLY : IU_FILE
USE FILE_MOD,   ONLY : IOERROR
USE TRACER_MOD, ONLY : N_TRACERS
USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM

USE CMN_SIZE_MOD     ! Size parameters
USE COMODE_LOOP_MOD  ! NAMEGAS, NSPEC
```

REVISION HISTORY:

```
30 Jul 2002 - M. Evans    - Initial version
(1 ) Now references GEOS_CHEM_STOP from "error_mod.f", which frees all
     allocated memory before stopping the run. (bmy, 10/15/02)
(2 ) Bug fix: replace missing commas in FORMAT statement (bmy, 3/23/03)
(3 ) Bug fix: replace NAMESPEC w/ NAMEGAS for SMVGEAR II (lyj, bmy, 7/9/09)
(4 ) Now locate reordered rxn numbers for SMVGEAR II. (mje, bmy, 8/1/03)
(5 ) Now flag N2O5 hydrolysis rxn as a special case (bmy, 8/8/03)
(6 ) Changed variable name prefix "DAO" to "GMAO".  Also added aerosol
     optical depths w/ tracer offset 2000. (bmy, 4/23/04)
(7 ) Now references N_TRACERS & ITS_A_FULLCHEM_SIM from "tracer_mod.f"
     (bmy, 7/20/04)
(8 ) Bug fix: extract tracer # when reading rxn rates (bmy, 1/7/05)
(9 ) Now computes column AOD's and AOD's below plane (bmy, 10/24/05)
(10) We need to trim NAMEGAS before comparing to LINE so that comparisons
     for species like "O3" will work.  Also set NCS=NCSURBAN at the top
     of the subroutine, to avoid out of bounds error. (dbm, bmy, 10/16/06)
29 Jul 2011 - R. Yantosca - Also search for MERRA SEAICExx met fields
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.3 read_points

Subroutine READ_POINTS reads the information (ID, date, time, lat, lon, pressure) for each measurement listed in the input file, and sorts these into the appropriate module variables.

INTERFACE:

```
SUBROUTINE READ_POINTS
```

USES:

```
      USE BPCH2_MOD, ONLY : GET_TAU0
      USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
      USE FILE_MOD,  ONLY : IU_FILE, IOERROR
```

REVISION HISTORY:

```
    30 Jul 2002 - M. Evans    - Initial version
    (1 ) Now references GEOS_CHEM_STOP from "error_mod.f", which frees all
         allocated memory before stopping the run. (bmy, 10/15/02)
    29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.4 ro2_setup

Subroutine RO2_SETUP saves the SMVGEAR species indices of RO2 constituents in the PRO2 array. Also computes the count NPRO2.

INTERFACE:

```
      SUBROUTINE RO2_SETUP
```

USES:

```
      USE ERROR_MOD,  ONLY : GEOS_CHEM_STOP
      USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM

      USE CMN_SIZE_MOD   ! Size parameters
      USE COMODE_LOOP_MOD       ! NSPEC, NAMEGAS, NCS
```

REVISION HISTORY:

```
    01 Aug 2003 - M. Evans    - Initial version
    (1 ) Now references GEOS_CHEM_STOP from "error_mod.f", which frees all
         allocated memory before stopping the run. (bmy, 10/15/02)
    (2 ) Now replace NAMESPEC w/ NAMEGAS for SMVGEAR II (bmy, 8/1/03)
    (3 ) Now references ITS_A_FULLCHEM_SIM from "tracer_mod.f" (bmy, 7/20/04)
    (4 ) Bug fix: PO3 should be PO2 (tmf, bmy, 4/23/07)
    (5 ) NOTE: PO3 was a bug, that should have been PO2 (tmf, 2/10/09)
    (6 ) Add new RO2 species according to 'globchem.dat' (tmf, 3/10/09)
    29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.5 noy_setup

Subroutine NOY_SETUP saves the SMVGEAR species indices of NOy constituents in the PNOY array. Also computes the count NPNOY.

INTERFACE:

```
SUBROUTINE NOY_SETUP
```

USES:

```
USE ERROR_MOD,  ONLY : GEOS_CHEM_STOP
USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM

USE CMN_SIZE_MOD   ! Size parameters
USE COMODE_LOOP_MOD       ! NSPEC, NAMEGAS, NCS
```

REVISION HISTORY:

```
01 Jun 2009 - F. Paulot   - Initial version
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.6 an_setup

Subroutine AN_SETUP saves the SMVGEAR species indices of AN constituents in the P_AN array. Also computes the count NPAN.

INTERFACE:

```
SUBROUTINE AN_SETUP
```

USES:

```
USE ERROR_MOD,  ONLY : GEOS_CHEM_STOP
USE TRACER_MOD, ONLY : ITS_A_FULLCHEM_SIM

USE CMN_SIZE_MOD   ! Size parameters
USE COMODE_LOOP_MOD       ! NSPEC, NAMEGAS, NCS
```

REVISION HISTORY:

```
04 Jan 2010 - F. Paulot   - Initial version
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.7 planeflight

Subroutine PLANEFLIGHT saves concentrations to disk at locations corresponding to a flight track.

INTERFACE:

```
SUBROUTINE PLANEFLIGHT
```

USES:

```
      USE COMODE_MOD,   ONLY : AIRDENS,        CSPEC,       JLOP
      USE COMODE_MOD,   ONLY : T3,             VOLUME,      ABSHUM
      USE COMODE_MOD,   ONLY : TAREA
      USE DAO_MOD,      ONLY : AD,             SEAICE00,    SEAICE10
      USE DAO_MOD,      ONLY : SEAICE20,       SEAICE30,    SEAICE40
      USE DAO_MOD,      ONLY : SEAICE50,       SEAICE60,    SEAICE70
      USE DAO_MOD,      ONLY : SEAICE80,       SEAICE90,    T
      USE DAO_MOD,      ONLY : UWND,           VWND
      USE ERROR_MOD,    ONLY : GEOS_CHEM_STOP
      USE PRESSURE_MOD, ONLY : GET_PEDGE
      USE TIME_MOD,     ONLY : GET_TAU,        GET_TS_DIAG
      USE TRACER_MOD,   ONLY : STT,            TCVV

      USE CMN_FJ_MOD,   ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ
      USE JV_CMN_MOD         ! ODAER, QAA, QAA_AOD
      USE COMODE_LOOP_MOD    ! CSPEC, etc.
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) Now reference AD from "dao_mod.f".  Now references GEOS_CHEM_STOP from
     "error_mod.f", which frees memory before stopping. (bmy, 10/15/02)
(2 ) Now uses functions GET_TAU, GET_TS_CHEM from "time_mod.f".
     (bmy, 3/27/03)
(3 ) Updated comments, cosmetic changes (bmy, 7/18/03)
(4 ) Now references T from "dao_mod.f", so that we can save out temperature
     for non-SMVGEAR runs. (bmy, 8/1/03)
(5 ) Now references UWND and VWND from "dao_mod.f".  Now references
     GET_PEDGE from "pressure_mod.f".  Added CASEs for surface pressure,
     UWND, VWND to the CASE statement (bmy, 4/23/04)
(6 ) Now references STT & TCVV from "tracer_mod.f" (bmy, 7/20/04)
(7 ) Now return if DO_PF = .FALSE. (bmy, 3/24/05)
(8 ) Now compute column AOD's and AOD's below plane.  Also now scale
     AOD's to 400nm. (bmy, 10/24/05)
(9 ) Bug fix: exit if PTAU(M) == PTAUE, so that we write out on the next !
     planeflight timestep (cdh, bmy, 12/12/06)
(10) Change planeflight output time step. (ccc, 8/27/09)
(11) Now scale AOD's to jv_spec_aod.dat wavelength. (clh, 5/14/09)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.8 test_valid

Subroutine TEST_VALID tests to see if we are w/in the tropopause, which is where SMVGEAR chemistry is done.

INTERFACE:

```
SUBROUTINE TEST_VALID( IND, PCHEM, JLOOP, I, J, L )
```

USES:

```
USE COMODE_MOD,     ONLY : JLOP
USE PRESSURE_MOD,   ONLY : GET_PEDGE
USE TRACER_MOD,     ONLY : ITS_A_FULLCHEM_SIM
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP
USE GRID_MOD,       ONLY : GET_XOFFSET
USE GRID_MOD,       ONLY : GET_YOFFSET

USE CMN_SIZE_MOD               ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: IND     ! # of the flight track point
```

OUTPUT PARAMETERS:

```
LOGICAL, INTENT(OUT) :: PCHEM   ! =T if chemistry is done here
INTEGER, INTENT(OUT) :: JLOOP   ! 1-D grid box index for SMVGEAR/KPP
INTEGER, INTENT(OUT) :: I       ! GEOS-Chem longitude index
INTEGER, INTENT(OUT) :: J       ! GEOS-Chem latitude index
INTEGER, INTENT(OUT) :: L       ! GEOS-Chem level index
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) Now use GET_PEDGE of "pressure_mod.f" to return the pressure at the
     bottom edge of box (I,J,L), for hybrid grid. (dsa, bdf, bmy, 8/21/02)
(2 ) Since JLOP is not allocated for non-SMVGEAR runs, set PCHEM=F and
     JLOOP=0 even if we are in the troposphere. (bmy, 7/18/03)
(3 ) Bug fix: add 0.5 in expression for I so that the rounding will
     be done correctly.  Also make sure that I is computed correctly
for points near the date line.  (bmy, 4/23/04)
(4 ) Now references ITS_A_FULLCHEM_SIM from "tracer_mod.f" (bmy, 7/20/04)
(5 ) Now references ITS_IN_THE_TROP from "tropopause_mod.f" (bmy, 8/22/05)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
08 Sep 2011 - L. Schiferl - Added correct definitions for I and J
                            based on nested regions
```

1.57.9 write_vars_to_file

Subroutine WRITE_VARS_TO_FILE writes the values of all the variables for a given flight track point to the output file.

INTERFACE:

```
SUBROUTINE WRITE_VARS_TO_FILE( IND, VARI )
```

USES:

```
USE FILE_MOD, ONLY : IU_PLANE
USE FILE_MOD, ONLY : IOERROR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: IND          ! # of the flight track point
REAL*8,  INTENT(IN) :: VARI(NPVAR)  ! Values to print to file
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) The max line length for output seems to be 1024 characters.  Adjust
     MAXVARS accordingly so that we don't exceed this. (bmy, 7/8/02)
(2 ) Now do not write file header -- this is now done in subroutine
     SETUP_PLANEFLIGHT at the start of each day (bmy, 3/25/05)
(3 ) Bug fix: make sure we have 3 spaces in exponential (phs, 7/13/09)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.10 archive_rxns_for_PF

Subroutine ARCHIVE_RXNS_FOR_PF is called from "calcrate.f" to pass reaction rates from the SMVGEAR solver for the planeflight diagnostic.

INTERFACE:

```
SUBROUTINE ARCHIVE_RXNS_FOR_PF( JO1D, N2O5 )
```

USES:

```
USE COMODE_MOD, ONLY : IXSAVE
USE COMODE_MOD, ONLY : IYSAVE
USE COMODE_MOD, ONLY : IZSAVE
USE ERROR_MOD,  ONLY : GEOS_CHEM_STOP

USE CMN_SIZE_MOD                    ! Size parameters
USE COMODE_LOOP_MOD                 ! RRATE, JLOOPLO, KBLOOP
USE CMN_DIAG_MOD                    ! ND40 switch
```

INPUT PARAMETERS:

```
REAL*8, INTENT(IN)  :: JO1D(KBLOOP)  ! JO1D photolysis rate [1/s]
REAL*8, INTENT(IN)  :: N2O5(KBLOOP)  ! N2O5 hydrolysis rate [molec/cm3/s]
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) Now avoid overflow/underflow errors in PRATE (bmy, 7/8/02)
(2 ) Now reference GEOS_CHEM_STOP from "error_mod.f", which frees all
     allocated memory before stopping the run (bmy, 10/15/02)
(3 ) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
(4 ) Now also pass N2O5 hydrolysis rxn rate array via the arg list.
     Also bug fix: replace TMP with RATE in under/overflow checking
     for JO1D and N2O5. (bmy, 8/8/03)
(5 ) Bug fix: Replace with DO_PF since this variable is reset to either T
     or F each day depending on whether there is plane flight data
     available (bmy, 5/20/05)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.11 set_planeflight

Subroutine SET_PLANEFLIGHT is used to pass values read in from the GEOS-Chem input file to "planeflight_mod.f".

INTERFACE:

```
SUBROUTINE SET_PLANEFLIGHT( PF, IN_FILE, OUT_FILE )
```

INPUT PARAMETERS:

```
LOGICAL,            INTENT(IN) :: PF         ! Turn on planeflight diag?
CHARACTER(LEN=255), INTENT(IN) :: IN_FILE    ! Input file to read
CHARACTER(LEN=255), INTENT(IN) :: OUT_FILE   ! Output file to write
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.12 init_planeflight

Subroutine INIT_PLANEFLIGHT reads the input file to compute the number of variables and flight track points to print out. Also allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_PLANEFLIGHT
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
USE FILE_MOD,  ONLY : IU_FILE
```

```
USE FILE_MOD,  ONLY : IOERROR

USE CMN_SIZE_MOD    ! Size Parameters
USE COMODE_LOOP_MOD ! ITLOOP
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) Now reference GEOS_CHEM_STOP from "error_mod.f", which frees all
      allocated memory before stopping the run.  Also reference ALLOC_ERR
      from "error_mod.f" (bmy, 10/15/02)
(2 ) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
(3 ) INIT_PLANEFLIGHT is now called each day but the arrays are only
      allocated once.  Arrays are now allocated to the maximum size.
      (bmy, 3/25/05)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.57.13 cleanup_planeflight

Subroutine CLEANUP_PLANEFLIGHT deallocates all allocatable module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_PLANEFLIGHT
```

REVISION HISTORY:

```
01 Jul 2001 - M. Evans    - Initial version
(1 ) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.58 Fortran: Module Interface retro_mod

Module RETRO_MOD reads emissions from the RETRO emissions inventory

INTERFACE:

```
MODULE RETRO_MOD

IMPLICIT NONE
PRIVATE
```

PUBLIC DATA MEMBERS:

```
REAL*4, ALLOCATABLE :: RETRO_ALK4(:,:)
REAL*4, ALLOCATABLE :: RETRO_ACET(:,:)
```

```
REAL*4, ALLOCATABLE :: RETRO_MEK(:,:)
REAL*4, ALLOCATABLE :: RETRO_ALD2(:,:)
REAL*4, ALLOCATABLE :: RETRO_PRPE(:,:)
REAL*4, ALLOCATABLE :: RETRO_C3H8(:,:)
REAL*4, ALLOCATABLE :: RETRO_C2H6(:,:)
REAL*4, ALLOCATABLE :: RETRO_CH2O(:,:)
REAL*4, ALLOCATABLE :: RETRO_BENZ(:,:)
REAL*4, ALLOCATABLE :: RETRO_TOLU(:,:)
REAL*4, ALLOCATABLE :: RETRO_XYLE(:,:)
REAL*4, ALLOCATABLE :: RETRO_C2H4(:,:)
REAL*4, ALLOCATABLE :: RETRO_C2H2(:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: CLEANUP_RETRO
PUBLIC  :: EMISS_RETRO
PUBLIC  :: GET_RETRO_ANTHRO
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: INIT_RETRO
PRIVATE :: READ_RETRO
PRIVATE :: TOTAL_ANTHRO_Tg
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial version
18 Aug 2011 - D. Millet   - Partition ketones into 25% MEK and 75% ACET
18 Aug 2011 - D. Millet   - Remove call to GET_ANNUAL_SCALAR
22 Aug 2011 - R. Yantosca - Added ProTeX headers
```

1.58.1 emiss_retro

Subroutine EMISS_RETRO reads all RETRO emissions at the beginning of each month.

INTERFACE:

```
SUBROUTINE EMISS_RETRO
```

USES:

```
USE BPCH2_MOD,            ONLY : GET_NAME_EXT_2D
USE BPCH2_MOD,            ONLY : GET_RES_EXT
USE FILE_MOD,             ONLY : IU_FILE
USE FILE_MOD,             ONLY : IOERROR
USE DIRECTORY_MOD,        ONLY : DATA_DIR
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_ALK4ff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_PRPEff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_C3H8ff
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_C2H6ff
```

```
      USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_VOCff
      USE LOGICAL_MOD,          ONLY : LFUTURE
      USE TIME_MOD,             ONLY : EXPAND_DATE
      USE TIME_MOD,             ONLY : GET_MONTH
      USE CMN_SIZE_MOD               ! Size parameters
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial version
22 Aug 2011 - R. Yantosca - Added ProTeX headers
```

1.58.2 read_retro

Subroutine READ_RETRO reads a BPCH file created from RETRO data. The data has units of [atoms C/cm2/s].

INTERFACE:

```
      SUBROUTINE READ_RETRO( FILENAME, ALK4, ACET, MEK,  ALD2, PRPE,
     &                       C3H8,     C2H6, CH2O, BENZ, TOLU, XYLE,
     &                       C2H4,     C2H2                          )
```

USES:

```
      USE BPCH2_MOD,        ONLY : OPEN_BPCH2_FOR_READ
      USE FILE_MOD,         ONLY : IU_FILE, IOERROR
      USE TRANSFER_MOD,     ONLY : TRANSFER_2D
      USE SCALE_ANTHRO_MOD, ONLY : GET_ANNUAL_SCALAR
      USE TIME_MOD,         ONLY : GET_YEAR
      USE CMN_SIZE_MOD           ! Size parameters
      USE CMN_O3_MOD             ! FSCLYR
```

INPUT PARAMETERS:

```
      ! Name of file to read
      CHARACTER(LEN=*), INTENT(IN)    :: FILENAME
```

INPUT/OUTPUT PARAMETERS:

```
      ! RETRO emissions for various VOC species [molec/cm2/s]
      REAL*4,           INTENT(INOUT) :: ALK4(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: ACET(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: MEK (IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: ALD2(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: PRPE(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: C3H8(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: CH2O(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: C2H6(IIPAR,JJPAR)
      REAL*4,           INTENT(INOUT) :: BENZ(IIPAR,JJPAR)
```

```
REAL*4,           INTENT(INOUT) :: TOLU(IIPAR,JJPAR)
REAL*4,           INTENT(INOUT) :: XYLE(IIPAR,JJPAR)
REAL*4,           INTENT(INOUT) :: C2H4(IIPAR,JJPAR)
REAL*4,           INTENT(INOUT) :: C2H2(IIPAR,JJPAR)
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial Version
18 Aug 2011 - D. Millet   - Remove call to GET_ANNUAL_SCALAR
22 Aug 2011 - R. Yantosca - Added ProTeX headers
```

1.58.3 TOTAL_ANTHRO_Tg

Subroutine TOTAL_ANTHRO_Tg to print total RETRO anthropogenic VOC emissions each month in [Tg C].

INTERFACE:

```
SUBROUTINE TOTAL_ANTHRO_Tg( THISMONTH )
```

USES:

```
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE TRACER_MOD,   ONLY : TRACER_MW_KG
USE TRACERID_MOD, ONLY : IDTALK4, IDTMEK,  IDTPRPE, IDTC3H8
USE TRACERID_MOD, ONLY : IDTCH2O, IDTC2H6, IDTBENZ, IDTTOLU
USE TRACERID_MOD, ONLY : IDTXYLE, IDTC2H4, IDTC2H2
USE TRACERID_MOD, ONLY : IDTACET, IDTALD2
USE CMN_SIZE_MOD       ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: THISMONTH   ! Current month
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial Version
22 Aug 2011 - R. Yantosca - Added ProTeX headers
```

1.58.4 get_retro_anthro

Function GET_RETRO_ANTHRO returns the monthly average anthropogenic VOC emissions at GEOS-Chem grid box (I,J). Data will be returned in units of [atoms C/cm2/s].

INTERFACE:

```
FUNCTION GET_RETRO_ANTHRO( I, J, N ) RESULT( RETRO )
```

USES:

```
USE TRACERID_MOD, ONLY : IDTALK4, IDTMEK,  IDTPRPE, IDTC3H8
USE TRACERID_MOD, ONLY : IDTCH2O, IDTC2H6, IDTBENZ, IDTTOLU
USE TRACERID_MOD, ONLY : IDTXYLE, IDTC2H4, IDTC2H2
USE TRACERID_MOD, ONLY : IDTACET, IDTALD2
USE CMN_SIZE_MOD       ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I   ! GEOS-Chem longitude index
INTEGER, INTENT(IN) :: J   ! GEOS-Chem latitude index
INTEGER, INTENT(IN) :: N   ! GEOS-Chem tracer index
```

RETURN VALUE:

```
REAL*8              :: RETRO   ! RETRO emissions [mole
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial Version
18 Aug 2011 - D. Millet   - Partition RETRO ketones into 75% acetone
                            and 25% MEK
```

1.58.5 init_retro

Subroutine INIT_RETRO allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_RETRO
```

USES:

```
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE LOGICAL_MOD, ONLY : LRETRO
USE CMN_SIZE_MOD      ! Size parameters
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial Version
22 Aug 2011 - R. Yantosca - Added ProTeX headers
```

1.58.6 cleanup_retro

Subroutine CLEANUP_RETRO deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_RETRO
```

REVISION HISTORY:

```
08 Mar 2011 - W. Reinhart - Initial Version
22 Aug 2011 - R. Yantosca - Added ProTeX headers
```

1.59 Fortran: Module Interface RnPbBe_mod

Module RnPbBe_MOD contains variables and routines used for the 222Rn-210Pb-7Be simulation. (hyl, swu, bmy, 6/14/01, 8/4/06)

INTERFACE:

```
MODULE RnPbBe_MOD
```

USES:

```
IMPLICIT NONE
#     include "define.h"
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: EMISSRnPbBe
PUBLIC  :: CHEMRnPbBe
PUBLIC  :: SLQ
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: READ_7Be
PRIVATE :: CORRECT_STE
```

REMARKS:

```
References:
============================================================================
(1 ) Liu,H., D.Jacob, I.Bey, and R.M.Yantosca, Constraints from 210Pb
      and 7Be on wet deposition and transport in a global three-dimensional
      chemical tracer model driven by assimilated meteorological fields,
      JGR, 106, D11, 12,109-12,128, 2001.
(2 ) Jacob et al.,Evaluation and intercomparison of global atmospheric
      transport models using Rn-222 and other short-lived tracers,
      JGR, 1997 (102):5953-5970
(3 ) Dorothy Koch, JGR 101, D13, 18651, 1996.
(4 ) Lal, D., and B. Peters, Cosmic ray produced radioactivity on the
      Earth. Handbuch der Physik, 46/2, 551-612, edited by K. Sitte,
      Springer-Verlag, New York, 1967.
```

REVISION HISTORY:

```
14 Jun 2001 - H. Liu      - Initial version
(1 ) Added existing routines to this module (bmy, 6/14/01)
(2 ) Updated comments (bmy, 9/4/01)
(3 ) Eliminate AVGF; redimensioned XTRA2 (bmy, 9/25/01)
(4 ) Replace references to PW(I,J) with P(I,J) (bmy, 10/3/01)
(5 ) Remove obsolete code from 9/01 and 10/01 (bmy, 10/23/01)
(6 ) Removed duplicate variable declarations (bmy, 11/15/01)
(7 ) Now read files from DATA_DIR/RnPbBe_200203/ directory.
      Also updated comments. (bmy, 3/29/02)
(8 ) Incorporated latest changes from Hongyu Liu.  Also split off the
      code to read in the 7Be emissions into a separate routine.
      Add parallel DO-loops in several places.  Cleaned up DRYFLXRnPbBe,
      and now make sure ND44 accurately represents the drydep fluxes
      of 210Pb and 7Be. (hyl, bmy, 8/7/02)
(9 ) Now reference AD from "dao_mod.f".  Now references "error_mod.f".
      Moved routine DRYFLXRnPbBe into "drydep_mod.f".  (bmy, 1/27/03)
(10) Now references the new "time_mod.f" (bmy, 2/11/03)
(11) Bug fix in EMISSRnPbBe -- take abs( lat) for 7Be emiss. (bmy, 6/10/03)
(12) Bug fix in EMISSRnPbBe -- shut off 222Rn emissions in polar regions
      (swu, bmy, 10/28/03)
(13) Now references "directory_mod.f", "logical_mod.f", and "tracer_mod.f"
      (bmy, 7/20/04)
(14) Now modified for GCAP and GEOS-5 met fields (swu, bmy, 5/24/05)
(15) Now references "tropopause_mod.f"
(16) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
19 Nov 2010 - R. Yantosca - Added ProTeX headers
08 Nov 2011 - R. Yantosca - Prevent out-of-bounds errors in diagnostics
```

1.59.1 read_7Be

Subroutine READ_7Be reads the 7Be emissions from Lal & Peters on 33 pressure levels. This only needs to be done on the very first timestep.

INTERFACE:

```
SUBROUTINE READ_7BE
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE FILE_MOD,      ONLY : IU_FILE, IOERROR

USE CMN_SIZE_MOD      ! Size parameters
```

REVISION HISTORY:

```
07 Aug 2002 - H. Liu - Initial version
```

```
(1 ) This code was split off from routine EMISSRnPbBe below. (bmy, 8/7/02)
(2 ) Now reference DATA_DIR from "directory_mod.f" (bmy, 7/19/04)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.59.2 correct_ste

Subroutine CORRECT_STE reduces the emission of 210Pb and/or 7Be in the stratosphere, to correct for too fast STE in the GEOS-CHEM model.

INTERFACE:

```
SUBROUTINE CORRECT_STE( EMISSION )
```

USES:

```
#     include "define.h"    ! Switches
```

INPUT PARAMETERS:

```
! Arguments
```

INPUT/OUTPUT PARAMETERS:

```
REAL*8, INTENT(INOUT) :: EMISSION   ! Emissions to be corrected [kg]
```

REVISION HISTORY:

```
07 Aug 2002 - H. Liu - Initial version
(1 ) Now updated for GCAP met fields (swu, bmy, 5/24/05)
(2 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.59.3 emissRnPbBe

Subroutine EMISSRnPbBe emits 222Rn and 7Be into the tracer array STT.

INTERFACE:

```
SUBROUTINE EMISSRnPbBe
```

USES:

```
USE DAO_MOD,         ONLY : AD, TS
USE DIAG_MOD,        ONLY : AD01
USE GRID_MOD,        ONLY : GET_AREA_CM2
USE GRID_MOD,        ONLY : GET_YMID
USE GRID_MOD,        ONLY : GET_YEDGE
USE LOGICAL_MOD,     ONLY : LEMIS
USE TIME_MOD,        ONLY : GET_TS_EMIS
```

```
      USE TRACER_MOD,     ONLY : STT, N_TRACERS
      USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_STRAT
      USE PRESSURE_MOD,   ONLY : GET_PCENTER

      USE CMN_SIZE_MOD       ! Size parameters
      USE CMN_DIAG_MOD       ! ND02
      USE CMN_DEP_MOD        ! FRCLND
```

REVISION HISTORY:

```
28 May 1999 - I. Bey - Initial version
(1 ) Also added Hongyu's code for emission of Be7 (bmy, 3/22/99)
(2 ) Now trap I/O errors with subroutine IOERROR (bmy, 5/28/99)
(3 ) Eliminate obsolete code and ND63 diagnostic (bmy, 4/12/00)
(4 ) Now reference TS from "dao_mod.f" instead of from common block
     header file "F77_CMN_TS". (bmy, 6/23/00)
(5 ) Cosmetic changes (bmy, 7/12/00)
(6 ) Now use IOS /= 0 criterion to trap both I/O errors and EOF
     condition. (bmy, 9/13/00)
(7 ) Added to module "RnPbBe_mod.f".  Also updated comments and made
     cosmetic changes. (bmy, 6/14/01)
(8 ) Replace PW(I,J) with P(I,J) (bmy, 10/3/01)
(9 ) Now reference DATA_DIR from "F77_CMN_SETUP".  Added FILENAME variable.
     Now read "7Be.Lal" file from DATA_DIR/RnPbBe_200203/ directory.
     (bmy, 3/29/02)
(10) Add diagnostics for Rn/Be emissions.  Also cleaned up some old code
     and added parallel DO-loops.  Correct for S-T exchange for 7Be
     emissions. Updated comments, cosmetic changes. (hyl, 8/6/02)
(11) Now reference routine GET_PCENTER from "pressure_mod.f", which
     returns the correct "floating" pressure. (dsa, bdf, bmy, 8/20/02)
(12) Now reference AD from "dao_mod.f".  Now make FIRSTEMISS a local SAVEd
     variable instead of an argument.  (bmy, 1/27/03)
(13) Now use routine GET_YMID from "grid_mod.f" instead of common block
     variable YLMID.  Now replace DXYP(JREF)*1d4 with routine GET_AREA_CM2
     of "grid_mod.f".  Now use routine GET_TS_EMIS from time_mod.
     (bmy, 2/11/03)
(14) Bug fix: take the absolute value of latitude -- this was a bug when
     implementing the GET_YMID function from v5-04. (bmy, 6/10/03)
(15) Now reference GET_YEDGE from "grid_mod.f".
(16) Bug fix: the Rn emission in antarctic area in the original code would
     lead to enormously hight Rn concentrations there, esp. after boundary
     layer mixing.  Now apply different emissions over land and water,
     and also shut off emissions poleward of 70 deg. (swu, bmy, 10/28/03)
(17) Now reference LEMIS from "logical_mod.f".  Now reference STT and
     N_TRACERS from "tracer_mod.f" (bmy, 7/20/04)
(18) Remove reference to CMN; it's obsolete.  Now use inquiry functions
     from "tropopause_mod.f" to diagnose strat boxes. (bmy, 8/15/05)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

```
08 Nov 2011 - R. Yantosca - Prevent out-of-bounds errors in diagnostics
```

1.59.4 chemRnPbBe

Subroutine CHEMRnPbBe performs loss chemistry on 222Rn, 210Pb, and 7Be.

INTERFACE:

```
SUBROUTINE CHEMRnPbBe
```

USES:

```
USE DIAG_MOD,       ONLY : AD01, AD02
USE TIME_MOD,       ONLY : GET_TS_CHEM
USE TRACER_MOD,     ONLY : STT, N_TRACERS
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_STRAT

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_DIAG_MOD       ! ND01, ND02
```

REVISION HISTORY:

```
31 Oct 1999 - H. Liu - Initial version
(1 ) Now use F90 syntax (bmy, hyl, 3/22/99)
(2 ) Add FIRSTCHEM as an argument.  Only compute the exponential terms
     when FIRSTCHEM = .TRUE., and save the values for later use
     (bmy, 3/24/99)
(3 ) Cosmetic changes (bmy, 10/13/99)
(4 ) Eliminate obsolete code and ND63 diagnostic (bmy, 4/12/00)
(5 ) Cosmetic changes (bmy, 7/12/00)
(6 ) Added to module "RnPbBe_mod.f".  Also updated comments
     and made cosmetic changes. (bmy, 6/14/01)
(7 ) Add diagnostics for Rn/Be emissions.  Also cleaned up some old code
     and added parallel DO-loops.  Updated comments. (hyl, 8/6/02)
(8 ) Now make FIRSTCHEM a local SAVEd variable.  (bmy, 1/27/03)
(9 ) Now use function GET_TS_CHEM from "time_mod.f" (bmy, 2/11/03)
(10) Now references STT and N_TRACERS from "tracer_mod.f" (bmy, 7/20/04)
(11) Remove reference to CMN; it's obsolete.  Now use inquiry functions
     from "tropopause_mod.f" to diagnose strat boxes. (bmy, 8/15/05)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
08 Nov 2011 - R. Yantosca - Prevent out-of-bounds errors in diagnostics
```

1.59.5 slq

Subroutine SLQ is an interpolation subroutine from a Chinese reference book (says Hongyu Liu).

INTERFACE:

```
      SUBROUTINE SLQ( X, Y, Z, N, M, U, V, W )
```

INPUT PARAMETERS:

```
      INTEGER :: N        ! First dimension of Z
      INTEGER :: M        ! Second dimension of Z
      REAL*8  :: X(N)     ! X-axis coordinate on original grid
      REAL*8  :: Y(M)     ! Y-axis coordinate on original grid
      REAL*8  :: Z(N,M)   ! Array of data on original grid
      REAL*8  :: U        ! X-axis coordinate for desired interpolated value
      REAL*8  :: V        ! Y-axis coordinate for desired interpolated value
```

OUTPUT PARAMETERS:

```
      REAL*8  :: W        ! Interpolated value of Z array, at coords (U,V)
```

REMARKS:

REVISION HISTORY:

```
   17 Mar 1998 - H. Liu      - Initial version
   (1 ) Added to "RnPbBe_mod.f" (bmy, 7/16/01)
   (2 ) Removed duplicate definition of IQ.  Added comments. (bmy, 11/15/01)
   08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.60 Fortran: Module Interface scale_anthro_mod

Module SCALE_ANTHRO_MOD contains routines to scale anthropogenic emissions from a base year to a simulation year.

INTERFACE:

```
      MODULE SCALE_ANTHRO_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: GET_ANNUAL_SCALAR
      PUBLIC  :: GET_ANNUAL_SCALAR_1x1
      PUBLIC  :: GET_ANNUAL_SCALAR_05x0666_NESTED
```

REVISION HISTORY:

```
   28 Jan 2009 - A. v. Donkelaar and P. Le Sager - Initial Version
```

REMARKS:

```
(1 ) Add GET_ANNUAL_SCALAR_05x0666_NESTED_CH for nested grid simulations
     over China. (tmf, 12/3/09)
(2 ) Renamed consistently variables: name depends on relation of variable
     to BASE or TARGET year. New data directory to account for updated
     scale factors for 1985-1989 (phs, 5/7/09)
(3 ) Adjusted GET_ANNUAL_SCALAR_05x0666_CH for new scalar format and
     renamed to GET_ANNUAL_SCALAR_05x0666 (amv, 10/29/2009)
18 Dec 2009 - Aaron van D - Updated scale factors thru 2006
18 Dec 2009 - Aaron van D - Updated routine GET_ANNUAL_SCALAR_05x0666_NESTED
10 Aug 2011 - D. Millet   - Now use updated scale factor file for CO, which
                            corrects a problem over Botswana/S. Africa
```

1.60.1 get_annual_scalar

Subroutine GET_ANNUAL_SCALAR returns annual scale factors to convert B_YEAR (base year) to T_YEAR (simulation year), on the current model resolution.

INTERFACE:

```
SUBROUTINE GET_ANNUAL_SCALAR( TRACER, B_YEAR, T_YEAR, AS )
```

USES:

```
USE REGRID_1x1_MOD, ONLY : DO_REGRID_1x1

USE CMN_SIZE_MOD                          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)    :: TRACER           ! Tracer number
INTEGER, INTENT(IN)    :: B_YEAR           ! Base year of emissions
INTEGER, INTENT(IN)    :: T_YEAR           ! Target year of emissions
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJPAR)  ! Scale factor array
```

REVISION HISTORY:

```
28 Jan 2009 - A. v. Donkelaar and P. Le Sager - Initial Version
```

1.60.2 get_annual_scalar_1x1

Subroutine GET_ANNUAL_SCALAR_1x1 returns annual scale factors to convert B_YEAR (base year) to T_YEAR (target year), on the 1x1 GEOS-Chem grid.

INTERFACE:

```
SUBROUTINE GET_ANNUAL_SCALAR_1x1( TRACER, B_YEAR, T_YEAR, AS_1x1 )
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR_1x1
USE BPCH2_MOD,     ONLY : GET_TAU0, READ_BPCH2

USE CMN_SIZE_MOD                          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)    :: TRACER            ! Tracer number
INTEGER, INTENT(IN)    :: B_YEAR            ! Base year of emissions
INTEGER, INTENT(IN)    :: T_YEAR            ! Target year of emissions
```

INPUT/OUTPUT PARAMETERS:

```
REAL*8,   INTENT(OUT)  :: AS_1x1(I1x1,J1x1)  ! Scale factor array
```

REVISION HISTORY:

```
28 Jan 2009 - A. v. Donkelaar and P. Le Sager - Initial Version
```

REMARKS:

```
(1) Scaling factors are for years between 1985 and 2005, on the GEOS-Chem
     1x1 grid (phs, 3/10/08)
18 Dec 2009 - Aaron van D - Updated scale factors through 2006,
                            changed to new, directory, reset year limits
18 Dec 2009 - Aaron van D - Reformated scale factors to a single file for
                            all years, made necessary input changes
10 Aug 2011 - D. Millet   - Now use updated scale factor file for CO, which
                            corrects a problem over Botswana/S. Africa
```

1.60.3 get_annual_scalar_05x0666_nested

Subroutine GET_ANNUAL_SCALAR_05x0666_NESTED returns annual scale factors to convert B_YEAR (base year) to T_YEAR (target year), on the 0.5x0.666 GEOS-Chem grid for nested China domain.

INTERFACE:

```
SUBROUTINE GET_ANNUAL_SCALAR_05x0666_NESTED
&                    ( TRACER, B_YEAR, T_YEAR, AS )
```

USES:

```
USE REGRID_1x1_MOD,       ONLY : DO_REGRID_1x1

USE CMN_SIZE_MOD             ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: TRACER
      INTEGER, INTENT(IN)  :: B_YEAR
      INTEGER, INTENT(IN)  :: T_YEAR
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*4,         INTENT(INOUT) :: AS(IIPAR,JJPAR)
```

REVISION HISTORY:

```
    28 Jan 2009 - A. v. Donkelaar and P. Le Sager - Initial Version
    12 Mar 2009 - T-M. Fu     - Initial Version
    03 Nov 2009 - Aaron van D - rewritten to employ GET_ANNUAL_SCALAR_1x1
                                and regrid.
    18 Dec 2009 - Aaron van D - Renamed to GET_ANNUAL_SCALAR_05x0666_NESTED
    18 Dec 2009 - Aaron van D - Rewrote GET_ANNUAL_SCALAR_05x0666_NESTED to
                                retrieve and regrid scale factors by calling
                                GET_ANNUAL_SCALAR_1x1 and regridding on fly
```

REMARKS:

```
    (1) Scaling factors are for years between 1985 and 2005, on the GEOS-Chem
        0.5x0.666 grid for China domain (tmf, 3/5/09)
```

1.61 Fortran: Module Interface tagged_ox_mod

Module TAGGED_OX_MOD contains variables and routines to perform a tagged Ox simulation. P(Ox) and L(Ox) rates need to be archived from a full chemistry simulation before you can run w/ Tagged Ox.

INTERFACE:

```
      MODULE TAGGED_OX_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: ADD_STRAT_POX
      PUBLIC  :: CHEM_TAGGED_OX
      PUBLIC  :: CLEANUP_TAGGED_OX
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: GET_REGIONAL_POX
      PRIVATE :: INIT_TAGGED_OX
      PRIVATE :: READ_POX_LOX
```

REVISION HISTORY:

```
20 Aug 2003 - A. Fiore    - Initial version
(1 ) Now accounts for GEOS-4 PBL being in meters (bmy, 1/15/04)
(2 ) Bug fix: don't put function call in WRITE statement (bmy, 2/20/04)
(3 ) Now bracket AD44 with an !$OMP CRITICAL block (bmy, 3/24/04)
(4 ) Now define regions w/ levels in GET_REGIONAL_POX (amf,rch,bmy,5/27/04)
(5 ) Bug fix-avoid seg fault if PBLFRAC isn't allocated (bdf, bmy, 10/12/04)
(6 ) Now reference "pbl_mix_mod.f" (bmy, 2/17/05)
(7 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(8 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(9 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(10) Modified for variable tropopause (phs, bmy, 1/19/07)
(11) Now use LLTROP instead of LLTROP_FIX everywhere (bmy, 12/4/07)
(12) Now use LD65 instead of LLTROP everywhere (phs, 11/17/08)
(13) Updates for LINOZ (dbj, jliu, bmy, 10/26/09)
19 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.61.1 add_strat_pox

Subroutine ADD_STRAT_POX adds the stratospheric influx of Ox to the stratospheric Ox tracer. This is called from routine UPBDFLX_O3, which is applied when the tracer array has units of [v/v].

INTERFACE:

```
SUBROUTINE ADD_STRAT_POX( I, J, L, POx )
```

USES:

```
USE TRACER_MOD, ONLY : STT

USE CMN_SIZE_MOD           ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I     ! GEOS-Chem grid box lon index
INTEGER, INTENT(IN) :: J     ! GEOS-Chem grid box lat index
INTEGER, INTENT(IN) :: L     ! GEOS-Chem grid box level index
REAL*8,  INTENT(IN) :: POx   ! P(Ox) in the stratosphere [v/v]
```

REVISION HISTORY:

```
19 Aug 2003 - R. Yantosca - Initial version
(1 ) Now references STT from "tracer_mod.f" (bmy, 7/20/04)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.61.2 read_pox_lox

Subroutine READ_POX_LOX reads previously-archived Ox production and loss rates from binary punch file format.

INTERFACE:

```
SUBROUTINE READ_POX_LOX
```

USES:

```
USE BPCH2_MOD,     ONLY : READ_BPCH2
USE DIRECTORY_MOD, ONLY : O3PL_DIR
USE TIME_MOD,      ONLY : EXPAND_DATE
USE TIME_MOD,      ONLY : GET_NYMD
USE TIME_MOD,      ONLY : GET_TAU
USE TRANSFER_MOD,  ONLY : TRANSFER_3D_TROP
! JLIU,2008/10/01
USE CHARPAK_MOD,   ONLY : STRREPL
USE TIME_MOD,      ONLY : YMD_EXTRACT
USE TIME_MOD,      ONLY : ITS_A_LEAPYEAR
USE TIME_MOD,      ONLY : GET_DAY_OF_YEAR
USE TIME_MOD,      ONLY : GET_YEAR
USE TIME_MOD,      ONLY : GET_HOUR
USE DIAG_PL_MOD                                    !dbj
USE JULDAY_MOD,    ONLY : JULDAY                   !dbj

USE CMN_SIZE_MOD ! Size parameters
USE CMN_DIAG_MOD ! LD65
```

REVISION HISTORY:

```
20 Aug 2003 - R. Yantosca - Initial version
(1 ) Updated from the old routine "chemo3_split.f" (rch, bmy, 8/20/03)
(2 ) Now references O3PL_DIR from "directory_mod.f" (bmy, 7/20/04)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(4 ) Use LLTROP_FIX to limit array size to case of non-variable tropopause.
     Also zero ARRAY to avoid numerical problems (phs, 1/19/07)
(5 ) Now use LLTROP instead of LLTROP_FIX (phs, bmy, 12/4/07)
(6 ) Now use LD65, since this is the number of levels use to
     save diag20 (phs, 11/17/08)
(7 ) Updates for LINOZ (dbj, jliu, bmy, 10/16/09)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.61.3 get_regional_pox

Subroutine GET_REGIONAL_POX returns the P(Ox) for each of the tagged Ox tracers. Tagged Ox tracers are defined by both geographic location and altitude.

INTERFACE:

```
SUBROUTINE GET_REGIONAL_POX( I, J, L, PP )
```

USES:

```
USE DAO_MOD,         ONLY : PBL
USE GRID_MOD,        ONLY : GET_XMID,  GET_YMID
USE TIME_MOD,        ONLY : GET_TS_CHEM
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_DIAG_MOD       ! ND44, ND65, LD65
USE CMN_GCTM_MOD       ! SCALE_HEIGHT
```

INPUT PARAMETERS:

```
! GEOS-Chem grid box indices for lon, lat, alt
INTEGER, INTENT(IN)  :: I, J, L
```

OUTPUT PARAMETERS:

```
! Array containing P(Ox) for each tagged tracer
REAL*8,  INTENT(OUT) :: PP(IIPAR,JJPAR,LD65,N_TAGGED)
```

REVISION HISTORY:

```
19 Aug 2003 - A. Fiore - Initial version
(1 ) Updated from the old routine "chemo3_split.f" (rch, bmy, 8/20/03)
(2 ) For GEOS-4, convert PBL from [m] to [hPa] w/ the hydrostatic law.
     Now references SCALE_HEIGHT from "F77_CMN_GCTM". (bmy, 1/15/04)
(3 ) Now uses model levels instead of pressure in order to delineate
     between PBL, MT, and UT regions (amf, rch, bmy, 5/27/04)
(4 ) Now references ITS_IN_THE_TROP from "tropopause_mod.f".  Now remove
     reference to "CMN", it's obsolete. (bmy, 8/22/05)
(5 ) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(6 ) Resize the PP array from LLTROP to LLTROP_FIX (phs, 1/19/07)
(7 ) Now use LLTROP instead of LLTROP_FIX (bmy, 12/4/07)
(8 ) Now use LD65 instead of LLTROP (phs, 11/17/08)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.61.4 chem_tagged_ox

Subroutine CHEM_TAGGED_OX performs chemistry for several Ox tracers which are tagged by geographic and altitude regions.

INTERFACE:

```
SUBROUTINE CHEM_TAGGED_OX
```

USES:

```
      USE DIAG_MOD,       ONLY : AD44
      USE DIAG_PL_MOD,    ONLY : AD65
      USE ERROR_MOD,      ONLY : GEOS_CHEM_STOP
      USE DRYDEP_MOD,     ONLY : DEPSAV
      USE GRID_MOD,       ONLY : GET_AREA_CM2
      USE LOGICAL_MOD,    ONLY : LDRYD
      USE PBL_MIX_MOD,    ONLY : GET_FRAC_UNDER_PBLTOP
      USE PBL_MIX_MOD,    ONLY : GET_PBL_MAX_L
      USE TIME_MOD,       ONLY : GET_TS_CHEM
      USE TIME_MOD,       ONLY : ITS_A_NEW_DAY
      USE TIME_MOD,       ONLY : TIMESTAMP_STRING
      USE TRACER_MOD,     ONLY : STT
      USE TRACER_MOD,     ONLY : N_TRACERS
      USE TRACER_MOD,     ONLY : XNUMOL
      USE TRACERID_MOD,   ONLY : IDTOX
      USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP
      USE LOGICAL_MOD,    ONLY : LNLPBL

      USE CMN_SIZE_MOD  ! Size parameters
      USE CMN_DIAG_MOD  ! ND44, ND65, LD65

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
    20 Aug 2003 - R. Hudman   - Initial version
    (1 ) Updated from the old routine "chemo3_split.f" (rch, bmy, 8/20/03)
    (2 ) Bug fix: don't put function call in WRITE statement (bmy, 2/20/04)
    (3 ) Now use ND44_TMP array to store vertical levels of drydep flux, then
         sum into AD44 array.  This prevents numerical differences when using
         multiple processors. (bmy, 3/24/04)
    (4 ) Now references LDRYD from "logical_mod.f".  Now references STT
         and N_TRACERS from "tracer_mod.f".  Now references AD65 from
         "diag_pl_mod.f".  Now uses ITS_A_NEW_DAY from "time_mod.f".
         (bmy, 7/20/04)
    (5 ) Bug fix: Now avoid a SEG FAULT error if PBLFRAC isn't allocated.
         (bdf, bmy, 10/12/04)
    (6 ) Replace PBLFRAC from "drydep_mod.f" with GET_FRAC_UNDER_PBLTOP
         from "pbl_mix_mod.f".  Now only sum ND44 diagnostic up to the
         maximum tropopsheric level. (bmy, 2/17/05)
    (7 ) Resize PP, N D44_TMP arrays from LLTROP to LLTROP_FIX.  Now only loop
         up to LLTROP_FIX (phs, 1/19/07)
    (8 ) Now use LLTROP instead of LLTROP_FIX (bmy, 12/4/07)
    (9 ) Now use LD65 instead of LLTROP (phs, 11/17/08)
```

```
(10) Now only compute loss rate in troposphere (dbj, bmy, 10/26/09)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.61.5 init_tagged_ox

Subroutine INIT_TAGGED_OX allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_TAGGED_OX
```

USES:

```
USE ERROR_MOD,  ONLY : ALLOC_ERR
USE ERROR_MOD,  ONLY : ERROR_STOP
USE TRACER_MOD, ONLY : N_TRACERS

USE CMN_SIZE_MOD   ! Size parameters
USE CMN_DIAG_MOD   ! ND44, ND65, LD65
```

REVISION HISTORY:

```
20 Aug 2003 - R. Yantosca - Initial version
(1 ) Now reference N_TRACERS from "tracer_mod.f" (bmy, 7/20/04)
(2 ) Now use LD65 instead of LLTROP to dimension P24H, L24H (phs, 11/18/08)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.61.6 cleanup_tagged_ox

CLEANUP_TAGGED_OX deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_TAGGED_OX
```

REVISION HISTORY:

```
20 Aug 2003 - R. Yantosca - Initial version
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.62 Fortran: Module Interface toms_mod

Module TOMS_MOD contains variables and routines for reading the TOMS/SBUV O3 column data from disk (for use w/ the FAST-J photolysis routines).

INTERFACE:

```
      MODULE TOMS_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      REAL*8, PUBLIC, ALLOCATABLE :: TOMS(:,:)
      REAL*8, PUBLIC, ALLOCATABLE :: DTOMS1(:,:)
      REAL*8, PUBLIC, ALLOCATABLE :: DTOMS2(:,:)
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC                      :: CLEANUP_TOMS
      PUBLIC                      :: READ_TOMS
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE                     :: INIT_TOMS
```

REMARKS:

```
    References:
    ===========================================================================
    TOMS/SBUV MERGED TOTAL OZONE DATA, Version 8, Revision 3.
    Resolution:  5 x 10 deg.
    Source: http://code916.gsfc.nasa.gov/Data_services/merged/index.html
    Contact person for the merged data product:
    Stacey Hollandsworth Frith (smh@hyperion.gsfc.nasa.gov)
```

REVISION HISTORY:

```
    14 Jul 2003 - R. Yantosca - Initial version
    (1 ) Now references "directory_mod.f" (bmy, 7/20/04)
    (2 ) Now can read files for GEOS or GCAP grids (bmy, 8/16/05)
    (3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
    (4 ) Now always use 2002 TOMS O3 data for GCAP (swu, bmy, 10/3/06)
    (5 ) Now reads from TOMS_200701 directory, w/ updated data (bmy, 2/1/07)
    (6 ) Now don't replace any tokens in the DATA_DIR variable (bmy, 12/5/07)
    (7 ) Latest year of TOMS data is now 2007 (bmy, 1/14/09)
    01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.62.1 read_toms

Subroutine READ_TOMS reads in TOMS O3 column data from a binary punch file for the given grid, month and year.

INTERFACE:

```
      SUBROUTINE READ_TOMS( THISMONTH, THISYEAR )
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_NAME_EXT_2D
      USE BPCH2_MOD,     ONLY : GET_RES_EXT
      USE BPCH2_MOD,     ONLY : GET_TAU0
      USE BPCH2_MOD,     ONLY : READ_BPCH2
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE TIME_MOD,      ONLY : EXPAND_DATE
      USE TRANSFER_MOD,  ONLY : TRANSFER_2D

      USE CMN_SIZE_MOD                    ! Size parameters
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)    :: THISMONTH   ! Current month
      INTEGER, INTENT(IN)    :: THISYEAR    ! Current year
```

REMARKS:

```
    TOMS/SBUV MERGED TOTAL OZONE DATA, Version 8, Revision 3.
    Resolution:  5 x 10 deg.

    Methodology (bmy, 2/12/07)
    ------------------------------------------------------------------
    FAST-J comes with its own default O3 column climatology (from
    McPeters 1992 & Nagatani 1991), which is stored in the input
    file "jv_atms.dat".  These "FAST-J default" O3 columns are used
    in the computation of the actinic flux and other optical
    quantities for the FAST-J photolysis.

    The TOMS/SBUV O3 columns and 1/2-monthly O3 trends (contained
    in the TOMS_200701 directory) are read into GEOS-Chem by routine
    READ_TOMS in "toms_mod.f".  Missing values (i.e. locations where
    there are no data) in the TOMS/SBUV O3 columns are defined by
    the flag -999.

    After being read from disk in routine READ_TOMS, the TOMS/SBUV
    O3 data are then passed to the FAST-J routine "set_prof.f".  In
    "set_prof.f", a test is done to make sure that the TOMS/SBUV O3
    columns and 1/2-monthly trends do not have any missing values
    for (lat,lon) location for the given month.  If so, then the
    TOMS/SBUV O3 column data is interpolated to the current day and
    is used to weight the "FAST-J default" O3 column.  This
    essentially "forces" the "FAST-J default" O3 column values to
    better match the observations, as defined by TOMS/SBUV.

    If there are no TOMS/SBUV O3 columns (and 1/2-monthly trends)
    at a (lat,lon) location for given month, then FAST-J will revert
```

```
to its own "default" climatology for that location and month.
Therefore, the TOMS O3 can be thought of as an  "overlay" data
-- it is only used if it exists.

Note that there are no TOMS/SBUV O3 columns at the higher
latitudes.  At these latitudes, the code will revert to using
the "FAST-J default" O3 columns.

As of February 2007, we have TOMS/SBUV data for 1979 thru 2005.
2006 TOMS/SBUV data is incomplete as of this writing.  For years
2006 and onward, we use 2005 TOMS O3 columns.

This methodology was originally adopted by Mat Evans.  Symeon
Koumoutsaris was responsible for creating the downloading and
processing the TOMS O3 data files from 1979 thru 2005 in the
TOMS_200701 directory.
```

REVISION HISTORY:

```
10 Dec 2002 - M. Evans - Initial version
(1 ) Bundled into "toms_mod.f" (bmy, 7/14/03)
(2 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(3 ) Now can read files for GEOS or GCAP grids (bmy, 8/16/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Now always use 2002 TOMS O3 data for GCAP (swu, bmy, 10/3/06)
(6 ) Now reads from TOMS_200701 directory, w/ updated data.  Also always
      use 1979 data prior to 1979 or 2005 data after 2005. (bmy, 2/12/07)
(7 ) Bug fix: don't include DATA_DIR in filename, just in case someone's
      file path has replaceable tokens (e.g. hh, mm, MM etc.) (bmy, 12/5/07)
(8 ) Latest year of TOMS data is now 2007 (bmy, 1/14/09)
(9 ) Updated TOMS data in TOMS_200906. Latest year is 2008. (ccc, 6/15/09)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.62.2 init_toms

Subroutine INIT_TOMS allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_TOMS
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
14 Jul 2003 - R. Yantosca - Initial version
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.62.3 cleanup_toms

Subroutine CLEANUP_TOMS deallocates all module arrays.

INTERFACE:

```
      SUBROUTINE CLEANUP_TOMS
```

REVISION HISTORY:

```
14 Jul 2003 - R. Yantosca - Initial version
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.63 Fortran: Module Interface tropopause_mod

Module TROPOPAUSE_MOD contains routines and variables for reading and returning the value of the annual mean tropopause.

INTERFACE:

```
      MODULE TROPOPAUSE_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_TROPOPAUSE
      PUBLIC  :: CHECK_VAR_TROP
      PUBLIC  :: COPY_FULL_TROP
      PUBLIC  :: DIAG_TROPOPAUSE
      PUBLIC  :: GET_MIN_TPAUSE_LEVEL
      PUBLIC  :: GET_MAX_TPAUSE_LEVEL
      PUBLIC  :: GET_TPAUSE_LEVEL
      PUBLIC  :: ITS_IN_THE_TROP
      PUBLIC  :: ITS_IN_THE_STRAT
      PUBLIC  :: READ_TROPOPAUSE
      PUBLIC  :: SAVE_FULL_TROP
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: INIT_TROPOPAUSE
```

REVISION HISTORY:

```
    22 Aug 2005 - R. Yantosca - Initial version
    (1 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
    (2 ) Simplify counting of tropospheric boxes (bmy, 11/1/05)
    (3 ) Added case of variable tropopause.
         The definition of the tropopause boxes is different in the two cases.
         They are part of the troposphere in the case of a variable
         troposphere. LMAX, LMIN are the min and max extent of the troposphere
         in that case.  (bdf, phs, 1/19/07)
    (4 ) Bug fix: set NCS=NCSURBAN for safety's sake (bmy, 4/25/07)
    (5 ) Updated comments (bmy, 9/18/07)
    (6 ) Bug fix: make ITS_IN_THE_STRAT more robust. (phs, 11/14/08)
    09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.1 copy_full_trop

Subroutine COPY_FULL_TROP takes the saved full troposphere and copies chemical species into the current troposphere that will be used in SMVGEAR for this timestep.

INTERFACE:

```
      SUBROUTINE COPY_FULL_TROP
```

USES:

```
      USE COMODE_MOD,     ONLY : CSPEC,  CSPEC_FULL
      USE COMODE_MOD,     ONLY : IXSAVE, IYSAVE, IZSAVE

      USE CMN_SIZE_MOD
      USE COMODE_LOOP_MOD
```

REMARKS:

```
    ROUTINE NEEDED BECAUSE WITH VARIABLE TROPOPAUSE
    JLOOP WILL NOT ALWAYS REFER TO THE SAME (I,J,L) BOX
```

REVISION HISTORY:

```
    14 Sep 2006 - P. Le Sager - Initial version
    (1 ) Very similar to a get_properties of an object. Should probably
         be in COMODE_MOD.F, and called GET_SPECIES_CONCENTRATION (phs)
    (2 ) Bug fix: set NCS=NCSURBAN for safety's sake (bmy, 4/25/07)
    09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.2 save_full_trop

Subroutine SAVE_FULL_TROP takes the current troposphere and copies chemical species into the full troposphere that will be used in SMVGEAR for this timestep.

INTERFACE:

```
SUBROUTINE SAVE_FULL_TROP
```

USES:

```
USE COMODE_MOD,     ONLY : CSPEC,  CSPEC_FULL
USE COMODE_MOD,     ONLY : IXSAVE, IYSAVE, IZSAVE

USE CMN_SIZE_MOD
USE COMODE_LOOP_MOD
```

REMARKS:

```
ROUTINE NEEDED BECAUSE WITH VARIABLE TROPOPAUSE
JLOOP WILL NOT ALWAYS REFER TO THE SAME (I,J,L) BOX
```

REVISION HISTORY:

```
14 Sep 2006 - P. Le Sager - Initial version
(1 ) Very similar to a set_properties of an object. Should probably
      be in COMODE_MOD.F, and called SAVE_SPECIES_CONCENTRATION (phs)
(2 ) Bug fix: set NCS=NCSURBAN for safety's sake! (bmy, 4/25/07)
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.3 check_var_trop

Subroutine CHECK_VAR_TROP checks that the entire variable troposphere is included in the 1..LLTROP range, and set the LMIN and LMAX to current min and max tropopause.

INTERFACE:

```
SUBROUTINE CHECK_VAR_TROP
```

USES:

```
USE DAO_MOD,       ONLY : TROPP
USE ERROR_MOD,     ONLY : GEOS_CHEM_STOP

USE CMN_SIZE_MOD      ! Size parameters
USE CMN_MOD           ! LPAUSE, for backwards compatibility
```

REVISION HISTORY:

```
24 Aug 2006 - P. Le Sager - Initial version
(1 ) LLTROP is set at the first level entirely above 20 km (phs, 9/29/06)
(2 ) Fix LPAUSE for CH4 chemistry (phs, 1/19/07)
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.4 read_tropopause

Subroutine READ_TROPOPAUSE reads in the annual mean tropopause.

INTERFACE:

```
SUBROUTINE READ_TROPOPAUSE
```

USES:

```
USE BPCH2_MOD,     ONLY : GET_NAME_EXT, GET_RES_EXT
USE BPCH2_MOD,     ONLY : GET_TAU0,     READ_BPCH2
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE ERROR_MOD,     ONLY : GEOS_CHEM_STOP
USE TRANSFER_MOD,  ONLY : TRANSFER_2D

USE CMN_SIZE_MOD      ! Size parameters
USE CMN_MOD           ! LPAUSE, for backwards compatibility
```

REVISION HISTORY:

```
13 Dec 1999 - Q. Li, R. Yantosca - Initial version
(1 ) Call READ_BPCH2 to read in the annual mean tropopause data
      which is stored in binary punch file format. (bmy, 12/13/99)
(2 ) Now also read integer flags for ND27 diagnostic -- these determine
      how to sum fluxes from boxes adjacent to the annual mean tropoause.
      (qli, bmy, 1/7/00)
(3 ) Cosmetic changes (bmy, 3/17/00)
(4 ) Reference F90 module "bpch2_mod" which contains routine "read_bpch2"
      for reading data from binary punch files (bmy, 6/28/00)
(5 ) Call TRANSFER_2D from "transfer_mod.f" to cast data from REAL*4 to
      INTEGER and also to resize to (IIPAR,JJPAR).  ARRAY needs to be of
      size (IIPAR,JJPAR).  Also updated comments and made cosmetic changes.
      Removed obsolete variables.(bmy, 9/26/01)
(6 ) Removed obsolete code from 9/01 (bmy, 10/26/01)
(7 ) Now read annual mean tropopause files from the ann_mean_trop_200202/
      subdirectory of DATA_DIR (bmy, 1/24/02)
(8 ) Eliminated obsolete code from 1/02 (bmy, 2/27/02)
(9 ) Now write file name to stdout (bmy, 4/3/02)
(10) Now reference GEOS_CHEM_STOP from "error_mod.f", which frees all
      allocated memory before stopping the run. (bmy, 10/15/02)
(11) Now call READ_BPCH2 with QUIET=.TRUE. to suppress printing of extra
```

```
      info to stdout.  Also updated FORMAT strings. (bmy, 3/14/03)
(12) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
(13) Now bundled into "tropopause_mod.f' (bmy, 2/10/05)
(14) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(15) Simplify counting of # of tropospheric boxes (bmy, 11/1/05)
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.5 get_max_tpause_level

Function GET_MAX_TPAUSE_LEVEL returns GEOS-Chem level at the highest extent of the annual mean tropopause.

INTERFACE:

```
FUNCTION GET_MAX_TPAUSE_LEVEL() RESULT( L_MAX )
```

RETURN VALUE:

```
INTEGER :: L_MAX    ! Maximum tropopause level
```

REVISION HISTORY:

```
10 Feb 2005 - R. Yantosca - Initial version
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.6 get_min_tpause_level

Function GET_MIN_TPAUSE_LEVEL returns GEOS-Chem level at the lowest extent of the annual mean tropopause.

INTERFACE:

```
FUNCTION GET_MIN_TPAUSE_LEVEL() RESULT( L_MIN )
```

RETURN VALUE:

```
INTEGER :: L_MIN   ! Minimum tropopause level
```

REVISION HISTORY:

```
10 Feb 2005 - R. Yantosca - Initial version
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.7 get_tpause_level

Function GET_TPAUSE_LEVEL returns the tropopause level L_TP at surface location (I,J). Therefore, grid box (I,J,L_TP) is partially in the troposphere and partially in the stratosphere. The grid box below this, (I,J,L_TP-1), is the last totally tropospheric box in the column.

INTERFACE:

```
FUNCTION GET_TPAUSE_LEVEL( I, J ) RESULT( L_TP )
```

USES:

```
USE DAO_MOD,      ONLY : TROPP, PSC2
USE LOGICAL_MOD,  ONLY : LVARTROP
USE ERROR_MOD,    ONLY : GEOS_CHEM_STOP
USE PRESSURE_MOD, ONLY : GET_PEDGE

USE CMN_SIZE_MOD            ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I      ! Longitude index
INTEGER, INTENT(IN) :: J      ! Latitude index
```

RETURN VALUE:

```
INTEGER             :: L_TP   ! Tropopause level at (I,J)
```

REVISION HISTORY:

```
22 Aug 2005 - R. Yantosca - Initial version
09 Sep 2010 - R. Yantosca - Added ProTeX headers
10 Sep 2010 - R. Yantosca - Update comments, remove obsolete documentation
```

1.63.8 its_in_the_trop

Function ITS_IN_THE_TROP returns TRUE if grid box (I,J,L) lies within the troposphere, or FALSE otherwise.

INTERFACE:

```
FUNCTION ITS_IN_THE_TROP( I, J, L ) RESULT ( IS_TROP )
```

USES:

```
USE DAO_MOD,      ONLY : TROPP, PSC2
USE LOGICAL_MOD,  ONLY : LVARTROP
USE PRESSURE_MOD, ONLY : GET_PEDGE
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I         ! Longitude index
      INTEGER, INTENT(IN) :: J         ! Latitude index
      INTEGER, INTENT(IN) :: L         ! Level index
```

RETURN VALUE:

```
      LOGICAL             :: IS_TROP   ! =T if we are in the troposphere
```

REMARKS:

REVISION HISTORY:

```
    10 Feb 2005 - P. Le Sager - Initial version
    (1 ) Modified for variable tropopause (phs, 9/14/06)
    09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.9 its_in_the_strat

Function ITS_IN_THE_STRAT returns TRUE if grid box (I,J,L) lies within the stratosphere, or FALSE otherwise.

INTERFACE:

```
      FUNCTION ITS_IN_THE_STRAT( I, J, L ) RESULT( IS_STRAT )
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I          ! Longitude index
      INTEGER, INTENT(IN) :: J          ! Latitude index
      INTEGER, INTENT(IN) :: L          ! Level index
```

RETURN VALUE:

```
      LOGICAL             :: IS_STRAT   ! =T if we are in the stratosphere
```

REVISION HISTORY:

```
    10 Feb 2005 - P. Le Sager - Initial version
    (1 ) Modified for variable tropopause (phs, 9/14/06)
    (2 ) Now return the opposite value of ITS_IN_THE_TROP.  This should help
         to avoid numerical issues. (phs, 11/14/08)
    09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.10 diag_tropopause

Subroutine TROPOPAUSE archives the ND55 tropopause diagnostic.

INTERFACE:

```
SUBROUTINE DIAG_TROPOPAUSE
```

USES:

```
USE DAO_MOD,        ONLY : BXHEIGHT
USE DAO_MOD,        ONLY : TROPP
USE DIAG_MOD,       ONLY : AD55
USE LOGICAL_MOD,    ONLY : LVARTROP
USE PRESSURE_MOD,   ONLY : GET_PCENTER
USE PRESSURE_MOD,   ONLY : GET_PEDGE

USE CMN_SIZE_MOD  ! Size parameters
USE CMN_DIAG_MOD  ! Diagnostic switches
```

REMARKS:

For GEOS-4, GEOS-5, 'MERRA', we use the tropopause pressure from the met field archive to determine if we are in the tropopause or not. Therefore, the 3rd slot of AD55 should be archived with the tropopause pressure from the met fields.

For other met fields, we have to estimate the tropopause pressure from the tropopause level. Archive the pressure at the midpoint of the level in which the tropopause occurs. NOTE: this may result in lower minimum tropopause pressure than reality.

REVISION HISTORY:

30 Nov 1999 - H. Liu, R. Yantosca - Initial version
(1) Make sure the DO-loops go in the order L-J-I, wherever possible.
(2) Now archive ND55 diagnostic here rather than in DIAG1.F. Also, use an allocatable array (AD55) to archive tropopause heights.
(3) HTPAUSE is now a local variable, since it is only used here.
(4) Make LTPAUSE a local variable, since LPAUSE is used to store the annual mean tropopause. (bmy, 4/17/00)
(5) Replace PW(I,J) with P(I,J). Also updated comments. (bmy, 10/3/01)
(6) Removed obsolete code from 9/01 and 10/01 (bmy, 10/24/01)
(7) Added polar tropopause for GEOS-3 in #if defined(GEOS_3) block (bmy, 5/20/02)
(8) Replaced all instances of IM with IIPAR and JM with JJPAR, in order to prevent namespace confusion for the new TPCORE (bmy, 6/25/02)
(9) Now use GET_PCENTER from "pressure_mod.f" to compute the pressure at the midpoint of box (I,J,L). Also deleted obsolete, commented-out code. (dsa, bdf, bmy, 8/21/02)
(10) Now reference BXHEIGHT and T from "dao_mod.f". Also reference routine ERROR_STOP from "error_mod.f" (bmy, 10/15/02)
(11) Now uses routine GET_YMID from "grid_mod.f" to compute grid box latitude. (bmy, 2/3/03)
(12) Add proper polar tropopause level for GEOS-4 (bmy, 6/18/03)
(13) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)

```
(14) Get tropopause level from TROPOPAUSE_MOD.F routines (phs, 10/17/06)
10 Sep 2010 - R. Yantosca - Added ProTeX headers
10 Sep 2010 - R. Yantosca - For GEOS-4, GEOS-5, MERRA met fields, take the
                            the tropopause pressure directly from the
                            met fields rather than computing it here.
10 Sep 2010 - R. Yantosca - Remove reference to LPAUSE, it's obsolete
10 Sep 2010 - R. Yantosca - Reorganize #if blocks for clarity
10 Sep 2010 - R. Yantosca - Renamed to DIAG_TROPOPAUSE and bundled into
                            tropopause_mod.f
```

1.63.11 init_tropopause

Subroutine INIT_TROPOPAUSE allocates and zeroes module arrays.

INTERFACE:

```
SUBROUTINE INIT_TROPOPAUSE
```

USES:

```
! References to F90 modules
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
10 Feb 2005 - R. Yantosca - Initial version
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.63.12 cleanup_tropopause

Subroutine CLEANUP_TROPOPAUSE deallocates module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_TROPOPAUSE
```

REVISION HISTORY:

```
10 Feb 2005 - R. Yantosca - Initial version
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.64 Fortran: Module Interface Tpcore_FvDas_Mod

Overview

Module Tpcore_Fvdas_Mod contains routines for the TPCORE transport scheme, as implemented in the GMI model (cf. John Tannahill), based on Lin Rood 1995. The Harvard Atmospheric Chemistry Modeling Group has added modifications to implement the Philip-Cameron Smith pressure fixer for mass conservation. Mass flux diagnostics have also been added.

References

1. Lin, S.-J., and R. B. Rood, 1996: *Multidimensional flux form semi-Lagrangian transport schemes*, Mon. Wea. Rev., **124**, 2046-2070.

2. Lin, S.-J., W. C. Chao, Y. C. Sud, and G. K. Walker, 1994: *A class of the van Leer-type transport schemes and its applications to the moisture transport in a General Circulation Model*, Mon. Wea. Rev., **122**, 1575-1593.

Selecting E/W, N/S and vertical advection options

The flags IORD, JORD, KORD select which transport schemes are used in the E/W, N/S, and vertical directions, respectively. Here is a list of the possible values that IORD, JORD, KORD may be set to (original notes from S-J Lin):

1. 1st order upstream scheme (too diffusive, not a real option; it can be used for debugging purposes; this is THE only known "linear" monotonic advection scheme.).
2. 2nd order van Leer (full monotonicity constraint; see Lin et al 1994, MWR)
3. monotonic PPM* (Collela & Woodward 1984)
4. semi-monotonic PPM (same as 3, but overshoots are allowed)
5. positive-definite PPM (constraint on the subgrid distribution is only strong enough to prevent generation of negative values; both overshoots & undershoots are possible).
6. un-constrained PPM (nearly diffusion free; faster but positivity of the subgrid distribution is not quaranteed. Use this option only when the fields and winds are very smooth.
7. Huynh/Van Leer/Lin full monotonicity constraint. Only KORD can be set to 7 to enable the use of Huynh's 2nd monotonicity constraint for piece-wise parabolic distribution.

Recommended values:

- IORD=JORD=3 for high horizontal resolution.
- KORD=3 or 7

The implicit numerical diffusion decreases as _ORD increases. DO NOT use option 4 or 5 for non-positive definite scalars (such as Ertel Potential Vorticity).

In GEOS-Chem we have been using IORD=3, JORD=3, KORD=7. We have tested the OpenMP parallelization with these options. GEOS-Chem users who wish to use different (I,J,K)ORD options should consider doing single-procsessor vs. multi-processor tests to test the implementation of the parallelization.

GEOS-4 and GEOS-5 Hybrid Grid Definition

For GEOS-4 and GEOS-5 met fields, the pressure at the bottom edge of grid box (I,J,L) is defined as follows:

$$P_{edge}(I,J,L) = A_k(L) + [B_k(L) * P_{surface}(I,J)]$$

where

- $P_{surface}$(I,J) is the "true" surface pressure at lon,lat (I,J)
- A_k(L) has the same units as surface pressure [hPa]
- B_k(L) is a unitless constant given at level edges

$A_k(L)$ and $B_k(L)$ are supplied to us by GMAO.

REMARKS:

```
 Ak(L) and Bk(L) are defined at layer edges.
                 ////////////////////////////////
              / \ ------ Model top P=ak(1) --------- ak(1), bk(1)
               |
   delp(1)     |  ..........  q(i,j,1)  ............
               |
              \ / ---------------------------------  ak(2), bk(2)
              / \ ---------------------------------  ak(k), bk(k)
               |
   delp(k)     |  ..........  q(i,j,k)  ............
               |
              \ / ---------------------------------  ak(k+1), bk(k+1)
              / \ ---------------------------------  ak(km), bk(km)
               |
   delp(km)    |  ..........  q(i,j,km)  .........
               |
              \ / -----Earth's surface P=Psfc ------ ak(km+1), bk(km+1)
                 ////////////////////////////////
 Note: surface pressure can be of any unit (e.g., pascal or mb) as
 long as it is consistent with the definition of (ak, bk) defined above.
 Winds (u,v), ps, and q are assumed to be defined at the same points.

 The latitudes are given to the initialization routine: init_tpcore.
```

INTERFACE:

```
 MODULE Tpcore_FvDas_Mod
```

USES:

```
   IMPLICIT NONE
#     include "define.h"
#     include "define.h"
   PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
   PUBLIC  ::  Init_Tpcore
   PUBLIC  ::  Exit_Tpcore
   PUBLIC  ::  Tpcore_FvDas
```

PRIVATE MEMBER FUNCTIONS:

```
   PRIVATE ::  Average_Const_Poles
   PRIVATE ::  Set_Cross_Terms
   PRIVATE ::  Calc_Vert_Mass_Flux
   PRIVATE ::  Set_Jn_Js
   PRIVATE ::  Calc_Advec_Cross_Terms
   PRIVATE ::  Qckxyz
   PRIVATE ::  Set_Lmts
   PRIVATE ::  Set_Press_Terms
   PRIVATE ::  Calc_Courant
   PRIVATE ::  Calc_Divergence
   PRIVATE ::  Do_Divergence_Pole_Sum
   PRIVATE ::  Do_Cross_Terms_Pole_I2d2
   PRIVATE ::  Xadv_Dao2
   PRIVATE ::  Yadv_Dao2
   PRIVATE ::  Do_Yadv_Pole_I2d2
   PRIVATE ::  Do_Yadv_Pole_Sum
   PRIVATE ::  Xtp
   PRIVATE ::  Xmist
   PRIVATE ::  Fxppm
   PRIVATE ::  Lmtppm
   PRIVATE ::  Ytp
   PRIVATE ::  Ymist
   PRIVATE ::  Do_Ymist_Pole1_I2d2
   PRIVATE ::  Do_Ymist_Pole2_I2d2
   PRIVATE ::  Fyppm
   PRIVATE ::  Do_Fyppm_Pole_I2d2
   PRIVATE ::  Do_Ytp_Pole_Sum
   PRIVATE ::  Fzppm
   PRIVATE ::  Average_Press_Poles
   !PRIVATE DATA MEMBERS:

   REAL*8, ALLOCATABLE, SAVE :: dtdx5(:)
```

```
REAL*8, ALLOCATABLE, SAVE :: dtdy5(:)
REAL*8, ALLOCATABLE, SAVE :: cosp(:)
REAL*8, ALLOCATABLE, SAVE :: cose(:)
REAL*8, ALLOCATABLE, SAVE :: gw(:)
REAL*8, ALLOCATABLE, SAVE :: DLAT(:)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, GMAO
Modified for GMI model by John Tannahill, LLNL (jrt@llnl.gov)
Implemented into GEOS-Chem by Claire Carouge (ccarouge@seas.harvard.edu)
ProTeX documentation added by Bob Yantosca (yantosca@seas.harvard.edu)
OpenMP parallelization added by Bob Yantosca (yantosca@seas.harvard.edu)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from the GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Added
                            OpenMP parallel loops in various routines (and
                            made some modifications to facilitate OpenMP).
01 Apr 2009 - C. Carouge  - Modified OpenMp parallelization and move the
                            loops over vertical levels outside the
                            horizontal transport routines for reducing
                            processing time.
```

1.64.1 Init_Tpcore

Subroutine Init_Tpcore allocates and initializes all module variables,

INTERFACE:

```
SUBROUTINE Init_Tpcore( IM, JM, KM, JFIRST, JLAST, NG, MG, dt, ae, clat )
```

USES:

```
USE CMN_GCTM_MOD
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)  :: IM        ! Global E-W dimension
INTEGER, INTENT(IN)  :: JM        ! Global N-S dimension
INTEGER, INTENT(IN)  :: KM        ! Vertical dimension
INTEGER, INTENT(IN)  :: NG        ! large ghost width
INTEGER, INTENT(IN)  :: MG        ! small ghost width
REAL*8,  INTENT(IN)  :: dt        ! Time step in seconds
REAL*8,  INTENT(IN)  :: ae        ! Earth's radius (m)
REAL*8,  INTENT(IN)  :: clat(JM)  ! latitude in radian
```

OUTPUT PARAMETERS:

```
INTEGER, INTENT(OUT) :: JFIRST    ! Local first index for N-S direction
INTEGER, INTENT(OUT) :: JLAST     ! Local last  index for N-S direction
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
```

1.64.2 Exit_Tpcore

Subroutine Exit_Tpcore deallocates all module variables.

INTERFACE:

```
SUBROUTINE Exit_Tpcore
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
```

1.64.3 Tpcore_FvDas

Subroutine Tpcore_FvDas takes horizontal winds on sigma (or hybrid sigma-p) surfaces and calculates mass fluxes, and then updates the 3D mixing ratio fields one time step (tdt). The basic scheme is a Multi-Dimensional Flux Form Semi-Lagrangian (FFSL) based on the van Leer or PPM (see Lin and Rood, 1995).

INTERFACE:

```
SUBROUTINE Tpcore_FvDas( dt,       ae,       IM,       JM,       KM,       &
                         JFIRST,   JLAST,    ng,       mg,       nq,       &
                         ak,       bk,       u,        v,        ps1,      &
                         ps2,      ps,       q,        iord,     jord,     &
```

```
                        kord,     n_adj,    XMASS,    YMASS,   FILL,     &
                        MASSFLEW, MASSFLNS, MASSFLUP, AREA_M2, TCVV,     &
                        ND24,     ND25,     ND26 )
```

USES:

```
    ! Include file w/ physical constants
    USE CMN_GCTM_MOD
```

INPUT PARAMETERS:

```
    ! Transport time step [s]
    REAL*8,  INTENT(IN)    :: dt

    ! Earth's radius [m]
    REAL*8,  INTENT(IN)    :: ae

    ! Global E-W, N-S, and vertical dimensions
    INTEGER, INTENT(IN)    :: IM
    INTEGER, INTENT(IN)    :: JM
    INTEGER, INTENT(IN)    :: KM

    ! Latitude indices for local first box and local last box
    ! (NOTE: for global grids these are 1 and JM, respectively)
    INTEGER, INTENT(IN)    :: JFIRST
    INTEGER, INTENT(IN)    :: JLAST

    ! Primary ghost region
    ! (NOTE: only required for MPI parallelization; use 0 otherwise)
    INTEGER, INTENT(IN)    :: ng

    ! Secondary ghost region
    ! (NOTE: only required for MPI parallelization; use 0 otherwise)
    INTEGER, INTENT(IN)    :: mg

    ! Ghosted latitudes (3 required by PPM)
    ! (NOTE: only required for MPI parallelization; use 0 otherwise)
    INTEGER, INTENT(IN)    :: nq

    ! Flags to denote E-W, N-S, and vertical transport schemes
    INTEGER, INTENT(IN)    :: iord
    INTEGER, INTENT(IN)    :: jord
    INTEGER, INTENT(IN)    :: kord

    ! Number of adjustments to air_mass_flux (0 = no adjustment)
    INTEGER, INTENT(IN)    :: n_adj

    ! Ak and Bk coordinates to specify the hybrid grid
    ! (see the REMARKS section below)
```

```
    REAL*8,  INTENT(IN)    :: ak(KM+1)
    REAL*8,  INTENT(IN)    :: bk(KM+1)

    ! u-wind (m/s) at mid-time-level (t=t+dt/2)
    REAL*8,  INTENT(IN)    :: u(IM,JFIRST:JLAST,KM)

    ! E/W and N/S mass fluxes [kg/s]
    ! (These are computed by the pressure fixer, and passed into TPCORE)
    REAL*8,  INTENT(IN)    :: XMASS(IM,JM,KM)
    REAL*8,  INTENT(IN)    :: YMASS(IM,JM,KM)

    ! Grid box surface area for mass flux diag [m2]
    REAL*8,  INTENT(IN)    :: AREA_M2(JM)

    ! Tracer masses for flux diag
    REAL*8,  INTENT(IN)    :: TCVV(NQ)

    ! Diagnostic flags
    INTEGER, INTENT(IN)    :: ND24    ! Turns on E/W     flux diagnostic
    INTEGER, INTENT(IN)    :: ND25    ! Turns on N/S     flux diagnostic
    INTEGER, INTENT(IN)    :: ND26    ! Turns on up/down flux diagnostic

    LOGICAL, INTENT(IN)    :: FILL    ! Fill negatives ?
```

INPUT/OUTPUT PARAMETERS:

```
    ! V-wind (m/s) at mid-time-level (t=t+dt/2)
    REAL*8,  INTENT(INOUT) :: v(IM, JFIRST-MG:JLAST+MG, KM)

    ! surface pressure at current time
    REAL*8,  INTENT(INOUT) :: ps1(IM, JFIRST:JLAST)

    ! surface pressure at future time=t+dt
    REAL*8,  INTENT(INOUT) :: ps2(IM, JFIRST:JLAST)

    ! Tracer "mixing ratios" [v/v]
    REAL*8,  INTENT(INOUT) :: q(IM, JFIRST-NG:JLAST+NG, KM, NQ)

    ! E/W, N/S, and up/down diagnostic mass fluxes
  --- Previous to (ccc, 12/3/09)
     REAL*8,  INTENT(INOUT) :: MASSFLEW(IM,JM,KM,NQ)  ! for ND24 diagnostic
     REAL*8,  INTENT(INOUT) :: MASSFLNS(IM,JM,KM,NQ)  ! for ND25 diagnostic
     REAL*8,  INTENT(INOUT) :: MASSFLUP(IM,JM,KM,NQ)  ! for ND26 diagnostic
    REAL*8,  INTENT(INOUT) :: MASSFLEW(:,:,:,:)  ! for ND24 diagnostic
    REAL*8,  INTENT(INOUT) :: MASSFLNS(:,:,:,:)  ! for ND25 diagnostic
    REAL*8,  INTENT(INOUT) :: MASSFLUP(:,:,:,:)  ! for ND26 diagnostic
```

OUTPUT PARAMETERS:

```
    ! "Predicted" surface pressure [hPa]
```

```
REAL*8,  INTENT(OUT)   :: ps(IM,JFIRST:JLAST)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Modified OpenMp parallelization and move the
                            loops over vertical levels outside the
                            horizontal transport routines for reducing
                            processing time.
03 Dec 2009 - C. Carouge  - Modify declarations of MASSFLEW, MASSFLNS and
                            MASSFLUP to save memory space.
```

1.64.4 Average_Const_Poles

Subroutine Average_Const_Poles averages the species concentrations at the Poles when the Polar cap is enlarged. It makes the last two latitudes equal.

INTERFACE:

```
SUBROUTINE Average_Const_Poles( dap ,   dbk,   rel_area, pctm1, const1, &
                                JU1_GL, J2_GL, I2_GL,    I1,    I2,     &
                                JU1,    J2,    ILO,    &
                                IHI,    JULO,  JHI )
```

INPUT PARAMETERS:

```
! Global latitude indices of the South Pole and North Pole
INTEGER, INTENT(IN)   :: JU1_GL, J2_GL

! Global max longitude index
INTEGER, INTENT(IN)   :: I2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)   :: I1,  I2
INTEGER, INTENT(IN)   :: JU1, J2
```

```
! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)   :: ILO,  IHI
INTEGER, INTENT(IN)   :: JULO, JHI

! Pressure difference across layer from (ai * pt) term [hPa]
REAL*8,  INTENT(IN)   :: dap

! Difference in bi across layer - the dSigma term
REAL*8,  INTENT(IN)   :: dbk

! Relative surface area of grid box [fraction]
REAL*8,  INTENT(IN)   :: rel_area(JU1:J2)

! CTM surface pressure at t1 [hPa]
REAL*8,  INTENT(IN)   :: pctm1( ILO:IHI, JULO:JHI )
```

INPUT/OUTPUT PARAMETERS:

```
! Species concentration, known at zone center [mixing ratio]
REAL*8, INTENT(INOUT) :: const1( I1:I2, JU1:J2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
```

1.64.5 Set_Cross_Terms

Subroutine Set_Cross_Terms sets the cross terms for E-W horizontal advection.

INTERFACE:

```
SUBROUTINE Set_Cross_Terms( crx,   cry,   ua, va, J1P,   J2P,   &
                            I1_GL, I2_GL, JU1_GL, J2_GL, ILO,   &
                            IHI,   JULO,  JHI,    I1,    I2,    &
                            JU1,   J2,    CROSS )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)   :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)   :: I1_GL,  I2_GL
INTEGER, INTENT(IN)   :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)   :: I1,     I2
INTEGER, INTENT(IN)   :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)   :: ILO,    IHI
INTEGER, INTENT(IN)   :: JULO,   JHI

! Courant number in E-W direction
REAL*8,  INTENT(IN) :: crx(ILO:IHI, JULO:JHI)

! Courant number in N-S direction
REAL*8,  INTENT(IN) :: cry(ILO:IHI, JULO:JHI)

! Logical switch.  If CROSS=T then cross-terms will be computed.
LOGICAL, INTENT(IN) :: CROSS
```

OUTPUT PARAMETERS:

```
! Average of Courant numbers from il and il+1
REAL*8, INTENT(OUT) :: ua(ILO:IHI, JULO:JHI)

! Average of Courant numbers from ij and ij+1
REAL*8, INTENT(OUT) :: va(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
```

```
                              make sure all numerical constants are declared
                              with the "D" double-precision exponent.  Added
                              OpenMP parallel DO loops.
    01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.6 Calc_Vert_Mass_Flux

Subroutine Calc_Vert_Mass_Flux calculates the vertical mass flux.

INTERFACE:

```
  SUBROUTINE Calc_Vert_Mass_Flux( dbk, dps_ctm, dpi, wz, I1,  &
                                  I2,  JU1,     J2,  K1, K2 )
```

INPUT PARAMETERS:

```
    ! Local min & max longitude (I), latitude (J), altitude (K) indices
    INTEGER, INTENT(IN)   :: I1,  I2
    INTEGER, INTENT(IN)   :: JU1, J2
    INTEGER, INTENT(IN)   :: K1,  K2

    ! Difference in bi across layer - the dSigma term
    REAL*8,  INTENT(IN)  :: dbk(K1:K2)

    ! CTM surface pressure tendency; sum over vertical of dpi
    ! calculated from original mass fluxes [hPa]
    REAL*8,  INTENT(IN)  :: dps_ctm(I1:I2, JU1:J2)

    ! Divergence at a grid point; used to calculate vertical motion [mb]
    REAL*8,  INTENT(IN)  :: dpi(I1:I2, JU1:J2, K1:K2)
```

OUTPUT PARAMETERS:

```
    ! Large scale mass flux (per time step tdt) in the vertical
    ! direction as diagnosed from the hydrostatic relationship [hPa]
    REAL*8, INTENT(OUT) :: wz(I1:I2, JU1:J2, K1:K2)
```

AUTHOR:

```
    Original code from Shian-Jiann Lin, DAO)
    John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
    05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                               Yeh with the TPCORE routines from GMI model.
                               This eliminates the polar overshoot in the
                               stratosphere.
    05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
```

```
Declare all REAL variables as REAL*8.  Also
make sure all numerical constants are declared
with the "D" double-precision exponent.  Added
OpenMP parallel DO loops
```

1.64.7 Set_Jn_Js

Subroutine Set_Jn_Js determines Jn and Js, by looking where Courant number is ¿ 1.

INTERFACE:

```
SUBROUTINE Set_Jn_Js( jn,  js,     crx,   ILO, IHI, JULO, &
                      JHI, JU1_GL, J2_GL, J1P, J2P, I1,   &
                      I2,  JU1,    J2,    K1,  K2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)   :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)   :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)   :: I1,     I2
INTEGER, INTENT(IN)   :: JU1,    J2
INTEGER, INTENT(IN)   :: K1,     K2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)   :: ILO,    IHI
INTEGER, INTENT(IN)   :: JULO,   JHI

! Courant number in E-W direction
REAL*8,  INTENT(IN)  :: crx(ILO:IHI, JULO:JHI, K1:K2)
```

OUTPUT PARAMETERS:

```
! Northward of latitude index = jn; Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(OUT) :: jn(K1:K2)

! Southward of latitude index = js; Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(OUT) :: js(K1:K2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REMARKS:

```
We cannot parallelize this subroutine because there is a CYCLE statement
within the outer loop.
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
```

1.64.8 Calc_Advec_Cross_Terms

Subroutine Calc_Advec_Cross_Terms calculates the advective cross terms.

INTERFACE:

```
SUBROUTINE Calc_Advec_Cross_Terms( jn,     js,    qq1,  qqu,  qqv,   &
                                   ua,     va,    J1P,  J2P,  I2_GL, &
                                   JU1_GL, J2_GL, ILO,  IHI,  JULO,  &
                                   JHI,    I1,    I2,   JU1,  J2,    &
                                   CROSS )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  ::         I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
```

```
INTEGER, INTENT(IN)  :: JULO,   JHI

! Northward of latitude index = jn, Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(IN)  :: Jn

! Southward of latitude index = js, Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(IN)  :: Js

! Species concentration (mixing ratio)
REAL*8,  INTENT(IN)  :: qq1(ILO:IHI, JULO:JHI)

! Average of Courant numbers from il and il+1
REAL*8,  INTENT(IN)  :: ua (ILO:IHI, JULO:JHI)

! Average of Courant numbers from ij and ij+1
REAL*8,  INTENT(IN)  :: va (ILO:IHI, JULO:JHI)

! Logical switch: If CROSS=T then cross-terms are being computed
LOGICAL, INTENT(IN)  :: CROSS
```

OUTPUT PARAMETERS:

```
! Concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(OUT) :: qqu(ILO:IHI, JULO:JHI)

! concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(OUT) :: qqv(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel do loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.9 Qckxyz

Subroutine Qckxyz routine checks for "filling".

INTERFACE:

```
SUBROUTINE Qckxyz( dq1, J1P, J2P,  JU1_GL, J2_GL, &
                   ILO, IHI, JULO, JHI,    I1,    &
                   I2,  JU1, J2,   K1,     K2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max latitude (J) indices
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2
INTEGER, INTENT(IN)  :: K1,     K2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI
```

INPUT/OUTPUT PARAMETERS:

```
! Species density [hPa]
REAL*8,  INTENT(INOUT) :: dq1(ILO:IHI, JULO:JHI, K1:K2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
```

1.64.10 Set_Lmts

Subroutine Set_Lmts sets ILMT, JLMT, KLMT.

INTERFACE:

```
SUBROUTINE Set_Lmts( ilmt, jlmt, klmt, I2_GL, J2_GL, iord, jord, kord )
```

INPUT PARAMETERS:

```
! Global maximum longitude (I) and longitude (J) indices
INTEGER, INTENT(IN)  :: I2_GL, J2_GL

! Flags to denote E-W, N-S, and vertical transport schemes
! (See REMARKS section of routine Tpcore_FvDas for more info)
INTEGER, INTENT(IN)  :: iord, jord, kord
```

OUTPUT PARAMETERS:

```
! Controls various options in E-W advection
INTEGER, INTENT(OUT) :: ilmt

! Controls various options in N-S advection
INTEGER, INTENT(OUT) :: jlmt

! Controls various options in vertical advection
INTEGER, INTENT(OUT) :: klmt
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
```

1.64.11 Set_Press_Terms

Subroutine Set_Press_Terms sets the pressure terms: DELP1, DELPM, PU.

INTERFACE:

```
SUBROUTINE Set_Press_Terms( dap,   dbk,  pres1,  pres2, delp1,   &
                           delpm, pu,   JU1_GL, J2_GL, ILO,     &
                           IHI,   JULO, JHI,    J1P,   J2P,     &
                           I1,    I2,   JU1,    J2)
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max latitude (J) indices
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Pressure difference across layer from (ai * pt) term [hPa]
REAL*8,  INTENT(IN)  :: dap

! Difference in bi across layer - the dSigma term
REAL*8,  INTENT(IN)  :: dbk

! Surface pressure at t1 [hPa]
REAL*8,  INTENT(IN)  :: pres1(ILO:IHI, JULO:JHI)

! Surface pressure at t1+tdt [hPa]
REAL*8,  INTENT(IN)  :: pres2(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Pressure thickness, the pseudo-density in a
! hydrostatic system at t1 [hPa]
REAL*8, INTENT(OUT) :: delp1(ILO:IHI, JULO:JHI)

! Pressure thickness, the pseudo-density in a
! hydrostatic system at t1+tdt/2 (approximate) [hPa]
REAL*8, INTENT(OUT) :: delpm(ILO:IHI, JULO:JHI)

! Pressure at edges in "u" [hPa]
REAL*8, INTENT(OUT) :: pu(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.12 Calc_Courant

Subroutine Calc_Courant calculates courant numbers from the horizontal mass fluxes.

INTERFACE:

```
SUBROUTINE Calc_Courant( cose, delpm, pu,     xmass, ymass, crx, cry,  &
                         J1P,  J2P,   JU1_GL, J2_GL, ILO,   IHI, JULO, &
                         JHI,  I1,    I2,     JU1,   J2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max latitude (J) indices
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Cosine of grid box edges
REAL*8,  INTENT(IN)  :: cose (JU1_GL:J2_GL)
```

```
! Pressure thickness, the pseudo-density in a hydrostatic system
! at t1+tdt/2 (approximate) (mb)
REAL*8,  INTENT(IN)  :: delpm(ILO:IHI, JULO:JHI)

! pressure at edges in "u"  (mb)
REAL*8,  INTENT(IN)  :: pu   (iLO:IHI, JULO:JHI)

! horizontal mass flux in E-W and N-S directions [hPa]
REAL*8,  INTENT(IN)  :: xmass(ILO:IHI, JULO:JHI)
REAL*8,  INTENT(IN)  :: ymass(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Courant numbers in E-W and N-S directions
REAL*8,  INTENT(OUT) :: crx(ILO:IHI, JULO:JHI)
REAL*8,  INTENT(OUT) :: cry(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO)
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.13 Calc_Divergence

Subroutine Calc_Divergence calculates the divergence.

INTERFACE:

```
SUBROUTINE Calc_Divergence( do_reduction, geofac_pc, geofac, dpi,   &
                            xmass,        ymass,     J1P,    J2P,   &
                            I1_GL,        I2_GL,     JU1_GL, J2_GL, &
                            ILO,          IHI,       JULO,   JHI,   &
                            I1,           I2,        JU1,    J2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Set to F if called on Master or T if called by Slaves
! (NOTE: This is only for MPI parallelization, for OPENMP it should be F)
LOGICAL, INTENT(IN)  :: do_reduction

! Special geometrical factor (geofac) for Polar cap
REAL*8 , INTENT(IN)  :: geofac_pc

! Geometrical factor for meridional advection; geofac uses correct
! spherical geometry, and replaces acosp as the meridional geometrical
! factor in TPCORE
REAL*8 , INTENT(IN)  :: geofac(JU1_GL:J2_GL)

! Horizontal mass flux in E/W and N/S directions [hPa]
REAL*8 , INTENT(IN)  :: xmass(ILO:IHI, JULO:JHI)
REAL*8 , INTENT(IN)  :: ymass(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Divergence at a grid point; used to calculate vertical motion [hPa]
REAL*8,  INTENT(OUT) :: dpi(I1:I2, JU1:J2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
```

```
                              stratosphere.
     05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                              Declare all REAL variables as REAL*8.  Also
                              make sure all numerical constants are declared
                              with the "D" double-precision exponent.  Added
                              OpenMP parallel DO loops.
     01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.14 Do_Divergence_Pole_Sum

Subroutine Do_Divergence_Pole_Sum sets the divergence at the Poles.

INTERFACE:

```
   SUBROUTINE Do_Divergence_Pole_Sum( do_reduction, geofac_pc, dpi, ymass, &
                                      I1_GL,        I2_GL,     J1P, J2P,   &
                                      JU1_GL,       J2_GL,     ILO, IHI,   &
                                      JULO,         JHI,       I1,  I2,    &
                                      JU1,          J2)
```

INPUT PARAMETERS:

```
     ! Global latitude indices at the edges of the S/N polar caps
     ! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
     ! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
     INTEGER, INTENT(IN)  :: J1P,    J2P

     ! Global min & max longitude (I) and latitude (J) indices
     INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
     INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

     ! Local min & max longitude (I), latitude (J), altitude (K) indices
     INTEGER, INTENT(IN)  :: I1,     I2
     INTEGER, INTENT(IN)  :: JU1,    J2

     ! Local min & max longitude (I) and latitude (J) indices
     INTEGER, INTENT(IN)  :: ILO,    IHI
     INTEGER, INTENT(IN)  :: JULO,   JHI

     ! Set to T if called on Master or F if called by slaves
     ! NOTE: This seems not to be used here....)
     LOGICAL, INTENT(IN)   :: do_reduction

     ! Special geometrical factor (geofac) for Polar cap
     REAL*8,  INTENT(in)   :: geofac_pc

     ! Horizontal mass flux in N-S direction [hPa]
     REAL*8,  INTENT(IN)   :: ymass(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Divergence at a grid point; used to calculate vertical motion [hPa]
REAL*8,  INTENT(OUT)  :: dpi(I1:I2, JU1:J2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent. Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.15 Do_Cross_Terms_Pole_I2d2

Subroutine Do_Cross_Terms_Pole_I2d2 sets "va" at the Poles.

INTERFACE:

```
SUBROUTINE Do_Cross_Terms_Pole_I2d2( cry,   va,  I1_GL, I2_GL, JU1_GL, &
                                     J2_GL, J1P, ILO,   IHI,   JULO,   &
                                     JHI,   I1,  I2,    JU1,   J2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edge of the South polar cap
! J1P=JU1_GL+1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2
```

```
! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Courant number in N-S direction
REAL*8,  INTENT(IN)  :: cry(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Average of Courant numbers from ij and ij+1
REAL*8,  INTENT(OUT) :: va(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.16 Xadv_Dao2

Subroutine Xadv_Dao2 is the advective form E-W operator for computing the adx (E-W) cross term.

INTERFACE:

```
SUBROUTINE Xadv_Dao2( iad,    jn,    js,  adx,  qqv, &
                      ua,     ILO,   IHI, JULO, JHI, &
                      JU1_GL, J2_GL, J1P, J2P,  I1,  &
                      I2,     JU1,   J2)
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max latitude (J) indices
```

```
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! if iad = 1, use 1st order accurate scheme;
! if iad = 2, use 2nd order accurate scheme
INTEGER, INTENT(IN)  :: iad

! Northward of latitude index = jn, Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(IN)  :: jn

! southward of latitude index = js, Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(IN)  :: js

! Concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqv(ILO:IHI, JULO:JHI)

! Average of Courant numbers from il and il+1
REAL*8,  INTENT(IN)  :: ua(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Cross term due to E-W advection [mixing ratio]
REAL*8,  INTENT(OUT) :: adx(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.17 Yadv_Dao2

Subroutine Yadv_Dao2 is the advective form N-S operator for computing the ady (N-S) cross term.

INTERFACE:

```
SUBROUTINE Yadv_Dao2( iad,   ady,    qqu,   va,  I1_GL, &
                      I2_GL, JU1_GL, J2_GL, J1P, J2P,   &
                      ILO,   IHI,    JULO,  JHI, I1,    &
                      I2,    JU1,    J2)
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! If iad = 1, use 1st order accurate scheme;
! If iad = 2, use 2nd order accurate scheme
INTEGER, INTENT(IN)  :: iad

! Concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqu(ILO:IHI, JULO:JHI)

! Average of Courant numbers from ij and ij+1
REAL*8,  INTENT(IN)  :: va(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Cross term due to N-S advection (mixing ratio)
REAL*8,  INTENT(OUT) :: ady(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.18 Do_Yadv_Pole_I2d2

Subroutine Do_Yadv_Pole_I2d2 sets "qquwk" at the Poles.

INTERFACE:

```
SUBROUTINE Do_Yadv_Pole_I2d2 ( qqu, qquwk, I1_GL, I2_GL, JU1_GL, J2_GL, &
                               J1P, ILO,   IHI,   JULO,  JHI,    I1,    &
                               I2,  JU1,   J2  )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the South polar cap
! J1P=JU1_GL+1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqu(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! qqu working array [mixing ratio]
REAL*8,  INTENT(OUT) :: qquwk(ILO:IHI, JULO-2:JHI+2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.19 Do_Yadv_Pole_Sum

Subroutine Do_Yadv_Pole_Sum sets the cross term due to N-S advection at the Poles.

INTERFACE:

```
SUBROUTINE Do_Yadv_Pole_Sum( ady, I1_GL, I2_GL, JU1_GL, J2_GL, J1P, &
                             ILO, IHI,   JULO,  JHI,    I1,    I2,  &
                             JU1, J2)
```

INPUT PARAMETERS:

```
! Global latitude index at the edge of the South polar cap
! J1P=JU1_GL+1; for a polar cap of 1 latitude band
! J1P=JU1_GL+2; for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)    :: J1P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: I1_GL,  I2_GL
INTEGER, INTENT(IN)    :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)    :: I1,     I2
INTEGER, INTENT(IN)    :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: ILO,    IHI
INTEGER, INTENT(IN)    :: JULO,   JHI
```

OUTPUT PARAMETERS:

```
! Cross term due to N-S advection (mixing ratio)
REAL*8,  INTENT(INOUT) :: ady(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.  Also make a logical
                            to test if we are using an extended polar cap.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.20 Xtp

Subroutine Xtp does horizontal advection in the E-W direction.

INTERFACE:

```
SUBROUTINE Xtp( ilmt, jn,  js,    pu,     crx,   dq1, qqv, xmass, fx,  &
                J1P,  J2P, I2_GL, JU1_GL, J2_GL, ILO, IHI, JULO,  JHI, &
                I1,   I2,  JU1,   J2,  iord )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)    :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    ::         I2_GL
INTEGER, INTENT(IN)    :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)    :: I1,     I2
INTEGER, INTENT(IN)    :: JU1,    J2
```

```
! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: ILO,    IHI
INTEGER, INTENT(IN)    :: JULO,   JHI

! Controls various options in E-W advection
INTEGER, INTENT(IN)    :: ilmt

! Northward of latitude index = jn, Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(IN)    :: jn

! Southward of latitude index = js, Courant numbers could be > 1,
! so use the flux-form semi-Lagrangian scheme
INTEGER, INTENT(IN)    :: js

! Option for E-W transport scheme.  See module header for more info.
INTEGER, INTENT(IN)    :: iord

! pressure at edges in "u" [hPa]
REAL*8,  INTENT(IN)    :: pu(ILO:IHI, JULO:JHI)

! Courant number in E-W direction
REAL*8,  INTENT(IN)    :: crx(ILO:IHI, JULO:JHI)

! Horizontal mass flux in E-W direction [hPa]
REAL*8,  INTENT(IN)    :: xmass(ILO:IHI, JULO:JHI)
```

INPUT/OUTPUT PARAMETERS:

```
! Species density [hPa]
REAL*8,  INTENT(INOUT) :: dq1(ILO:IHI, JULO:JHI)

! Concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(INOUT) :: qqv(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! E-W flux [mixing ratio]
REAL*8,  INTENT(OUT)   :: fx(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
```

```
                              This eliminates the polar overshoot in the
                              stratosphere.
     05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                              Declare all REAL variables as REAL*8.  Also
                              make sure all numerical constants are declared
                              with the "D" double-precision exponent.  Added
                              OpenMP parallel DO loops.
     01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.21 Xmist

Subroutine Xmist computes the linear tracer slope in the E-W direction. It uses the Lin et. al. 1994 algorithm.

INTERFACE:

```
SUBROUTINE Xmist( dcx,  qqv, J1P, J2P, I2_GL, JU1_GL, J2_GL, ILO, IHI, &
                  JULO, JHI, I1,  I2,  JU1,   J2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  ::         I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqv(-I2/3:I2+I2/3, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Slope of concentration distribution in E-W direction [mixing ratio]
REAL*8,  INTENT(OUT) :: dcx(-I2/3:I2+I2/3, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.22 Fxppm

Subroutine Fxppm is the 1D "outer" flux form operator based on the Piecewise Parabolic Method (PPM; see also Lin and Rood 1996) for computing the fluxes in the E-W direction.

INTERFACE:

```
SUBROUTINE Fxppm( ij,  ilmt, crx, dcx, fx, qqv,     &
                  ILO, IHI, JULO, JHI, I1,  I2 )
```

INPUT PARAMETERS:

```
! Local min & max longitude (I) and altitude (K) indices
INTEGER, INTENT(IN)    :: I1,     I2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: ILO,    IHI
INTEGER, INTENT(IN)    :: JULO,   JHI

! Latitude (IJ) and altitude (IK) indices
INTEGER, INTENT(IN)    :: ij

! Controls various options in E-W advection
INTEGER, INTENT(IN)    :: ilmt

! Courant number in E-W direction
REAL*8,  INTENT(IN)    :: crx(I1:I2, JULO:JHI)
```

INPUT/OUTPUT PARAMETERS:

```
  ! Concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(INOUT) :: qqv(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Slope of concentration distribution in E-W direction (mixing ratio)
REAL*8,  INTENT(OUT)   :: dcx(ILO:IHI, JULO:JHI)
```

```
! E-W flux [mixing ratio]
REAL*8,  INTENT(OUT)   :: fx(I1:I2, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REMARKS:

```
This routine is called from w/in a OpenMP parallel loop fro
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
                            Also remove the allocatable arrays, which
                            interfere w/ OpenMP parallelization.
01 Apr 2009 - C. Carouge  - The input arrays are now 2D only.
```

1.64.23 Lmtppm

Subroutine Lmtppm enforces the full monotonic, semi-monotonic, or the positive-definite constraint to the sub-grid parabolic distribution of the Piecewise Parabolic Method (PPM).

INTERFACE:

```
SUBROUTINE Lmtppm( lenx, lmt, a6, al, ar, dc, qa )
```

INPUT PARAMETERS:

```
! If 0 => full monotonicity;
! If 1 => semi-monotonic constraint (no undershoots);
! If 2 => positive-definite constraint
INTEGER, INTENT(IN)    :: lmt

! Vector length
INTEGER, INTENT(IN)    :: lenx
```

INPUT/OUTPUT PARAMETERS:

```
! Curvature of the test parabola
REAL*8,  INTENT(INOUT) :: a6(lenx)

! Left edge value of the test parabola
REAL*8,  INTENT(INOUT) :: al(lenx)

! Right edge value of the test parabola
REAL*8,  INTENT(INOUT) :: ar(lenx)

! 0.5 * mismatch
REAL*8,  INTENT(INOUT) :: dc(lenx)

! Cell-averaged value
REAL*8,  INTENT(INOUT) :: qa(lenx)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.
```

1.64.24 Ytp

Subroutine Ytp does horizontal advection in the N-S direction.

INTERFACE:

```
SUBROUTINE Ytp( jlmt,  geofac_pc, geofac, cry,  dq1,   qqu,    qqv,    &
                ymass, fy,        J1P,    J2P,  I1_GL, I2_GL,  JU1_GL, &
                J2_GL, ilong,     ILO,    IHI,  JULO,  JHI,    I1,     &
                I2,    JU1,       J2,    jord )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)    :: J1P,    J2P
```

```
! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: I1_GL,  I2_GL
INTEGER, INTENT(IN)    :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)    :: I1,     I2
INTEGER, INTENT(IN)    :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: ILO,    IHI
INTEGER, INTENT(IN)    :: JULO,   JHI

! ???
INTEGER, INTENT(IN)    :: ilong

! Controls various options in N-S advection
INTEGER, INTENT(IN)    :: jlmt

! N-S transport scheme (see module header for more info)
INTEGER, INTENT(IN)    :: jord

! special geometrical factor (geofac) for Polar cap
REAL*8,  INTENT(IN)    :: geofac_pc

! geometrical factor for meridional advection; geofac uses correct
! spherical geometry, and replaces acosp as the  meridional geometrical
! factor in tpcore
REAL*8,  INTENT(IN)    :: geofac(JU1_GL:J2_GL)

! Courant number in N-S direction
REAL*8,  INTENT(IN)    :: cry(ILO:IHI, JULO:JHI)

! Concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(IN)    :: qqu(ILO:IHI, JULO:JHI)

! Horizontal mass flux in N-S direction [hPa]
REAL*8,  INTENT(IN)    :: ymass(ILO:IHI, JULO:JHI)
```

INPUT/OUTPUT PARAMETERS:

```
! Species density [hPa]
REAL*8,  INTENT(INOUT) :: dq1(ILO:IHI, JULO:JHI)

! Concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(INOUT) :: qqv(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! N-S flux [mixing ratio]
```

```
REAL*8,  INTENT(OUT)   :: fy(ILO:IHI, JULO:JHI+1)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.25 Ymist

Subroutine Ymist computes the linear tracer slope in the N-S direction. It uses the Lin et. al. 1994 algorithm.

INTERFACE:

```
SUBROUTINE Ymist( id,    dcy, qqu, I1_GL, I2_GL, JU1_GL, &
                  J2_GL, J1P, ILO, IHI,   JULO,  JHI,    &
                  I1,    I2,  JU1, J2 )
```

INPUT PARAMETERS:

```
! Global latitude index at the edge of the South polar cap
! J1P=JU1_GL+1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
```

```
INTEGER, INTENT(IN)  :: JULO,   JHI

! The "order" of the accuracy in the computed linear "slope"
! (or mismatch, Lin et al. 1994); it is either 2 or 4.
INTEGER, INTENT(IN)  :: id

! Concentration contribution from E-W advection (mixing ratio)
REAL*8,  INTENT(IN)  :: qqu(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Slope of concentration distribution in N-S direction [mixing ratio]
REAL*8,  INTENT(OUT) :: dcy(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.26 Do_Ymist_Pole1_I2d2

Subroutine Do_Ymist_Pole1_I2d2 sets "dcy" at the Poles.

INTERFACE:

```
SUBROUTINE Do_Ymist_Pole1_I2d2( dcy,   qqu, I1_GL, I2_GL, JU1_GL,   &
                                J2_GL, ILO, IHI,   JULO,  JHI,      &
                                I1,    I2,  JU1,   J2 )
```

INPUT PARAMETERS:

```
! Global min & max longitude (I) and latitude (J) indices
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL
```

```
! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqu(ILO:IHI, JULO-2:JHI+2)
```

OUTPUT PARAMETERS:

```
! Slope of concentration distribution in N-S direction [mixing ratio]
REAL*8, INTENT(OUT)  :: dcy(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.27 Do_Ymist_Pole2_I2d2

Subroutine Do_Ymist_Pole2_I2d2 sets "dcy" at the Poles.

INTERFACE:

```
SUBROUTINE Do_Ymist_Pole2_I2d2( dcy,   qqu, I1_GL, I2_GL, JU1_GL, &
                                J2_GL, J1P, ILO,   IHI,   JULO,   &
                                JHI,   I1,  I2,    JU1,   J2 )
```

INPUT PARAMETERS:

```
! Global latitude index at the edge of the South polar cap
! J1P=JU1_GL+1 for a polar cap of 1 latitude band
```

```
! J1P=JU1_GL+2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! Concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqu(ILO:IHI, JULO-2:JHI+2)
```

OUTPUT PARAMETERS:

```
! Slope of concentration distribution in N-S direction [mixing ratio]
REAL*8,  INTENT(OUT) :: dcy(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.28 Fyppm

Subroutine Fyppm is the 1D "outer" flux form operator based on the Piecewise Parabolic Method (PPM; see also Lin and Rood 1996) for computing the fluxes in the N-S direction.

INTERFACE:

```
SUBROUTINE Fyppm( jlmt,  cry,   dcy,    qqu,   qqv,   j1p, j2p,    &
                  i1_gl, i2_gl, ju1_gl, j2_gl, ilong, ilo, ihi,    &
                  julo,  jhi,   i1,     i2,    ju1,   j2 )
```

INPUT PARAMETERS:

```
! Global latitude indices at the edges of the S/N polar caps
! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
INTEGER, INTENT(IN)  :: J1P,    J2P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: I1_GL,  I2_GL
INTEGER, INTENT(IN)  :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)  :: I1,     I2
INTEGER, INTENT(IN)  :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)  :: ILO,    IHI
INTEGER, INTENT(IN)  :: JULO,   JHI

! ILONG ??
INTEGER, INTENT(IN)  :: ilong

! Controls various options in N-S advection
INTEGER, INTENT(IN)  :: jlmt

! Courant number in N-S direction
REAL*8,  INTENT(IN)  :: cry(ILO:IHI, JULO:JHI)

! Slope of concentration distribution in N-S direction [mixing ratio]
REAL*8,  INTENT(IN)  :: dcy(ILO:IHI, JULO:JHI)

! Concentration contribution from E-W advection [mixing ratio]
REAL*8,  INTENT(IN)  :: qqu(ILO:IHI, JULO:JHI)
```

OUTPUT PARAMETERS:

```
! Concentration contribution from N-S advection [mixing ratio]
REAL*8,  INTENT(OUT) :: qqv(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.29 Do_Fyppm_Pole_I2d2

Subroutine Do_Fyppm_Pole_I2d2 sets "al" & "ar" at the Poles.

INTERFACE:

```
SUBROUTINE Do_Fyppm_Pole_I2d2( al,  ar,  I1_GL, I2_GL, JU1_GL, J2_GL, &
                               ILO, IHI, JULO,  JHI,   I1,     I2,    &
                               JU1, J2 )
```

INPUT PARAMETERS:

```
! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: I1_GL,  I2_GL
INTEGER, INTENT(IN)    :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)    :: I1,     I2
INTEGER, INTENT(IN)    :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: ILO,    IHI
INTEGER, INTENT(IN)    :: JULO,   JHI
```

OUTPUT PARAMETERS:

```
! Left (al) and right (ar) edge values of the test parabola
REAL*8,  INTENT(INOUT) :: al(ILO:IHI, JULO:JHI)
REAL*8,  INTENT(INOUT) :: ar(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
  05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                              Yeh with the TPCORE routines from GMI model.
                              This eliminates the polar overshoot in the
                              stratosphere.
  05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                              Declare all REAL variables as REAL*8.  Also
                              make sure all numerical constants are declared
                              with the "D" double-precision exponent.  Added
                              OpenMP parallel DO loops.
  01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.30 Do_Ytp_Pole_Sum

Subroutine Do_Ytp_Pole_Sum sets "dq1" at the Poles.

INTERFACE:

```
SUBROUTINE Do_Ytp_Pole_Sum( geofac_pc, dq1,    qqv,   fy,  I1_GL,  &
                            I2_GL,     JU1_GL, J2_GL, J1P, J2P,    &
                            ILO,       IHI,    JULO,  JHI, I1,     &
                            I2,        JU1,    J2 )
!input PARAMETERS:
  ! Global latitude indices at the edges of the S/N polar caps
  ! J1P=JU1_GL+1; J2P=J2_GL-1 for a polar cap of 1 latitude band
  ! J1P=JU1_GL+2; J2P=J2_GL-2 for a polar cap of 2 latitude bands
  INTEGER, INTENT(IN)    :: J1P,    J2P

  ! Global min & max longitude (I) and latitude (J) indices
  INTEGER, INTENT(IN)    :: I1_GL,  I2_GL
  INTEGER, INTENT(IN)    :: JU1_GL, J2_GL

  ! Local min & max longitude (I), latitude (J), altitude (K) indices
  INTEGER, INTENT(IN)    :: I1,     I2
  INTEGER, INTENT(IN)    :: JU1,    J2

  ! Local min & max longitude (I) and latitude (J) indices
  INTEGER, INTENT(IN)    :: ILO,    IHI
  INTEGER, INTENT(IN)    :: JULO,   JHI

  ! Special geometrical factor (geofac) for Polar cap
  REAL*8,  INTENT(IN)    :: geofac_pc

  ! Concentration contribution from N-S advection [mixing ratio]
  REAL*8,  INTENT(IN)    :: qqv(ILO:IHI, JULO:JHI)
```

INPUT/OUTPUT PARAMETERS:

```
  ! Species density [hPa]
```

```
REAL*8,  INTENT(INOUT) :: dq1(ILO:IHI, JULO:JHI)

! N-S mass flux [mixing ratio]
REAL*8,  INTENT(INOUT) :: fy (ILO:IHI, JULO:JHI+1)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
                            stratosphere.
05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                            Declare all REAL variables as REAL*8.  Also
                            make sure all numerical constants are declared
                            with the "D" double-precision exponent.  Added
                            OpenMP parallel DO loops.
01 Apr 2009 - C. Carouge  - Moved the IK loop outside the subroutine.
```

1.64.31 Fzppm

Subroutine Fzppm is the 1D "outer" flux form operator based on the Piecewise Parabolic Method (PPM; see also Lin and Rood 1996) for computing the fluxes in the vertical direction.

Fzppm was modified by S.-J. Lin, 12/14/98, to allow the use of the KORD=7 (klmt=4) option. KORD=7 enforces the 2nd monotonicity constraint of Huynh (1996). Note that in Huynh's original scheme, two constraints are necessary for the preservation of monotonicity. To use Huynh's algorithm, it was modified as follows. The original PPM is still used to obtain the first guesses for the cell edges, and as such Huynh's 1st constraint is no longer needed. Huynh's median function is also replaced by a simpler yet functionally equivalent in-line algorithm.

INTERFACE:

```
SUBROUTINE Fzppm( klmt,  delp1,  wz,  dq1, qq1,  fz,      &
                  J1P,   JU1_GL, J2_GL, ILO, IHI, JULO, JHI,     &
                  ILONG, IVERT,  I1,    I2,  JU1, J2,   K1,  K2 )
```

INPUT PARAMETERS:

```
! Global latitude index at the edges of the South polar cap
! J1P=JU1_GL+1 for a polar cap of 1 latitude band
! J1P=JU1_GL+2 for a polar cap of 2 latitude bands
```

```
INTEGER, INTENT(IN)    :: J1P

! Global min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: JU1_GL, J2_GL

! Local min & max longitude (I), latitude (J), altitude (K) indices
INTEGER, INTENT(IN)    :: I1,     I2
INTEGER, INTENT(IN)    :: JU1,    J2
INTEGER, INTENT(IN)    :: K1,     K2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)    :: ILO,    IHI
INTEGER, INTENT(IN)    :: JULO,   JHI

! Dimensions in longitude & altitude ???
INTEGER, INTENT(IN)    :: ilong,  ivert

! Controls various options in vertical advection
INTEGER, INTENT(IN)    :: klmt

! Pressure thickness, the pseudo-density in a
! hydrostatic system at t1 [hPa]
REAL*8,  INTENT(IN)    :: delp1(ILO:IHI, JULO:JHI, K1:K2)

! Large scale mass flux (per time step tdt) in the vertical
! direction as diagnosed from the hydrostatic relationship [hPa]
REAL*8,  INTENT(IN)    :: wz(I1:I2, JU1:J2, K1:K2)

! Species concentration [mixing ratio]
REAL*8,  INTENT(IN)    :: qq1(ILO:IHI, JULO:JHI, K1:K2)
```

INPUT/OUTPUT PARAMETERS:

```
! Species density [hPa]
REAL*8,  INTENT(INOUT) :: dq1(ILO:IHI, JULO:JHI, K1:K2)
```

OUTPUT PARAMETERS:

```
! Vertical flux [mixing ratio]
REAL*8,  INTENT(OUT)   :: fz(ILO:IHI, JULO:JHI,  K1:K2)
```

AUTHOR:

```
Original code from Shian-Jiann Lin, DAO
John Tannahill, LLNL (jrt@llnl.gov)
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
```

```
                              Yeh with the TPCORE routines from GMI model.
                              This eliminates the polar overshoot in the
                              stratosphere.
     05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                              Declare all REAL variables as REAL*8.  Also
                              make sure all numerical constants are declared
                              with the "D" double-precision exponent.
```

1.64.32 Average_Press_Poles

Subroutine Average_Press_Poles averages pressure at the Poles when the Polar cap is enlarged. It makes the last two latitudes equal.

INTERFACE:

```
SUBROUTINE Average_Press_Poles( area_1D, press, I1,  I2,   JU1,  &
                                J2,      ILO,   IHI, JULO, JHI )
```

INPUT PARAMETERS:

```
! Local min & max longitude (I), latitude (J)
INTEGER, INTENT(IN)   :: I1,     I2
INTEGER, INTENT(IN)   :: JU1,    J2

! Local min & max longitude (I) and latitude (J) indices
INTEGER, INTENT(IN)   :: ILO,    IHI
INTEGER, INTENT(IN)   :: JULO,   JHI

! Surface area of grid box
REAL*8,  INTENT(IN)   :: AREA_1D(JU1:J2)
```

INPUT/OUTPUT PARAMETERS:

```
! Surface pressure [hPa]
REAL*8, INTENT(INOUT) :: press(ILO:IHI, JULO:JHI)
```

AUTHOR:

```
Philip Cameron-Smith and John Tannahill, GMI project @ LLNL (2003)
Implemented into GEOS-Chem by Claire Carouge (ccarouge@seas.harvard.edu)
```

REMARKS:

```
Subroutine from pjc_pfix.  Call this one once everything is working fine.
```

REVISION HISTORY:

```
05 Dec 2008 - C. Carouge  - Replaced TPCORE routines by S-J Lin and Kevin
                            Yeh with the TPCORE routines from GMI model.
                            This eliminates the polar overshoot in the
```

```
                              stratosphere.
     05 Dec 2008 - R. Yantosca - Updated documentation and added ProTeX headers.
                              Declare all REAL variables as REAL*8.  Also
                              make sure all numerical constants are declared
                              with the "D" double-precision exponent.
```

1.65 Fortran: Module Interface transport_mod

Module TRANSPORT_MOD is used to call the proper version of the TPCORE advection scheme for GEOS-3, GEOS-4, GEOS-5, or GCAP nested-grid or global simulations.

INTERFACE:

```
      MODULE TRANSPORT_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: CLEANUP_TRANSPORT
      PUBLIC  :: DO_TRANSPORT
      PUBLIC  :: INIT_TRANSPORT
      PUBLIC  :: INIT_GEOS5_WINDOW_TRANSPORT
      PUBLIC  :: SET_TRANSPORT
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: GEOS4_GEOS5_GLOBAL_ADV
      PRIVATE :: GEOS3_GLOBAL_ADV
      PRIVATE :: GCAP_GLOBAL_ADV
      PRIVATE :: DO_GEOS5_WINDOW_TRANSPORT
      PRIVATE :: DO_WINDOW_TRANSPORT
      PRIVATE :: GET_AIR_MASS
```

REVISION HISTORY:

```
    10 Mar 2003 - Y. Wang, R. Yantosca - Initial version
    (1 ) Now can select transport scheme for GEOS-3 winds.  Added code for PJC
         pressure fixer. (bdf, bmy, 5/8/03)
    (2 ) Now delete DSIG array, it's obsolete.  Also added new PRIVATE function
         GET_AIR_MASS to compute air masses from the input/output pressures
         from the new GEOS-4/fvDAS TPCORE. (bmy, 6/24/03)
    (3 ) Now references DEBUG_MSG from "error_mod.f". (bmy, 8/7/03)
    (4 ) Bug fix in DO_GLOBAL_TRANSPORT (bmy, 10/21/03)
    (5 ) IORD, JORD, KORD are now module variables.  Now references
```

```
      "logical_mod.f" and "tracer_mod.f" (bmy, 7/20/04)
(6 ) Add mass-flux diagnostics to TPCORE_FVDAS (bdf, bmy, 9/28/04)
(7 ) Now references "diag_mod.f" (bmy, 9/28/04)
(8 ) Now modified for GEOS-5 and GCAP met fields (swu, bmy, 5/25/05)
(9 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(10) Now flip arrays in call to TPCORE_FVDAS (bmy, 6/16/06)
(11) Added modifications for SUN compiler (bmy, 7/12/06)
(12) Bug fixes in DO_GLOBAL_TRANSPORT (bmy, 11/29/06)
(13) Split off GCAP, GEOS-3, GEOS-4/GEOS-5 specific calling sequences
      into separate subroutines.  Also removed some obsolete module
      variables. (bmy, 10/30/07)
(14) Modifications for GEOS-5 nested grid (yxw, dan, bmy, 11/6/08)
(15) Bug fix in mass balance in GCAP_GLOBAL_ADV and GEOS4_GEOS5_GLOBAL_ADV.
      (ccc, 2/17/09)
26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
26 Feb 2010 - R. Yantosca - Added ProTex Headers
08 Mar 2010 - C. Carouge  - Modify call to tpcore_fvdas. We do not re-order
                            mass fluxes diagnostics anymore.
```

1.65.1 do_transport

Subroutine DO_TRANSPORT is the driver routine for the proper TPCORE program for GEOS-3, GEOS-4/GEOS-5, or window simulations.

INTERFACE:

```
SUBROUTINE DO_TRANSPORT
```

USES:

```
USE GRID_MOD,      ONLY : ITS_A_NESTED_GRID
USE TPCORE_BC_MOD, ONLY : INIT_TPCORE_BC

USE CMN_SIZE_MOD      ! Size parameters
```

REVISION HISTORY:

```
10 Mar 2003 - R. Yantosca - Initial version
(1 ) Removed IORD, JORD, KORD from the arg list.  Also now removed
      reference to CMN, it's not needed. (bmy, 7/20/04)
(2 ) Now call separate routines for different met fields. (bmy, 10/30/07)
(3 ) Now references subroutine INIT_TPCORE_BC from tpcore_bc_mod.f and
      DO_GEOS5_FVDAS_WINDOW_TRANSPORT from
      "tpcore_geos5_fvdas_window_mod.f90". (yxw, dan, bmy, 11/6/08)
26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
26 Feb 2010 - R. Yantosca - Added ProTeX headers
06 Oct 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5.
```

1.65.2 geos4_geos5_global_adv

Subroutine GEOS4_GEOS5_GLOBAL_ADV is the driver routine for TPCORE with the GMAO GEOS-4 or GEOS-5 met fields.

INTERFACE:

```
      SUBROUTINE GEOS4_GEOS5_GLOBAL_ADV
```

USES:

```
      USE DAO_MOD,          ONLY : PSC2, UWND, VWND
      USE DIAG_MOD,         ONLY : MASSFLEW, MASSFLNS, MASSFLUP
      USE ERROR_MOD,        ONLY : IT_IS_NAN, DEBUG_MSG, SAFE_DIV
      USE LOGICAL_MOD,      ONLY : LFILL, LMFCT, LPRT, LWINDO
      USE PJC_PFIX_MOD,     ONLY : DO_PJC_PFIX
      USE PRESSURE_MOD,     ONLY : GET_PEDGE, SET_FLOATING_PRESSURE
      USE TIME_MOD,         ONLY : GET_TS_DYN
      USE TPCORE_BC_MOD,    ONLY : SAVE_GLOBAL_TPCORE_BC
      USE TPCORE_FVDAS_MOD, ONLY : TPCORE_FVDAS
      USE TRACER_MOD,       ONLY : N_TRACERS, STT, TCVV
#if   defined( APM )
      USE TRACER_MOD,       ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD         ! Size parameters
      USE CMN_DIAG_MOD         ! NDxx flags
      USE CMN_GCTM_MOD         ! Physical constants
```

REVISION HISTORY:

```
   30 Oct 2007 - R. Yantosca - Initial version
   (1 ) Split off the GEOS-4 & GEOS-5 relevant parts from the previous
        routine DO_GLOBAL_TRANSPORT (bmy, 10/30/07)
   (2 ) Activate the call to SAVE_GLOBAL_TPCORE_BC (yxw, dan, bmy, 11/6/08)
   (3 ) Bug fix in mass balance: only account for cells of STT with non-zero
        concentrations when doing the computation (ccc, bmy, 2/17/09)
   26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
   26 Feb 2010 - R. Yantosca - Added ProTeX headers
   16 Feb 2011 - R. Yantosca - Add modifications for APM microphysics (G. Luo)
```

1.65.3 geos3_global_adv

Subroutine GEOS3_GLOBAL_ADV is the driver routine for TPCORE with the GMAO GEOS-3 met fields.

INTERFACE:

```
      SUBROUTINE GEOS3_GLOBAL_ADV
```

USES:

```
      USE DAO_MOD,          ONLY : PSC2, UWND, VWND
      USE DIAG_MOD,         ONLY : MASSFLEW, MASSFLNS, MASSFLUP
      USE ERROR_MOD,        ONLY : IT_IS_NAN, DEBUG_MSG
      USE LOGICAL_MOD,      ONLY : LFILL, LMFCT, LPRT, LWINDO
      USE PRESSURE_MOD,     ONLY : GET_PEDGE, SET_FLOATING_PRESSURE
      USE TIME_MOD,         ONLY : GET_TS_DYN
      USE TPCORE_BC_MOD,    ONLY : SAVE_GLOBAL_TPCORE_BC
      USE TPCORE_MOD,       ONLY : TPCORE
      USE TRACER_MOD,       ONLY : N_TRACERS, STT, TCVV
#if   defined( APM )
      USE TRACER_MOD,       ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD         ! Size parameters
      USE CMN_DIAG_MOD         ! NDxx flags
      USE CMN_GCTM_MOD         ! Physical constants
```

REVISION HISTORY:

```
   30 Oct 2007 - R. Yantosca - Initial version
   (1 ) Split off the GEOS-3 relevant parts from the previous routine
        DO_GLOBAL_TRANSPORT (bmy, 10/30/07)
   26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
   26 Feb 2010 - R. Yantosca - Added ProTeX headers
   16 Feb 2011 - R. Yantosca - Add modifications for APM microphysics (G. Luo)
```

1.65.4 gcap_global_adv

Subroutine GCAP_GLOBAL_ADV is the driver routine for TPCORE with the GCAP/GISS met fields.

INTERFACE:

```
      SUBROUTINE GCAP_GLOBAL_ADV
```

USES:

```
      USE DAO_MOD,          ONLY : PSC2, UWND, VWND
      USE DIAG_MOD,         ONLY : MASSFLEW, MASSFLNS, MASSFLUP
      USE ERROR_MOD,        ONLY : IT_IS_NAN, DEBUG_MSG
      USE LOGICAL_MOD,      ONLY : LFILL, LMFCT, LPRT, LWINDO
      USE PJC_PFIX_MOD,     ONLY : DO_PJC_PFIX
      USE PRESSURE_MOD,     ONLY : GET_PEDGE, SET_FLOATING_PRESSURE
      USE TIME_MOD,         ONLY : GET_TS_DYN
      USE TPCORE_FVDAS_MOD, ONLY : TPCORE_FVDAS
      USE TRACER_MOD,       ONLY : N_TRACERS, STT, TCVV
```

```
#if   defined( APM )
      USE TRACER_MOD,       ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD         ! Size parameters
      USE CMN_DIAG_MOD         ! NDxx flags
      USE CMN_GCTM_MOD         ! Physical constants
```

REVISION HISTORY:

```
   30 Oct 2007 - R. Yantosca - Initial version
   (1 ) Split off the GCAP relevant parts from the previous routine
        DO_GLOBAL_TRANSPORT (bmy, 10/30/07)
   (2 ) Bug fix in mass balance: only account for cells of STT with non-zero
        concentrations when doing the computation (ccc, bmy, 2/17/09)
   26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
   26 Feb 2010 - R. Yantosca - Added ProTeX headers
   16 Feb 2011 - R. Yantosca - Add modifications for APM microphysics (G. Luo)
```

1.65.5 do_geos5_window_transport

Subroutine DO_GEOS5_WINDOW_TRANSPORT is the driver program for the proper TP-CORE program for the GEOS-5 nested-grid simulations.

INTERFACE:

```
      SUBROUTINE DO_GEOS5_WINDOW_TRANSPORT
```

USES:

```
      ! References to F90 modules
      USE DAO_MOD,                   ONLY : PSC2,     UWND,     VWND
      USE DIAG_MOD,                  ONLY : MASSFLEW, MASSFLNS, MASSFLUP
      USE ERROR_MOD,                 ONLY : IT_IS_NAN,     DEBUG_MSG
      USE GRID_MOD,                  ONLY : GET_XOFFSET,   GET_YOFFSET
      USE LOGICAL_MOD,               ONLY : LFILL,  LMFCT
      USE LOGICAL_MOD,               ONLY : LPRT,   LWINDO
      USE PJC_PFIX_GEOS5_WINDOW_MOD, ONLY : DO_PJC_PFIX_GEOS5_WINDOW
      USE PRESSURE_MOD,              ONLY : GET_PEDGE
      USE PRESSURE_MOD,              ONLY : SET_FLOATING_PRESSURE
      USE TIME_MOD,                  ONLY : GET_TS_DYN
      USE TPCORE_BC_MOD,             ONLY : I0_W, J0_W, I1_W, J1_W
      USE TPCORE_BC_MOD,             ONLY : I2_W, J2_W, IM_W, JM_W, IGZD
      USE TPCORE_BC_MOD,             ONLY : DO_WINDOW_TPCORE_BC
      USE TPCORE_WINDOW_MOD,         ONLY : TPCORE_WINDOW
      USE TPCORE_GEOS5_WINDOW_MOD,   ONLY : TPCORE_GEOS5_WINDOW
      USE TRACER_MOD,                ONLY : N_TRACERS, STT, TCVV
```

```
#if   defined( APM )
      USE TRACER_MOD,               ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD                 ! Size parameters
      USE CMN_DIAG_MOD                 ! NDxx flags
      USE CMN_GCTM_MOD                 ! Physical constants
```

REVISION HISTORY:

```
   10 Mar 2003 - R. Yantosca - Initial version

   26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
   26 Feb 2010 - R. Yantosca - Added ProTeX headers
   16 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.65.6 do_window_transport

Subroutine DO_WINDOW_TRANSPORT is the driver program for the proper TPCORE program for nested-grid window simulations.

INTERFACE:

```
      SUBROUTINE DO_WINDOW_TRANSPORT
```

USES:

```
      USE DAO_MOD,           ONLY : PSC2, UWND, VWND
      USE ERROR_MOD,         ONLY : DEBUG_MSG
      USE GRID_MOD,          ONLY : GET_XOFFSET, GET_YOFFSET
      USE LOGICAL_MOD,       ONLY : LFILL, LMFCT, LPRT
      USE PRESSURE_MOD,      ONLY : GET_PEDGE, SET_FLOATING_PRESSURE
      USE TIME_MOD,          ONLY : GET_TS_DYN
      USE TPCORE_BC_MOD,     ONLY : I0_W, J0_W, I1_W, J1_W
      USE TPCORE_BC_MOD,     ONLY : I2_W, J2_W, IM_W, JM_W, IGZD
      USE TPCORE_BC_MOD,     ONLY : DO_WINDOW_TPCORE_BC
      USE TPCORE_WINDOW_MOD, ONLY : TPCORE_WINDOW
      USE TRACER_MOD,        ONLY : STT, N_TRACERS
#if   defined( APM )
      USE TRACER_MOD,        ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD          ! Size parameters
      USE CMN_GCTM_MOD          ! Re
```

REVISION HISTORY:

```
07 Aug 2003 - Y. Wang & R. Yantosca - Initial version
(1 ) Now references DEBUG_MSG from "error_mod.f" (bmy, 8/7/03)
(2 ) Removed IORD, JORD, KORD from the arg list, since these are now
      module variables.  Now reference LFILL, LMFCT, LPRT from
      "logical_mod.f".  Now reference STT, N_TRACERS from "tracer_mod.f".
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
26 Feb 2010 - R. Yantosca - Added ProTeX headers
16 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.65.7 get_air_mass

Function GET_AIR_MASS returns the air mass based on the pressures returned before and after the call to the GEOS-4/fvDAS TPCORE code. (bmy, 6/24/03)

INTERFACE:

```
FUNCTION GET_AIR_MASS( I, J, L, P_SURF ) RESULT( AIR_MASS )
```

USES:

```
USE CMN_SIZE_MOD              ! Size parameters
USE CMN_GCTM_MOD              ! g0_100
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I, J, L   ! GEOS-Chem lon, lat, level indices
REAL*8,  INTENT(IN) :: P_SURF    ! Surface pressure [hPa] at (I,J,L=1)
```

REVISION HISTORY:

```
24 Jun 2003 - R. Yantosca - Initial version
26 Feb 2010 - R. Yantosca - Added ProTeX headers
```

1.65.8 set_transport

Subroutine SET_TRANSPORT passes IORD, JORD, KORD values from "input_mod.f".

INTERFACE:

```
SUBROUTINE SET_TRANSPORT( I_ORD, J_ORD, K_ORD )
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: I_ORD  ! IORD option for E/W advection
INTEGER, INTENT(IN) :: J_ORD  ! JORD option for N/S advection
INTEGER, INTENT(IN) :: K_ORD  ! KORD option for vertical diffusion
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
26 Feb 2010 - R. Yantosca - Added ProTeX headers
```

1.65.9 init_transport

Subroutine INIT_TRANSPORT initializes all module variables and arrays.

INTERFACE:

```
SUBROUTINE INIT_TRANSPORT
```

USES:

```
USE ERROR_MOD,        ONLY : ALLOC_ERR
USE GRID_MOD,         ONLY : GET_AREA_M2, GET_YMID_R
USE LOGICAL_MOD,      ONLY : LTPFV,       LTRAN
USE PRESSURE_MOD,     ONLY : GET_AP,      GET_BP
USE TIME_MOD,         ONLY : GET_TS_DYN
USE TPCORE_FVDAS_MOD, ONLY : INIT_TPCORE
USE TRACER_MOD,       ONLY : N_TRACERS

USE CMN_SIZE_MOD         ! Size parameters
USE CMN_GCTM_MOD         ! Re
```

REVISION HISTORY:

```
10 Mar 2003 - R. Yantosca - Initial version
(1 ) Now references GET_TS_DYN from "time_mod.f", INIT_TPCORE_FVDAS from
     "tpcore_fvdas_mod.f90", and GET_YMID_R from "grid_mod.f".  Now also
     include "F77_CMN_SETUP".  (bdf, bmy, 4/28/03)
(2 ) Remove reference to DSIG, it's obsolete. (bmy, 6/24/03)
(3 ) Now references LEMBED & LTPFV from "logical_mod.f".  Now references
     N_TRACERS from "tracer_mod.f". (bmy, 7/20/04)
(4 ) Now modified for GEOS-5 and GCAP met fields (swu, bmy, 5/25/05)
(5 ) Removed reference to USE_GEOS_4_TRANSPORT, STT_I1, STT_I2, STT_J1,
     STT_J2, variables (bmy, 10/30/07)
(6 ) Deleted reference to CMN, it's not needed anymore (bmy, 11/6/08)
26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
26 Feb 2010 - R. Yantosca - Added ProTeX headers
```

1.65.10 init_geos5_window_transport

Subroutine INIT_GEOS5_WINDOW_TRANSPORT initializes all module variables and arrays for the GEOS-5 nested grid simulation. This routine is only called if we are using the

GEOS-5 nested grid simulation.

INTERFACE:

```
SUBROUTINE INIT_GEOS5_WINDOW_TRANSPORT
```

USES:

```
USE ERROR_MOD,               ONLY : ALLOC_ERR
USE GRID_MOD,                ONLY : GET_AREA_M2
USE GRID_MOD,                ONLY : GET_YMID_R_W
USE LOGICAL_MOD,             ONLY : LTPFV,  LTRAN
USE PRESSURE_MOD,            ONLY : GET_AP, GET_BP
USE TIME_MOD,                ONLY : GET_TS_DYN
USE TPCORE_FVDAS_MOD,        ONLY : INIT_TPCORE
USE TPCORE_BC_MOD,           ONLY : I0_W, J0_W, I1_W, J1_W
USE TPCORE_BC_MOD,           ONLY : I2_W, J2_W, IM_W, JM_W
USE TPCORE_BC_MOD,           ONLY : IGZD, INIT_TPCORE_BC
USE TPCORE_GEOS5_WINDOW_MOD, ONLY : INIT_GEOS5_WINDOW
USE TRACER_MOD,              ONLY : N_TRACERS

USE CMN_SIZE_MOD                ! Size parameters
USE CMN_GCTM_MOD                ! Re
```

REVISION HISTORY:

```
06 Jun 2008 - D. Chen & R. Yantosca - Initial version
26 Feb 2010 - R. Yantosca - Removed references to obsolete LEMBED switch
26 Feb 2010 - R. Yantosca - Added ProTeX headers
```

1.65.11 cleanup_transport

Subroutine CLEANUP_TRANSPORT deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_TRANSPORT
```

REVISION HISTORY:

```
10 Mar 2003 - R. Yantosca - Initial version
(1 ) Remove reference to DSIG, it's obsolete. (bmy, 6/24/03)
(2 ) Remove obsolete embedded chemistry arrays (bmy, 10/30/07)
26 Feb 2010 - R. Yantosca - Added ProTeX headers
```

1.66 Fortran: Module Interface upbdflx_mod

Module UPBDFLX_MOD contains subroutines which impose stratospheric boundary conditions on O3 and NOy.

INTERFACE:

```
      MODULE UPBDFLX_MOD
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC  :: DO_UPBDFLX
      PUBLIC  :: UPBDFLX_O3
      PUBLIC  :: UPBDFLX_NOY
      PUBLIC  :: UPBDFLX_HD
      PUBLIC  :: INIT_UPBDFLX
```

REVISION HISTORY:

```
   28 Jun 2001 - Q. Li, B. Field, M. Evans, R. Yantosca - Initial version
   (1 ) Routine "upbdflx_noy" now correctly reprocessed P(NOy) files from
        /data/ctm/GEOS_4x5/pnoy_200106 or /data/ctm/GEOS_2x2.5/pnoy_200106.
        (mje, bmy, 6/28/01)
   (2 ) Updated comments (bmy, 9/4/01)
   (3 ) Fixes for reading binary punch files of global size (bmy, 9/27/01)
   (4 ) Removed obsolete commented out code from 9/01 (bmy, 10/24/01)
   (5 ) Removed obsolete commented out code from 7/01 (bmy, 11/26/01)
   (6 ) Updated comments (bmy, 5/28/02)
   (7 ) Replaced all instances of IM with IIPAR and JM with JJPAR, in ordr
        to prevent namespace confusion for the new TPCORE (bmy, 6/25/02)
   (8 ) Now references "pressure_mod.f" (dsa, bdf, bmy, 8/21/02)
   (9 ) Now references BXHEIGHT from "dao_mod.f".  Also deleted obsolete
        code from 8/02.  Now references IDTNOx, IDTOX, from "tracerid_mod.f"
        instead of from "comtrid.h". (bmy, 11/6/02)
   (10) Added driver routine DO_UPBDFLX.  Also added lat limits for 1x1 in
        UPBDFLX_O3. (bmy, 3/14/03)
   (11) Now references AD from "dao_mod.f" in UPBDFLX_NOY (bnd, bmy, 4/14/03)
   (12) Added printout of O3 in Tg/yr in UPBDFLX_O3 (mje, bmy, 8/15/03)
   (13) Change O3 flux for GEOS-3 to 500 Tg/yr in UPBDFLX_O3 (bmy, 9/15/03)
   (14) Now references "tagged_ox_mod.f" (bmy, 8/19/03)
   (15) Now activated parallel DO loops (bmy, 4/15/04)
   (16) Now made IORD, JORD, KORD module variables.  Now added routine
        SET_UPBDFLX.  Now added routine SET_TRANSPORT (bmy, 7/20/04)
   (17) Bug fix for COMPAQ compiler.  Now supports 1x125 grid. (bmy, 12/1/04)
```

```
(18) Now supports GEOS-5 and GCAP grids (swu, bmy, 5/25/05)
(19) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(20) Now references "tropopause_mod.f" (bmy, 11/1/05)
(21) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(22) Added UPBDFLX_HD from the strat-trop flux of HD (lyj, phs, 9/18/07)
(23) Cap 1-XRATIO in UPBDFLX_NOY to prevent underflow (phs, 6/30/08)
(24) Modifications for GEOS-5 nested grid (yxw, dan, bmy, 11/6/08)
(25) Remove support for COMPAQ compiler (bmy, 7/8/09)
(26) Added support for LINOZ (dbj, jliu, bmy, 10/16/09)
13 Aug 2010 - R. Yantosca - Add modifications for MERRA (treat like GEOS-5)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.66.1 do_upbdflx

Subroutine DO_UPBDFLX is the driver routine for the stratospheric (upper-boundary) routines for Ox and NOy.

INTERFACE:

```
SUBROUTINE DO_UPBDFLX
```

USES:

```
USE ERROR_MOD,   ONLY : DEBUG_MSG
USE LOGICAL_MOD, ONLY : LPRT
USE LOGICAL_MOD, ONLY : LLINOZ
USE TRACER_MOD,  ONLY : ITS_A_FULLCHEM_SIM
USE TRACER_MOD,  ONLY : ITS_A_TAGOX_SIM
USE TRACER_MOD,  ONLY : ITS_A_H2HD_SIM
USE LINOZ_MOD,   ONLY : DO_LINOZ

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
11 Mar 2003 - R. Yantosca - Initial version
(1 ) Removed IORD, JORD, KORD from the arg list.  Now references LPRT
     from "logical_mod.f".  Now references ITS_A_FULLCHEM_SIM and
     ITS_A_TAGOX_SIM from "tracer_mod.f" (bmy, 7/20/04)
(2 ) Now references ITS_A_H2HD_SIM from "tracer_mod.f".  Now call routine
     UPBDFLX_HD for H2/HD simulation. (lyj, phs, 9/18/07)
(3 ) Added support for LINOZ (dbm, jliu, bmy, 10/16/09)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.66.2 upbdflx_O3

Subroutine UPBDFLX_O3 establishes the flux boundary condition for Ozone coming down from the stratosphere, using the Synoz algorithm of McLinden et al, 2000.

INTERFACE:

```
SUBROUTINE UPBDFLX_O3
```

USES:

```
USE DAO_MOD,         ONLY : AD, BXHEIGHT, T, TROPP
USE ERROR_MOD,       ONLY : ERROR_STOP
USE LOGICAL_MOD,     ONLY : LVARTROP
USE PRESSURE_MOD,    ONLY : GET_PEDGE, GET_PCENTER
USE TAGGED_OX_MOD,   ONLY : ADD_STRAT_POX
USE TIME_MOD,        ONLY : GET_TS_DYN
USE TRACER_MOD,      ONLY : STT, ITS_A_TAGOX_SIM
USE TRACERID_MOD,    ONLY : IDTOX
USE TROPOPAUSE_MOD, ONLY : GET_TPAUSE_LEVEL

USE CMN_SIZE_MOD       ! Size parameters
USE CMN_GCTM_MOD       ! Rdg0
```

REMARKS:

```
Reference:
============================================================================
C. A. McLinden, S. Olsen, B. Hannegan, O. Wild, M. J. Prather, and
J. Sundet, "Stratospheric Ozone in 3-D models: A simple chemistry
and the cross-tropopause flux".

                                                                           .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% NOTE: This SYNOZ scheme is now obsolete, replaced by LINOZ   %%%%
%%%% We keep this for backwards compatibility w/ older met fields %%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

REVISION HISTORY:

```
13 Dec 1999 - Q. Li, R. Martin - Initial version
(1 ) The parameter Rdg0 from "F77_CMN_GCTM" = R / g0 = 28.97.
(2 ) Pass PW = PS - PTOP to UPBDFLX via "CMN".
(3 ) Now pass IORD, JORD, KORD as arguments (bmy, 12/6/00)
(4 ) Now compute the proper value of PO3_vmr that will yield 475 Tg O3/yr
     for various settings of IORD, JORD, KORD (rvm, bey, bmy, 12/5/00)
                                                                           .
     ************************************************************
     ***** You must use this version of UPBDFLX_O3 if you are *****
     ***** using the Parallel Processor TPCORE v. 7.1         *****
     ************************************************************
```

```
(5 ) Added to "upbdflx_mod.f".  Also updated comments and made some
     cosmetic changes. (bmy, 6/28/01)
(6 ) Now reference F77_CMN_SETUP for LSPLIT.  Also store strat O3 into
     tracer #11 for multi-tracer Ox run. (amf, bmy, 7/3/01)
(7 ) Removed IREF, JREF -- these are obsolete.  Also T(IREF,JREF,L) is
     now T(I,J,L). (bmy, 9/27/01)
(8 ) Also replace PW(I,J) with P(I,J) (bmy, 10/3/01)
(9 ) Removed obsolete commented out code from 9/01 (bmy, 10/24/01)
(10) Removed obsolete commented out code from 7/01 (bmy, 11/26/01)
(11) Now write file names to stdout (bmy, 4/3/02)
(12) Replaced all instances of IM with IIPAR and JM with JJPAR, in order
     to prevent namespace confusion for the new TPCORE (bmy, 6/25/02)
(13) Now use GET_PEDGE and GET_PCENTER from "pressure_mod.f" to compute
     the pressure at the bottom edge and center of grid box (I,J,L).
     Also removed obsolete, commented-out code.  Removed G_SIG and
     G_SIGE from the arg list. (dsa, bdf, bmy, 8/21/02)
(14) Now reference BXHEIGHT and T from "dao_mod.f".  Also reference routine
     ERROR_STOP from "error_mod.f".  Now references IDTOX from F90 module
     "tracerid_mod.f" instead of from "comtrid.h". (bmy, 11/6/02)
(15) Now define J30S and J30N for 1x1 nested grid (bmy, 3/11/03)
(16) Make sure to pass AD via "dao_mod.f" for GEOS-1 (bnd, bmy, 4/14/03)
(17) On the first timestep, print how much O3 flux is coming down from the
     stratosphere in Tg/yr. (mje, bmy, 8/15/03)
(18) Change O3 flux to 500 Tg/yr for GEOS-3 (mje, bmy, 9/15/03)
(19) Now calls routine ADD_STRAT_POX from "tagged_ox_mod.f" in order to
     pass stratospheric flux of Ox to the proper tagged tracer w/o
     resorting to hardwiring w/in this routine. (bmy, 8/18/03)
(20) Add GEOS_4 to the #if defined block. (bmy, 1/29/04)
(21) Activated parallel DO-loops.  Now made STFLUX a local array
     in order to facilitate parallelization. (bmy, 4/15/04)
(22) Removed IORD, JORD, KORD from the arg list.  Now reference STT and
     ITS_A_TAGOX_SIM from "tracer_mod.f".  (bmy, 7/20/04)
(23) Use an #ifdef block to comment out an EXIT statement from w/in a
     parallel loop for COMPAQ compiler.  COMPAQ seems to have some
     problems with this.  Now supports 1x125 grid. (auvray, bmy, 12/1/04)
(24) Now modified for GEOS-5 and GCAP met fields (swu, bmy, 5/25/05)
(25) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(26) Now set J30S and J30N for GEOS-5 nested grid (yxw, dan, bmy, 11/6/08)
(27) Remove support for COMPAQ compiler (bmy, 7/8/09)
(28) Now do not call ADD_STRAT_POx for tagged Ox (dbj, bmy, 10/16/09)
13 Aug 2010 - R. Yantosca - Treat MERRA like GEOS-5 (bmy, 8/13/10)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.66.3 upbdflx_NOy

Subroutine UPBDFLX_NOy imposes NOy (NOx + HNO3) upper boundary condition in the stratosphere. The production rates for NOy are provided by Dylan Jones, along with NOx and HNO3 concentrations.

INTERFACE:

```
SUBROUTINE UPBDFLX_NOy( IFLAG )
```

USES:

```
USE BPCH2_MOD,      ONLY : GET_NAME_EXT, GET_RES_EXT
USE BPCH2_MOD,      ONLY : GET_TAU0,     READ_BPCH2
USE DAO_MOD,        ONLY : AD
USE DIRECTORY_MOD,  ONLY : DATA_DIR
USE ERROR_MOD,      ONLY : ERROR_STOP
USE TRACERID_MOD,   ONLY : IDTNOX,       IDTHNO3
USE TIME_MOD,       ONLY : GET_TS_DYN,   GET_MONTH
USE TIME_MOD,       ONLY : ITS_A_NEW_MONTH
USE TRACER_MOD,     ONLY : STT,          XNUMOLAIR
USE TRANSFER_MOD,   ONLY : TRANSFER_ZONAL
USE TROPOPAUSE_MOD, ONLY : GET_MIN_TPAUSE_LEVEL
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_STRAT

USE CMN_SIZE_MOD       ! Size parameters
```

INPUT PARAMETERS:

```
! IFLAG=1 will partition    [NOy] before transport
! IFLAG=2 will re-partition [NOy] after  transport
INTEGER, INTENT(IN) :: IFLAG
```

REVISION HISTORY:

```
22 Dec 1999 - Q. Li, R. Martin - Initial version
(1 ) Use READ_BPCH2 to read data from disk in binary punch file format.
(2 ) Now partition total [NOy] into [NOx] and [HNO3], instead of
     partitioning P(NOy) into P(NOx) and P(HNO3).  (qli, bmy, 12/22/1999)
(3 ) Also echo back to the user when reading data from disk.  This
     allows the user to trace I/O errors more easily. (bmy, 2/1/00)
(4 ) Cosmetic changes, updated comments (bmy, 3/17/00)
(5 ) Reference F90 module "bpch2_mod" which contains routine "read_bpch2"
     for reading data from binary punch files (bmy, 6/28/00)
(6 ) Only add P(NOy) above 10mb (archived in files "pnoy_above_10mb.*)
     into the top layer of the GEOS-1 and GEOS-STRAT grids.  The GEOS-2
     and GEOS-3 grids extend well above 10mb and so they will contain
     all of the P(NOy) up there (bmy, 6/29/00)
(7 ) Now use function GET_TAU0 (from "bpch2_mod.f") to return the TAU0
     value used to index the binary punch file. (bmy, 7/20/00)
```

```
(8 ) Only dump P(NOy) above 10mb for GEOS-1 grid.  The GEOS-STRAT grid
     will already have this contribution, since it extends to 0.1 mb.
     Also fix regridding error in P(NOy) data file.  Add parallel
     processor DO-loops. (rvm, qli, bmy, 12/6/00)
(9 ) Now scale P(NOy) by 0.7 for TPCORE flags 337, in order to prevent
     excess NOy from building up in the stratosphere. (rvm, bmy, 12/12/00)
(10) Now read properly regridded P(NOy) files from the pnoy_200106/
     subdirectory of DATA_DIR.  Also updated comments and made a
     few cosmetic changes. (mje, bmy, 6/28/01)
(11) Now use 3 arguments (M/D/Y) in call to GET_TAU0.  ARRAY needs to be
     of size (1,JJPAR,LGLOB).  Use JJPAR,LGLOB in calls to READ_BPCH2.
     Use TRANSFER_ZONAL (from "transfer_mod.f") to cast from REAL*4 to
     REAL*8 and resize arrays to (JJPAR,LLPAR) (bmy, 9/27/01)
(12) Removed obsolete commented out code from 9/01 (bmy, 10/24/01)
(13) Now write file name to stdout (bmy, 4/3/02)
(14) Now reference ERROR_STOP from "error_mod.f".  Also references IDTNOX
     and IDTHNO3 from "tracerid_mod.f". (bmy, 11/6/02)
(15) Rename MONTHSAVE to LASTMONTH.  Now use functions GET_TS_DYN and
     GET_MONTH from "time_mod.f".  Now call READ_BPCH2 with QUIET=.TRUE.
     to suppress printing of extra info.  Cosmetic changes.  Now references
     AD from "dao_mod.f" for GEOS-1 (bmy, 4/14/03)
(16) Activated parallel DO-loops.  Moved the computation of XRATIO into
     the IF block which only gets done once per month. (bmy, 4/15/04)
(17) Now references STT from "tracer_mod.f".  Now references DATA_DIR
     from "directory_mod.f". (bmy, 7/20/04)
(18) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(19) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(20) Now references ITS_A_NEW_MONTH from "time_mod.f". Now reference
     GET_MIN_TPAUSE_LEVEL from "tropopause_mod.f".  Now replace reference
     to LPAUSE with ITS_IN_THE_STRAT from "tropopause_mod.f" (bmy, 11/1/05)
(21) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(22) Cap 1-XRATIO to avoid numerical problems later (bmy, 6/30/08)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.66.4 upbdflx_HD

Subroutine UPBDFLX_HD establishes the flux boundary condition for HD coming down from the stratosphere. This is adapted from the UPBDFLX_O3 routine.

INTERFACE:

```
SUBROUTINE UPBDFLX_HD
```

USES:

```
USE DAO_MOD,      ONLY : AD, BXHEIGHT, T
USE ERROR_MOD,    ONLY : ERROR_STOP
USE PRESSURE_MOD, ONLY : GET_PEDGE, GET_PCENTER
```

```
      USE TIME_MOD,     ONLY : GET_TS_DYN
      USE TRACER_MOD,   ONLY : STT
      USE TRACERID_MOD, ONLY : IDTHD, IDTH2

      USE CMN_SIZE_MOD     ! Size parameters
      USE CMN_GCTM_MOD     ! Rdg0
```

REMARKS:

```
    Instead of calculating the fractionation of H2 in the stratosphere
    (where we would have to take into account fractionation of CH4),
    we simply set the HD tracer concentrations in the stratosphere to
    reproduce observed profiles in the UT/LS.

                                                                             .
    References:
    ============================================================================
    (1) "Global Budget of Molecular Hydrogen and its Deuterium Content:
          Constraints from Ground Station, Cruise, and Aircraft Observations"
          Price, H., L. Jaegl, A. Rice, P. Quay, P.C. Novelli, R. Gammon,
          submitted to J. Geophys. Res., 2007.
```

REVISION HISTORY:

```
    18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager - Initial version
    (1 ) First adapted from UPBDFLX_03 (G-C v5-05-03) then merged w/ v7-04-12.
          Added parallel DO loops. (phs, 9/18/07)
    (26) Now set J30S and J30N for GEOS-5 nested grid (yxw, dan, bmy, 11/6/08)
    (27) Remove support for COMPAQ compiler (bmy, 7/8/09)
    13 Aug 2010 - R. Yantosca - Treat MERRA like GEOS-5
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.66.5 init_upbdflx

Subroutine INIT_UPBDFLX passes IORD, JORD, and KORD values from "input_mod.f" to "upbdflx_mod.f"

INTERFACE:

```
      SUBROUTINE INIT_UPBDFLX( I_ORD, J_ORD, K_ORD )
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I_ORD   ! TPCORE IORD parameter (for E/W)
      INTEGER, INTENT(IN) :: J_ORD   ! TPCORE JORD parameter (for N/S)
      INTEGER, INTENT(IN) :: K_ORD   ! TPCORE KORD parameter (for Vertical)
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.67 Fortran: Module Interface vdiff_mod

Module VDIFF_MOD includes all routines for the non-local PBL mixing scheme.

INTERFACE:

```
 MODULE VDIFF_MOD
```

USES:

```
   USE TRACER_MOD,    ONLY : pcnst => N_TRACERS
   USE VDIFF_PRE_MOD, ONLY : LLPAR
   USE LOGICAL_MOD,   ONLY : LPRT
   USE ERROR_MOD,     ONLY : DEBUG_MSG

   IMPLICIT NONE
#     include "define.h"
#     include "define.h"

   PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
   public :: DO_PBL_MIX_2
   !PRIVATE DATA MEMBERS:

   save

   integer, parameter :: plev = LLPAR, plevp = plev + 1

   real*8, parameter ::          &
        rearth = 6.37122d6,      & ! radius earth (m)
        cpwv   = 1.81d3,         &
        cpair  = 1004.64d0,      &
        rair   = 287.04d0,       &
        rh2o   = 461.d0,         &
        zvir   = rh2o/rair - 1., &
        gravit = 9.80616d0,      &
        ra     = 1.d0/rearth,    &
        epsilo = 0.622d0,        &
        latvap = 2.5104d06,      &
        latice = 3.336d5,        &
        cappa  = rair/cpair,     &
        rhoh2o = 1.d3,           &
        r_g    = rair / gravit,  &
        tfh2o  = 273.16d0

  -----------------------------------------------------------------------
    ... pbl constants
```

```
!-----------------------------------------------------------------------

 ! These are constants, so use PARAMETER tag
 real*8, parameter ::   &
      betam  = 15.d0,   & ! constant in wind gradient expression
      betas  =  5.d0,   & ! constant in surface layer gradient expression
      betah  = 15.d0,   & ! constant in temperature gradient expression
      fak    =  8.5d0,  & ! constant in surface temperature excess
      fakn   =  7.2d0,  & ! constant in turbulent prandtl number
      ricr   =   .3d0,  & ! critical richardson number
      sffrac =   .1d0,  & ! surface layer fraction of boundary layer
      vk     =   .4d0     ! von karmans constant

 ! These are assigned later, so we can't use the PARAMETER tag
 real*8 ::              &
      g,                & ! gravitational acceleration
      onet,             & ! 1/3 power in wind gradient expression
      ccon,             & ! fak * sffrac * vk
      binm,             & ! betam * sffrac
      binh                ! betah * sffrac

!-----------------------------------------------------------------------
  ... constants used in vertical diffusion and pbl
!-----------------------------------------------------------------------
 real*8 :: &
      zkmin            ! minimum kneutral*f(ri)
 real*8 :: ml2(plevp)   ! mixing lengths squared
 real*8, allocatable :: qmincg(:)   ! min. constituent concentration
                                    !  counter-gradient term

 integer :: &
      ntopfl, &        ! top level to which vertical diffusion is applied.
      npbl             ! maximum number of levels in pbl from surface

 logical, parameter :: divdiff = .true. , arvdiff = .false.

 logical, parameter :: pblh_ar = .true.

 logical, parameter :: pbl_mean_drydep = .false.  ! use mean concentration
                                                  !  within the  PBL for
                                                  ! calculating drydep fluxes
 logical, parameter :: drydep_back_cons = .false. ! backward consistency
                                                  !  with previous GEOS-Chem
                                                  !  drydep budgets
                                                  !-- useless when
                                                  !   pbl_mean_drydep=.false.
```

REVISION HISTORY:

```
(1 ) This code is modified from mo_vdiff.F90 in MOZART-2.4. (lin, 5/14/09)
07 Oct 2009 - R. Yantosca - Added CVS Id Tag
24 Sep 2010 - J. Lin      - Modified ND15 to account for all mixing
                            processes but not dry deposition and emissions.
17 Dec 2010 - R. Yantosca - Declare constants w/ the PARAMETER attribute
20 Dec 2010 - R. Yantosca - Bug fixes for the parallelization
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
25 Mar 2011 - R. Yantosca - Corrected bug fixes noted by Jintai Lin
```

1.67.1 pbinti

Subroutine PBINTI initializes time independent variables of pbl package

INTERFACE:

```
subroutine pbinti( gravx )
```

USES:

```
implicit none
```

INPUT PARAMETERS:

```
real*8, intent(in) :: gravx     !  acceleration of gravity
```

REVISION HISTORY:

```
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
```

1.67.2 pbldif

Subroutine PBLDIF computes the atmospheric boundary layer. The nonlocal scheme determines eddy diffusivities based on a diagnosed boundary layer height and a turbulent velocity scale. Also, countergradient effects for heat and moisture, and constituents are included, along with temperature and humidity perturbations which measure the strength of convective thermals in the lower part of the atmospheric boundary layer.

References:

1. Holtslag, A. A. M., and B. A. Boville, 1993: *Local versus nonlocal boundary-layer diffusion in a global climate model*, J. Clim., **6**, 1825-1842.

INTERFACE:

```
subroutine pbldif( th      ,q       ,z       ,u       ,v, &
                   t       ,pmid    ,kvf     ,cflx    ,shflx, &
                   kvm     ,kvh, &
                   cgh     ,cgq     ,cgs     ,pblh    ,tpert, &
                   qpert   ,wvflx   ,cgsh    ,plonl, &
                   taux    ,tauy    ,ustar)
```

USES:

```
  implicit none
```

INPUT PARAMETERS:

```
  integer, intent(in) :: &
plonl
  real*8, intent(in) :: &
       th(plonl,plev), &          ! potential temperature [k]
       q(plonl,plev), &           ! specific humidity [kg/kg]
       z(plonl,plev), &           ! height above surface [m]
       u(plonl,plev), &           ! windspeed x-direction [m/s]
       v(plonl,plev), &           ! windspeed y-direction [m/s]
       t(plonl,plev), &           ! temperature (used for density)
       pmid(plonl,plev), &        ! midpoint pressures
       kvf(plonl,plevp), &        ! free atmospheric eddy diffsvty [m2/s]
       cflx(plonl,pcnst), &       ! surface constituent flux (kg/m2/s)
       wvflx(plonl), &            ! water vapor flux (kg/m2/s)
       shflx(plonl)               ! surface heat flux (w/m2)
```

INPUT/OUTPUT PARAMETERS:

```
  real*8, optional, intent(inout) :: &
       taux(plonl), &            ! x surface stress (n)
       tauy(plonl), &            ! y surface stress (n)
       ustar(plonl)              ! surface friction velocity

  real*8, intent(inout) :: pblh(plonl)       ! boundary-layer height [m]
```

OUTPUT PARAMETERS:

```
  real*8, intent(out) :: &
       kvm(plonl,plevp), &        ! eddy diffusivity for momentum [m2/s]
       kvh(plonl,plevp), &        ! eddy diffusivity for heat [m2/s]
       cgh(plonl,plevp), &        ! counter-gradient term for heat [k/m]
       cgq(plonl,plevp,pcnst), &  ! counter-gradient term for constituents
       cgsh(plonl,plevp), &       ! counter-gradient term for sh
       cgs(plonl,plevp), &        ! counter-gradient star (cg/flux)
       tpert(plonl), &            ! convective temperature excess
       qpert(plonl)               ! convective humidity excess
```

REVISION HISTORY:

```
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
```

1.67.3 qvdiff

Subroutine QVDIFF solve vertical diffusion eqtn for constituent with explicit srfc flux.

INTERFACE:

```
subroutine qvdiff( ncnst, qm1, qflx, cc, ze, &
            term, qp1, plonl )
```

USES:

```
implicit none
```

INPUT PARAMETERS:

```
integer, intent(in) :: &
     plonl
integer, intent(in) :: &
     ncnst                    ! num of constituents being diffused
real*8, intent(in) :: &
     qm1(plonl,plev,ncnst), & ! initial constituent
     qflx(plonl,ncnst), &     ! sfc q flux into lowest model level
     cc(plonl,plev), &        ! -lower diag coeff.of tri-diag matrix
     term(plonl,plev)         ! 1./(1. + ca(k) + cc(k) - cc(k)*ze(k-1))
```

INPUT/OUTPUT PARAMETERS:

```
real*8, intent(inout) :: &
     ze(plonl,plev)           ! term in tri-diag. matrix system
```

OUTPUT PARAMETERS:

```
real*8, intent(out) :: &
     qp1(plonl,plev,ncnst)    ! final constituent
```

REMARKS:

```
Procedure for solution of the implicit equation follows :
Richtmyer and Morton (1967,pp 198-199)
```

REVISION HISTORY:

```
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
```

1.67.4 vdiffar

Subroutine VDIFFAR is the driver routine to compute vertical diffusion of trace constituents using archived coefficients for cgs and kvh. This is a gutted version of vdiff.

INTERFACE:

```
SUBROUTINE VDIFFAR( lat   ,tadv , &
                    pmid  ,pint ,rpdel_arg ,rpdeli_arg  ,ztodt, &
                    sflx  ,as2  ,kvh_arg   ,cgs_arg     ,plonl )
```

USES:

```
implicit none
```

INPUT PARAMETERS:

```
integer, intent(in) :: lat     ! latitude index
integer, intent(in) :: plonl   ! lon tile dim
real*8, intent(in) :: &
     ztodt , &                 ! 2 delta-t
     tadv(:,:,:), &        ! temperature input
     pmid(:,:,:), &     ! midpoint pressures
     pint(:,:,:), &    ! interface pressures
     rpdel_arg(:,:,:), &      ! 1./pdel  (thickness bet interfaces)
     rpdeli_arg(:,:,:), &     ! 1./pdeli (thickness bet midpoints)
     sflx(:,:,:), &      ! surface constituent flux (kg/m2/s)
     kvh_arg(:,:,:), &       ! coefficient for heat and tracers
     cgs_arg(:,:,:)          ! counter-grad star (cg/flux)
```

INPUT/OUTPUT PARAMETERS:

```
real*8, intent(inout) :: &
     as2(:,:,:,:)     ! moist, tracers after vert. diff
```

REVISION HISTORY:

```
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
```

1.67.5 pbldifar

Subroutine PBLDIFAR is a modified version of pbldif which only calculates cgq given cgs.

INTERFACE:

```
SUBROUTINE PBLDIFAR( t, pmid, cflx, cgs, cgq, plonl )
```

USES:

```
implicit none
```

INPUT PARAMETERS:

```
integer, intent(in) :: &
     plonl
real*8, intent(in) :: &
     t(plonl,plev), &        ! temperature (used for density)
     pmid(plonl,plev), &     ! midpoint pressures
     cflx(plonl,pcnst), &     ! surface constituent flux (kg/m2/s)
     cgs(plonl,plevp)        ! counter-gradient star (cg/flux)
```

OUTPUT PARAMETERS:

```
real*8, intent(out) :: &
     cgq(plonl,plevp,pcnst)  ! counter-gradient term for constituents
```

REVISION HISTORY:

```
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
```

1.67.6 vdinti

Subroutine VDINTI initializes time independent fields for vertical diffusion. Calls initialization routine for boundary layer scheme.

INTERFACE:

```
SUBROUTINE VDINTI
```

USES:

```
USE PRESSURE_MOD, ONLY : GET_AP, GET_BP
USE ERROR_MOD,   ONLY : ALLOC_ERR

implicit none
```

REVISION HISTORY:

```
02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                            involve explicitly using "D" exponents
```

1.67.7 vdiffdr

Subroutine VDIFFDR calculates the vertical diffusion on a latitude slice of data.

1. The dummy argument as2 is in vv. (lin, 06/04/08)
2. TCVV and TRACER_MW_KG assume 12 g/mol for all HCs. Thus, when using them to convert units of HCs to be the inputs for vdiffdr, the converted units are NOT kg/kg for concentrations and kg/m2/s for surface flux. However, since the units for both inputs are consistent, there should not be any problem. (lin, 06/04/08)

INTERFACE:

```
SUBROUTINE VDIFFDR(as2)
```

USES:

```
      USE TRACER_MOD,   ONLY : N_TRACERS,  TRACER_MW_KG, TCVV, &
                               ID_EMITTED, TRACER_COEFF, TRACER_COEFF, &
                               TRACER_NAME
      USE TRACER_MOD,   ONLY : ITS_A_TAGOX_SIM, ITS_A_TAGCO_SIM
      USE TRACER_MOD,   ONLY : ITS_A_CH4_SIM
      USE DAO_MOD,      ONLY : um1 => UWND, vm1 => VWND, tadv => T, &
                               hflx => HFLUX, eflux => EFLUX, &
                               USTAR, BXHEIGHT, shp => SPHU, PS => PSC2, &
                               AD,PBL
      USE PRESSURE_MOD, ONLY : GET_PEDGE, GET_PCENTER
      USE TIME_MOD,     ONLY : GET_TS_CONV, GET_TS_EMIS
      USE COMODE_MOD,   ONLY : JLOP,      REMIS,   VOLUME
      USE DRYDEP_MOD,   ONLY : DEPNAME, NUMDEP, NTRAIND, DEPSAV
      USE PBL_MIX_MOD,  ONLY : GET_PBL_TOP_m, COMPUTE_PBL_HEIGHT, &
                               GET_PBL_MAX_L, GET_FRAC_UNDER_PBLTOP

       USE VDIFF_PRE_MOD, ONLY : IIPAR, JJPAR, IDEMS, NEMIS, NCS, ND15, ND44, &
                                 NDRYDEP, emis_save
       USE DIAG_MOD,     ONLY : TURBFLUP, AD44
      USE VDIFF_PRE_MOD, ONLY : IIPAR, JJPAR, IDEMS, NEMIS, NCS, ND44, &
                                NDRYDEP, emis_save

      USE DIAG_MOD,     ONLY : AD44
      USE GRID_MOD,     ONLY : GET_AREA_M2

      USE TRACER_MOD,   ONLY : ITS_A_MERCURY_SIM ! (cdh 8/28/09)
      USE DEPO_MERCURY_MOD, ONLY : ADD_Hg2_DD, ADD_HgP_DD
      USE DEPO_MERCURY_MOD, ONLY : ADD_Hg2_SNOWPACK
      USE TRACERID_MOD, ONLY : IS_Hg0, IS_Hg2, IS_HgP
      USE LOGICAL_MOD,  ONLY : LDYNOCEAN, LGTMM !cdh
      USE DAO_MOD,      ONLY : LWI, IS_ICE, IS_LAND, SNOMAS, SNOW !cdh
      USE DAO_MOD,      ONLY : FRSNO, FRLANDIC, FROCEAN ! jaf
      USE OCEAN_MERCURY_MOD,  ONLY : LHg2HalfAerosol !cdh
      USE DRYDEP_MOD,   ONLY : DRYHg0, DRYHg2, DRYHgP !cdh
      USE TRACER_MOD,   ONLY: ITS_A_FULLCHEM_SIM  !bmy


#     include "define.h"

      implicit none
```

INPUT/OUTPUT PARAMETERS:

```
      real*8, intent(inout) :: as2(IIPAR,JJPAR,LLPAR,N_TRACERS) ! advected species

       REAL*8                :: SNOW_HT !cdh - obsolete
      REAL*8                :: FRAC_NO_HG0_DEP !jaf
      LOGICAL               :: ZERO_HG0_DEP !jaf
```

REVISION HISTORY:

```
   (1 ) Calls to vdiff and vdiffar are now done with full arrays as arguments.
        (ccc, 11/19/09)
    04 Jun 2010 - C. Carouge  - Updates for mercury simulations with GTMM
    25 Aug 2010 - R. Yantosca - Treat MERRA in the same way as GEOS-5
    24 Sep 2010 - J. Lin      - Move ND15 to vdiff.
    21 Dec 2010 - R. Yantosca - Add logical flags for different sim types
    21 Dec 2010 - R. Yantosca - Now call ITS_A_FULLCHEM_SIM instead of
                                relying on NCS == 0
    22 Dec 2010 - C. Carouge  - Combine array flipping w/ unit conversion
                                to save on operations
    02 Mar 2011 - R. Yantosca - Bug fixes for PGI compiler: these mostly
                                involve explicitly using "D" exponents
    26 Apr 2011 - J. Fisher   - Use MERRA land fraction information
```

1.67.8 do_pbl_mix_2

Subroutine DO_PBL_MIX_2 is the driver routine for planetary boundary layer mixing. The PBL layer height and related quantities are always computed. Mixing of tracers underneath the PBL top is toggled by the DO_TURBDAY switch.

INTERFACE:

```
   SUBROUTINE DO_PBL_MIX_2( DO_TURBDAY )
```

USES:

```
     USE LOGICAL_MOD,   ONLY : LTURB, LPRT
     USE TRACER_MOD,    ONLY : N_TRACERS, STT, TCVV, ITS_A_FULLCHEM_SIM
     USE PBL_MIX_MOD,   ONLY : INIT_PBL_MIX, COMPUTE_PBL_HEIGHT

     USE VDIFF_PRE_MOD, ONLY : EMISRR, EMISRRN
     USE ERROR_MOD,     ONLY : DEBUG_MSG
     USE TIME_MOD,      ONLY : ITS_TIME_FOR_EMIS

     IMPLICIT NONE
#    include "define.h"
#    include "define.h"
```

INPUT PARAMETERS:

```
     LOGICAL, INTENT(IN) :: DO_TURBDAY  ! Switch which turns on PBL mixing of
                                        ! tracers
```

REVISION HISTORY:

```
    11 Feb 2005 - R. Yantosca - Initial version
    21 Dec 2010 - R. Yantosca - Now only call SETEMIS for fullchem simulations
    22 Dec 2010 - R. Yantosca - Bug fix: print debug output only if LPRT=T
```

1.68 Fortran: Module Interface vdiff_pre_mod

Module VDIFF_PRE_MOD contains variables used in VDIFF_MOD.

INTERFACE:

```
      MODULE VDIFF_PRE_MOD
```

USES:

```
      USE TRACER_MOD, ONLY : N_TRACERS

#     include "define.h"
      USE CMN_SIZE_MOD
      USE COMODE_LOOP_MOD                    ! IDEMS, NEMIS, NCS
      USE CMN_O3_MOD                        ! EMISRR, EMISRRN
      USE CMN_DIAG_MOD                      ! ND15

      IMPLICIT NONE

      PRIVATE
```

PUBLIC DATA MEMBERS:

```
      PUBLIC :: IIPAR, JJPAR, LLPAR         ! from "F77_CMN_SIZE"
      PUBLIC :: IDEMS, NEMIS, NCS, NDRYDEP  ! from "comode.h"
      PUBLIC :: EMISRR, EMISRRN             ! from "F77_CMN_O3"
      PUBLIC :: ND15, ND44                  ! from "F77_CMN_DIAG"
      PUBLIC :: emis_save

      ! Make sure MAXTRACERS >= N_TRACERS
      INTEGER, PARAMETER :: MAXTRACERS = 100

      REAL*8 :: emis_save(IIPAR, JJPAR, MAXTRACERS) = 0.d0
```

REVISION HISTORY:

```
   01 Jun 2009 - C. Carouge & J. Lin - Initial version
   07 Oct 2009 - R. Yantosca         - Added CVS Id tag
```

1.69 Fortran: Module Interface vistas_anthro_mod

Module VISTAS_ANTHRO_MOD contains variables and routines to read the VISTAS anthropogenic emissions.

INTERFACE:

```
      MODULE VISTAS_ANTHRO_MOD
```

USES:

```
      USE EPA_NEI_MOD, ONLY : GET_USA_MASK

      IMPLICIT NONE
#     include "define.h"
      PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_VISTAS_ANTHRO
      PUBLIC :: EMISS_VISTAS_ANTHRO
      PUBLIC :: GET_VISTAS_ANTHRO
```

PRIVATE MEMBER FUNCTIONS:

```
      PRIVATE :: INIT_VISTAS_ANTHRO
      PRIVATE :: VISTAS_SCALE_FUTURE
      PRIVATE :: TOTAL_ANTHRO_Tg
```

REVISION HISTORY:

```
   24 Nov 2008 - A. v. Donkelaar - Initial version
   28 Jan 2009 - P. Le Sager     - Initial Version in GEOS-Chem
```

1.69.1 get_vistas_anthro

Function GET_VISTAS_ANTHRO returns the VISTAS emission for GEOS-Chem grid box (I,J) and tracer N. Emissions can be returned in units of [kg/s] or [molec/cm2/s].

INTERFACE:

```
      FUNCTION GET_VISTAS_ANTHRO( I,        J,           N,
     &                            WEEKDAY,  MOLEC_CM2_S, KG_S )
     &  RESULT( VALUE )
```

USES:

```
      USE TRACER_MOD,   ONLY : XNUMOL
      USE TRACERID_MOD, ONLY : IDTNOx
```

INPUT PARAMETERS:

```
      ! Longitude, latitude, and tracer indices
      INTEGER, INTENT(IN)           :: I, J, N

      ! Return weekday or weekend emissions
      LOGICAL, INTENT(IN)           :: WEEKDAY

      ! OPTIONAL -- return emissions in [molec/cm2/s]
      LOGICAL, INTENT(IN), OPTIONAL :: MOLEC_CM2_S

      ! OPTIONAL -- return emissions in [kg/s]
      LOGICAL, INTENT(IN), OPTIONAL :: KG_S
```

RETURN VALUE:

```
! Emissions output
REAL*8                          :: VALUE
```

REVISION HISTORY:

28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial Version

1.69.2 emiss_vistas_anthro

Subroutine EMISS_VISTAS_ANTHRO reads the VISTAS emission fields at 1x1 resolution and regrids them to the current model resolution.

INTERFACE:

```
SUBROUTINE EMISS_VISTAS_ANTHRO
```

USES:

```
USE BPCH2_MOD,          ONLY : GET_TAU0,      READ_BPCH2
USE DIRECTORY_MOD,      ONLY : DATA_DIR_1x1
USE LOGICAL_MOD,        ONLY : LFUTURE
USE REGRID_1x1_MOD,     ONLY : DO_REGRID_1x1
USE TIME_MOD,           ONLY : GET_YEAR, GET_MONTH
USE SCALE_ANTHRO_MOD,   ONLY : GET_ANNUAL_SCALAR_1x1

USE CMN_SIZE_MOD          ! Size parameters
USE CMN_O3_MOD            ! FSCALYR
```

REVISION HISTORY:

28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial Version

1.69.3 vistas_scale_future

Subroutine VISTAS_SCALE_FUTURE applies the IPCC future scale factors to the VISTAS anthropogenic emissions.

INTERFACE:

```
SUBROUTINE VISTAS_SCALE_FUTURE
```

USES:

```
USE FUTURE_EMISSIONS_MOD, ONLY : GET_FUTURE_SCALE_NOxff

USE CMN_SIZE_MOD             ! Size parameters
```

REVISION HISTORY:

28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial Version

1.69.4 total_anthro_Tg

Subroutine TOTAL_ANTHRO_TG prints the totals for the anthropogenic emissions of NOx.

INTERFACE:

```
SUBROUTINE TOTAL_ANTHRO_TG( YEAR, THISMONTH )
```

USES:

```
USE GRID_MOD,     ONLY : GET_AREA_CM2
USE TRACER_MOD,   ONLY : TRACER_MW_KG
USE TRACERID_MOD, ONLY : IDTNOX

USE CMN_SIZE_MOD   ! Size parameters
```

INPUT PARAMETERS:

```
! Year and month of data for which to compute totals
INTEGER, INTENT(IN) :: YEAR, THISMONTH
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.69.5 init_vistas_anthro

Subroutine INIT_VISTAS_ANTHRO allocates and zeroes all module arrays. (phs, 1/28/09)

INTERFACE:

```
SUBROUTINE INIT_VISTAS_ANTHRO
```

USES:

```
USE ERROR_MOD,   ONLY : ALLOC_ERR
USE GRID_MOD,    ONLY : GET_AREA_CM2
USE LOGICAL_MOD, ONLY : LVISTAS

USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.69.6 cleanup_vistas_anthro

Subroutine CLEANUP_VISTAS_ANTHRO deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_VISTAS_ANTHRO
```

REVISION HISTORY:

```
28 Jan 2009 - P. Le Sager - Initial Version
```

1.70 Fortran: Module Interface Individual GEOS-Chem subroutines

Here follows a list of GEOS-Chem subroutines which do not belong to any F90 module.

1.70.1 anthroems

Subroutine ANTHROEMS reads anthropogenic tracers for each season. NOx emissions at levels other than the surface are now accounted for.

INTERFACE:

```
SUBROUTINE ANTHROEMS( NSEASON )
```

USES:

```
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_ALK4ff
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_C2H6ff
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_C3H8ff
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_COff
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_NOxff
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_PRPEff
USE FUTURE_EMISSIONS_MOD,ONLY : GET_FUTURE_SCALE_TONEff
USE GEIA_MOD,            ONLY : READ_GEIA,    READ_C3H8_C2H6_NGAS
USE GEIA_MOD,            ONLY : READ_LIQCO2,  READ_TODX
USE GEIA_MOD,            ONLY : READ_TOTCO2,  TOTAL_FOSSIL_TG
USE GRID_MOD,            ONLY : GET_AREA_CM2, GET_XOFFSET
USE GRID_MOD,            ONLY : GET_YOFFSET
USE LOGICAL_MOD,         ONLY : LFUTURE
USE TIME_MOD,            ONLY : GET_TS_EMIS,  GET_YEAR
USE TIME_MOD,            ONLY : GET_SEASON
USE TRACER_MOD,          ONLY : TRACER_MW_KG
USE TRACERID_MOD,        ONLY : IDEACET,      IDEALK4
USE TRACERID_MOD,        ONLY : IDEC2H6,      IDEC3H8
USE TRACERID_MOD,        ONLY : IDECO,        IDEMEK
USE TRACERID_MOD,        ONLY : IDENOX,       IDEPRPE
USE TRACERID_MOD,        ONLY : NEMANTHRO
USE TRACERID_MOD,        ONLY : IDEBENZ,     IDETOLU,    IDEXYLE
USE TRACERID_MOD,        ONLY : IDEC2H4,      IDEC2H2
USE TRACERID_MOD,        ONLY : IDTBENZ,     IDTTOLU,    IDTXYLE
USE TRACERID_MOD,        ONLY : IDTC2H4,      IDTC2H2
USE SCALE_ANTHRO_MOD,    ONLY : GET_ANNUAL_SCALAR
USE SCALE_ANTHRO_MOD,    ONLY : GET_ANNUAL_SCALAR_05x0666_NESTED
USE EDGAR_MOD,           ONLY : READ_AROMATICS, READ_C2H4
USE EDGAR_MOD,           ONLY : READ_C2H2
USE EDGAR_MOD,           ONLY : READ_AROMATICS_05x0666
USE EDGAR_MOD,           ONLY : READ_C2H4_05x0666
USE EDGAR_MOD,           ONLY : READ_C2H2_05x0666

USE CMN_SIZE_MOD              ! Size parameters
```

```
      USE COMODE_LOOP_MOD              ! IDEMS
      USE CMN_O3_MOD                 ! EMIST, EMISR, EMISRR, etc.

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: NSEASON   ! Current season (1-4)
```

REMARKS:

```
    NSEASON:  is the seasonal index for NOx emissions:
      NSEASON=1 --> winter (Dec, Jan, Feb)
      NSEASON=2 --> spring (Mar, Apr, May)
      NSEASON=3 --> summer (Jun, Jul, Aug)
      NSEASON=4 --> autumn (Sep, Oct, Nov)

    Passed Via F77_CMN_O3:
    ============================================================================
    Fossil Fuel arrays: EMISTNOX,  EMISTCO,   EMISTETHE, EMISTPRPE,
                        EMISTC2H6, EMISTC3H8, EMISTALK4, EMISTACET,
                        EMISTMEK,  EMISTSOX

    Emissions arrays:   EMIST, EMISTN, EMISR, EMISRN, EMISRR, EMISRRN
```

REVISION HISTORY:

```
    04 Jun 1998 - R. Yantosca - Initial version
    (1 ) We now read the new merge file, created for SASS. (bey, 2/99)
    (2 ) ANTHROEMS should be called each time the season changes, since
         the GEIA NOx emissions are seasonal.
    (3 ) NOx emissions are stored separately in EMISTN, EMISRN, EMISRRN.
         This is because the NOx emissions can be located across several
         sigma levels, whereas the other tracers are only emitted into
         the surface level.
    (4 ) NO2 is no longer emitted as the emission species for Ox.
         (bey, bmy, 4/14/99)
    (5 ) There are 3 different types of scale factors for anthro emissions:
         (a) Yearly since 1985: done in anthroems.f
         (b) Weekday/weekend:   done in emf_scale.f
         (c) Time of day:       done in emfossil.f
    (6 ) At present NEMANTHRO = Total number of emitted tracers
         (set in tracerid.f).  We no longer use moments in emissions.
         ORDER = NOx, CO, PRPE, C3H8, ALK4, C2H6, ALD2.
    (7 ) NOx is assumed to be the first tracer (N=1).  The first usable
         row for tracers other than NOx in EMIST(I,J,N), etc. is N=2.
```

```
(8 ) Need to offset EMISR, which has global dimensions.
     EMIST has window dimensions.
(9 ) Now trap I/O errors and stop gracefully if file open or read
     errors are encountered.  Print an error message to alert user
     which file triggered the I/O error. (bmy, 4/14/99)
(10) Eliminate GISS-specific code and PLUMES code (bmy, 4/14/99)
(11) Now use F90 syntax where expedient. (bmy, 4/14/99)
(12) Cosmetic changes, added comments (bmy, 3/17/00)
(13) Do not let SCALYEAR go higher than 1996, since right now we don't
     have FF scaling data beyond 1996.  Also cosmetic changes and
     updated comments. (bmy, 4/6/01)
(14) Now reference routines from GEIA_MOD for reading scale factor and
     other emissions data from disk. (bmy, 4/23/01)
(15) Now read fossil-fuel emissions from a binary punch file (bmy, 4/23/01)
(16) CO and hydrocarbons are read from disk once per year.  Fossil fuel
     scale factors are also applied once per
(17) Now comment out LNAPAPNOX.  Also total fossil fuel emissions
     and echo to std output. (bmy, 4/27/01)
(18) Bug fix: Now convert units for CO, Hydrocarbon tracers only once
     per year.  Convert units for NOx once per season. (bmy, 6/7/01)
(19) Bug fix: Now index CH26 correctly when totaling it (bmy, 8/30/01)
(20) Now take C3H8 and C2H6 emissions as scaled from natural gas.  Read
     these in subroutine READ_C3H8_C2H6_NGAS.  Also scale anthropogenic
     ACET by 0.82 in order to match the acetone paper (bdf, bmy, 9/10/01)
(21) Removed obsolete, commented-out code from 6/01 (bmy, 11/26/01)
(22) Eliminated obsolete code from 11/01 (bmy, 2/27/02)
(23) Replaced all instances of IM with IIPAR and JM with JJPAR, in order
     to prevent namespace confusion for the new TPCORE (bmy, 6/25/02)
(24) Now reference IDTNOX, IDENOX, etc. from "tracerid_mod.f".  Also
     do not let SCALEYEAR exceed 1998. (bmy, 1/13/03)
(25) Now replace DXYP(JREF)*1d4 with routine GET_AREA_CM2 from "grid_mod.f"
     Now use functions GET_XOFFSET and GET_YOFFSET from "grid_mod.f".
     Now I0 and J0 are local variables.  Now use functions GET_TS_EMIS,
     GET_YEAR, GET_SEASON from "time_mod.f". (bmy, 2/11/03)
(26) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(27) Now replace FMOL with TRACER_MW_KG (bmy, 10/25/05)
(28) Modified for IPCC future emissions scale factors (swu, bmy, 5/30/06)
(29) Extend max value for FSCALYR to 2002 (bmy, 7/18/06)
(30) Use updated int'annual scale factors for 1985-2003 (amv, 08/24/07)
(31) As default, use EDGARv2.0 emission (fossil fuel + industry)
     for year 1985, scale to target year with CO2 from liquid fuel,
     for aromatics, C2H4, and C2H2. (tmf, 6/13/07)
(32) GET_ANNUAL_SCALAR_05x0666_NESTED_CH renamed to
     GET_ANNUAL_SCALAR_05x0666_NESTED (amv, bmy, 12/18/09)
19 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.70.2 boxvl

The new function BOXVL converts the DAO grid box volume values stored in AIRVOL from m3 to cm3. The conversion factor is (100)**3 = 1e6 cm3 per m3.

INTERFACE:

```
      REAL*8 FUNCTION BOXVL( I, J, L )
```

USES:

```
      USE DAO_MOD, ONLY : AIRVOL

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I   ! Longitude index
      INTEGER, INTENT(IN) :: J   ! Latitude index
      INTEGER, INTENT(IN) :: L   ! Level index
```

REVISION HISTORY:

```
   30 Jan 1998 - R. Yantosca - Initial version
   (1 ) F77_CMN_VOL is used to pass AIRVOL.
   (2 ) Use C-preprocessor #include statement to include F77_CMN_SIZE, which
        has IIPAR, JJPAR, LLPAR, IIPAR, JJPAR, LGLOB.
   (3 ) Now use F90 syntax for declarations (bmy, 10/5/99)
   (4 ) Now reference AIRVOL from "dao_mod.f" instead of from common
        block header file "F77_CMN_VOL". (bmy, 6/26/00)
   (5 ) Removed obsolete code from 6/26/00 (bmy, 8/31/00)
   (6 ) Updated comments (bmy, 8/5/02)
   02 Dec 2010 - R. Yantosca - Initial version
```

1.70.3 diag1

Subroutine DIAG1 accumulates diagnostic quantities on every dynamic timestep.

INTERFACE:

```
      SUBROUTINE DIAG1
```

USES:

```
      ! References to F90 modules
      USE DAO_MOD,        ONLY : AD,  AIRDEN, AVGW,     BXHEIGHT
      USE DAO_MOD,        ONLY : PBL, IS_ICE, IS_WATER, IS_LAND, IS_NEAR
      USE DIAG_MOD,       ONLY : AD30, AD31, AD33, AD35, AD45, AD54
      USE DIAG_MOD,       ONLY : AD47, AD67, AD68, AD69, LTOTH, LTO3
      USE DIAG_MOD,       ONLY : AD57
```

```
      USE DAO_MOD,         ONLY : T
      USE PRESSURE_MOD,    ONLY : GET_PCENTER
      USE GRID_MOD,        ONLY : GET_AREA_M2
      USE PRESSURE_MOD,    ONLY : GET_PEDGE
      USE TIME_MOD,        ONLY : ITS_TIME_FOR_CHEM
      USE TRACER_MOD,      ONLY : N_TRACERS, STT, TCVV
      USE TRACER_MOD,      ONLY : ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,      ONLY : XNUMOLAIR
      USE TRACERID_MOD,    ONLY : IDTOX
      USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP
#if   defined( APM )
      USE TRACER_MOD,      ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD  ! Size parameters
      USE CMN_O3_MOD    ! FRACO3
      USE CMN_DIAG_MOD  ! Diagnostic arrays & parameters
      USE CMN_GCTM_MOD  ! Physical constants

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
(1 ) This subroutine was reconstructed from gmg's version of (10/10/97)
(2 ) GISS-specific code has been eliminated (bmy, 3/15/99)
(3 ) UWND, VWND, WW no longer needs to be passed (bmy, 4/7/99)
(4 ) Use F90 syntax for declarations, etc (bmy, 4/7/99)
(5 ) Remove counter KWACC...this is now redundant (bmy, 11/5/99)
(6 ) ND31, ND33, ND35, ND67, and ND69 now use dynamically
     allocatable arrays declared in "diag_mod.f". (bmy, 3/9/00)
(7 ) LTOTH is now an allocatable array in "diag_mod.f". (bmy, 3/17/00)
(8 ) Add parallel loops over tracer where expedient (bmy, 5/4/00)
(9 ) Updated comments and diagnostics list.  Also add more parallel
     loops for ND31 and ND68.  (bmy, 6/21/00)
(10) Use NTRACE to dimension STT_VV instead of NNPAR (bmy, 10/17/00)
(11) Removed obsolete code from 10/17/00 (bmy, 12/21/00)
(12) Updated diagnostic list & comments, cosmetic changes (bmy, 6/19/01)
(13) Updated diagnostic list & comments (bmy, 9/4/01)
(14) Now reference AVGW from "dao_mod.f", and make sure it is allocated
     before we reference it in the ND68 diagnostic.  Also reference PBL,
     PS, AIRDEN from "dao_mod.f". (bmy, 9/25/01)
(15) Removed obsolete code from 9/01 (bmy, 10/23/01)
(16) Renamed ND33 to "ATMOSPHERIC COLUMN SUM OF TRACER", since this is
     a sum over all levels and not just in the troposphere.  Also
     removed more obsolete code from 9/01.  Now use P(I,J)+PTOP instead
     of PS, since that is the way to ensure that we use will be used
     consistently.  Remove reference to PS from "dao_mod.f"(bmy, 4/11/02)
```

```
(17) Replaced all instances of IM with IIPAR and JM with JJPAR, in order
     to prevent namespace confusion for the new TPCORE.  Also removed
     obsolete, commented-out code.  Also now replaced reference to
     P(IREF,JREF) with P(I,J). (bmy, 6/25/02)
(18) Replaced references to P(I,J) with call to GET_PEDGE(I,J,1) from
     "pressure_mod.f"  Eliminated obsolete commented-out code from
     6/02. (dsa, bdf, bmy, 8/20/02)
(19) Now reference AD, and BXHEIGHT from "dao_mod.f".  Removed obsolete
     code.  Now refEerence IDTOX from "tracerid_mod.f". (bmy, 11/6/02)
(20) Now replace DXYP(J) with routine GET_AREA_M2 from "grid_mod.f"
     (bmy, 2/4/03)
(21) Now compute PBL top for ND67 for GEOS-4/fvDAS.  Also now include
     SCALE_HEIGHT from header file "F77_CMN_GCTM". (bmy, 6/23/03)
(22) Now references N_TRACERS, STT, and ITS_A_FULLCHEM_SIM from
     "tracer_mod.f" (bmy, 7/20/04)
(23) Fixed ND67 PS-PBL for GCAP and GEOS-5 met fields (swu, bmy, 6/9/05)
(24) Now archive ND30 diagnostic for land/water/ice flags (bmy, 8/18/05)
(25) Now reference XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(26) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(27) Added count for time in the troposphere - array AD54 (phs, 9/22/06)
(28) Now only archive O3 in ND45 and ND47 at chem timsteps (phs, 1/24/07)
(29) Bug fix: Update ND30 for both GEOS-3 and otherwise.  Also now save
     3-D pressure edges in ND31 instead of PS-PTOP.  Revert to the !
     pre-near-land ND30 diagnostic algorithm. (bmy, 1/28/04)
(30) Use LTO3 for O3 in ND45. (ccc, 7/20/09)
(31) Add potential temperature diagnostic in ND57 (fp, 2/3/10)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
15 Feb 2011 - R. Yantosca - Added modifications for APM from G. Luo
```

REMARKS:

```
For a complete list of GEOS-Chem diagnostics, please see this web page:
   http://acmg.seas.harvard.edu/geos/doc/man/appendix_5.html
```

1.70.4 diag3

Subroutine DIAG3 prints out diagnostics to the BINARY PUNCH format file.

INTERFACE:

```
SUBROUTINE DIAG3
```

USES:

```
USE BPCH2_MOD
! NBIOMAX now refers to the maximum number of possible
! BB species (hotp 7/31/09)
! NBIOTRCE is the number for a given simulation and
```

```
! set of tracers
! NBIOMAX in F77_CMN_SIZE (FP)
USE BIOMASS_MOD,  ONLY : BIOTRCE !     NBIOMAX
USE BIOFUEL_MOD,  ONLY : NBFTRACE,    BFTRACE
USE DIAG_MOD,     ONLY : AD01,        AD02,        AD05
USE DIAG_MOD,     ONLY : AD06,        AD07,        AD07_BC
USE DIAG_MOD,     ONLY : AD07_SOAGM
USE DIAG_MOD,     ONLY : AD07_OC,     AD07_HC,     AD08
USE DIAG_MOD,     ONLY : AD09,        AD09_em,     AD11
USE DIAG_MOD,     ONLY : AD12,        AD13_DMS,    AD13_SO2_ac
USE DIAG_MOD,     ONLY : AD13_SO2_an, AD13_SO2_bb, AD13_SO2_bf
USE DIAG_MOD,     ONLY : AD13_SO2_ev, AD13_SO2_nv, AD13_SO4_an
USE DIAG_MOD,     ONLY : AD13_SO4_bf, AD13_SO2_sh, AD13_NH3_an
USE DIAG_MOD,     ONLY : AD13_NH3_na, AD13_NH3_bb, AD13_NH3_bf
USE DIAG_MOD,     ONLY : CONVFLUP,    TURBFLUP,    AD16
USE DIAG_MOD,     ONLY : CT16,        AD17,        CT17
USE DIAG_MOD,     ONLY : AD18,        CT18,        AD21
USE DIAG_MOD,     ONLY : AD21_cr,     AD22,        LTJV
USE DIAG_MOD,     ONLY : CTJV,        MASSFLEW,    MASSFLNS
USE DIAG_MOD,     ONLY : MASSFLUP,    AD28,        AD29
USE DIAG_MOD,     ONLY : AD30,        AD31
! potential temperature (hotp 7/31/09)
USE DIAG_MOD,     ONLY : AD57
USE DIAG_MOD,     ONLY : AD32_ac,     AD32_an,     AD32_bb
USE DIAG_MOD,     ONLY : AD32_bf,     AD32_fe,     AD32_li
USE DIAG_MOD,     ONLY : AD32_so,     AD32_ub,     AD33
USE DIAG_MOD,     ONLY : AD34,        AD35,        AD36
USE DIAG_MOD,     ONLY : AD37,        AD38,        AD39
USE DIAG_MOD,     ONLY : AD43,        LTNO
USE DIAG_MOD,     ONLY : CTNO,        LTOH,        CTOH
USE DIAG_MOD,     ONLY : LTHO2,       CTHO2,       LTNO2
USE DIAG_MOD,     ONLY : CTNO2,       LTNO3,       CTNO3
! update for arom (dkh, 06/21/07)
! to save the amount of RO2 consumed by HO2 (*H) or NO (*N)
! CTLxRO2x : # of times a grid box was in the ND43 time range between
! the last .bpch write and current .bpch write
USE DIAG_MOD,     ONLY : CTLBRO2H,      CTLBRO2N
USE DIAG_MOD,     ONLY : CTLTRO2H,      CTLTRO2N
USE DIAG_MOD,     ONLY : CTLXRO2H,      CTLXRO2N
USE DIAG_MOD,     ONLY : AD44,        AD45,        LTOTH
USE DIAG_MOD,     ONLY : CTOTH,       AD46,        AD47
USE DIAG_MOD,     ONLY : AD52
USE DIAG_MOD,     ONLY : AD54,        CTO3,        CTO3_24h
USE DIAG_MOD,     ONLY : AD19,        AD58,        AD60
USE DIAG_MOD,     ONLY : AD55,        AD66,        AD67
USE DIAG_MOD,     ONLY : AD68,        AD69
USE DIAG_MOD,     ONLY : AD10,        AD10em
USE DIAG03_MOD,   ONLY : ND03,        WRITE_DIAG03
```

```
      USE DIAG04_MOD,   ONLY : ND04,        WRITE_DIAG04
      USE DIAG41_MOD,   ONLY : ND41,        WRITE_DIAG41
      USE DIAG42_MOD,   ONLY : ND42,        WRITE_DIAG42
      USE DIAG56_MOD,   ONLY : ND56,        WRITE_DIAG56
      USE DIAG_PL_MOD,  ONLY : AD65
      ! For mercury simulation. (ccc, 6/4/10)
      USE DEPO_MERCURY_MOD, ONLY : UPDATE_DEP
      USE DRYDEP_MOD,   ONLY : NUMDEP,      NTRAIND
      ! To handle tracers with several dry dep. tracers
      !(ccc, 2/3/10)
      USE DRYDEP_MOD,   ONLY : DEPNAME
      USE FILE_MOD,     ONLY : IU_BPCH
      USE GRID_MOD,     ONLY : GET_AREA_M2, GET_XOFFSET, GET_YOFFSET
      USE LOGICAL_MOD,  ONLY : LCARB,       LCRYST,      LDUST
      USE LOGICAL_MOD,  ONLY : LSHIPSO2,    LSOA,        LSSALT
      USE LOGICAL_MOD,  ONLY : LEDGARSHIP,  LARCSHIP,    LEMEPSHIP
      USE LOGICAL_MOD,  ONLY : LICOADSSHIP, LGTMM

      USE TIME_MOD,     ONLY : GET_DIAGb,   GET_DIAGe,   GET_CT_A3
      USE TIME_MOD,     ONLY : GET_CT_A6,   GET_CT_CHEM, GET_CT_CONV
      USE TIME_MOD,     ONLY : GET_CT_DYN,  GET_CT_EMIS, GET_CT_I6
      USE TIME_MOD,     ONLY : GET_CT_DIAG, GET_CT_A1
      USE TRACER_MOD,   ONLY : N_TRACERS,   STT,         TRACER_MW_G
      USE TRACER_MOD,   ONLY : TRACER_NAME
      USE TRACER_MOD,   ONLY : ITS_AN_AEROSOL_SIM
      USE TRACER_MOD,   ONLY : ITS_A_CH3I_SIM
      USE TRACER_MOD,   ONLY : ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,   ONLY : ITS_A_H2HD_SIM
      USE TRACER_MOD,   ONLY : ITS_A_MERCURY_SIM
      USE TRACER_MOD,   ONLY : ITS_A_RnPbBe_SIM
      USE TRACER_MOD,   ONLY : ITS_A_TAGOX_SIM
      USE TRACERID_MOD, ONLY : IDTPB,       IDTDST1,     IDTDST2
      USE TRACERID_MOD, ONLY : IDTDST3,     IDTDST4,     IDTBCPI
      USE TRACERID_MOD, ONLY : IDTOCPI,     IDTALPH,     IDTLIMO
      USE TRACERID_MOD, ONLY : IDTSOA1,     IDTSOA2,     IDTSOA3
      ! aromatic SOA
      USE TRACERID_MOD, ONLY : IDTSOA5
      USE TRACERID_MOD, ONLY : IDTSALA,     IDTSALC,     IDTDMS
      USE TRACERID_MOD, ONLY : IDTSO2,      IDTSO4,      IDTNH3
      USE TRACERID_MOD, ONLY : IDTOX,       IDTNOX,      IDTHNO3
      USE TRACERID_MOD, ONLY : IDTISOP,     IDTACET,     IDTPRPE
      USE TRACERID_MOD, ONLY : IDTH2,       IDTHD
      USE TRACERID_MOD, ONLY : NEMANTHRO ,  IDTSOA4
      USE TRACERID_MOD, ONLY : IDTSOAG,     IDTSOAM
      USE TRACERID_MOD, ONLY : IDTMONX,     IDTMBO,      IDTC2H4
      USE TRACERID_MOD, ONLY : IS_Hg2
      USE WETSCAV_MOD,  ONLY : GET_WETDEP_NSOL
      USE WETSCAV_MOD,  ONLY : GET_WETDEP_IDWETD
```

```
#if   defined( APM )
      USE DIAG_MOD,     ONLY : AD07_OM
      USE TRACER_MOD,   ONLY : N_APMTRA
      USE APM_DRIV_MOD, ONLY : IFTEMPOUT
      USE APM_DRIV_MOD, ONLY : TEMPOUT
      USE APM_DRIV_MOD, ONLY : NTEMPOUT
      USE APM_DRIV_MOD, ONLY : NPOUTSTEPS
#endif

      USE CMN_SIZE_MOD     ! Size parameters
      USE COMODE_LOOP_MOD     ! IDEMS
      USE CMN_O3_MOD       ! FMOL, XNUMOL
      USE CMN_DIAG_MOD     ! Diagnostic switches & arrays
      USE CMN_MOD          ! IFLX, LPAUSE

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

(40) Bug fix: Save levels 1:LD13 for ND13 diagnostic for diagnostic categories "SO2-AC-$" and "SO2-EV-$". Now reference F90 module "tracerid_mod.f". Now reference NUMDEP from "drydep_mod.f". Now save anthro, biofuel, biomass NH3 in ND13; also fixed ND13 tracer numbers. For ND13, change scale factor from SCALESRCE to 1. Now references "wetscav_mod.f". Now also save true tracer numbers for ND38 and ND39 diagnostic. Now also write out biomass SO2. Now convert ND01, ND02, ND44 diagnostics for Rn/Pb/Be from kg to kg/s here. (bmy, 1/24/03)

(41) Now save out natural NH3 in ND13 as "NH3-NATU" (rjp, bmy, 3/23/03)

(42) Now replace DXYP(JREF) by routine GET_AREA_M2, GET_XOFFSET, and GET_YOFFSET of "grid_mod.f". Now references "time_mod.f". DIAGb, DIAGe are now local variables. Now remove obsolete statements IF (LBPNCH > 0). Removed SCALE1, replaced with SCALEDYN. (bmy, 2/24/03)

(43) Added TSKIN, PARDF, PARDR, GWET to ND67 diagnostic. For GEOS-4/fvDAS, UWND, VWND, TMPU, SPHU are A-6 fields. Adjust the ND66 scale factors accordingly. Delete KZZ from ND66. Updated comments. (bmy, 6/23/03)

(44) Bug fix: use LD68 instead of ND68 in DO-loop to avoid out-of-bounds error. (bec, bmy, 7/15/03)

(45) Now print out NTRACE drydep fluxes for tagged Ox. Also tagged Ox now saves drydep in molec/cm2/s. Now print out Kr85 prod/loss in ND03. (bmy, 8/20/03)

(46) Now use actual tracer number for ND37 diagnostic. (bmy, 1/21/04)

(47) Now loop over the actual # of soluble tracers for ND17, ND18. (bmy, 3/19/04)

(48) Now use the actual tracer # for ND17 and ND18 diagnostics.

```
      Rearrange ND44 code for clarity. (bmy, 3/23/04)
(49) Added ND06 (dust aerosol) and ND07 (carbon aerosol) diagnostics.
      Now scale online dust optical depths by SCALECHEM in ND21 diagnostic.
      (rjp, tdf, bmy, 4/5/04)
(50) Added ND08 (seasalt aerosol) diagnostic (rjp, bec, bmy, 4/20/04)
(51) Now save out SO2 from ships (if LSHIPSO2=T) (bec, bmy, 5/20/04)
(52) Added NVOC source diagnostics for ND07 (rjp, bmy, 7/13/04)
(53) Now reference "logical_mod.f", "tracer_mod.f", and "diag_pl_mod.f".
      Bug fix in write to DMS_BIOG. (bmy, 7/20/04)
(54) Comment out ND27 for GEOS-4.  It isn't working 100% right.  If you
      examine the flux at 200 hPa, you get the same info. (bmy, 10/15/04)
(55) Added biofuel SO4 to the bpch file under ND13.  Bug fix: replace ND68
      with LD68 in call to BPCH2 (auvray, bmy, 11/17/04)
(56) Now save ND03 mercury diagnostic arrays to bpch file.  Also updated
      ND44 for tagged Hg tracers (eck, bmy, 12/14/04)
(57) Now print out extra ND21 diagnostics for crystalline sulfur tracers.
      Also now save total oceanic mass of Hg0 and Hg2.  Now call
      WRITE_DIAG03 from "diag03_mod.f" (bmy, 1/21/05)
(58) Now call WRITE_DIAG41 from "diag41_mod.f" (bmy, 2/17/05)
(59) Add P(SO4s) to row 8 of ND05 diagnostic.  Also remove special tracer
      numbers for the ND67 diagnostic.  Now do not save CLDMAS for ND67
      for GEOS-4, since GEOS-4 convection uses different met fields.
      (bec, bmy, 5/3/05)
(60) Bug fix in ND68 diagnostic: use LD68 instead of ND68 in call to BPCH2.
      Now modified for GEOS-5 and GCAP met fields.  Remove references to
      CO-OH param simulation.  Also remove references to TRCOFFSET since
      that is always zero now.  Now call GET_HALFPOLAR from "bpch2_mod.f"
      to get the HALFPOLAR value for GEOS or GCAP grids. (swu, bmy, 6/24/05)
(61) References ND04, WRITE_DIAG04 from "diag04_mod.f".  Also now updated
      ND30 diagnostic for land/water/ice flags.  Also remove reference
      to LWI array. (bmy, 8/18/05)
(62) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(63) Added MBO as tracer #5 in ND46 diagnostic (tmf, bmy, 10/20/05)
(64) Removed duplicate variable declarations.  Now remove restriction on
      printing out cloud mass flux in GEOS-4 for the ND66 diagnostic.
      (bmy, 3/14/06)
(65) References ND56, WRITE_DIAG56 from "diag56_mod.f" (ltm, bmy, 5/5/06)
(66) Now remove TRCOFFSET; it's obsolete.  References ND42, WRITE_DIAG42
      from "diag42_mod.f" (dkh, bmy, 5/22/06)
(67) Updated ND36 diagnostic for CH3I (bmy, 7/25/06)
(68) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(69) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
      (bmy, 9/5/06)
(70) Now write diag 54 (time in the troposphere) if asked for (phs, 9/22/06)
(71) Now use new time counters for ND43 & ND45,  Also now average between
      0 and 24 UT for ND47.  Bug fix in ND36. (phs, bmy, 3/5/07)
(72) Bug fix in ND65: use 3-D counter array (phs, bmy, 3/6/07)
(73) Bug fix in ND07: now save out IDTSOA4 tracer.  Modifications for H2/HD
```

```
      diagnostics (ND10, ND27, ND44) (tmf, phs, bmy, 9/18/07)
(74) Now save out true pressure at 3-D level edges for ND31.  Change ND31
      diagnostic category name to "PEDGE-$". Bug fix in ND28 diagnostic to
      allow you to print out individual biomass tracers w/o having to print
      all of them. (bmy, dkh, 1/24/08)
(75) Bug fix: Now divide ALBEDO in ND67 by SCALE_I6 for GEOS-3 met, but
      by SCALE_A3 for all other met types (phs, bmy, 10/7/08)
(76) Fix ND65, ND47, and ozone case in ND45. Now only ND45 depends
      on LD45 (phs, 11/17/08)
(77) Bug fix: Select the right index of AD34 to write.  Pick the right
       tracer field from AD22 if only a subset of tracers are requested
       to be printed out. (ccc, 12/15/08)
(78) Added ND52 for gamma(HO2) (jaegle, 02/26/09)
(79) Updated test on ship emissions flag for AD13 (phs, 3/3/09)
(80) Add AD07_SOAGM for dicarbonyl SOA formation (tmf, 3/6/09)
(81) Add output in AD22 for dicarbonyl photolysis J values (tmf, 3/6/09)
(82) Add output in AD46 for biogenic C2H4 emissions (tmf, 3/6/09)
(83) Modify ND17, ND18, ND37, ND38, ND44 to output the tracers selected
      by the user. (ccc, 5/29/09)
(84) Add EFLUX output information for ND67. (lin, ccc, 5/29/09)
(85) Add test on ICOADS (cklee, 06/30/09)
(86) Add SCALE_DIAG to scale diagnostics with the number of accumulation
      steps. (ccc, 7/20/09)
(87) Add diagnostics 19, 58 and 60 for methane. (kjw, 8/18/09)
(88) Account for 3D AD13_NH3_an now (phs, 10/22/09)
(89) NBIOMAX is now in F77_CMN_SIZE (hotp 7/31/09)
(90) Add SOA5 to ND07_HC, add AD57 for potential temperature. (fp, 2/3/10)
(91) Modify ND44 for tracers with several deposition tracers. (ccc, 2/3/10)
(92) Add aromatics to ND43. (dkh, 06/21/07)
(93) Add ND57 for potential temperature. (fp, 2/3/10)
(94) Re-order levels in mass fluxes diagnostics before writing them to file.
     (ND24, 25, 26). (ccc, 3/8/10)
(95) Add call to update_dep for mercury simulation at the end.(ccc, 7/19/10)
20 Aug 2010 - R. Yantosca - Added ProTeX headers
20 Aug 2010 - R. Yantosca - Now pick proper scale for ND66 for MERRA
20 Aug 2010 - R. Yantosca - Now pick proper scale for ND67 for MERRA
20 Aug 2010 - R. Yantosca - Now added SCALE_A1 for hourly data
20 Aug 2010 - R. Yantosca - Now reference GET_A1_TIME from "time_mod.f"
26 May 2011 - R. Yantosca - For ND44, omit the special treatment of
                            isoprene tracers if we are not doing fullchem
27 May 2011 - R. Yantosca - Now use SCALEDIAG for ND54 (time-in-trop) diag
```

1.70.5 diag_2pm

Subroutine DIAG_2PM constructs the diagnostic flag arrays:

- LTJV: J-values (ND22)

- LTOH: OH concentrations (ND43)
- LTNO: NO concentrations (ND43)
- LTNO2: NO2 concentrations (ND43)
- LTHO2: HO2 concentrations (ND43)
- LTOTH: used for tracers (ND45)
- LTO3: for O3 (ND45)

These arrays are either 1 (if it is within a certain time interval) or 0 (if it is not within a certain time interval). The limits of the time intervals for CTOTH and CTJV are now defined in input.geos The arrays CTOTH, CTOH, CTNO, CTJV count the number of times the diagnostics are accumulated for each grid box (i.e LTOTH is 1)

INTERFACE:

```
      SUBROUTINE DIAG_2PM
```

USES:

```
      USE DIAG_MOD,       ONLY : LTJV,  CTJV,  LTNO,  CTNO,  CTO3
      USE DIAG_MOD,       ONLY : LTOH,  CTOH,  LTOTH, CTOTH, LTNO2
      USE DIAG_MOD,       ONLY : CTNO2, LTHO2, CTHO2, LTNO3, CTNO3
      USE DIAG_MOD,       ONLY : CTO3_24h, LTO3
      USE DIAG_MOD,       ONLY : LTLBRO2H, LTLBRO2N
      USE DIAG_MOD,       ONLY : LTLTRO2H, LTLTRO2N
      USE DIAG_MOD,       ONLY : LTLXRO2H, LTLXRO2N
      USE DIAG_MOD,       ONLY : CTLBRO2H, CTLBRO2N
      USE DIAG_MOD,       ONLY : CTLTRO2H, CTLTRO2N
      USE DIAG_MOD,       ONLY : CTLXRO2H, CTLXRO2N
      USE TIME_MOD,       ONLY : GET_LOCALTIME
      USE TIME_MOD,       ONLY : ITS_TIME_FOR_DIAG, ITS_TIME_FOR_CHEM
      USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP
      USE TIME_MOD,       ONLY : GET_ELAPSED_MIN
      USE TIME_MOD,       ONLY : GET_TS_DIAG

      USE CMN_SIZE_MOD   ! Size parameters
      USE CMN_DIAG_MOD   ! HR_OH1, HR_OH2, etc.

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
   26 Mar 1999 - R. Yantosca - Initial version
   (1 ) Now use F90 syntax (bmy, 3/26/99)
   (2 ) Now reference LTNO2, CTNO2, LTHO2, CTHO2 arrays from "diag_mod.f".
        Updated comments, cosmetic changes.  (rvm, bmy, 2/27/02)
```

```
(3 ) Now removed NMIN from the arg list.  Now use functions GET_LOCALTIME,
     ITS_TIME_FOR_CHEM, ITS_TIME_FOR_DYN from "time_mod.f" (bmy, 2/11/03)
(4 ) Now rewritten using a parallel DO-loop (bmy, 7/20/04)
(5 ) Now account for the time spent in the troposphere for ND43 and ND45
     pure O3.  Now only accumulate counter for 3D pure O3 in ND45 if
     it's a chemistry timestep. (phs, 1/24/07)
(6 ) Added 3D counter for ND65 and O3 in ND47 (phs, 11/17/08)
(7 ) Change re-initialization of ND45: only at the timestep after the
     diagnostics are accumulated. Add ITS_AFTER_DIAG and PREV_TS variables.
     (ccc, 6/12/09)
(8 ) Add LTO3 to accumulate O3 in ND45 at the same place as the
     chemistry (ccc, 7/17/09)
```

1.70.6 diagoh

Subroutine DIAGOH saves chemical diagnostic quantities for the ND43 chemical diagnostics.

INTERFACE:

```
      SUBROUTINE DIAGOH
```

USES:

```
      USE DIAG_MOD, ONLY: AD43, LTNO, LTOH, LTNO2, LTHO2, LTNO3

      USE CMN_SIZE_MOD  ! Size parameters
      USE CMN_O3_MOD    ! SAVEOH, SAVENO
      USE CMN_DIAG_MOD  ! Diagnostic switches & arrays

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
01 May 1998 - R. Yantosca - Initial version
(1 ) Now use F90 syntax for declarations (bmy, 3/29/99)
(2 ) Cosmetic changes (bmy, 3/29/99)
(3 ) AD43 and DIAGCHLORO are now declared allocatable in "diag_mod.f".
     Also eliminate obsolete code. (bmy, 11/29/99)
(4 ) LTNO, LTOH are now allocatable arrays in "diag_mod.f" (bmy, 3/17/00)
(5 ) Don't save OH into STT(:,:,:NTRACER+2) anymore.  The SAVEOH
     array is now used to save OH concentrations for diagnostics.
     Also revised out-of-date comments. (bmy, 4/24/00)
(6 ) Also save out NO2 and HO2 for use w/ the ND43 diagnostic.
     Now also reference LTNO2, LTHO2 arrays from "diag_mod.f".
```

```
      Updated comments, cosmetic changes. (rvm, bmy, 2/27/02)
(7 ) Removed obsolete reference to DIAGCHLORO (bmy, 8/2/02)
(8 ) Now save NO3 [molec/cm3] as AD43(:,:,:,5) (bmy, 1/13/03)
(9 ) Corrected typo in comments (bmy, 8/10/09)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.70.7 emfossil

Subroutine EMFOSSIL emits fossil fuels into the EMISRR and EMISRRN arrays, which are then passed to SMVGEAR.

INTERFACE:

```
SUBROUTINE EMFOSSIL( I, J, N, NN, IREF, JREF, JSCEN )
```

USES:

```
USE BRAVO_MOD,          ONLY : GET_BRAVO_ANTHRO, GET_BRAVO_MASK
USE CAC_ANTHRO_MOD,     ONLY : GET_CANADA_MASK,  GET_CAC_ANTHRO
USE DAO_MOD,            ONLY : IS_WATER
USE DIAG_MOD,           ONLY : AD29,   AD32_an,  AD36
USE EDGAR_MOD,          ONLY : GET_EDGAR_CO,     GET_EDGAR_NOx
USE EDGAR_MOD,          ONLY : GET_EDGAR_TODN
USE EMEP_MOD,           ONLY : GET_EMEP_ANTHRO,  GET_EUROPE_MASK
USE EPA_NEI_MOD,        ONLY : GET_EPA_ANTHRO,   GET_USA_MASK
USE GRID_MOD,           ONLY : GET_AREA_CM2
USE LOGICAL_MOD,        ONLY : LBRAVO, LEMEP,    LNEI99
USE LOGICAL_MOD,        ONLY : LEDGARNOx,        LEDGARCO
USE LOGICAL_MOD,        ONLY : LSTREETS,         LCAC
USE LOGICAL_MOD,        ONLY : LEDGARSHIP,       LARCSHIP
USE LOGICAL_MOD,        ONLY : LEMEPSHIP,        LVISTAS
USE LOGICAL_MOD,        ONLY : LICARTT,          LNEI05
USE LOGICAL_MOD,        ONLY : LRETRO
USE RETRO_MOD,          ONLY : GET_RETRO_ANTHRO
USE NEI2005_ANTHRO_MOD, ONLY : GET_NEI2005_ANTHRO
USE NEI2005_ANTHRO_MOD, ONLY : NEI05_MASK => USA_MASK
USE LOGICAL_MOD,        ONLY : LICOADSSHIP !(cklee, 6/30/09)

USE STREETS_ANTHRO_MOD, ONLY : GET_SE_ASIA_MASK
USE STREETS_ANTHRO_MOD, ONLY : GET_STREETS_ANTHRO
USE TIME_MOD,           ONLY : GET_TS_EMIS,      GET_DAY_OF_WEEK
USE TIME_MOD,           ONLY : GET_HOUR
USE TRACER_MOD,         ONLY : ITS_A_TAGCO_SIM
USE TRACER_MOD,         ONLY : XNUMOL
USE TRACERID_MOD,       ONLY : IDENOX, IDEOX,    IDEHNO3
USE TRACERID_MOD,       ONLY : IDTOX,  IDTCO,    IDTHNO3
USE VISTAS_ANTHRO_MOD,  ONLY : GET_VISTAS_ANTHRO
USE ICOADS_SHIP_MOD,    ONLY : GET_ICOADS_SHIP !(cklee, 7/09/09)
```

```
      USE CMN_SIZE_MOD              ! Size parameters
      USE COMODE_LOOP_MOD              ! IHOUR
      USE CMN_O3_MOD                ! EMISR, EMISRR, etc...
      USE CMN_DIAG_MOD              ! Diagnostic switches & arrays

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)   :: I       ! GEOS-Chem longitude index
      INTEGER, INTENT(IN)   :: J       ! GEOS-Chem latitude index
      INTEGER, INTENT(IN)   :: N       ! GEOS-Chem emission species index
      INTEGER, INTENT(IN)   :: NN      ! GEOS-Chem advected tracer index
      INTEGER, INTENT(IN)   :: IREF    ! Offset index I+I0
      INTEGER, INTENT(IN)   :: JREF    ! Offset index J+J0
      INTEGER, INTENT(IN)   :: JSCEN   ! Day index (Sat=1, Sun=2, Weekday=3)
```

REMARKS:

```
    In most cases, I0=J0=0, so IREF=I and JREF=J.  The offsets I0 and J0 are
    mostly historical baggage.
```

REVISION HISTORY:

```
    19 Apr 1999 - R. Yantosca - Initial version
    (1 ) Uses the correct seasonal NOx and multi-level NOx (anthroems.f)
    (2 ) Uses anthro scale factors for years since 1985 (from anthroems.f)
    (3 ) Scales emissions based on weekday/weekend (emf_scale.f)
    (4 ) Preserves old sensitivity study cases (emf_scale.f, emissdr.f)
    (5 ) Scales emissions based on time of day (emfossil.f)
    (6 ) Get rid of all GISS and PLUMES code (bmy, 4/19/99)
    (7 ) Now use F90 syntax for declarations, etc. (bmy, 4/19/99)
    (8 ) Now use allocatable arrays for ND29 and ND36 diagnostics.
         Also made minor cosmetic changes & updated comments. (bmy, 3/16/00)
    (9 ) Eliminate obsolete code and ND63 diagnostic (bmy, 4/12/00)
    (10) Enhance anthropogenic CO emission by 8%, to account for CO production
         from oxidation of anthropogenic VOC's (bnd, bmy, 1/2/01)
    (11) Comment out scaling by 1.08 for anthro CO (bmy, 2/12/01)
    (12) Eliminate obsolete commented-out code (bmy, 4/20/01)
    (13) Now use 2% as the enhancment factor for CO instead of 1.08,
         according to new jal numbers (bmy, 4/26/01)
    (14) Now references "tracerid_mod.f" (bmy, 11/6/02)
    (15) Now replaced DXYP(JREF)*1d4 with GET_AREA_CM2(J).  Now use function
         GET_TS_EMIS() from "time_mod.f" (bmy, 2/11/03)
    (16) Now can overwrite existing emissions with EPA/NEI data over the
```

```
      continental USA if LNEI99=T.  Now reference LNEI99 from F90
      module "logical_mod.f".  Now reference GET_EPA_ANTHRO and
      GET_USA_MASK from "epa_nei_mod.f". (rch, rjp, bmy, 11/5/04)
(17) Now references GET_DAY_OF_WEEK from "time_mod.f" to correctly figure
      out if this is a weekday or weekend. (bmy, 7/6/05)
(18) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(19) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(20) Now apply EMEP European emissions if necessary.  Remove reference
      to CMN, it's now obsolete. (bdf, bmy, 11/1/05)
(21) Rewrite IF statements to avoid seg fault errors when LEMEP and LNEI99
      are turned off. (bmy, 2/1/06)
(22) Now apply BRAVO Mexican emissions if necessary (rjp, kfb, bmy, 6/26/06)
(23) Now apply EDGAR emissions if necessary.  Also now only do the the
      EDGAR, EPA, EMEP, and BRAVO function calls in the LL=1 block.
      (avd, bmy, 7/10/06)
(24) Now do BRAVO emissions before EPA/NEI99 emissions in order to avoid
      zero emissions in some boxes.  Now add David Streets emissions for
      NOx over SE Asia and CO over just China (yxw, bmy, 8/17/06)
(25) Bug fix: Now only execute EDGAR CO block if the tracer is CO.
      Also, David Streets' CO is now applied over SE ASIA. (bmy, 9/8/06)
(26) Now references ITS_A_TAGCO_SIM from "tracer_mod.f".  Enhance CO prod
      by 18.5% for tagged CO sim here instead of in "tagged_co_mod.f".
      (bmy, 2/14/08)
(27) Use more robust test to only screen out "missing" values in EMEP,
      BRAVO, and David Streets emissions. (avd, phs, bmy, 11/19/08)
(28) Ship NOx is emitted as HNO3+10*O3  (phs, 3/4/08)
(29) Apply spatially-varying diurnal scalars for NOx (amv, 08/24/07)
(30) Now apply CAC Canadian emissions if necessary (amv, 01/09/08)
(31) Moved down BRAVO parts and add BRAVO and EPA emissions where they
      overlap (phs, 5/7/08)
(32) Now overwrite USA NOx with VISTAS if necessary (amv, 12/02/08)
(33) Modified CO scaling (jaf, 2/25/09)
(34) Add a test on existing emissions for EPA/NEI. (hotp, ccc, 5/29/09)
(35) Updated ship treatment (phs, 7/0/09)
(36) Add NEI2005 (amv, phs, 10/20/09)
(37) Bug fix for tagged CO and 0.5 x 0.666 Nested Grid (yxw, bmy, 11/23/09)
(38) Bug fix for array EMISRR, if emissions are already present in this
      array (e.g. ship O3 or HNO3) they no longer get overwritten.
      (gvinken, 11/16/10)
19 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.70.8 emf_scale

Subroutine EMF_SCALE does the following:

- Saves original values of EMISR, EMISRN, EMISPN so that they can be restored later (after scaling)

- Scales emissions to weekend or weekday usage (using scale factors stored in the SCNR89 array)

INTERFACE:

```
      SUBROUTINE EMF_SCALE( I,    J,    N,     NN,
     &                      IREF, JREF, JSCEN, XEMISR, XEMISRN )
```

USES:

```
      USE TRACERID_MOD, ONLY : IDTALK4, IDTC3H8, IDTISOP, IDTCO
      USE TRACERID_MOD, ONLY : IDTNOX,  IDTOX,   IDTPRPE
      USE TRACERID_MOD, ONLY : IDTMEK,  IDTC2H2, IDTC2H4, IDTACET
      USE TRACERID_MOD, ONLY : IDTBENZ, IDTTOLU, IDTXYLE, IDTC2H6

      USE CMN_SIZE_MOD
      USE COMODE_LOOP_MOD
      USE CMN_O3_MOD

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)    :: I       ! GEOS-Chem longitude index
      INTEGER, INTENT(IN)    :: J       ! GEOS-Chem latitude index
      INTEGER, INTENT(IN)    :: N       ! GEOS-Chem emission species index
      INTEGER, INTENT(IN)    :: NN      ! GEOS-Chem advected tracer index
      INTEGER, INTENT(IN)    :: IREF    ! Offset index I+I0
      INTEGER, INTENT(IN)    :: JREF    ! Offset index J+J0
      INTEGER, INTENT(IN)    :: JSCEN   ! Day index (Sat=1, Sun=2, Weekday=3)
```

INPUT/OUTPUT PARAMETERS:

```
      REAL*8,  INTENT(INOUT) :: XEMISR               ! HC emissions, scaled
      REAL*8,  INTENT(INOUT) :: XEMISRN(NOXLEVELS)   ! NOx emissions, scaled
```

REMARKS:

```
    This is historical baggage...we need to clean this up one of these days.
```

REVISION HISTORY:

```
    02 Apr 1998 - R. Yantosca - Initial version
    (1 ) Use F90 syntax for declarations, etc. (bmy, 4/14/99)
    (2 ) Now test with N instead of NN.  N is the emission species, and can
         be equal to zero, which denotes that the species is not emitted.
         This is necessary now, since IDEOX always = 0, but IDTOX is always
         nonzero. (bmy, 4/19/99)
```

```
(3 ) Commented out special cases via ICASE.  Also made a few cosmetic
     changes and updated comments. (bmy, 1/2/01)
(4 ) Remove old obsolete commented-out code (bmy, 4/20/01)
(5 ) Now references "tracerid_mod.f" (bmy, 11/6/02)
(6 ) Now references LFFNOX from "logical_mod.f" (bmy, 7/20/04)
(7 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(8 ) Modified to add weekday/weekend scaling to aromatics,
     C2H4, C2H2 (tmf, 1/7/09)
19 Nov 2010 - R. Yantosca - Added ProTeX headers
```

1.70.9 emmonot

Subroutine EMMONOT computes the BIOGENIC MONOTERPENE EMISSIONS for each grid box in units of [atoms C/box/step].

INTERFACE:

```
      FUNCTION EMMONOT( IJLOOP, TMMP, XNUMOL )
```

USES:

```
      USE CMN_SIZE_MOD             ! Size parameters
      USE CMN_MONOT_MOD            ! BASEMONOT
      USE CMN_VEL_MOD              ! XYLAI, IJREG, IJLAND, IJUSE

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: IJLOOP   ! 1-D grid box index
      REAL*8,  INTENT(IN) :: TMMP     ! Local air temperature (K)
      REAL*8,  INTENT(IN) :: XNUMOL   ! Number of atoms C / kg C
```

RETURN VALUE:

```
      REAL*8              :: EMMONOT
```

REMARKS:

```
Important Common Block Variables:
================================================================================
(1 ) XYLAI     (F77_CMN_VEL ) : Leaf Area Index of land type for current MONTH
(2 ) IJREG     (F77_CMN_VEL ) : Number of Olson land types per grid box
(3 ) IJLAND+1  (F77_CMN_VEL ) : Olson land type index
(4 ) IJUSE     (F77_CMN_VEL ) : Olson land type fraction per box (in mils)
(5 ) BASEMONOT (F77_CMN_ISOP) : Baseline MONOTERPENE emissions [kg C/box/step]
```

REVISION HISTORY:

```
04 Sep 2001 - Y. H. Wang, B. Field, R. Yantosca  - Initial version
(1 ) Now use F90 syntax.  Use "D" exponents to force double precision.
      Updated comments, and mad cosmetic changes (bmy, 9/4/01)
(2 ) Removed obsolete, commented-out code from 8/01 (bmy, 11/26/01)
02 Dec 2010 - R. Yantosca - Initial version
```

1.70.10 fast_j.f

Subroutine FAST_J loops over longitude and latitude, and calls PHOTOJ to compute J-Values for each column at every chemistry time-step.

References:

1. H. Liu, J.H. Crawford, R.B. Pierce, P. Norris, S.E. Platnick, G. Chen, J.A. Logan, R.M. Yantosca, M.J. Evans, C. Kittaka, Y. Feng, and X. Tie, *Radiative effect of clouds on tropospheric chemistry in a global three-dimensional chemical transport model*, J. Geophys. Res., **111**, D20303, doi:10.1029/2005JD006403, 2006. http://research.nianet.org/ hyl/publicatio

INTERFACE:

```
      SUBROUTINE FAST_J( SUNCOS, OD, ALBD )
```

USES:

```
      USE DAO_MOD,      ONLY : T, CLDF
      USE ERROR_MOD,    ONLY : ERROR_STOP
      USE GRID_MOD,     ONLY : GET_YMID
      USE PRESSURE_MOD, ONLY : GET_PEDGE
      USE TIME_MOD,     ONLY : GET_MONTH, GET_DAY, GET_DAY_OF_YEAR
      USE TIME_MOD,     ONLY : GET_TAU,   GET_YEAR
      USE TOMS_MOD,     ONLY : READ_TOMS

#     include "define.h"

      USE CMN_SIZE_MOD, ONLY : IIPAR, JJPAR, LLPAR
      USE CMN_SIZE_MOD, ONLY : NDUST, MAXIJ, NAER, NRH
      USE CMN_FJ_MOD, ONLY : IPAR, JPAR, LPAR, JPMAX, JPPJ     ! IPAR, JPAR, LPAR, F77_CMN_SI
      USE JV_CMN_MOD, ONLY : ODMDUST, PJ, NB, ODAER

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      ! Cosine of solar zenith angle [unitless]
      REAL*8, INTENT(IN)    :: SUNCOS(MAXIJ)

      ! Cloud optical depth [unitless]
      REAL*8, INTENT(IN)    :: OD(LLPAR,IIPAR,JJPAR)
```

```
      ! UV albedo [unitless]
      REAL*8, INTENT(IN)    :: ALBD(IIPAR,JJPAR)
```

REMARKS:

```
Parameter to choose cloud overlap algorithm:
=============================================================================
(1 ) OVERLAP (INTEGER) : 1 - Linear Approximation (used up to v7-04-12)
                         2 - Approximate Random Overlap (default)
                         3 - Maximum Random Overlap (computation intensive)
```

REVISION HISTORY:

```
01 Apr 1998 - P. Murti, R. Martin, R. Yantosca - Initial version
(1 ) Call this routine EACH chemistry time-step, before solver.
(2 ) This routine must know IMAX, JMAX, LMAX.
(3 ) Now use new !$OMP compiler directives for parallelization (bmy, 5/2/00)
(4 ) Now reference "cmn_fj.h" and "jv_cmn.h" for the aerosol
     optical depths (bmy, 10/2/00)
(5 ) Add OPTDUST as a local variable -- make OPTDUST private for
     the parallel DO-loop, since it stores 1 column of aerosol optical
     depth for each dust type (bmy, rvm, 10/2/00)
(6 ) For now, LPAR in "cmn_fj.h" = LGLOB in "F77_CMN_SIZE".  Therefore we
     assume that we are always doing global runs. (bmy, 10/2/00)
(7 ) Removed obsolete code from 10/2/00 (bmy, 12/21/00)
(8 ) Replace {IJL}GLOB w/ IIPAR,JJPAR,LLPAR everywhere.  Also YLMID(NLAT)
     needs to be referenced by YLMID(NLAT+J0). (bmy, 9/26/01)
(9 ) Remove obsolete code from 9/01.  Updated comments. (bmy, 10/24/01)
(10) Add OPTAER as a local variable, make it private for the parallel
     DO loop, since it stores 1 column of aerosol optical depths for each
     aerosol type.  Pass OPTAER to PHOTOJ via the argument list.  Declare
     OPTAER as PRIVATE for the parallel DO-loop. (rvm, bmy, 2/27/02)
(11) Now reference GET_PEDGE from "pressure_mod.f", which returns the
     correct "floating" pressure. (dsa, bdf, bmy, 8/20/02)
(12) Now reference T from "dao_mod.f" (bmy, 9/23/02)
(13) Now uses routine GET_YMID from "grid_mod.f" to compute grid box
     latitude.  Now make IDAY, MONTH local variables.  Now use function
     GET_DAY_OF_YEAR from "time_mod.f".  Bug fix: now IDAY (as passed to
     photoj.f) is day of year rather than cumulative days since Jan 1,
     1985. (bmy, 2/11/03)
(14) Now reference routine GET_YEAR from "time_mod.f".  Added LASTMONTH
     as a SAVEd variable.  Now call READ_TOMSO3 from "toms_mod.f" at the
     beginning of a new month (or the first timestep) to read TOMS O3
     columns which will be used by "set_prof.f".  Now also reference
     routine GET_DAY from "time_mod.f".  Rename IDAY to DAY_OF_YR. Pass
     day of month to PHOTOJ.  Updated comments, cosmetic changes.
     (bmy, 7/17/03)
(15) Bug fix: PRES needs to be the true surface pressure for GEOS-4, but
```

```
      PS-PTOP for all prior GEOS models.  (bmy, 2/6/04)
(16) Now account for cloud overlap (Maximum-Random Overlap and Random
      Overlap) in each column (hyl, phs, bmy, 9/18/07)
(17) Now initialize the PJ array here, instead of two layers below in
      "set_prof.f".  Now no longer pass PRES to "photoj.f". (bmy, 11/29/07)
(18) Now switch to approx. random overlap option (hyl, phs, bmy, 10/7/08)
(19) Now can handle GEOS-5 reprocessed met data with OPTDEPTH being
      in-cloud optical depths. (bmy, hyl, 10/24/08)
(10) Remove references to IN_CLOUD_OD (bmy, 10/15/09)
13 Aug 2010 - R. Yantosca - Added ProTeX headers
13 Aug 2010 - R. Yantosca - Treat GEOS-5 in the same way as MERRA
```

1.70.11 findmon

Function FINDMON finds which month JDAY (day of this year) is in. FINDMON is called by the Leaf Area Index routine rdlai.f.

INTERFACE:

```
      SUBROUTINE FINDMON( JDAY, INMONTH, INYEAR, MM, YYYY, STARTDAY )
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN)  :: JDAY           ! Current day of year
      INTEGER, INTENT(IN)  :: INMONTH        ! Current month
      INTEGER, INTENT(IN)  :: INYEAR         ! Current year
      INTEGER, INTENT(IN)  :: STARTDAY(13)   ! Starting days for LAI data
```

OUTPUT PARAMETERS:

```
      INTEGER, INTENT(OUT) :: MM             ! Output month for LAI
      INTEGER, INTENT(OUT) :: YYYY           ! Output year for LAI
```

REVISION HISTORY:

```
05 Jan 1994 - Y. H. Wang, G.M. Gardner, D. Jacob - Initial version
(1 ) Updated comments, cosmetic changes (bmy, 4/4/03)
(2 ) Add the current simulation year as input & the current LAI as output.
     This is necessary for reading in MODIS LAI (mpb,2009).
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.70.12 initialize

Subroutine INITIALIZE does the following:

1. Zeroes globally defined GEOS-CHEM variables.
2. Zeroes accumulating diagnostic arrays.
3. Resets certain year/month/day and counter variables used in GEOS-Chem diagnostic subroutines.

INTERFACE:

```
SUBROUTINE INITIALIZE( IFLAG )
```

USES:

```
USE DIAG_MOD,    ONLY : AD01,         AD02,         AD05
USE DIAG_MOD,    ONLY : AD06,         AD07,         AD07_BC
USE DIAG_MOD,    ONLY : AD07_OC,      AD07_HC,      AD08
USE DIAG_MOD,    ONLY : AD07_SOAGM
USE DIAG_MOD,    ONLY : AD09,         AD09_em,      AD11
USE DIAG_MOD,    ONLY : AD12,         AD13_DMS,     AD13_SO2_ac
USE DIAG_MOD,    ONLY : AD13_SO2_an, AD13_SO2_bb, AD13_SO2_bf
USE DIAG_MOD,    ONLY : AD13_SO2_ev, AD13_SO2_nv, AD13_SO4_an
USE DIAG_MOD,    ONLY : AD13_SO4_bf, AD13_SO2_sh, AD13_NH3_an
USE DIAG_MOD,    ONLY : AD13_NH3_na, AD13_NH3_bb, AD13_NH3_bf
USE DIAG_MOD,    ONLY : CONVFLUP,     TURBFLUP,     AD16
USE DIAG_MOD,    ONLY : CT16,         AD17,         CT17
USE DIAG_MOD,    ONLY : AD18,         CT18,         AD21
USE DIAG_MOD,    ONLY : AD21_cr,      AD22,         LTJV
USE DIAG_MOD,    ONLY : CTJV,         MASSFLEW,     MASSFLNS
USE DIAG_MOD,    ONLY : MASSFLUP,     AD28,         AD29
USE DIAG_MOD,    ONLY : AD30,         AD31
USE DIAG_MOD,    ONLY : AD57
USE DIAG_MOD,    ONLY : AD32_ac,      AD32_an,      AD32_bb
USE DIAG_MOD,    ONLY : AD32_bf,      AD32_fe,      AD32_li
USE DIAG_MOD,    ONLY : AD32_so,      AD32_ub,      AD33
USE DIAG_MOD,    ONLY : AD34,         AD35,         AD36
USE DIAG_MOD,    ONLY : AD37,         AD38,         AD39
USE DIAG_MOD,    ONLY : AD43,         LTNO
USE DIAG_MOD,    ONLY : CTNO,         LTOH,         CTOH
USE DIAG_MOD,    ONLY : LTHO2,        CTHO2,        LTNO2
USE DIAG_MOD,    ONLY : CTNO2,        LTNO3,        CTNO3
USE DIAG_MOD,    ONLY : CTLBRO2H,     CTLBRO2N
USE DIAG_MOD,    ONLY : CTLTRO2H,     CTLTRO2N
USE DIAG_MOD,    ONLY : CTLXRO2H,     CTLXRO2N
USE DIAG_MOD,    ONLY : AD44,         AD45,         LTOTH
USE DIAG_MOD,    ONLY : CTOTH,        AD46,         AD47
USE DIAG_MOD,    ONLY : AD52
```

```
      USE DIAG_MOD,    ONLY : AD54,        CTO3,        CTO3_24h
      USE DIAG_MOD,    ONLY : AD19,        AD58,        AD60
      USE DIAG_MOD,    ONLY : AD55,        AD66,        AD67
      USE DIAG_MOD,    ONLY : AD68,        AD69
      USE DIAG_MOD,    ONLY : AD10,        AD10em
      USE DIAG03_MOD,  ONLY : ND03,        ZERO_DIAG03
      USE DIAG04_MOD,  ONLY : ND04,        ZERO_DIAG04
      USE DIAG41_MOD,  ONLY : ND41,        ZERO_DIAG41
      USE DIAG42_MOD,  ONLY : ND42,        ZERO_DIAG42
      USE DIAG56_MOD,  ONLY : ND56,        ZERO_DIAG56
      USE DIAG_PL_MOD, ONLY : AD65,        FAM_PL
      USE ERROR_MOD,   ONLY : ERROR_STOP
      USE LOGICAL_MOD, ONLY : LCRYST
      USE TIME_MOD
#if   defined( APM )
      USE DIAG_MOD,    ONLY : AD07_OM
#endif

      USE CMN_SIZE_MOD    ! Size parameters
      USE CMN_DIAG_MOD    ! NDxx flags

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      ! If IFLAG=1, zero global CTM arrays
      ! If IFLAG=2, zero accumulating diagnostic arrays
      ! If IFLAG=3, zero accumulating diagnostic counters
      INTEGER, INTENT(IN)  :: IFLAG
```

REMARKS:

```
   Eventually we will fold this into "diag_mod.f" in a cleaner,
    more consistent fashion.  Think about this later (bmy, 11/14/02)
```

REVISION HISTORY:

```
   15 Jun 1998 - M. Prather  - Initial version
   (1 ) INITIALIZE is written in Fixed-Form Fortran 90.
   (2 ) To ensure double precision accuracy, use 0d0 instead of 0.0.
   (3 ) Also zero the mass flux arrays from TPCORE (bmy, 4/26/99)
   (4 ) Only zero allocatable arrays that are turned on. (bmy, 11/29/99)
   (5 ) Added arrays for ND13 diagnostic -- sulfur emissions.
        Also updated comments (bmy, 6/21/00)
   (6 ) Remove SAVEJ and SAVEL -- we don't call DIAG0 anymore (bmy, 9/8/00)
   (7 ) Add array AD32_bf for ND32 NOx biofuel diagnostic (bmy, 9/12/00)
```

```
(8 ) Also zero the FAMPL array for ND65 (bmy, 12/5/00)
(9 ) Now initialize AD34 array for biofuel emissions (bmy, 3/15/01)
(10) Now initialize AD12 array for boundary layer emissions in "setemis.f".
     Also made cosmetic changes & updated comments. (bdf, bmy, 6/15/01)
(11) Now initialize AD11 array for acetone diagnostic (bmy, 8/1/01)
(12) Remove reference to AVGF -- it is obsolete.  Also, AVGW is now
     included in "dao_mod.f", and is initialized there. (bmy, 9/25/01)
(13) Removed obsolete code from 9/01 (bmy, 10/24/01)
(14) Make sure FAMPL is allocated before we reference it (bmy, 1/15/02)
(15) Eliminated obsolete code from 1/02.  Now also zero CTNO2, CTHO2
     counter arrays. (bmy, 2/27/02)
(16) Bug fix: CTHO2 and CTNO2 should be zeroed if ND43 > 0, not if
     ND45 > 0.  Fix this typo. (bmy, 4/19/02)
(17) Now also zero AD01, AD02 arrays (bmy, 8/7/02)
(18) Remove reference to arrays P, SIG, SIGE from "CMN", since we now
     use floating pressure + the hybrid grid. (dsa, bdf, bmy, 8/21/02)
(19) Now zero the AD05 array for sulfate P-L (rjp, bdf, bmy, 9/20/02)
(20) Now we no longer have to zero the T array.  Also reference ERROR_STOP
     from "error_mod.f". Now also initialize AD13_NH3_an, AD13_NH3_bb,
     AD13_NH3_bf. (bmy, 12/13/02)
(21) Now also zero AD13_NH3_na array for ND13 (rjp, bmy, 3/23/03)
(22) Now references "time_mod.f" (bmy, 3/27/03)
(23) Now zeroes AD03 array for Kr85 prod/loss diag. (jsw, bmy, 8/20/03)
(24) Now also zeroes AD06 and AD07* arrays (rjp, tdf, bmy, 4/5/04)
(25) Now also zeroes AD08 array (rjp, bec, bmy, 4/20/04)
(26) Now also initialize AD13_SO2_sh array (bec, bmy, 5/20/04)
(27) Now also initialize AD07_HC array (rjp, bmy, 7/13/04)
(28) Now references AD65 & FAM_PL from "diag_pl_mod.f".  Now remove
     reference to DIAGCHLORO, it's obsolete. (bmy, 7/20/04)
(29) Now initialize extra arrays for ND03 mercury diag.  Also remove
     reference to obsolete TOFDY0 variable. (eck, bmy, 12/7/04)
(30) Now initialize AD21_cr array for ND21 diag.  Also references
     LCRYST from "logical_mod.f"  Now call ZERO_DIAG03 from "diag03_mod.f"
     to zero ND03 arrays (bmy, 1/21/05)
(31) Now call ZERO_DIAG41 from "diag41_mod.f".  Also removed references
     to AD41 and AFTTOT. (bmy, 2/17/05)
(32) Now zero AD09 and AD09_em for HCN simulation (xyp, bmy, 6/27/05)
(33) Now references ND04, ZERO_DIAG04 from "diag04_mod.f".  Also remove
     reference to "CMN" and XTRA2.  Now zeroes AD30 array (bmy, 8/18/05)
(34) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(35) Now resets SET_CT_XTRA at the beginning of the run. (tmf, 10/20/05)
(36) Now references ND56, ZERO_DIAG56 from "diag56_mod.f" (ltm, bmy, 5/5/06)
(37) Now references ND42, ZERO_DIAG42 from "diag42_mod.f" (dkh, bmy,5/22/06)
(38) take care of AD54 (time in the troposphere diagnostic) (phs, 10/17/06)
(39) Now also zero CTO3 array.  Bug fix: ZERO_DIAG42 is now called when
     ND42 is turned on. (phs, bmy, 1/30/07)
(40) Now zero AD10 and AD10em for H2HD simulation (phs, 9/18/07)
(41) Now zero CTO3_24h (phs, 11/17/08)
```

```
(42) Now zero AD52 for Gamma HO2 diag. (ccc, jaegle, 2/26/09)
(43) Updated to diagnose GLYX production of SOAG in ND07. (tmf, 1/7/09)
(44) Add initialization of counter for diag time steps. (ccc, 7/20/09)
(45) Define new diagnostics, ND19, ND58, ND60 for methane
     (kjw, 8/18/09)
(46) Add potential temperature diagnostic. (fp, 06/09)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
25 Aug 2010 - R. Yantosca - Now also reset the counter for A1 timesteps
```

1.70.13 ndxx_setup

Subroutine NDXX_SETUP dynamically allocates memory for certain diagnostic arrays that are declared allocatable in "diag_mod.f".

This allows us to reduce the amount of memory that needs to be declared globally. We only allocate memory for arrays if the corresponding diagnostic is turned on.

INTERFACE:

```
SUBROUTINE NDXX_SETUP
```

USES:

```
!NBIOMAX moved to F77_CMN_SIZE (fp, 6/2009)
!USE BIOMASS_MOD,     ONLY : NBIOMAX
USE BIOFUEL_MOD,     ONLY : NBFTRACE
USE DIAG_MOD,        ONLY : AD01,        AD02,        AD05
USE DIAG_MOD,        ONLY : AD06,        AD07,        AD07_BC
USE DIAG_MOD,        ONLY : AD07_OC,     AD07_HC,     AD08
USE DIAG_MOD,        ONLY : AD07_SOAGM
USE DIAG_MOD,        ONLY : AD09,        AD09_em,     AD11
USE DIAG_MOD,        ONLY : AD12,        AD13_DMS,    AD13_SO2_ac
USE DIAG_MOD,        ONLY : AD13_SO2_an, AD13_SO2_bb, AD13_SO2_bf
USE DIAG_MOD,        ONLY : AD13_SO2_ev, AD13_SO2_nv, AD13_SO4_an
USE DIAG_MOD,        ONLY : AD13_SO4_bf, AD13_SO2_sh, AD13_NH3_an
USE DIAG_MOD,        ONLY : AD13_NH3_na, AD13_NH3_bb, AD13_NH3_bf
USE DIAG_MOD,        ONLY : CONVFLUP,    TURBFLUP,    AD16
USE DIAG_MOD,        ONLY : CT16,        AD17,        CT17
USE DIAG_MOD,        ONLY : AD18,        CT18,        AD21
USE DIAG_MOD,        ONLY : AD21_cr,     AD22,        LTJV
USE DIAG_MOD,        ONLY : CTJV,        MASSFLEW,    MASSFLNS
USE DIAG_MOD,        ONLY : MASSFLUP,    AD28,        AD29
USE DIAG_MOD,        ONLY : AD30,        AD31
!FP_ISOP potential temperature diag (6/2009)
USE DIAG_MOD,        ONLY : AD57
USE DIAG_MOD,        ONLY : AD32_ac,     AD32_an,     AD32_bb
USE DIAG_MOD,        ONLY : AD32_bf,     AD32_fe,     AD32_li
USE DIAG_MOD,        ONLY : AD32_so,     AD32_ub,     AD33
```

```
      USE DIAG_MOD,        ONLY : AD34,        AD35,        AD36
      USE DIAG_MOD,        ONLY : AD37,        AD38,        AD39
      USE DIAG_MOD,        ONLY : AD43,        LTNO
      USE DIAG_MOD,        ONLY : CTNO,        LTOH,        CTOH
      USE DIAG_MOD,        ONLY : LTHO2,       CTHO2,       LTNO2
      USE DIAG_MOD,        ONLY : CTNO2,       LTNO3,       CTNO3
      ! update for arom (dkh, 06/21/07)
      USE DIAG_MOD,        ONLY : CTLBRO2H,    CTLBRO2N
      USE DIAG_MOD,        ONLY : CTLTRO2H,    CTLTRO2N
      USE DIAG_MOD,        ONLY : CTLXRO2H,    CTLXRO2N
      USE DIAG_MOD,        ONLY : LTLBRO2H,    LTLBRO2N
      USE DIAG_MOD,        ONLY : LTLTRO2H,    LTLTRO2N
      USE DIAG_MOD,        ONLY : LTLXRO2H,    LTLXRO2N
      USE DIAG_MOD,        ONLY : AD44,        AD45,        LTOTH
      USE DIAG_MOD,        ONLY : CTOTH,       AD46,        AD47
      USE DIAG_MOD,        ONLY : AD52,        AD54
      USE DIAG_MOD,        ONLY : AD19,        AD58,        AD60
      USE DIAG_MOD,        ONLY : AD55,        AD66,        AD67
      USE DIAG_MOD,        ONLY : AD68,        AD69,        CTO3
      USE DIAG_MOD,        ONLY : AD10,        AD10em,      CTO3_24h
      ! Add O3 for ND45 diag. (ccc, 8/12/09)
      USE DIAG_MOD,        ONLY : LTO3
      USE DIAG_OH_MOD,     ONLY : INIT_DIAG_OH
      USE DRYDEP_MOD,      ONLY : NUMDEP
      USE ERROR_MOD,       ONLY : ALLOC_ERR,   ERROR_STOP
      USE LOGICAL_MOD,     ONLY : LDUST, LCARB, LSSALT, LCRYST, LDRYD
      ! Added for mercury simulation. (ccc, 6/4/10)
      USE LOGICAL_MOD,     ONLY : LGTMM
      USE PLANEFLIGHT_MOD, ONLY : SETUP_PLANEFLIGHT
      USE TRACER_MOD,      ONLY : ITS_A_CH3I_SIM
      USE TRACER_MOD,      ONLY : ITS_A_FULLCHEM_SIM
      USE TRACER_MOD,      ONLY : ITS_A_MERCURY_SIM
      USE TRACER_MOD,      ONLY : ITS_A_TAGOX_SIM
      USE TRACER_MOD,      ONLY : ITS_A_H2HD_SIM
      USE TRACER_MOD,      ONLY : N_TRACERS
      USE TRACERID_MOD,    ONLY : NEMANTHRO
      USE WETSCAV_MOD,     ONLY : GET_WETDEP_NMAX
#if   defined( APM )
      USE DIAG_MOD,        ONLY : AD07_OM
      USE TRACER_MOD,      ONLY : N_APMTRA
#endif

      USE CMN_SIZE_MOD          ! Size parameters
      USE CMN_DIAG_MOD          ! Diagnostic switches & arrays

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
16 Jun 1998 - I. Bey, R. Yantosca - Initial version
(1 ) This subroutine was split off from subroutine INPUT, for clarity
(2 ) Added call to READ49 (bey, 2/99)
(3 ) Eliminate GISS-Specific code, and AIJ, AIL diagnostics (bmy, 3/15/99)
(4 ) Define tracer offset TRCOFFSET for "alternate chemistry" runs.
(5 ) Multi-level diagnostics ND21, ND22, ND43, ND45, ND66, and ND68 have
     now been split off from the AIJ arrays (bmy, 3/29/99)
(6 ) Added code for ND14 and ND15.  Also eliminated obsolete code
     and updated comments (bmy, 11/10/99)
(7 ) Added new ND41 and ND51 diagnostics (from amf).  Freed up obsolete
     diagnostics ND34. ND37, and ND42 and updated comments. (bmy, 11/15/99)
     Also note: ND41 uses allocatable array AD41. (bmy, 12/6/99)
(8 ) The following diagnostic arrays are now declared allocatable
     in "diag_mod.f": AD21, AD22, AD38, AD39, AD43, AD45, AD47,
     AD66, AD68, CONVFLUP, TURBFLUP, MASSFLEW, MASSFLNS, MASSFLUP, TCOBOX
     Allocate memory for these arrays only if their respective
     diagnostic is turned on.  This will save memory. (bmy, 11/29/99)
(9 ) Added ND55 diagnostic for tropopause heights (hyl, bmy, 12/1/99)
(10) ND50 and ND20 now have dynamically allocatable arrays. (bmy, 1/5/00)
(11) ND27 diagnostic now also turns on ND24, ND25, ND26 (bmy, 1/7/00)
(12) ND31, ND33, ND35, ND37, ND67, and ND69 now use dynamically
     allocatable arrays declared in "diag_mod.f". (bmy, 2/17/00)
(13) ND16, ND17, ND18 now use allocatable arrays.  Also now use internal
     subroutine "alloc_err" to print error messages. (bmy, 3/14/00)
(14) AIJ is now obsolete.  All diagnostic variables now use allocatable
     arrays (cf. "diag_mod.f").  This is necessary in order to keep the
     size of the 2 x 2.5 executable within machine limits. (bmy, 3/28/00)
(15) Removed obsolete code.  Added TRCOFFSET of 3 for CO run
     with parameterized OH.  Removed reference to KAIJPAR. (bmy, 4/19/00)
(16) Add TRCOFFSET of 50 for DMS/SO2/SO4/MSA.  Also added arrays for
     ND13 diagnostic for sulfur emissions (bmy, 6/6/00)
(17) Add reference to F90 module "biomass_mod.f".  Also added array
     AD32_bf for biofuel NOx. (bmy, 9/11/00)
(18) Use NTRACE + 2 prodloss families for Tagged CO for the
     ND65 diagnostic (bmy, 10/6/00)
(19) Adjust TRCOFFSET for 10-tracer Tagged CO run.  Redimensioned
     AD45 and AD47 to save memory.  Renamed STATUS to AS. (bmy, 10/18/00)
(20) Removed obsolete code from 10/00.  Save out ND65 only to LLTROP
     levels for full chemistry.  Save out ND43 only to LLTROP levels
     for full chemistry.  Dimension DIAGCHLORO up to LLTROP for
     full chemistry (or LLPAR for CO/OH chemistry).  ND24, ND25, ND26
     can now save out less than LLPAR levels.  Eliminate dependence
     on PD35, PD37, PD39 parameters (bmy, 12/5/00)
(21) Only save out a maximum of LCONVM layers for ND14 (bmy, 12/7/00)
(22) Removed obsolete code from 7/00, 9/00, and 12/00 (bmy, 12/21/00)
(23) Increase to NTRACE + 4 prodloss families for Tagged CO (bmy, 1/2/01)
```

```
(24) Add TRCOFFSET of 54 for CH4 chemistry (NSRCX == 9) (bmy, 1/16/01)
(25) Now allocate DIAGCHLORO (ND23 diagnostic) for CH4 runs (bmy, 1/18/01)
(26) For ND43, save up to LLTROP for full chemistry, but save up to
     LLPAR for Tagged CO or CO-OH chemistry (bmy, 2/12/01)
(27) Now allocate AD34 for biofuel burning emissions (bmy, 3/15/01)
(28) Add L(CH3I) to ND65 diagnostic (nad, bmy, 3/20/01)
(29) For full chemistry, we only need to save up to LLTROP levels
     for the ND22 J-value diagnostic (bmy, 4/2/01)
(30) Remove reference to NBIOMAX from "biomass_mod.f" (bmy, 4/17/01)
(31) Eliminate obsolete commented-out code (bmy, 4/20/01)
(32) Now also allocate the AD12 diagnostic array (bdf, bmy, 6/15/01)
(33) Now assign TRCOFFSET = 40 for multi-tracer Ox run (when NSRCX = 6
     and LSPLIT = T).  Reference F77_CMN_SETUP for LSPLIT.  Allocate AD44
     with NTRACE instead of NUMDEP for single or multi-tracer Ox runs
     (NSRCX = 6).  Now define NFAM as NTRACE*2 for single or multi-tracer
     Ox runs.  Updated comments & made cosmetic changes. (bmy, 7/3/01)
(34) Added AD11 diagnostic for acetone source.  Also removed obsolete
     code from 7/01. (bmy, 9/4/01)
(35) Turn off ND23 unless NSRCX = 3, 5, or 9.  This prevents us from
     referencing an unallocated DIAGCHLORO array.  Add error check for
     ND65, make sure that NFAM > 0.  Also clean up the code that
     allocates AD65 and FAMPL arrays. (bmy, 1/14/02)
(36) Now set TRCOFFSET = 64 for tagged C2H6 chemistry (bmy, 1/25/02)
(37) Eliminate obsolete code from 1/02 and 2/02.  Also allocate LTNO2,
     CTNO2, LTHO2, CTHO2 for the ND43 diagnostic. (bmy, 2/27/02)
(38) Call SETUP_PLANEFLIGHT to initialize the ND40 plane flight diagnostic
     for non-SMVGEAR chemistry runs. (mje, bmy, 7/2/02)
(39) Now set up variables & arrays for ND01 and ND02 diagnostics (i.e.
     Rn-Pb-Be emissions and decay).  (bmy, 9/20/02)
(40) Now allocate AD05 array.   Now allocate routines ALLOC_ERR and
     ERROR_STOP from "error_mod.f".  Now reference NEMANTHRO from F90
     module "tracerid_mod.f" instead of "comtrid.h".  Also added array
     AD13_SO2_bf for biofuel SO2. (bmy, 1/16/03)
(41) Now also allocate AD13_NH3_na array for ND13 (rjp, bmy, 3/23/03)
(42) Added ND03 diagnostic for Kr85 prod/loss.  Also removed special case
     TRCOFFSET for single-tracer Ox. (jsw, bmy, 8/20/03)
(43) Now use GET_WETDEP_NMAX to get max # of soluble tracers for ND37,
     ND18, and ND19.  Also set NFAM=NTRACE+5 for Tagged CO simulation.
     (3/18/04)
(44) Now initialize AD06 and AD07* arrays (rjp, tdf, bmy, 4/5/04)
(45) Now initialize AD08 array.  Reset TRCOFFSET for tagged CO from
     84 to 80.  Also activate ND52 diagnostic for ICARTT.
     (rjp, bec, stu, cas, bmy, 4/20/04)
(46) Now allocate AD13_SO2_sh array for ND13 (bec, bmy, 5/20/04)
(47) Now allocate AD07_HC array for ND07 (rjp, bmy, 7/13/04)
(48) Now references "tracer_mod.f" and "logical_mod.f" instead of "CMN"
     and "F77_CMN_SETUP".  Now references INIT_DIAG_OH from "diag_oh_mod.f"
     Adjust TRCOFFSET for various aerosol simulations. (bmy, 7/20/04)
```

```
(49) Make sure ND21 only goes from 1-LLTROP (bmy, 9/28/04)
(50) Now allocate AD13_SO4_bf array (bmy, 11/17/04)
(51) Now allocate extra arrays for ND03 mercury diag.  Also set up for
     mercury tracers in ND44 diagnostic. (bmy, 12/14/04)
(52) Added separate ND21 array for cryst sulfur tracers.  Now reinstated
     AD03 array for mercury simulation.  Now move ND03 diagnostics into
     a separate module.  Remove TCOBOX reference, it's obsolete.
     (cas, sas, bmy, 1/21/05)
(53) Now remove references to AD41 & AFTTOT.  Now call SETUP_PLANEFLIGHT
     for non-full-chemistry runs in main.f -- this will allow it to look
     for flight files for each day (bmy, 3/24/05)
(54) Now use PD05=10 to dimension AD05 array (bmy, 4/13/05)
(55) Now also allocates AD09 and AD09_em (bmy, 6/27/05)
(56) Now allocates AD30 (bmy, 8/18/05)
(57) Removed duplicate variable declarations (bmy, 2/6/06)
(58) Now remove NBIOTRCE; it's obsolete.  Replace w/ NBIOMAX (bmy, 4/5/06)
(59) Now remove TRCOFFSET; it's obsolete (bmy, 5/16/06)
(60) Added the ND54 for time spend in the troposphere (phs, 10/17/06)
(61) Now allocate ND43 and ND45 counter arrays as 3-D (phs, 1/19/07)
(62) For ND20 diagnostic, reset ND65 diagnostic with LLTROP_FIX instead of
     LLTROP.  Added ND10 diagnostic setup.  Added modifications for H2-HD
     simulation. (phs, bmy, 9/18/07)
(63) Now save true pressure edges for ND31 diagnostic (bmy, 11/16/07)
(64) Now stop the run if ND20 is defined but ND65 isn't (bmy, 12/4/07)
(65) Allocate CTO3_24h (phs, 11/18/08)
(66) We don't need to set LD65=1 here anymore, we now call NDXX_SETUP!
     after DIAG_PL_MOD. (phs, bmy, 12/18/08)
(67) Added ND52 for GAMMA HO2 diagnostic. (ccc, jaegle, 2/26/09)
(68) Add AD07_SOAGM (tmf, 1/7/09)
(67) Added ND52 for GAMMA HO2 diagnostic. (ccc, jaegle, 2/26/09)
(68) Add AD07_SOAGM (tmf, 1/7/09)
(69) Now always allocate Mass Flux arrays (phs, 4/15/09)
(70) Allocate LTO3. (ccc, 7/20/09)
(71) Add AD19, AD58, AD60 (kjw, 8/18/09)
(72) Now AD13_SO2_an and AD13_SO4_an have NOXLEVELS levels to accomodate
   NEI 2005 (amv, 10/9/09)
(73) AD13_NH3_an is 3D now (phs, 10/22/09)
(74) NBIOMAX is now in F77_CMN_SIZE. (fp, 2/26/10)
26 Aug 2010 - R. Yantosca - Added ProTeX headers
16 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
```

1.70.14 ohsave

Subroutine OHSAVE stores the concentrations of OH, HO2, NO, NO2, and NO3 for the ND43 diagnostic. Also the O3/Ox, NO/NOx and NO2/NOx fractions are computed and returned to the calling program.

INTERFACE:

```
      SUBROUTINE OHSAVE( N_TRACERS, XNUMOL,  STT,    FRACO3,
     &                   FRACNO,    FRACNO2, SAVEOH, SAVEHO2,
     &                   SAVENO,    SAVENO2, SAVENO3 )
```

USES:

```
      USE COMODE_MOD,   ONLY : AIRDENS, CSPEC, JLOP, T3, VOLUME
      USE DIAG_MOD,     ONLY : DIAGCHLORO
      USE TRACERID_MOD, ONLY : IDTOX, IDTNOX, IDO3,  IDNO
      USE TRACERID_MOD, ONLY : IDNO2, IDOH,   IDHO2, IDNO3

      USE CMN_SIZE_MOD     ! Size parameters
      USE COMODE_LOOP_MOD     ! VOLUME, CSPEC, NPVERT, NLAT, NLONG

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      ! Number of tracers in XNUMOL and STT
      INTEGER, INTENT(IN) :: N_TRACERS

      ! Array of molec/kg for each tracer
      REAL*8, INTENT(IN)  :: XNUMOL(N_TRACERS)

      ! Array containing CTM tracers
      REAL*8, INTENT(IN)  :: STT(IIPAR,JJPAR,LLPAR,N_TRACERS)
```

OUTPUT PARAMETERS:

```
      ! Array of O3/Ox fractions
      REAL*8, INTENT(OUT) :: FRACO3(IIPAR,JJPAR,LLPAR)

      ! Array of NO/NOx fractions
      REAL*8, INTENT(OUT) :: FRACNO(IIPAR,JJPAR,LLPAR)

      ! Array of NO2/NOx fractions
      REAL*8, INTENT(OUT) :: FRACNO2(IIPAR,JJPAR,LLPAR)

      ! Array of OH  concentrations [molec/cm3]
      REAL*8, INTENT(OUT) :: SAVEOH(IIPAR,JJPAR,LLPAR)

      ! Array of HO2 concentrations [v/v]
      REAL*8, INTENT(OUT) :: SAVEHO2(IIPAR,JJPAR,LLPAR)

      ! Array of NO  concentrations [v/v]
      REAL*8, INTENT(OUT) :: SAVENO(IIPAR,JJPAR,LLPAR)
```

```
      ! Array of NO2 concentrations [v/v]
      REAL*8, INTENT(OUT) :: SAVENO2(IIPAR,JJPAR,LLPAR)

      ! Array of NO3 concentrations [v/v]
      REAL*8, INTENT(OUT) :: SAVENO3(IIPAR,JJPAR,LLPAR)
```

REVISION HISTORY:

```
   27 Feb 2002 - R. Yantosca - Initial version
   (1 ) Original code from lwh, gmg, djj, jyl, etc, 1990's.  Modified for
        GEOS-CHEM by Bob Yantosca et al.
   (2 ) Added comment header and F90 declaration syntax.  Also now specify
        the units of each variable for clarity.
   (3 ) Deleted NTRACER, it is not used.  Also added FRACNO2 and SAVEHO2
        variables.  Updated comments, cosmetic changes (rvm, bmy, 2/27/02)
   (4 ) Bug fix: swap the order of the lines where TMPNOX is computed.
        Also deleted obsolete code from 2/02. (bmy, 7/31/02)
   (5 ) Now reference IDTOX, IDTNOX, etc from "tracerid_mod.f". (1/13/03)
   (6 ) Added OpenMP parallelization commands (bmy, 8/1/03)
   (7 ) Now compute quantities for mean OH in "diag_oh_mod.f".  Now also
        references STT from "tracer_mod.f".  Added N_TRACERS to the arg list.
        Now dimension args XNUMOL, STT w/ N_TRACERS and not NNPAR.
        (bmy, 7/20/04)
   (8 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   (9 ) Reset FRAC* and SAVE* arrays, so that we don't carry dubious data
        over from boxes that used to be in the tropopause but aren't anymore.
        (phs, 1/19/07)
   15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.70.15 rdlai

Subroutine RDLAI is used for soil NOx emissions

INTERFACE:

```
      SUBROUTINE RDLAI( JDAY, MONTH, YEAR )
```

USES:

```
      USE GRID_MOD, ONLY : GET_XOFFSET, GET_YOFFSET

      USE CMN_SIZE_MOD
      USE CMN_VEL_MOD
      USE CMN_DEP_MOD

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER JDAY        ! Simulated day
      INTEGER MONTH       ! Simulated month
      INTEGER YEAR        ! Simulation year
```

REVISION HISTORY:

```
    Y. Wang, G. Gardner, D. Jacob - Original version (release v2.1)
    06 Oct 1999 - R. Yantosca     - Be sure to force double precision with
                                    the DBLE function and the "D" exponent,
                                    wherever necessary
    25 Jun 2002 - R. Yantosca     - Replace IMX with IIPAR and JMX with JJPAR
    19 Nov 2009 - M. Barkley      - Included the simulation and LAI years
```

1.70.16 rdland

Subroutine RDLAND reads the land types and fractions (times 1000) from the "vegtype.global" file.

INTERFACE:

```
      SUBROUTINE RDLAND
```

USES:

```
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE ERROR_MOD,     ONLY : ERROR_STOP
      USE GRID_MOD,      ONLY : GET_XOFFSET, GET_YOFFSET
      USE LOGICAL_MOD,   ONLY : LAVHRRLAI

      USE CMN_SIZE_MOD      ! Size parameters
      USE CMN_VEL_MOD       ! IJREG, IJLAND, IJUSE
      USE CMN_DEP_MOD       ! FRCLND, IREG, ILAND, IUSE

      IMPLICIT NONE
#     include "define.h"
```

REMARKS:

```
    Common-block variables from header file "F77_CMN_DEP":
    ============================================================================
    (1 ) FRCLND(I,J)        : Land fraction (0.0 - 1.0)
    (2 ) IREG(I,J)          : Number of landtypes in each grid box
    (3 ) ILAND(I,J,LDT)     : Land type ID for element LDT =1, IREG(I,J)
    (4 ) IUSE(I,J,LDT)      : Fraction (per mil) of gridbox area occupied by
                              land type element LDT

    Common-block variables from header file "F77_CMN_VEL":
```

```
=============================================================================
(1 ) IJREG(IJLOOP)      : 2-D (I*J, LDT) version of IJREG  (for DEPVEL)
(2 ) IJLAND(IJLOOP,LDT) : 2-D (I*J, LDT) version of IJLAND (for DEPVEL)
(3 ) IJUSE(IJLOOP,LDT)  : 2-D (I*J, LDT) version of IJUSE  (for DEPVEL)
```

REVISION HISTORY:

```
01 Oct 1995 - M. Prather  - Initial version
(1 ) Now read the "vegtype.global" file from the leaf_area_index_200412
     subdirectory of DATA_DIR.  This is the same Olson land map as was
     used previously.  Also updated comments and added standard GEOS-CHEM
     program documentation header. (tmf, bmy, 12/6/04)
(2 ) Now read the "vegtype.global" file from the leaf_area_index_200412
     subdirectory if LAVHRRLAI=T.  Also updated comments and added
     standard GEOS-CHEM program documentation header. (bmy, 12/20/04)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.70.17 rdsoil

Subroutine RDSOIL reads in soiltype data, fertilizer data, and monthly soil precipitation data.

INTERFACE:

```
      SUBROUTINE RDSOIL
```

USES:

```
      USE BPCH2_MOD,     ONLY : GET_RES_EXT
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE FILE_MOD,      ONLY : IU_FILE, IOERROR
      USE ERROR_MOD,     ONLY : GEOS_CHEM_STOP
      USE TIME_MOD,      ONLY : GET_MONTH

      USE CMN_SIZE_MOD   ! Size parameters
      USE COMMSOIL_MOD ! Soil variables

      IMPLICIT NONE
#     include "define.h"
```

REMARKS:

```
RDSOIL is one of the original GEOS-CHEM subroutines, and has its origins
from the GISS-II model that was used at Harvard in the early 90's.  This
was cleaned up and improved error checking was added. (bmy, 4/2/02)

Variables from "commsoil.h" header file:
```

```
=============================================================================
(1 ) NCONSOIL  (INTEGER) : Olson -> soil type mapping index
(2 ) INDEXSOIL (INTEGER) : Array containing grid box indices (I,J)
(3 ) SOILFERT  (REAL*8 ) : Array containing fertilizer NOx [ng N/m2/s]
(4 ) SOILPREP  (REAL*8 ) : Array containing 2 months of observed
                           soil precipitation [mm/day]
                                                                             .
Files read in by "rdsoil.f":
=============================================================================
(1 ) DATA_DIR/soil_NOx_200203/soiltype.dat       : Olson and soil land types
(2 ) DATA_DIR/soil_NOx_200203/fert_scale.dat     : NOx from fertilizers
(3 ) DATA_DIR/soil_NOx_200203/climatprep4x5.dat  : 1x1   monthly soil precip
                              climatprep2x25.dat : 2x2.5 monthly soil precip
                              climatprep1x1.dat  : 4x5   monthly soil precip
```

REVISION HISTORY:

```
05 Jan 1994 - Y. H. Wang, G. M. Gardner, - Initial version
(1 ) Be sure to force double precision with the DBLE function and the "D"
     exponent, wherever necessary (bmy, 10/6/99)            *
(2 ) Now read soil data files directly from the from
     DATA_DIR/soil_NOx_200203/ subdirectory.  Now use IOERROR to trap
     I/O errors across all platforms.  Added comment header.  Updated
     comments, cosmetic changes. (bmy, 4/2/02)
(3 ) Removed obsolete code from April 2002.  Now reference IU_FILE and
     IOERROR from "file_mod.f".  Now use IU_FILE as the file unit number,
     assign it to IUNIT. (bmy, 6/27/02)
(4 ) Now reference GEOS_CHEM_STOP from "error_mod.f".  Bug fix: remove
     duplicate declaration of IOS.  This causes compile errors for the
     ALPHA platform. (gcc, bmy, 11/6/02)
(5 ) Now use function GET_MONTH from "time_mod.f".  Now make MONTH a local
     variable. (bmy, 2/11/03)
(6 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.70.18 rdlight

Subroutine RDLIGHT reads the polynomial coefficients for isoprene emissions from disk.

INTERFACE:

```
SUBROUTINE RDLIGHT
```

USES:

```
USE DIRECTORY_MOD, ONLY : DATA_DIR
USE FILE_MOD,      ONLY : IU_FILE, IOERROR
```

```
      USE CMN_SIZE_MOD  ! Size parameters
      USE CMN_ISOP_MOD  ! SOPCOEFF

      IMPLICIT NONE
#     include "define.h"
```

REVISION HISTORY:

```
06 Jul 2001 - Y. H. Wang, R. Yantosca - Initial version
(1 ) Now use F90 syntax.  Now reads the file "light.table" directly
     from DATA_DIR so that symbolic links are unnecessary.  Also use
     IOERROR to trap I/O errors.  Updated comments and made cosmetic
     changes (bmy, 7/6/01)
(2 ) Deleted obsolete code from ages ago.  Also print full pathname
     of the "light.table" file. (bmy, 9/4/01)
(3 ) Now read file "light.table" from the DATA_DIR/biogenic_200203/
     directory.  Added FILENAME variable. (bmy, 3/29/02)
(4 ) Deleted obsolete code from March 2002.  Now reference IU_FILE and
     IOERROR from "file_mod.f".  Now use IU_FILE instead of IUNIT as
     the file unit number. (bmy, 6/27/02)
(5 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.70.19 rdmonot

Subroutine RDMONOT reads baseline monoterpene emission values from Guenther et al. (1995), as a function of Olson landtype area.

INTERFACE:

```
      SUBROUTINE RDMONOT( GMONOT )
```

USES:

```
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE FILE_MOD,      ONLY : IU_FILE, IOERROR

      USE CMN_SIZE_MOD  ! Size parameters

      IMPLICIT NONE
#     include "define.h"
```

OUTPUT PARAMETERS:

```
      ! Monoterpene emissions for each landtype [atoms C/cm2 leaf/s]
      REAL*8, INTENT(OUT) :: GMONOT(NVEGTYPE)
```

REVISION HISTORY:

```
06 Jul 2001 - B. Field    - Initial version
(1 ) Now read updated file "monotemis.v4-13.table" (bdf, bmy, 6/6/01)
(2 ) Now reference DATA_DIR from "F77_CMN_SETUP. (bmy, 6/6/01)
(3 ) Now use IOERROR to trap I/O errors (bmy, 6/6/01)
(4 ) IUNIT=65 is now a parameter (bmy, 7/6/01)
(5 ) Now read file "monotemis.v4-13.table" from the
     DATA_DIR/biogenic_200203 directory (bmy, 3/29/02)
(6 ) Removed obsolete code from March 2002.  Now reference IU_FILE and
     IOERROR from "file_mod.f".  Now use IU_FILE as the file unit number
     instead of IUNIT. (bmy, 6/27/02)
(7 ) Now references DATA_DIR from "directory_mod.f" (bmy, 7/20/04)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.70.20 readlai

Subroutine READLAI reads the leaf area indices from disk for two months. (yhw, gmg, djj, 1994; bmy, 12/20/04)

INTERFACE:

```
      SUBROUTINE READLAI( MM, YYYY )
```

USES:

```
      USE DIRECTORY_MOD, ONLY : DATA_DIR
      USE FILE_MOD,      ONLY : IU_FILE
      USE LOGICAL_MOD,   ONLY : LAVHRRLAI
      USE LOGICAL_MOD,   ONLY : LMODISLAI ! (mpb,2009)

      USE CMN_SIZE_MOD   ! Size parameters
      USE CMN_VEL_MOD    ! XLAI, XLAI2
      USE CMN_DEP_MOD    ! IREG, ILAND, IUSE

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: MM
      INTEGER, INTENT(IN) :: YYYY ! (mpb,2009)
```

REVISION HISTORY:

```
06 Oct 1999 - R. Yantosca - Be sure to force double precision with the
                            DBLE function and the "D" exponent, wherever
                            necessary
05 Jul 2001 - R. Yantosca - Now reads the LAI files directly from the data
```

```
                              directory, so you don't have to create symbolic
                              links anymore
    27 Feb 2002 - R. Yantosca - Deleted obsolete code
    25 Jun 2002 - R. Yantosca - Replaced IMX with IIPAR and JMX with JJPAR
    31 Jul 2002 - R. Yantosca - Now reference IU_FILE from "file_mod.f"
    13 Nov 2002 - R. Yantosca - Now define FILENAME and echo FILENAME to stdout.
                              Now use F90 style declaration statements.
                              Cleaned up old code.
    20 Jul 2004 - R. Yantosca - Now references DATA_DIR from "directory_mod.f"
    20 Dec 2004 - M. Fu       - Now use AVHRR LAI derived leaf-area index data
                              (stored in the leaf_area_index_200412 subdir of
                              DATA_DIR) if the logical switch LAVHRRLAI=T.
                              Otherwise use the old LAI data.
```

1.70.21 ruralbox

Subroutine RURALBOX computes which boxes are tropospheric and which are stratospheric. SMVGEAR arrays are initialized with quantities from tropospheric boxes.

INTERFACE:

```
  !-----------------------------------------------------------------------------
   Prior to 10/5/11:
   SUNCOS is no longer used in RURALBOX, we can remove it (bmy, 10/5/11)
        SUBROUTINE RURALBOX( AD, T, AVGW, ALBD, SUNCOS )
  !-----------------------------------------------------------------------------
       SUBROUTINE RURALBOX( AD, T, AVGW, ALBD )
```

USES:

```
       USE COMODE_MOD,     ONLY : ABSHUM, AIRDENS,  IXSAVE, IYSAVE
       USE COMODE_MOD,     ONLY : IZSAVE, JLOP,     PRESS3, T3,  VOLUME
       USE PRESSURE_MOD,   ONLY : GET_PCENTER,      GET_PEDGE
       USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_STRAT, ITS_IN_THE_TROP

 #     include "define.h"

       USE CMN_SIZE_MOD       ! Size parameters
       USE COMODE_LOOP_MOD       ! NPVERT

       IMPLICIT NONE
```

INPUT PARAMETERS:

```
       REAL*8,  INTENT(IN) :: AD(IIPAR,JJPAR,LLPAR)     ! Air mass [kg]
       REAL*8,  INTENT(IN) :: T(IIPAR,JJPAR,LLPAR)      ! Temperature [K]
       REAL*8,  INTENT(IN) :: AVGW(IIPAR,JJPAR,LLPAR)   ! Mix rat. of H2O [v/v]
```

```
      REAL*8,  INTENT(IN) :: ALBD(IIPAR,JJPAR)        ! Sfc albedo [unitless]
 ------------------------------------------------------------------------------
  Prior to 10/5/11:
  SUNCOS is no longer used in RURALBOX, we can remove it (bmy, 10/5/11)
       REAL*8,  INTENT(IN) :: SUNCOS(MAXIJ)            ! Cos of SZA [unitless]
 ------------------------------------------------------------------------------
```

REMARKS:

```
  Developers: amf, bey, ljm, lwh, gmg, bdf, bmy, 7/16/01, 2/25/10)
```

REVISION HISTORY:

```
  01 Oct 1995 - M. Prather  - Initial version
  (1 ) Remove PTOP from the arg list.  PTOP is now a parameter
       in "F77_CMN_SIZE". (bmy, 2/10/00)
  (2 ) Add C-preprocessor switch LSLOWJ to bracket code for
       SLOW-J photolysis (bmy, 2/25/00)
  (3 ) Now reference ABHSUM, AIRDENS, IXSAVE, IYSAVE, IZSAVE, JLOP, PRESS3,
       T3, and VOLUME from F90 module "comode_mod.f" (bmy, 10/19/00)
  (4 ) PTOP is already a parameter in "F77_CMN_SIZE", don't declare it here
       (bmy, 7/16/01)
  (5 ) Replace IGCMPAR,JGCMPAR,LGCMPAR with IIPAR,JJPAR,LLPAR.  Also moved
       CLOUDREF to SLOW-J block.  Also remove IREF, JREF, IOFF, JOFF, these
       are now obsolete.  Updated comments. (bmy, 9/25/01)
  (6 ) Eliminate I00 and J00 as arguments, these are obsolete (bmy, 9/28/01)
  (7 ) Removed obsolete, commented out code from 9/01 (bmy, 10/24/01)
  (8 ) Updated comment header.  Also updated comments, and made cosmetic
       changes. (bmy, 4/15/02)
  (9 ) Bug fix: declare variables for SLOW-J photolysis.  Also eliminated
       obsolete code from 4/15/02. (bmy, 8/5/02)
  (10) Now reference GET_PCENTER and GET_PEDGE from "pressure_mod.f",
       which return the correct "floating" pressure.  Also deleted obsolete,
       commented-out code.  Also eliminate P, SIG, and NSKIPL from the arg
       list, since we don't need them anymore. (dsa, bdf, bmy, 8/20/02)
  (11) Added modifications for SMVGEAR II (gcc, bdf, bmy, 4/1/03)
  (12) SLOW-J is now obsolete; remove LSLOWJ #ifdef blocks (bmy, 6/23/05)
  (13) Now reference ITS_IN_THE_TROP and ITS_IN_THE_STRAT from
       "tropopause_mod.f" to diagnose trop & strat boxes.  Also remove
       LPAUSE from the arg list (bmy, 8/22/05)
  (14) Remove ALT and CLOUDS from arg list -- they are obsolete (bmy, 4/10/06)
  (15) Remove obsolete embedded chemistry stuff (bmy, 2/25/10)
  10 Sep 2010 - R. Yantosca - Added ProTeX headers
```

1.70.22 setemis.f

Subroutine SETEMIS places emissions computed from GEOS-Chem subroutines into arrays for SMVGEAR II chemistry.

SETEMIS converts from units of [molec tracer/box/s] to units of [molec chemical species/cm3/s], and stores in the REMIS array. For hydrocarbons that are carried through the GEOS-CHEM model as [molec C], these are converted back to [molec hydrocarbon], and then stored in REMIS.

INTERFACE:

```
      SUBROUTINE SETEMIS( EMISRR, EMISRRN )
```

USES:

```
      USE AIRCRAFT_NOX_MOD,  ONLY : EMIS_AC_NOx
      USE BIOFUEL_MOD,       ONLY : BIOFUEL,   BFTRACE, NBFTRACE
      USE BIOMASS_MOD,       ONLY : BIOMASS,   BIOTRCE
      ! Use this array to determine if emissions are handled here (hotp 8/3/09)
      USE BIOMASS_MOD,       ONLY : BIOBGAS
      USE COMODE_MOD,        ONLY : JLOP,      REMIS,   VOLUME
      USE COMODE_MOD,        ONLY : IYSAVE
      USE DIAG_MOD,          ONLY : AD12
      USE GRID_MOD,          ONLY : GET_AREA_CM2
      USE LIGHTNING_NOX_MOD, ONLY : EMIS_LI_NOx
      USE PBL_MIX_MOD,       ONLY : GET_PBL_TOP_L
      USE PRESSURE_MOD,      ONLY : GET_PEDGE
      USE TRACERID_MOD,      ONLY : CTRMB,     IDEMIS,  IDENOX
      USE TROPOPAUSE_MOD,    ONLY : ITS_IN_THE_STRAT
      USE LOGICAL_MOD,       ONLY : LNLPBL ! (Lin, 03/31/09)
      USE LOGICAL_MOD, ONLY : LPRT

      ! NOx emissions scaling FP 15/12/09
      USE EMISSIONS_MOD,     ONLY : NOx_SCALING

#     include "define.h"
      USE CMN_SIZE_MOD  ! Size parameters
      USE COMODE_LOOP_MOD  ! IDEMS, NEMIS
      USE CMN_DIAG_MOD  ! Diagnostic flags
      USE CMN_NOX_MOD   ! GEMISNOX2

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      ! CO, hydrocarbon emission   [molec tracer/box/s]
      REAL*8,  INTENT(IN) :: EMISRR(IIPAR,JJPAR,NEMPARA+NEMPARB)

      ! Multi-level NOx emissions  [molec NOx/box/s]
      REAL*8,  INTENT(IN) :: EMISRRN(IIPAR,JJPAR,NOXEXTENT)
```

REMARKS:

```
Developers: lwh, jyl, gmg, djj, bdf, bmy, 6/8/98, 6/11/08
(lwh, jyl, gmg, djj, bdf, bmy, 6/8/98, 6/11/08)

REMIS(JLOOP,N) = emis. rate of species corr. to tracer N in box JLOOP
                 (reaction number NTEMIS(N))
```

REVISION HISTORY:

```
(1 ) Original code from Harvard Tropospheric Chemistry Module for 3-D
     applications by Larry Horowitz, Jinyou Liang, Gerry Gardner,
     Prof. Daniel Jacob of Harvard University (Release V2.0)
(2 ) New version 3.0 by Bob Yantosca to place NOx emissions into boxes
     above the surface. (bmy, 6/8/98)
(3 ) Also now do chemistry up to the location of the annual mean
      tropopause (bmy, 12/9/99)
(4 ) BURNEMIS is now dynamically allocatable and is contained in F90
     module "biomass_mod.f".  BIOTRCE and NBIOTRCE are also contained
     in "biomass_mod.f".  (bmy, 9/12/00)
(5 ) BIOFUEL is now dynamically allocatable and is contained in F90
     module "biofuel_mod.f".  BFTRACE and NBFTRACE are also contained
     in "biofuel_mod.f" (bmy, 9/12/00, 4/17/01)
(6 ) BURNEMIS and BIOFUEL are now treated as true global arrays,
     and need to be referenced by the global offset variables
     IREF = I + I0 and JREF = J + J0 (bmy, 9/12/00)
(7 ) Now reference JLOP, REMIS, VOLUME from F90 module "comode_mod.f",
     in order to save memory (bmy, 10/19/00)
(8 ) Now add in up to NBFTRACE biofuel species (bmy, 4/17/01)
(9 ) Add new subroutine header, updated comments, cosmetic changes.
     (bmy, 4/17/01)
(10) Updated comments -- GEMISNOX is [molec/cm3/s]. (bdf, bmy, 6/7/01)
(11) For GEOS-3, we now distributes surface emissions throughout the
     boundary layer.  This is necessary since the first couple of GEOS-3
     surface layers are very thin.  Piling up of emissions into a small
     layer will cause SMVGEAR to choke.  (bdf, bmy, 6/15/01)
(12) Also now reference BFTRACE and NBFTRACE from "biofuel_mod.f",
     and reference AD12 from "diag_mod.f". (bdf, bmy, 6/15/01)
(13) For GEOS-1, GEOS-STRAT, emit into the surface layer, as we did
     in prior versions. (bmy, 6/26/01)
(14) Bug fix: corrected a typo for the biofuel emissions (bmy, 7/10/01)
(15) Bug fix: make sure BIOMASS and BIOFUEL, and SOIL NOx emissions have
     units of [molec/box/s] before distributing thru the boundary layer.
     This involves multiplication by VOLUME(JLOOP1) and division by
     VOLUME(JLOOP). (bmy, 7/16/01)
(16) XTRA2(IREF,JREF,5) is now XTRA2(I,J).  BIOFUEL(:,IREF,JREF) is now
     BIOFUEL(:,I,J). BURNEMIS(:,IREF,JREF) is now BURNEMIS(:,I,J).
     Replace PW(I,J) with P(I,J). (bmy, 9/28/01)
(17) Removed obsolete code from 9/01 (bmy, 10/24/01)
(18) Now references GET_PEDGE from "pressure_mod.f", to compute P at
     the bottom edge of grid box (I,J,L).  (dsa, bdf, bmy, 8/21/02)
```

```
(19) Now reference IDTNOX, IDENOX, etc from "tracerid_mod.f" (bmy, 11/6/02)
(20) Remove references to IREF, JREF (bmy, 2/11/03)
(21) NEMIS is now NEMIS(NCS) for SMVGEAR II (gcc, bdf, bmy, 4/1/03)
(22) Added parallel loop over N.  Also directly substituted JLOP(I,J,1)
     for all instances of JLOOP1.  Updated comments. (hamid, bmy, 3/19/04)
(23) Bug fix for COMPAQ compiler...do not use EXIT from w/in parallel loop.
     (auvray, bmy, 11/29/04)
(24) Now replace XTRA2 with GET_PBL_TOP_L in "pbl_mix_mod.f".  Now remove
     reference to CMN, it's obsolete.  Now references GET_TPAUSE_LEVEL
     from "tropopause_mod.f" (bmy, 8/22/05)
(25) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(26) Now updated for new "biomass_mod.f" (bmy, 4/5/06)
(27) Now account for the different definition of tropopause in case
     of variable tropopause.   The BIOMASS array from "biomass_mod.f" is
     now in units of [molec CO/cm2/s].  Adjust unit conversion accordingly.
     Also replace NBIOMAX with NBIOMAX_GAS, since aerosol biomass is
     handled elsewhere.  (bdf, phs, bmy, 9/27/06)
(28) Now replace GEMISNOX array (from F77_CMN_NOX) with module arrays
     EMIS_LI_NOx and EMIS_AC_NOx (ltm, bmy, 10/3/07)
(29) Bug fix: resize EMISRR to be consistent w/ F77_CMN_O3 (bmy, jaf, 6/11/08)
(30) Limit emissions into the surface level only (lin, 5/29/09)
(31) Bug fix: cycle if IDEMIS(NN) <= 0 to avoid array-out-of-bounds
     errors (bmy, 8/6/09)
(32) Check for emissions above PBL -anthro NOx only for now- (phs, 10/27/09)
(33) Modify selection of biomass burning emissions (hotp, 8/3/09)
(34) Moved NOx scaling to improve parallelization. (ccc, 11/10/10)
16 Dec 2010 - R. Yantosca - Removed obsolete, commented-out code
16 Dec 2010 - R. Yantosca - Added ProTeX headers
21 Dec 2010 - R. Yantosca - Now set REMIS=0d0.  Also updated comments.
```

1.70.23 sfcwindsqr

Function SFCWINDSQR computes the surface wind squared from the U and V winds at 10 m above the surface.

INTERFACE:

```
      REAL*8 FUNCTION SFCWINDSQR( I, J )
```

USES:

```
      USE DAO_MOD, ONLY : U10M, V10M

      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      INTEGER, INTENT(IN) :: I   ! Longitude index
      INTEGER, INTENT(IN) :: J   ! Latitude index
```

REVISION HISTORY:

```
21 Dec 1998 - R. Yantosca - Initial version
(1 ) The old SFCWINDSQR computed the surface wind squared (m/s)^2 from the
     the Harvard CTM winds (kg/s).  But since the DAO winds are already
     in units of (m/s) then the previous unit conversion is unnecessary
     and costly in terms of computer resources.
(2 ) Since GEOS-1 has U and V at 10 m, these are more representative
     of the surface than UWND(I,J,1) and VWND(I,J,1).
(3 ) Pass GEOS-1 U10M and V10M fields via F77_CMN_UV10M so that the argument
     list does not have to be modified in several existing Harvard CTM
     subroutines.
(4 ) GEOS-STRAT does not store U10M and V10M, so compute 10 m wind speed
     from UWND(I,J,1) and VWND(I,J,1) in MAKE_WIND10M.
(5 ) Now check for NaN's (bmy, 4/27/00)
(6 ) Now reference U10M and V10M from "dao_mod.f" instead of from
     common block header files "F77_CMN_UV10M".  Also extend code
     to GEOS-2 and GEOS-3 met fields. (bmy, 7/11/00)
(7 ) Now use interface IT_IS_NAN (from "error_mod.f") to trap NaN's.
     This will work on DEC/Compaq and SGI platforms. (bmy, 3/8/01)
(8 ) Now call CHECK_VALUE from "error_mod.f".  This will test SFCWINDSQR
     for NaN or Infinity conditions.  Also updated comments and made
     cosmetic changes. (bmy, 7/16/01)
(9 ) Removed obsolete, commented-out code from 7/01 (bmy, 11/26/01)
(10) Remove support for GEOS-1 and GEOS-STRAT met fields.  Also remove
     call to CHECK_VALUE. (bmy, 8/4/06)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

1.70.24 tcorr

Function TCORR applies the temperature correction for isoprene emissions, according to Guenther et al.(92)

INTERFACE:

```
      FUNCTION TCORR( TEMP )
```

USES:

```
      IMPLICIT NONE
#     include "define.h"
```

INPUT PARAMETERS:

```
      REAL*8, INTENT(IN) :: TEMP    ! Temperature [K]
```

RETURN VALUE:

```
      REAL*8             :: TCORR   ! Corrected temp for ISOP emissions [K]
```

REMARKS:

```
    References:
    ============================================================================
    Guenther et al, 1992, ...
```

REVISION HISTORY:

```
    15 Nov 1993 - Y. H. Wang  - Initial version
    (1 ) Removed DATA statements, replaced w/ F90 syntax.  Updated comments
         and made cosmetic changes (bmy, 4/4/03)
    19 Nov 2010 - R. Yantosca - Added ProTeX headers
```