

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

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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- 30 Nov 1999 - R. Yantosca - DO_MASSFLUX is obsolete, since the mass flux arrays are now declared allocatable in "diag_mod.f".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, LSLWJ, 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

1.1.2 Include File CMN_SIZE

CMN_SIZE contains size parameters for GEOS-Chem arrays.

USES:

```
! C Preprocessor #define statements for conditional compilation
#   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
! IGLOBAL = global longitude dimension
! JGLOBAL = global latitude dimension
! LGLOBAL = max number of sigma levels
! IIPAR = window longitude dimension
! JJPARG = 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, JJPARG=JGLOB, LLPAR=LGLOBAL.
! For nested grids, then IIPAR<IGLOB, JJPARG<JGLOB, LLPAR<LGLOBAL.
!=====
#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 :: JJPARGLOB   = 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 :: JJPARGLOB   = 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 :: IO5x0666   = 540
INTEGER, PARAMETER :: JO5x0666   = 361

!=====
! TRACER & EMISSION SPECIES PARAMETERS
! NNPAR   = max number of tracers
! NEMPARG = max number of anthropogenic emission species
! NEMPARG = max number of biogenic      emission species
!=====
! increase NNPAR and NEMPARG an extra amount (hotp 7/31/09)
#if defined( TOMAS )
INTEGER, PARAMETER :: NNPAR   = 320   ! For TOMAS (win, bmy, 1/25/10)
#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 :: NEMPARG = 21
INTEGER, PARAMETER :: NEMPARG = 26

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

```

```
! 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 (rvn, bmy, 11/15/01)
INTEGER, PARAMETER :: NDUST = 7

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

! NRH -- number of relative humidity bins (rvn, 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
```

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 obsolete (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 NNPARG=31 for coupled fullchem/sulfate
simulations. (rjp, bdf, bmy, 11/15/02)
- (12) Removed IO, JO; 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 NNPARG from 31 to 39 for carbon & dust tracers. Also
declare NDSTBIN as # of dust bins. (rvm, tdf, bmy, 4/1/04)
- (17) Increase NNPARG to 41 for seasalt tracers (rjp, bec, bmy, 4/20/04)
- (18) Increase NNPARG 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 NNPARG to 52 (bmy, 12/6/05)
- (23) Increase NNPARG 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).

1.1.3 Include File CMN_DIAG

This include file contains size parameters and common blocks for the GEOS-Chem diagnostic arrays. This is mostly historical baggage.

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, KDA SRCE, 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. (kjl, 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

```

1.2 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
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: CLEANUP_ACETONE
PUBLIC :: EMISS_BIOACET
PUBLIC :: OCEAN_SOURCE_ACET
PUBLIC :: OCEAN_SINK_ACET
PUBLIC :: READ_J01D
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

**1.2.1 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

```

```

include "CMN_SIZE" ! Size parameters

```

## INPUT PARAMETERS:

```

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

```

## REMARKS:

J-values for 01D are are stored in the J01D module array in [s<sup>-1</sup>].

## 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

```

### 1.2.2 read\_resp

Subroutine READ\_RESP reads in the monthly heterotrophic respiration measured in g of plant matter/m<sup>2</sup> 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

```

```

include "CMN_SIZE" ! Size parameters

```

#### INPUT PARAMETERS:

```

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

```

#### REMARKS:

Respiration values are stored in the RESP module array in [g C/m<sup>2</sup>/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,JJPARG). 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

```

---

### 1.2.3 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DEP" ! FRCLND
include "CMN_DIAG" ! ND11

```

**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  $u = \text{SQRT}(U10M^2 + V10M^2)$  as  $\text{SQRT}(\text{SFCWINDSQR}(I,J))$ .  
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  $-5 \leq TC \leq 30$ , 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
-

### 1.2.4 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! ND11
include "CMN_DEP" ! 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 CMN\_UV10M and CMN\_LWI -- these are now obsolete in GEOS-CHEM versions 4.18 and higher (bmy, 9/5/01)
  - (2 ) Now compute  $u = \text{SQRT}(U10M^2 + V10M^2)$  as  $\text{SQRT}(SFCWINDSQR(I,J))$ . 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 parallelized 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  $-5 \leq TC \leq 30$ , 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

---

### 1.2.5 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_MONOT" ! BASEMONOT
include "CMN_DIAG" ! ND11

```

#### 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

---

### 1.2.6 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

---

### 1.3 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
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 SO<sub>2</sub> differs from existing EDGAR inventory. All other species are disregarded for now, except CO<sub>2</sub> 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/](http://www-lscedods.cea.fr/aerocom/AEROCOM_HC/readme_ship/).  
 If you have further questions, please contact Thomas directly (thomas.diehl@nasa.gov).

**1.3.1 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/cm<sup>2</sup>/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

---

**1.3.2 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
```

```
include "CMN_SIZE" ! Size parameters
```

**INPUT PARAMETERS:**

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

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

---

**1.3.3 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,
& TRACER, 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
```

```
include "CMN_SIZE" ! 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,JJPARG)

```

**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

**1.3.4 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

```

```

include "CMN_SIZE" ! Size parameters

```

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

**1.3.5 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

---

**1.3.6 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

---

**1.4 Fortran: Module Interface bravo\_mod****Overview**

Module BRAVO\_MOD contains variables and routines to read the BRAVO Mexican anthropogenic emission inventory for NO<sub>x</sub>, CO, and SO<sub>2</sub>. (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
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

```

---

#### 1.4.1 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

```

---

#### 1.4.2 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)
```

---

**1.4.3 emiss\_bravo**

Subroutine EMISS\_BRAVO reads the BRAVO emission fields at 1x1 resolution and regrid 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

include "CMN_SIZE" ! Size parameters
include "CMN_03" !
```

**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)
```

---

#### 1.4.4 **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_S02ff
```

```
include "CMN_SIZE" ! Size parameters
```

##### **REVISION HISTORY:**

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

---

#### 1.4.5 **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, IDTS02
```

```
include "CMN_SIZE" ! 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)
```

---



### 1.4.6 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
```

```
include "CMN_SIZE" ! 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)
```

---

### 1.4.7 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
```

```
include "CMN_SIZE" ! Size parameters
```

#### REVISION HISTORY:

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

---

### 1.4.8 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

---

## 1.5 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  
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

---

### 1.5.1 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

---

#### 1.5.2 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

---

### 1.5.3 emiss\_cac\_anthro

Subroutine EMISS\_CAC\_ANTHRO reads the Critical Air Contaminants emission fields at 1x1 resolution and regrid 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_03" ! 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

### 1.5.4 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_03" ! 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)

**1.5.5 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

# include "CMN\_SIZE" ! Size parameters

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

**1.5.6 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:**

# include "CMN\_SIZE" ! Size parameters

**INPUT PARAMETERS:**

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

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

**1.5.7 read\_canada\_mask**

Subroutine READ\_CANADA\_MASK reads and regrid 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

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

---

**1.5.8 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

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

---

**1.5.9 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

```

```

include "CMN_SIZE" ! Size parameters

```

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

---

**1.5.10 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

---

**1.6 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
PRIVATE

```

**PUBLIC MEMBER FUNCTIONS:**

```

PUBLIC :: DO_CHEMISTRY
PUBLIC :: GCKPP_DRIVER

```

**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)  
 17 Dec 2009 - R. Yantosca - Added ProTeX headers  
 28 Jan 2010 - C. Carouge, R. Yantosca - Modified for ISORROPIA II

---

### 1.6.1 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:

```
! References to F90 modules
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 ISORROPIAII_MOD, ONLY : DO_ISORROPIAII
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 : LNLPL ! (Lin, 03/31/09)

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! NDxx flags
include "comode.h" ! NPHOT

```

## 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 "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 ISORROPIA 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 all references 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
- 

### 1.6.2 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.
- 

## 1.7 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.
- Corbett and Koehler (2003) *Updated emissions from ocean shipping*, J. Geophys. Res., **108**, D20, 4650.
- Corbett and Koehler (2004) *Considering alternative input parameters in an activity-based ship fuel consumption and emissions model: Reply ...* J. Geophys. Res., D23303.
- Endresen et al. (2007) *A historical reconstruction of ships fuel consumption and emissions*, J. Geophys. Res. **112**, D12301.
- Kim et al. (2005) *System for assessing Aviation's Global Emissions (SAGE) Version 1.5 global Aviation Emissions Inventories for 2000-2004*
- Kim et al. (2007) *System for assessing Aviation's Global Emissions (SAGE) Part 1: Model description and inventory results*
- LeQuere et al. (2009) *Trends in the sources and sinks of carbon dioxide*, Nature Geoscience, doi:10.1038/ngeo689.
- Olsen and Randerson (2004), *Differences between surface and column atmospheric CO2 and implications for carbon cycle research*, J. Geophys. Res., **109**, D02301,
- Potter et al. (1993), *Terrestrial Ecosystem Production: A process model based on global satellite and surface data*, Glob. Biogeochem. Cycles, **7**(4), 811-841.
- Randerson, J.T, M.V. Thompson, T.J.Conway, I.Y. Fung, and C.B. Field, *The contribution of terrestrial sources and sinks to trends in the seasonal cycle of atmospheric carbon dioxide*, Glob. Biogeochem. Cycles, **11**, 535-560, 1997.
- 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. Wanninkhof, D. Chipman, S. Sutherland, and T. Takahashi (1997), *Global air-sea flux of CO<sub>2</sub>: An estimate based on measurements of sea-air pCO<sub>2</sub> difference*, Proceedings of the National Academy of Sciences, **94**, 8292-8299.
- Takahashi, T, et al. (2009), *Climatological mean and decadal change in surface ocean pCO<sub>2</sub>, and net sea-air CO<sub>2</sub> flux over the global oceans*, **Deep-Sea Research II**, doi:10.1016/j.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 CO<sub>2</sub> and NO<sub>x</sub> 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
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)

```

---

### 1.7.1 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 : 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 : LCHEMC02

```

```
include "CMN_SIZE" ! 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)
- 

**1.7.2 read\_chemco2**

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

**INTERFACE:**

```
SUBROUTINE READ_CHEMC02
```

**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

```

```
include "CMN_SIZE" ! Size parameters
```

**REMARKS:****REVISION HISTORY:**

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

---

### 1.7.3 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

```

```

include "CMN_SIZE" ! 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

### 1.7.4 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

```

```

include "CMN_SIZE" ! 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

### 1.7.5 aviation\_dom\_corr

This subroutine downscales national fossil fuels emissions for the CO2 which is attributed 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.

## INTERFACE:

```

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

```

```

include "CMN_SIZE" ! 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

---

**1.7.6 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REMARKS:**

See References Above

**REVISION HISTORY:**

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

---

**1.7.7 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

```

```

include "CMN_SIZE" ! 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

---

### 1.7.8 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

```

```

include "CMN_SIZE" ! Size parameters

```

## REVISION HISTORY:

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

---

### 1.7.9 read\_shipco2\_icoads

Subroutine READ\_SHIPCO2\_ICOADS reads in ICOADS monthly ship CO2 emissions

### INTERFACE:

## SUBROUTINE READ\_SHIPC02\_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

```

```

include "CMN_SIZE" ! 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

## 1.7.10 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:

```
include "CMN_SIZE" ! Size parameters
```

This is a modified version of READ\_AIRCRAFT\_SO2 from:  
rjp, bdf, bmy, 9/18/02, 10/3/05

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

```
(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
```

```
! 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

```

```
include "CMN_SIZE" ! 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 variability 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

---

### 1.7.12 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

```

```
include "CMN_SIZE" ! 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

---

**1.7.13 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

```

```

include "CMN_SIZE" ! 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 CO<sub>2</sub> 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

---

**1.7.14 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
```

```
include "CMN_SIZE" ! 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,JJP) ! BB Emissions
 ! [molec/cm2/month]
```

**REVISION HISTORY:**

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

---

**1.7.15 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
```

```
include "CMN_SIZE" ! Size parameters
```

**OUTPUT PARAMETERS:**



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

**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

---

**1.7.16 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
```

```
include "CMN_SIZE" ! Size parameters
```

**OUTPUT PARAMETERS:**

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

**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

---

**1.7.17 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
```

```
include "CMN_SIZE" ! Size parameters
```

**OUTPUT PARAMETERS:**

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

**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
```

---

**1.7.18 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 : 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

```

```
include "CMN_SIZE"
```

## REVISION HISTORY:

```

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

```

---

### 1.7.19 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

```

---

## 1.8 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
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(:, :, :)
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). (rvn, 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 BCP0 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
- 

### 1.8.1 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
```

```
include "CMN_SIZE"
include "comode.h"
```

#### 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
- 

### 1.8.2 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
```

---

**1.9 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
```

```
IMPLICIT NONE
PRIVATE
```

```
include "smv_errcode.h"
include "smv_physconst.h"
```

**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 LDYNOCAN=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
- 

### 1.9.1 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 : LDYNOCAN
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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! Diagnostic flags

```

## REVISION HISTORY:

```

25 May 2005 - S. Wu - Initial version
08 Feb 2007 - R. Yantosca - Now reference "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 LDYNOCAN 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

```

### 1.9.2 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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

---

### 1.9.3 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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

#### 1.9.4 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 : LDYNOCAN, 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
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! Diagnostic switches & arrays
```

#### 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,JJP,LLPAR)

! Detrainment mass flux [kg/m2/s]
```

```
REAL*8, INTENT(IN) :: DTRN(IIPAR,JJPARG,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,JJPARG,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<br>(SJ Lin) | New Method |             |
|------------------------|------------|-------------|
| -----                  | -----      | 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<br>(SJ Lin) | New Method  |
|------------------------|-------------|
| k-1      ^             | k+1      ^  |
| ----- -----            | ----- ----- |
|                        |             |
| CMFMC(k)               | CMFMC(k)    |

becomes

|                                                                                                                                               |                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| $\begin{array}{c} k \\ \text{DTRAIN}(k), \\ \text{QC}(k), Q(k) \\ \text{-----}  \text{-----} \\   \\ k+1 \quad \text{CMFMC}(k+1) \end{array}$ | $\begin{array}{c} k \\ \text{DTRAIN}(k), \\ \text{QC}(k), Q(k) \\ \text{-----}  \text{-----} \\   \\ k-1 \quad \text{CMFMC}(k-1) \end{array}$ |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|

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



```

& 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 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 BMAS:

```

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

```

---

### 1.10 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:

```
IMPLICIT NONE
PRIVATE
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! Physical constants
```

#### PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: AVGPOLE
PUBLIC :: AIRQNT
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 :: TO31 (:,:)
REAL*8, ALLOCATABLE, PUBLIC :: TO32 (:,:)
REAL*8, ALLOCATABLE, PUBLIC :: TO3 (:,:)
REAL*8, ALLOCATABLE, PUBLIC :: TT03 (:,:)
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 :: TAUCW (:,:,)
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 (:,:,)

```

## 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}GCMPPAR 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
 AVGPOL 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) AVGPOL 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 (kjl, 8/18/09)
(32) Bug fix in AVGPOL (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 CMN_SIZE, CMN_DIAG to top of module
25 Aug 2010 - R. Yantosca - Now read LWI (land/water/ice) for MERRA met

```

### 1.10.1 avgpole

Subroutine AVGPOL computes average quantity near polar caps, defined by ( $J = 1, 2$ ) and ( $J = JPAR-1, JPAR$ ).

## INTERFACE:

SUBROUTINE AVGPOLE( Z )

**USES:**

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

### INPUT/OUTPUT PARAMETERS:

[illegible]

**REVISION HISTORY:**

- 30 Jan 1998 - R. Yantosca - Initial version
- (1 ) AVGPOL 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(JGLOB), to AVGPOL. Use window offset J+J0 when accessing DXYP. Add JGLOB 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
- 

**1.10.2 airqnt**

Subroutine AIRQNT calculates the volume [ $\text{m}^3$  and  $\text{cm}^3$ ], mass [kg], density, [ $\text{kg}/\text{m}^3$ ], and pressure thickness [hPa] of air for each grid box (I,J,L). The quantity (surface pressure - P<sub>TOP</sub>) [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 [ $\text{m}^3$  ]
- (4 ) AD (REAL\*8 ) : Mass of air in a grid box [kg ]
- (5 ) AIRDEN (REAL\*8 ) : Density of air in a grid box [ $\text{kg}/\text{m}^3$  ]

**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,JJPARG) 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 "CMN\_SIZE". Also updated comments. (bmy, 2/22/00)
  - (6 ) Replace IM, JM, LM with IIPAR, JJPARG, LLPARG 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 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

### 1.10.3 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(IGCMPPAR,JGCMPPAR,LGCMPPAR) 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}GCMPPAR 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
- 

#### 1.10.4 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 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

---

### 1.10.5 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 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

---

**1.10.6 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
```

---

**1.10.7 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
```

### 1.10.8 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,JJPARG,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
```

### 1.10.9 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

---

**1.10.10 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

---

**1.10.11 cossza**

COSSZA computes the cosine of the solar zenith angle.

**INTERFACE:**

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

**USES:**

```
USE GRID_MOD, ONLY : GET_YMID_R
USE TIME_MOD, ONLY : GET_LOCALTIME
USE TIME_MOD, ONLY : GET_TS_SUN_2
```

**INPUT PARAMETERS:**

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

**OUTPUT PARAMETERS:**

```
REAL*8, INTENT(OUT) :: SUNCOS(MAXIJ) ! COS(Solar zenith angle)
```

**REVISION HISTORY:**

- 21 Jan 1998 - R. Yantosca - Initial version
  - (1 ) COSSZA is written in Fixed-Form Fortran 90.
  - (2 ) Use IMPLICIT NONE to declare all variables explicitly.
  - (3 ) Use C-preprocessor #include statement to include CMN\_SIZE, which  
has IIPAR, JJPAR, LLPAR, IGLOB, JGLOB, LGLOB.
  - (4 ) Use IM and JM (in 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
-

**1.10.12 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,JJPAP,LLPAR)
```

**OUTPUT PARAMETERS:**

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

**1.10.13 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
```

---

**1.10.14 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, LDYRD, 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) Eliminated 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

### 1.10.15 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 ) Eliminated 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

---

### 1.11 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
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 :: HgOdryGEOS(:, :), HgIIIdryGEOS(:, :),
& HgIIwetGEOS(:, :)
!PRIVATE DATA MEMBERS:
 CHARACTER(LEN=255) :: GTMM_RST_FILE
 LOGICAL :: LHGSNOW

```

## REVISION HISTORY:

23 Apr 2010 - C. Carouge - Initial version

---

### 1.11.1 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

---

### 1.11.2 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

```

---

**1.11.3 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

```

---

**1.11.4 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

```

---

**1.11.5 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
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

```

---

**1.11.6 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
```

---

### 1.11.7 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
```

```
include "CMN_SIZE" ! 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
```

---

### 1.11.8 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

```

```

 # include "CMN_SIZE"

```

**INPUT PARAMETERS:**

```

 INTEGER, INTENT(IN) :: YYYYMMDD, HHMMSS

```

**OUTPUT PARAMETERS:**

```

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

```

**REVISION HISTORY:**

```

 15 Sep 2009 - C. Carouge - Initial version

```

---

**1.11.9 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

```

---

### 1.11.10 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
include "CMN_SIZE"
```

#### INPUT PARAMETERS:

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

#### REVISION HISTORY:

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

---

### 1.11.11 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
```

```
include "CMN_SIZE" ! 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
```

---

**1.11.12 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

---

**1.12 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
PRIVATE
```

**DEFINED PARAMETERS:**

```
INTEGER, PUBLIC, PARAMETER :: PD03 = 18 ! Dim of AD03 array
```

**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
```

---

**1.12.1 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

include "CMN_SIZE" ! 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
```

---

**1.12.2 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 ! CDH for sea salt loss rate
USE TRACERID_MOD, ONLY : N_Hg_CATS

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! TINDEX

```

## REMARKS:

| #    | : Field   | : Description                     | : Units | : Scale factor              |
|------|-----------|-----------------------------------|---------|-----------------------------|
| (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

### 1.12.3 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
```

```
include "CMN_SIZE"
```

#### 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

### 1.12.4 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

### 1.13 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
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
-

**1.13.1 zero\_diag04**

Subroutine ZERO\_DIAG04 zeroes the ND04 diagnostic array.

**INTERFACE:**

```
SUBROUTINE ZERO_DIAG04
```

**USES:**

```
include "CMN_SIZE" ! 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
```

---

**1.13.2 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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 ADO4\_PLANE, ADO4\_CHEM  
 18 May 2010 - R. Yantosca - Added ProTeX headers

---

**1.13.3 init\_diag04**

Subroutine INIT\_DIAG04 allocates all module arrays.

**INTERFACE:**

```
SUBROUTINE INIT_DIAG04
```

**USES:**

```
USE ERROR_MOD, ONLY : ALLOC_ERR
```

```
include "CMN_SIZE"
```

**REVISION HISTORY:**

26 Jul 2005 - R. Yantosca - Initial version  
 18 May 2010 - R. Nassar - Now initialize ADO4\_PLANE, ADO4\_CHEM  
 18 May 2010 - R. Yantosca - Added ProTeX headers

---

**1.13.4 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

---

**1.14 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
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
```

### 1.14.1 zero\_diag41

Subroutine ZERO\_DIAG41 zeroes the ND41 diagnostic arrays.

## INTERFACE:

```
SUBROUTINE ZERO_DIAG41
```

## USES:

```
include "CMN_SIZE" ! Size parameters
```

## REVISION HISTORY:

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

### 1.14.2 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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
```

### 1.14.3 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

```

```

include "CMN_SIZE" ! 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

## 1.14.4 init\_diag41

Subroutine CLEANUP\_DIAG41 allocates and zeroes all module arrays.

## INTERFACE:

```

SUBROUTINE INIT_DIAG41

```

## USES:

```

USE ERROR_MOD, ONLY : ALLOC_ERR

```

```

include "CMN_SIZE" ! Size parameters

```

**REVISION HISTORY:**

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

---

**1.14.5 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

---

**1.15 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
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

---

**1.15.1 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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

---

**1.15.2 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

---

**1.15.3 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

---

**1.15.4 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

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

---

**1.15.5 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

---

**1.16 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  
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 IO, JO 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)

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

### 1.16.1 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 : IDTHN03, IDTHN04, IDTN205, IDTNOX
USE TRACERID_MOD, ONLY : IDTPAN, IDTPMN, IDTPPN, IDTOX
USE TRACERID_MOD, ONLY : IDTR4N2, IDTSALA, IDTSALC

include "cmn_fj.h" ! FAST-J stuff, includes CMN_SIZE
include "jv_cmn.h" ! ODAER, QAA, QAA_AOD (clh)
include "CMN_03" ! Pure 03, SAVEN02
include "CMN_GCTM" ! 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
- 

### 1.16.2 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
- 

### 1.16.3 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

---

### 1.16.4 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:

```
include "CMN_SIZE" ! 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

---

### 1.16.5 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

```

```

include "CMN_SIZE" ! 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 IO and JO 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

```

## 1.17 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

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 IO and JO 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

**1.17.1 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

### 1.17.2 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 : IDTHN03, IDTHN04, IDTN205, IDTNOX
USE TRACERID_MOD, ONLY : IDTPAN, IDTPMN, IDTPPN, IDTOX
USE TRACERID_MOD, ONLY : IDTR4N2, IDTSALA, IDTSALC
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP

include "cmn_fj.h" ! includes CMN_SIZE
include "jv_cmn.h" ! ODAER, QAA, QAA_OUT
include "CMN_03" ! FRACO3, FRACNO, SAVE03, SAVENO2, SAVEHO2, FRACNO2
include "CMN_GCTM" ! SCALE_HEIGHT
include "comode.h" ! NPVERT

```

#### 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. (rvrm, 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

---

### 1.17.3 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

---

### 1.17.4 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

include "CMN_SIZE" ! 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)





**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

```

```

include "CMN_SIZE"

```

**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 IO and JO 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

```

---

**1.17.7 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
```

**1.18 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
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 IO and JO 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

### 1.18.1 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

### 1.18.2 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
```

```
include "CMN_SIZE" ! 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
```

### 1.18.3 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 : IDTHN03, IDTHN04, IDTN205, IDTNOX
USE TRACERID_MOD, ONLY : IDTPAN, IDTPMN, IDTPPN, IDTOX
USE TRACERID_MOD, ONLY : IDTR4N2, IDTSALA, IDTSALC
USE TROPOPAUSE_MOD, ONLY : ITS_IN_THE_TROP

include "cmn_fj.h" ! includes CMN_SIZE
include "jv_cmn.h" ! ODAER, QAA, QAA_AOD
include "CMN_03" ! FRACO3, FRACNO, SAVE03, SAVENO2, SAVEH02, FRACNO2
include "CMN_GCTM" ! 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
-

#### 1.18.4 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
```

---

#### 1.18.5 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

include "CMN_SIZE" ! 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

### 1.18.6 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:

```
include "CMN_SIZE" ! 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
```

### 1.18.7 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

```

```

include "CMN_SIZE" ! 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

---

### 1.18.8 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
```

---

### 1.19 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
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

---

### 1.19.1 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

---

### 1.19.2 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

---

**1.19.3 init\_diag56**

Subroutine INIT\_DIAG56 allocates all module arrays, 5/11/06)

**INTERFACE:**

```
SUBROUTINE INIT_DIAG56
```

**USES:**

```
USE ERROR_MOD, ONLY : ALLOC_ERR
```

```
include "CMN_SIZE"
```

**REVISION HISTORY:**

11 May 2006 - R. Yantosca - Initial version  
 15 Sep 2010 - R. Yantosca - Added ProTeX headers

---

**1.19.4 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

---

**1.20 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" (NO<sub>x</sub>-O<sub>x</sub>-Hydrocarbon-aerosol) mechanism.

**INTERFACE:**

```
MODULE DIAG_PL_MOD
```

## USES:

```
IMPLICIT NONE
PRIVATE
```

## PUBLIC DATA MEMBERS:

```
! Scalars
LOGICAL, PUBLIC :: DO_SAVE_PL
INTEGER, PUBLIC :: TAG03_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
```

---

### 1.20.1 setjfam

Subroutine SETJFAM stores info into SMVGEAR arrays for the ND65 prod/loss diagnostic.

#### INTERFACE:

```
SUBROUTINE SETJFAM(NACTIVE, NINAC)
```

#### USES:

```
include "CMN_SIZE" ! Size parameters
include "comode.h" ! 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

---

### 1.20.2 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

```

```

include "CMN_SIZE"
include "comode.h"

```

**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

---

**1.20.3 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! LD65
include "comode.h" ! SMVGEAR II arrays

```

**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

---

### 1.20.4 diag20

Subroutine DIAG20 computes production and loss rates of O<sub>3</sub>, 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 O<sub>3</sub> 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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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(0x) and L(0x) 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
```

---

### 1.20.5 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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
```

---

### 1.20.6 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

---

**1.20.7 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

---

**1.20.8 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

---

**1.20.9 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
```

**1.20.10 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! ND65, LD65
include "comode.h" ! LFAMILY, NFAMILIES
```

**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) :: SAVE03

! 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

---

**1.20.11 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

---

**1.21 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/cm<sup>3</sup>. This is a metric of how certain chemistry simulations are performing.

**INTERFACE:**

```
MODULE DIAG_OH_MOD
```

## USES:

```
IMPLICIT NONE
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)
```

---

### 1.21.1 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
```

```
include "CMN_SIZE" ! Size parameters
include "comode.h" ! NPVERT, NLAT, NLONG
```

## REVISION HISTORY:

```
07 Jul 2004 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
```

---

### 1.21.2 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

```

---

**1.21.3 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

```

---

**1.21.4 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

```

```

include "CMN_SIZE" ! Size parameters

```

## REVISION HISTORY:

```

07 Jul 2004 - R. Yantosca - Initial version
(1) Remove references to CO-OH simulation and to CMN_DIAG (bmy, 6/24/05)
15 Sep 2010 - R. Yantosca - Added ProTeX headers

```

---

### 1.21.5 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

```

---

### 1.22 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
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(:,:,:,:)

! 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_S02_ac(:,:,:,:)
REAL*4, ALLOCATABLE :: AD13_S02_an(:,:,:,:)
REAL*4, ALLOCATABLE :: AD13_S02_bb(:,:)
REAL*4, ALLOCATABLE :: AD13_S02_bf(:,:)
REAL*4, ALLOCATABLE :: AD13_S02_nv(:,:,:,:)
REAL*4, ALLOCATABLE :: AD13_S02_ev(:,:,:,:)
REAL*4, ALLOCATABLE :: AD13_S02_sh(:,:)
REAL*4, ALLOCATABLE :: AD13_S04_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 -- tropospheric 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 :: LTH02(:,:)
INTEGER, ALLOCATABLE :: CTH02(:,:,:)
INTEGER, ALLOCATABLE :: LTN03(:,:)
INTEGER, ALLOCATABLE :: CTN03(:,:,:)
! update for arom (dkh, 06/21/07)
INTEGER, ALLOCATABLE :: CTLBR02H(:,:,:)
INTEGER, ALLOCATABLE :: CTLBR02N(:,:,:)
INTEGER, ALLOCATABLE :: CTLTR02H(:,:,:)
INTEGER, ALLOCATABLE :: CTLTR02N(:,:,:)
INTEGER, ALLOCATABLE :: CTLXR02H(:,:,:)
INTEGER, ALLOCATABLE :: CTLXR02N(:,:,:)
INTEGER, ALLOCATABLE :: LTLBR02H(:,:)
INTEGER, ALLOCATABLE :: LTLBR02N(:,:)
INTEGER, ALLOCATABLE :: LTLTR02H(:,:)
INTEGER, ALLOCATABLE :: LTLTR02N(:,:)
INTEGER, ALLOCATABLE :: LTLXR02H(:,:)
INTEGER, ALLOCATABLE :: LTLXR02N(:,:)

! 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 :: CT03(:,:,:)
INTEGER, ALLOCATABLE :: LT03(:,:)

! For ND46 -- Tracer concentration diagnostic
REAL*4, ALLOCATABLE :: AD46(:,:,:)

! For ND47 -- 24-h tracer concentration diagnostic
REAL*4, ALLOCATABLE :: AD47(:,:,:)

! For ND47(03) / ND65 -- 24-h tracer diagnostic
INTEGER, ALLOCATABLE :: CT03_24h(:,:,:)

! Dynamically allocatable array -- local only to DIAG50.F
REAL*8, ALLOCATABLE :: STT_TEMP02(:,:,:)

! For ND52 -- gamma H02 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 anymore
- (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 (rvn, 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 emissions 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\_S02\_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\_S04\_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 CT03 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 CT03\_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 LT03 for ND45 diag. (ccc, 7/20/09)
- (32) Add AD19, AD58, AD60 for CH4 (kjl, 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

### 1.22.1 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 deallocate AD13\_S02\_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 CT03, AD10, AD10em arrays (phs, 9/18/07)
- 

### 1.23 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
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_GINOX
```

#### 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 BCP0 and OCP0) 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

---

### 1.23.1 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
```

```
include "CMN_SIZE" ! 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

---

### 1.23.2 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! g0
include "CMN_DIAG" ! 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) 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
```

### 1.23.3 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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
```

---

### 1.23.4 *emissdust*

Subroutine EMISSDUST is the driver routine for the dust emission module. You may call either the GINOX 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
```

```
include "CMN_SIZE" ! 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
```

---

### 1.23.5 *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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! ND06
include "CMN_GCTM" ! 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 mislabeled in GEOS-5  
                                   and has units of mm H2O instead of m H2O  
                                   so we need to convert to m H2O.

---

**1.23.6 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! ND19, LD13 (for now)
include "CMN_GCTM" ! g0
```

**INPUT/OUTPUT PARAMETERS:**

```
REAL*8, INTENT(INOUT) :: TC(IIPAR,JJP,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

**1.23.7 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)
```

**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
```

```
include "cmn_fj.h" ! LPAR, CMN_SIZE
include "jv_cmn.h" ! ODMDUST, QAA, RAA, QAA_AOD (clh)
include "CMN_DIAG" ! ND21, LD21
include "comode.h" ! NTTLOOP
```

**INPUT/OUTPUT PARAMETERS:**

```
REAL*8, INTENT(IN) :: DUST(IIPAR,JJPAR,LLPAR,NDUST) ! Dust [kg/m3]
```

**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 OCP0), WTAREA and WERADIUS. (tmf, 3/6/09)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
```

**1.23.8 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)
```

**USES:**

```
! References to F90 modules
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

```

```

IMPLICIT NONE

```

```

include "cmn_fj.h" ! LPAR, CMN_SIZE
include "jv_cmn.h" ! ODMDUST, QAA, RAA
include "CMN_DIAG" ! ND21, LD21
include "comode.h" ! NTTLOOP

```

## INPUT PARAMETERS:

```

INTEGER, INTENT(IN) :: THISMONTH ! Current month (1-12)
INTEGER, INTENT(IN) :: THISYEAR ! Current year (YYYY format)

```

## REVISION HISTORY:

- (1 ) RDUST was patterned after rdaerosol.f (rvn, 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 "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. (rvn, bmy, 11/21/00)
- (5 ) CONC is now declared as REAL\*8 (rvn, bmy, 12/15/00)
- (6 ) Removed obsolete code from 12/15/00 (bmy, 12/21/00)
- (7 ) CONC(IGLOB,JGLOB,LGLOB,NDUST) is now CONC(IIPAR,JJPARG,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,JJPARG,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

```

---

### 1.23.9 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

```

```
include "CMN_SIZE" ! 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

```

---

**1.23.10 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
```

---

**1.24 Fortran: Module Interface emep\_mod****Overview**

Module EMEP\_MOD contains variables and routines to read the EMEP European anthropogenic emission inventory for CO, NO<sub>x</sub>, 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/mscw/mscw\_publications.html)

[http://www.emep.int/publ/reports/2002/mscw\\\_note\\\_1\\\_2002.pdf](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
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

```

#### 1.24.1 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

---

### 1.24.2 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)

---

### 1.24.3 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! 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)

## 1.24.4 emiss\_emep\_05x0666

Subroutine EMISS\_EMEP reads the EMEP emission fields at 05x0666 resolution and re-grids 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! SCALEYEAR

```

## REVISION HISTORY:

23 Oct 2006 - A. v. Donkelaar - Initial version, modified from EMISS\_EMEP

### 1.24.5 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
```

```
include "CMN_SIZE" ! Size parameters
```

#### REVISION HISTORY:

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

---

### 1.24.6 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
```

```
include "CMN_SIZE" ! 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)
- 

**1.24.7 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
```

```
include "CMN_SIZE" ! 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)
- 

**1.24.8 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

```

```

include "CMN_SIZE" ! 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)

```

---

### 1.24.9 read\_emep\_updated

Subroutine READ\_EMEP\_UPDATED reads updated EMEP emissions from the year 1990 including SO<sub>x</sub> 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! 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,JJP) ! 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)

```

---



**1.24.10 read\_emep\_updated\_05x0666**

Subroutine READ\_EMEP\_UPDATED reads updated EMEP emissions from the year 1990 including SO<sub>x</sub> 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 : IDTN0x, IDTCO, IDTSO2, IDTNH3
 USE GRID_MOD, ONLY : GET_AREA_CM2

 # include "CMN_SIZE" ! Size parameters
 # include "CMN_03" ! 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,JJPARG) ! 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)

```

**1.24.11 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

```

```

include "CMN_SIZE" ! 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.

```

---

### 1.24.12 cleanup\_emep

Subroutine CLEANUP\_EMEP deallocates all module arrays.

## INTERFACE:

```

SUBROUTINE CLEANUP_EMEP

```

## REVISION HISTORY:

```

1 Nov 2005 - R. Yantosca - Initial Version

```

---

### 1.25 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
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 Feb 2010 - Fabien P. - Add scaling for isoprene and Nox emissions

### 1.25.1 do\_emissions

Subroutine DO\_EMISSIONS is the driver routine which calls the appropriate emissions sub-routine for the various GEOS-CHEM simulations.

#### INTERFACE:

SUBROUTINE DO\_EMISSIONS

#### USES:

NBIOMAX has been moved to CMN\_SIZE by FP (hotp 7/31/09)

|                            |                                  |
|----------------------------|----------------------------------|
| USE BIOMASS_MOD,           | ONLY : NBIOMAX                   |
| 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 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)

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! 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 CMN\_SIZE

## 1.26 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
PRIVATE
```

### PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: QQ2_F
PUBLIC :: QQ1_F
PUBLIC :: TFACA_F
PUBLIC :: TFACO_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.

---

**1.26.1 tfaca\_f**

Calculates temperature interpolation factors for acetone

**INTERFACE:**

```
 FUNCTION TFACA_F(TTT, IV)
 !USES
 # include "cmn_fj.h"
 # include "jv_cmn.h"
```

**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.
```

---

**1.26.2 tfac0\_f**

Calculates temperature interpolation factors for acetone

**INTERFACE:**

```
 FUNCTION TFACO_F(TTT, IV)

 !USES:

 # include "cmn_fj.h"
 # include "jv_cmn.h"
```

**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 :: TFACO_F
```

---

### 1.26.3 tfac\_f

Calculates temperature interpolation factors for acetone

#### INTERFACE:

```
FUNCTION TFAC_F(TTT, IV)
```

#### USES:

```
include "cmn_fj.h"
include "jv_cmn.h"
```

#### 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
```

---

### 1.26.4 qq2\_f

This routine computes the cross-section for acetone.

#### INTERFACE:

```
FUNCTION QQ2_F(TFACO, IV, K, TTT)
```

#### USES:

```
include "cmn_fj.h"
include "jv_cmn.h"
```

#### 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 TFACO_F function
REAL*8 :: TFACO
!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 02, 03
 and 01-D. (ccc, 4/20/19)

```

---

### 1.26.5 qq1\_f

This routine computes the cross-section for acetone.

#### INTERFACE:

```

FUNCTION QQ1_F(TFAC, IV, K)

```

#### USES:

```

include "cmn_fj.h"
include "jv_cmn.h"

```

#### 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 02, 03
 and 01-D. (ccc, 4/20/19)

```

---



## 1.27 Fortran: Module Interface gamap\_mod

Module GAMAP\_MOD contains routines to create GAMAP "tracerinfo.dat" and "diag-info.dat" files which are customized to each particular GEOS-Chem simulation.

### INTERFACE:

```
MODULE GAMAP_MOD
```

### USES:

```
IMPLICIT NONE
PRIVATE
```

```
include "CMN_SIZE" ! Dimensions of arrays
include "CMN_DIAG" ! Diagnostic parameters
```

### 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 troposphere (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 H02 (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 "CMN\_SIZE" and  
#include "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

### 1.27.1 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

### 1.27.2 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
```

---

### 1.27.3 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 & APRD info (tmf, havala, bmy, 2/6/07)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

---

### 1.27.4 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
```

#### 1.27.5 write\_separator

Subroutine WRITE\_SEPARATOR writes a separator block to the customized "tracer-info.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
```

#### 1.27.6 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 (kjlw, 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.

**1.27.7 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
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 : IDBCH20, 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 : IDTCH20, 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

---

### 1.27.8 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 : HDEFFNAME
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

```

---

### 1.27.9 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

```

---

## 1.28 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
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:**

```

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

```

---

**1.28.1 get\_global\_Br\_new**

Subroutine GET\_GLOBAL\_Br\_NEW 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:**

```

SUBROUTINE GET_GLOBAL_Br_NEW(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 TRANSFER_MOD, ONLY : TRANSFER_3D
USE TRANSFER_MOD, ONLY : TRANSFER_3D_TROP
USE TROPOPAUSE_MOD, ONLY : GET_TPAUSE_LEVEL

```

```

include "CMN_SIZE" ! 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

```

---

### 1.28.2 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:

```
SUBROUTINE GET_GLOBAL_Br(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 TRANSFER_MOD, ONLY : TRANSFER_3D
```

```
include "CMN_SIZE" ! Size parameters
```

#### INPUT PARAMETERS:

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

#### 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
```

---

### 1.28.3 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
```

```
include "CMN_SIZE"
```

#### REVISION HISTORY:

```
05 Jul 2006 - C. Holmes - Copied from "global_oh_mod.f"
01 Dec 2010 - R. Yantosca - Added ProTeX headers
```

---

### 1.28.4 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
```

## 1.29 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
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
```

### 1.29.1 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
```

```
include "CMN_SIZE" ! 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
```

### 1.29.2 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
```

```
include "CMN_SIZE"
```

## 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
```

---

### 1.29.3 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
```

---

### 1.30 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
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

---

**1.30.1 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
```

```
include "CMN_SIZE" ! 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 IGLOB,JGLOB,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 (IGLOB,JGLOB,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

---

### 1.30.2 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
```

```
include "CMN_SIZE"
```

#### REVISION HISTORY:

28 Jul 2000 - R. Yantosca - Initial version

(1 ) BNOX now needs to be sized (IIPAR,JJPARG,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

---

### 1.30.3 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

---

### 1.31 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
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
```

---

#### 1.31.1 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
```

```
include "CMN_SIZE" ! 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 (IGLOB,JGLOB,LGLOB). (bmy, 1/11/02)  
 (3 ) Now point to new O1D files in the ??? subdirectory.  
 01 Dec 2010 - R. Yantosca - Added ProTeX headers

---

**1.31.2 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

# include "CMN\_SIZE"

**REVISION HISTORY:**

18 Sep 2007 - H. U. Price, P. Le Sager - Initial version  
 01 Dec 2010 - R. Yantosca - Added ProTeX headers

---

**1.31.3 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

---

### 1.32 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
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

#### 1.32.1 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

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE" ! Size parameters

```

#### 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

```

---

### 1.32.2 init\_global\_o3

Subroutine INIT\_GLOBAL\_O3 allocates the O3 module array.

#### INTERFACE:

```

SUBROUTINE INIT_GLOBAL_O3

```

#### USES:

```

 USE ERROR_MOD, ONLY : ALLOC_ERR

```

```

include "CMN_SIZE" ! 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

```

---

### 1.32.3 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

```

---

### 1.33 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
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,JJPARG,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

### 1.33.1 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 of-fine 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
```

```
include "CMN_SIZE" ! 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 IGLOBAL,JGLOBAL,LGLOBAL. 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 (IGLOBAL,JGLOBAL,LGLOBAL). (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

---

### 1.33.2 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
```

```
include "CMN_SIZE"
```

#### REVISION HISTORY:

28 Jul 2000 - R. Yantosca - Initial version  
 (1 ) OH array now needs to be sized (IGLOB,JGLOB,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,JJPARG,LLPAR): avoid subscript errors (bmy, 5/4/04)  
 01 Dec 2010 - R. Yantosca - Added ProTeX headers

---

### 1.33.3 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

---

### 1.34 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
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
```

---

#### 1.34.1 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_LIQC02, READ_TOTCO2, READ_TODX
USE GRID_MOD, ONLY : GET_XOFFSET, GET_YOFFSET, GET_AREA_CM2
USE LOGICAL_MOD, ONLY : LANTHRO, LGFED2BB
USE LOGICAL_MOD, ONLY : LBIOMASS, LBIOFUEL, LNEI99
USE LOGICAL_MOD, ONLY : LSTREETS, LEDGAR, LBRAVO
```

```

USE MEGANUT_MOD, ONLY : XLTMP
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

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! FSCALYR, SCNR89, TODH, EMISTCO
include "CMN_DIAG" ! 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 XLTMP 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

---

### 1.34.2 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DEP" ! FRCLND
include "CMN_DIAG" ! ND65

```

## REVISION HISTORY:

18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version  
 02 Dec 2010 - R. Yantosca - Added ProTeX headers

---

### 1.34.3 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

```

```

include "CMN_SIZE" ! 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

---

### 1.34.4 read\_h2yield

Subroutine READ\_H2YIELD reads in the relative H<sub>2</sub>/CO yield from photochemical production. This has been archived monthly (PH<sub>2</sub>/PCO using the PRODLOSS diagnostic and turning H<sub>2</sub> 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
```

```
include "CMN_SIZE" ! 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
```

---

### 1.34.5 init\_h2\_hd

Subroutine INIT\_H2\_HD allocates memory to module arrays.

#### INTERFACE:

```
SUBROUTINE INIT_H2_HD
```

#### USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR
```

```
include "CMN_SIZE"
```

#### REVISION HISTORY:

```
18 Sep 2007 - L. Jaegle, H. U. Price, P. Le Sager -- Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

---

**1.34.6 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
```

---

**1.35 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
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 NO<sub>x</sub>, SO<sub>x</sub>, 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
```

---

**1.35.1 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

---

**1.35.2 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_03" ! FSCALYR
```

#### REVISION HISTORY:

21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version

---

### 1.35.3 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
```

```
include "CMN_SIZE" ! Size parameters
```

#### REVISION HISTORY:

21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version

---

### 1.35.4 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:

```
include "CMN_SIZE" ! 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

---

**1.35.5 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

21 Jul 2009 - Chulkyu Lee & P. Le Sager - Initial Version

---

**1.35.6 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

---

**1.36 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
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 LAVHRLAI 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 (kjl, 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

### 1.36.1 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

```

---

**1.36.2 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

```

---

### 1.36.3 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
```

---

### 1.36.4 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

### 1.36.5 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

```

```

include "CMN_SIZE" ! 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

### 1.36.6 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_REEDGE_um, SALC_REEDGE_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

### 1.36.7 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, L BIOGENIC, LBIOMASS, LBIONOX
USE LOGICAL_MOD, ONLY : LCOOKE
USE LOGICAL_MOD, ONLY : LEMIS, LFOSSIL, LLIGHTNOX, LMONOT
USE LOGICAL_MOD, ONLY : LNEI99, LSHIPS02, 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 : LICOADSSHIP, LNEI05
USE LOGICAL_MOD, ONLY : L8DAYBB, L3HRBB, LSYNOPBB
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

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! 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 LAVHRR\_LAI-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

---

### 1.36.8 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 : 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_03" ! FSCALYR
```

#### REVISION HISTORY:

```
02 Mar 2009 - R. Nassar - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

---

### 1.36.9 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
```

**1.36.10 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
```

```
include "CMN_SIZE" ! 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
```



**1.36.11 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
```

---

**1.36.12 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
```

---

### 1.36.13 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
```

#### 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
```

---

### 1.36.14 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
```

---

**1.36.15 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! NJDAY
```

**REVISION HISTORY:**

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

---

**1.36.16 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 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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 CMN\_SIZE (fp, 6/2009)
- 27 Aug 2010 - R. Yantosca - Added ProTeX headers

### 1.36.17 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:

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

```

---

**1.36.18 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

include "CMN_SIZE" ! MAXFAM
include "CMN_DIAG" ! ND40

```

**REVISION HISTORY:**

```

20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers

```

---

**1.36.19 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
```

---

**1.36.20 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

```
20 Jul 2004 - R. Yantosca - Initial version
27 Aug 2010 - R. Yantosca - Added ProTeX headers
```

---

**1.36.21 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

---

**1.36.22 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

---

**1.36.23 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! NDxx flags
```

## REVISION HISTORY:

21 Dec 2009 - Aaron van D - Initial version  
 27 Aug 2010 - R. Yantosca - Added ProTeX headers

---

### 1.36.24 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
```

```
include "CMN_SIZE" ! MAXFAM
include "CMN_DIAG" ! 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

---

### 1.36.25 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

---

**1.36.26 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

---

**1.36.27 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

---

**1.36.28 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

---

**1.36.29 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

---

**1.36.30 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
```

---

**1.36.31 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, LWEST
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
```

---

**1.36.32 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_NYMDc
```

```
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
```

**1.36.33 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

```

---

### 1.36.34 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

```

---

**1.36.35 is\_last\_day\_good**

Subroutine 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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
```

---

**1.36.36 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, LAVHRLAI, 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 : L BIOGENIC, LBBSEA, LEMIS
USE LOGICAL_MOD, ONLY : LFFNOX, LFOSSIL, LLIGHTNOX
USE LOGICAL_MOD, ONLY : LMONOT, LNEI99, LSHIPS02
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 : LEDGARNOx, LEDGARCO, LEDGARSHIP
USE LOGICAL_MOD, ONLY : LEDGARS0x, LVARTR0P
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

```

## 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 LAVHRRSLAI 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 initialize 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 LVARTR0P switch (phs, 9/14/06)
(9) Now initialize LOTDREG, LOTDLOC, LCTH, LMFLUX, LPRECON (bmy, 1/31/07)
(10) Now initialize LOTDS0ALE (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

---

### 1.37 Fortran: Module Interface isoropiaii\_mod

Module ISOROPAIIMOD contains the routines that provide the interface between ISORROPIA II and GEOS-Chem.

The actual ISORROPIA II code which performs Na-SO<sub>4</sub>-NH<sub>3</sub>-NO<sub>3</sub>-Cl-(Ca-K-Mg) aerosol thermodynamic equilibrium is in `isoropiaIicode.f`.

#### INTERFACE:

```
MODULE ISOROPAIIMOD
```

#### USES:

```
IMPLICIT NONE
PRIVATE
```

#### PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: CLEANUP_ISOROPAIIMOD
PUBLIC :: DO_ISOROPAIIMOD
PUBLIC :: GET_GN03
PUBLIC :: GET_ISRINFO
```

#### PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: GET_HNO3
PRIVATE :: INIT_ISOROPAIIMOD
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, ISORROPIA II performs exactly like ISOROPIAv1.7  
Ca, K, Mg, Na from dust is not currently considered

To implement ISORROPIA II into GEOS-Chem:

- \* `cleanup_isoropiaII` needs to be called from `cleanup.f`
- \* `DO_ISOROPIA` needs to be replaced with `DO_ISOROPAIIMOD` 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 Havalala 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

### 1.37.1 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
```

```
include "CMN_SIZE" ! Size parameters
```

## REMARKS:

Original isoropia v1.3 implmentation: (rjp, bec, bmy, 12/17/01, 8/22/05)

|             |                |                                                                                        |
|-------------|----------------|----------------------------------------------------------------------------------------|
| 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                                         |

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.

```
FUNCTION SAFELOG10(X) RESULT (SAFLOG)
```

```
REAL*8, INTENT(IN) :: X ! Argument for LOG10 function
```

```
REAL*8 :: SAFLOG ! LOG10 output --
```

11 Aug 2009 - H. O. T. Pye - Initial version, in ISORROPIA II  
29 Jan 2010 - R. Yantosca - Added ProTeX headers

Subroutine GET\_ISRINFO returns information related to aerosol pH.

```
FUNCTION GET_ISRINFO(I, J, L, N) RESULT (RETURNVALUE)
```

```

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

```

```
REAL*8 :: RETURNVALUE
```

**REVISION HISTORY:**

11 Aug 2009 - H. O. T. Pye - Initial version  
 29 Jan 2010 - R. Yantosca - Added ProTeX headers

---

**1.37.4 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

---

**1.37.5 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

---

**1.37.6 get\_gno3**

Function GET\_GNO3 returns the gas-phase HNO<sub>3</sub> [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

---

**1.37.7 init\_isoropiaII**

Subroutine INIT\_ISOROPIAII initializes all module arrays.

**INTERFACE:**

```
SUBROUTINE INIT_ISOROPIAII
```

**USES:**

```
USE ERROR_MOD, ONLY : ALLOC_ERR
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

06 Jul 2007 - H. O. T. Pye - Initial version  
 29 Jan 2010 - R. Yantosca - Added ProTeX headers

---

### 1.37.8 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
```

---

### 1.38 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
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
```

---

### 1.38.1 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
```

```
include "CMN_SIZE" ! Size parameters
```

#### INPUT PARAMETERS:

```
LOGICAL, INTENT(IN) :: LHGSNOW ! Use Hg0 from snow?
```

#### OUTPUT PARAMETERS:

```
REAL*8, INTENT(OUT) :: LFLUX(IIPAR,JJPARG,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
```

### 1.38.2 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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  $1.5 \times 10^{-7}$  mol Hg/ mol CO, we chose the highest value ( $2.1 \times 10^{-7}$  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

### 1.38.3 vegemis

Subroutine VEGEMIS is the subroutine for Hg(0) emissions from vegetation by evapotranspiration.

#### INTERFACE:

```

SUBROUTINE VEGEMIS(LGCAPEMIS, 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DEP" ! FRCLND

```

#### INPUT PARAMETERS:

```

LOGICAL, INTENT(IN) :: LGCAPEMIS
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)

$F_c = E_c C_w$

$F_c$  is Hg0 flux ( $\text{ng m}^{-2} \text{s}^{-1}$ )

$E_c$  is canopy transpiration ( $\text{m s}^{-1}$ )

$C_w$  is conc of Hg0 in surface soil water ( $\text{ng m}^{-3}$ )

Calculate  $C_w$  from the Allison and Allison (2005) equilibrium formula

$C_w = C_s / K_d$

$C_s$  is the concentration of Hg in surface soil solids,  $\text{ng/g}$

$K_d$  is the equilibrium constant =  $[\text{sorbed}]/[\text{dissolved}]$

$\log K_d = 3.8 \text{ L/kg} \rightarrow K_d = 6310 \text{ L/kg} = 6.31 \times 10^{-3} \text{ m}^3/\text{g}$

We assume a global mean  $C_s = 45 \text{ ng/g}$  for the preindustrial period. In iterative simulations we redistribute this according to the deposition pattern while maintaining the global mean. The scaling factor,  $\text{EHg0\_dist}$ , 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

**1.38.4 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DEP" ! 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

#### 1.38.5 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

```

```

include "CMN_SIZE" ! Size parameters

```

## REMARKS:

Data source:

[http://gcmd.nasa.gov/records/GCMD\\_MINTZ\\_WALKER\\_SOIL\\_AND\\_EVAP0.html](http://gcmd.nasa.gov/records/GCMD_MINTZ_WALKER_SOIL_AND_EVAP0.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

**1.38.6 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

```

```

include "CMN_SIZE" ! Size parameters

```

## INPUT PARAMETERS:

```

LOGICAL, INTENT(IN) :: LHGSNOW ! Use Hg from snow?

```

**OUTPUT PARAMETERS:**

```
REAL*8, INTENT(OUT) :: FLUX(IIPAR,JJPARG,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  $T < 270\text{K}$  and 7 d when  $T > 270\text{K}$

$E = k * \text{SNOW\_HG}$  :  $k = 6\text{D-}8$  if  $T < 270\text{K}$ ,  $1.6\text{D-}6$  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

---

**1.38.7 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
```

```
include "CMN_SIZE" ! Size parameters
```

**INPUT PARAMETERS:**

```
! Emission of Hg0 calculated by GTMM for the month [kg/s]
REAL*8, INTENT(OUT) :: Hg0gtm(IIPAR, JJPARG)
```

**REVISION HISTORY:**

15 Sep 2009 - C. Carouge - Initial version

---

### 1.38.8 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
```

```
include "CMN_SIZE" ! Size parameters
```

#### REVISION HISTORY:

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

---

### 1.38.9 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
```

---

## 1.39 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
PRIVATE
```

#### PUBLIC MEMBER FUNCTIONS:

```

PUBLIC :: LIGHTNING
PUBLIC :: EMLIGHTNING
PUBLIC :: CLEANUP_LIGHTNING_NOX

```

#### PRIVATE MEMBER FUNCTIONS:

```

PRIVATE :: LIGHTDIST
PRIVATE :: FLASHES_CTH
!-----
! Prior to 1/25/11:
! These are now obsolete and will be removed later (ltm, bmy, 1/25/11)
!PRIVATE :: FLASHES_MFLUX
!PRIVATE :: FLASHES_PRECON
!-----
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 OTDSIZE 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 emisisions 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 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

1.39.1 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

```

```

#    include "CMN_SIZE"      ! Size parameters
#    include "CMN_GCTM"      ! 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

1.39.2 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

```

```

#      include "CMN_SIZE"                ! 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_N0x_200203/ subdirectory.
     Now read the "light_dist.dat" file for GEOS-1, GEOS-STRAT directly
     from the DATA_DIR/lightning_N0x_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

1.39.3 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

1.39.4 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
```

1.39.5 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
```

```
#      include "CMN_SIZE"          ! 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
-

1.39.6 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
```

```
# include "CMN_SIZE"          ! Size parameters
# include "CMN_DIAG"          ! 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 "CMN_03" 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 CMN_NOX) with module variable EMIS_LI_NOx. (ltm, bmy, 10/3/07)
- 10 Nov 2010 - R. Yantosca - Added ProTeX headers
-

1.39.7 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 redistrib (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
```

1.39.8 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
```

```
#    include "CMN_SIZE"      ! 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 OTDSscale 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

1.39.9 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 OTDSscale (ltm, bmy, 5/10/06)
- (2) Rename OTDSscale 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

```

1.40 Fortran: Module Interface *linoz_mod*

Module LINOZ_MOD contains routines to perform the Linoz stratospheric ozone chemistry.

INTERFACE:

```
MODULE LINOZ_MOD
```

USES:

```

IMPLICIT NONE
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@atmosph.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

1.40.1 do_linoz

Subroutine DO_LINOZ is the main driver for the Linoz stratospheric Ozone chemistry package.

INTERFACE:

```
SUBROUTINE DO_LINOZ
```

USES:

```
USE TIME_MOD
```

```
#    include "CMN_SIZE"
```

REVISION HISTORY:

24 Jun 2003	- B. Field & D. Jones	- Further updates for GEOS-Chem
-------------	-----------------------	---------------------------------

1.40.2 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

```

```

#   include "CMN_SIZE"
#   include "CMN"

```

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

```

1.40.3 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

```

```

#   include "CMN_SIZE"
#   include "CMN"

```

REVISION HISTORY:

```

24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem

```


1.40.4 linoz_strt2m

Subroutine LINOZ_STRT2M sets up a std z^* atmosphere: $p = 1000 * 10^{**}(-z^*/16 \text{ km})$.

INTERFACE:

```
SUBROUTINE LINOZ_STRT2M(STRTX,NX,STRTOL,STRT1L,STRT2L,POL,NSTRT)
```

USES:

```
#      include "CMN_SIZE"
```

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)    :: POL(LLPAR+1)
```

OUTPUT PARAMETERS:

```
REAL*8,  INTENT(OUT)   :: STRTOL(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

1.40.5 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: $P1 \downarrow P2$ (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': $F(x)=f0$ $b \leq x \leq c$, =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

1.40.6 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

```

```
      #      include "CMN_SIZE"
```

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

1.40.7 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

1.40.8 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

#   include "CMN_SIZE"
#   include "CMN"
```

REVISION HISTORY:

24 Jun 2003 - B. Field & D. Jones - Further updates for GEOS-Chem

1.40.9 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
```

```
#    include "CMN_SIZE"
```

REVISION HISTORY:

```
16 Oct 2009 - R. Yantosca - Initial version
```

1.40.10 cleanup_linoz

Subroutine CLEANUP_LINOZ deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_LINOZ
```

REVISION HISTORY:

```
16 Oct 2009 - R. Yantosca - Initial version
```

1.41 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
```

REVISION HISTORY:

```
05 Nov 2004 - R. Yantosca - Added LNEI99 switch to toggle EPA/NEI emissions
20 Dec 2004 - R. Yantosca - Added LAVHRRRLAI 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 LVARTRIP 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 LOTDSALE
 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 LNLPLB, 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 LOTDSALE for lightning

1.42 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 uncertainties 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 communication. (Nov, 2004)

INTERFACE:

```
MODULE MEGAN_MOD
```

USES:

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

```
IMPLICIT NONE
```

```
PRIVATE
```

```
#    include "CMN_SIZE"                                ! Size parameters
```

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 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

1.42.1 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 manual

```

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

```

1.42.2 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

```

1.42.3 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

1.42.4 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
```

1.42.5 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

1.42.6 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

```

```

#    include "CMN_GCTM"    ! 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

1.42.7 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

1.42.8 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

1.42.9 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

```

1.42.10 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:

```

#      include "CMN_GCTM"      ! 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
```

1.42.11 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

1.42.12 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 manual 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

1.42.13 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 regrid 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

1.42.14 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

1.42.15 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

1.42.16 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
```

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
```

1.42.17 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)

1.42.18 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

1.43 Fortran: Module Interface meganut_mod

Module MEGANUT_MOD contains functions used by MEGAN.

INTERFACE:

```
MODULE MEGANUT_MOD
```

USES:

```
IMPLICIT NONE
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: XLTMP
PUBLIC :: XLPARDF
PUBLIC :: XLPARDR
```

!REVISION HISTORY

20 Nov 2009 - C. Carouge - Create the module with xlttmp, xlpardf and
 xlpardr functions.

1.43.1 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
```

```
#    include "CMN_SIZE"
```

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 CMN_SIZE, which has IIPAR, JJPAR,
                                LLPAR, IGLOB, JGLOB, LGLOB.
23 Jun 2000 - R. Yantosca - Now reference TS from "dao_mod.f" instead of
                                from common block header file "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,JJPARG) 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
```

```
#    include "CMN_SIZE"
```

```
!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
```

1.43.2 xlpardf

Function XLPARDF passes the value of the DAO meterological field PARDF(IIPAR,JJPARG) 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
```

```
#    include "CMN_SIZE"
```

```
!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 Feb 3 15:04:21 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
```

```
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

1.43.3 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.

1.43.4 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

1.43.5 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

```

```

#      include "CMN_SIZE"          ! 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

1.43.6 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,      ZOM                      )

```

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

```

```

#      include "CMN_SIZE"           ! Size parameters
#      include "CMN_DIAG"          ! 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,JJPARG) ! Sfc albedo [unitless]
      REAL*8,  INTENT(OUT) :: CLDTOT  (IIPAR,JJPARG) ! Column cld fraction
      REAL*8,  INTENT(OUT) :: EFLUX   (IIPAR,JJPARG) ! Latent heat flux [W/m2]
      REAL*8,  INTENT(OUT) :: EVAP    (IIPAR,JJPARG) ! Surface evap [kg/m2/s]
      REAL*8,  INTENT(OUT) :: FRSEAICE(IIPAR,JJPARG) ! Sfc sea ice fraction
      REAL*8,  INTENT(OUT) :: FRSNO   (IIPAR,JJPARG) ! Sfc snow fraction
      REAL*8,  INTENT(OUT) :: GRN     (IIPAR,JJPARG) ! Greenness fraction
      REAL*8,  INTENT(OUT) :: GWETROOT(IIPAR,JJPARG) ! Root soil wetness [frac]
      REAL*8,  INTENT(OUT) :: GWETTOP (IIPAR,JJPARG) ! Topsoil wetness [frac]
      REAL*8,  INTENT(OUT) :: HFLUX   (IIPAR,JJPARG) ! Sensible H-flux [W/m2]
      REAL*8,  INTENT(OUT) :: LAI     (IIPAR,JJPARG) ! Leaf area index [m2/m2]
      REAL*8,  INTENT(OUT) :: LWI     (IIPAR,JJPARG) ! Leaf area index [m2/m2]

```

```

REAL*8,  INTENT(OUT) :: LWGNT   (IIPAR,JJPARG) ! Net LW rad @ sfc [W/m2]
REAL*8,  INTENT(OUT) :: PARDF   (IIPAR,JJPARG) ! Diffuse PAR [W/m2]
REAL*8,  INTENT(OUT) :: PARDR   (IIPAR,JJPARG) ! Direct PAR [W/m2]
REAL*8,  INTENT(OUT) :: PBLH    (IIPAR,JJPARG) ! PBL height [m]
REAL*8,  INTENT(OUT) :: PRECANV (IIPAR,JJPARG) ! Anv prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECTOT (IIPAR,JJPARG) ! Tot prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECCON (IIPAR,JJPARG) ! CV prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECLSC (IIPAR,JJPARG) ! LS prec @ sfc [kg/m2/s]
REAL*8,  INTENT(OUT) :: PRECSNO (IIPAR,JJPARG) ! Snow precip [kg/m2/s]
REAL*8,  INTENT(OUT) :: SEAICE00(IIPAR,JJPARG) ! Sea ice coverage 00-10%
REAL*8,  INTENT(OUT) :: SEAICE10(IIPAR,JJPARG) ! Sea ice coverage 10-20%
REAL*8,  INTENT(OUT) :: SEAICE20(IIPAR,JJPARG) ! Sea ice coverage 20-30%
REAL*8,  INTENT(OUT) :: SEAICE30(IIPAR,JJPARG) ! Sea ice coverage 30-40%
REAL*8,  INTENT(OUT) :: SEAICE40(IIPAR,JJPARG) ! Sea ice coverage 40-50%
REAL*8,  INTENT(OUT) :: SEAICE50(IIPAR,JJPARG) ! Sea ice coverage 50-60%
REAL*8,  INTENT(OUT) :: SEAICE60(IIPAR,JJPARG) ! Sea ice coverage 60-70%
REAL*8,  INTENT(OUT) :: SEAICE70(IIPAR,JJPARG) ! Sea ice coverage 70-80%
REAL*8,  INTENT(OUT) :: SEAICE80(IIPAR,JJPARG) ! Sea ice coverage 80-90%
REAL*8,  INTENT(OUT) :: SEAICE90(IIPAR,JJPARG) ! Sea ice coverage 90-100%
REAL*8,  INTENT(OUT) :: SLP      (IIPAR,JJPARG) ! Sea level pressure [hPa]
REAL*8,  INTENT(OUT) :: SNODP   (IIPAR,JJPARG) ! Snow depth [m]
REAL*8,  INTENT(OUT) :: SNOMAS  (IIPAR,JJPARG) ! Snow mass [kg/m2]
REAL*8,  INTENT(OUT) :: SWGNT   (IIPAR,JJPARG) ! SW rad @ sfc [W/m2]
REAL*8,  INTENT(OUT) :: TROPPT  (IIPAR,JJPARG) ! T'pause pressure [hPa]
REAL*8,  INTENT(OUT) :: T2M     (IIPAR,JJPARG) ! T @ 2m height [K]
REAL*8,  INTENT(OUT) :: TS      (IIPAR,JJPARG) ! Sfc skin T [K]
REAL*8,  INTENT(OUT) :: U10M    (IIPAR,JJPARG) ! U-wind @ 10m [m/s]
REAL*8,  INTENT(OUT) :: USTAR   (IIPAR,JJPARG) ! Friction velocity [m/s]
REAL*8,  INTENT(OUT) :: V10M    (IIPAR,JJPARG) ! V-wind @ 10m [m/s]
REAL*8,  INTENT(OUT) :: ZOM     (IIPAR,JJPARG) ! 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

1.43.7 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

1.44 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
      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

1.44.1 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

1.44.2 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

```

```

      #      include "CMN_SIZE"      ! 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

1.44.3 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
```

```
#      include "CMN_SIZE"          ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: NYMD      ! YYYYMMDD and
INTEGER, INTENT(IN) :: NHMS      ! hhhmss of desired data fields
```

REVISION HISTORY:

20 Aug 2010 - R. Yantosca - Initial version, based on a3_read_mod.f

1.44.4 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

```

```

#    include "CMN_SIZE"           ! Size parameters
#    include "CMN_DIAG"          ! ND66, LD66, ND67

```

INPUT PARAMETERS:

```

INTEGER, INTENT(IN)  :: NYMD           ! YYYYMMDD & hhmmss
INTEGER, INTENT(IN)  :: NHMS           !   of desired data

```

OUTPUT PARAMETERS:

```

! Fields dimensioned as (I,J)
INTEGER, INTENT(OUT) :: CLDTOPS (IIPAR,JJPARG)

```

```

! Fields dimensioned as (I,J,L)
REAL*8, INTENT(OUT) :: CMFMC (IIPAR,JJPARG,LLPAR+1)
REAL*8, INTENT(OUT) :: DQRCU (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: DQRLSAN (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: DQIDTMST(IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: DQLDTMST(IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: DQVDTMST(IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: DTRAIN (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: PFICU (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: PFILSAN (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: PFLCU (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: PFLLSAN (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: QI (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: QL (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: QV (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: REEVAPCN(IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: REEVAPLS(IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: T (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: TAUCLI (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: TAUCLW (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: U (IIPAR,JJPARG,LLPAR )
REAL*8, INTENT(OUT) :: V (IIPAR,JJPARG,LLPAR )

```

```

! Fields dimensioned as (L,I,J)
REAL*8, INTENT(OUT) :: CLOUD (LLPAR,IIPARG,JJPARG )
REAL*8, INTENT(OUT) :: MOISTQ (LLPAR,IIPARG,JJPARG )
REAL*8, INTENT(OUT) :: OPTDEPTH(LLPAR,IIPARG,JJPARG )

```

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

1.44.5 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

1.45 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:

```
IMPLICIT NONE
PRIVATE
```

```
#    include "CMN_SIZE"           ! Size parameters
#    include "CMN_DIAG"           ! NDxx flags
#    include "CMN_GCTM"           ! g0
```

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
```

1.45.1 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
```

1.45.2 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

1.45.3 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,JJPARG)

! Fraction of grid box covered by land ice [unitless]
REAL*8, INTENT(OUT) :: FRLAND (IIPAR,JJPARG)

! Fraction of grid box covered by land ice [unitless]
REAL*8, INTENT(OUT) :: FRLANDIC(IIPAR,JJPARG)

```

```

! Fraction of grid box covered by ocean [unitless]
REAL*8, INTENT(OUT) :: FROCEAN (IIPAR,JJPARG)

! Surface geopotential height [m2/s2]
REAL*8, INTENT(OUT) :: PHIS      (IIPAR,JJPARG)

```

REVISION HISTORY:

19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f

1.45.4 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

1.46 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
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

1.46.1 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

1.46.2 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

1.46.3 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

1.46.4 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

```

```

#    include "CMN_SIZE"                ! Size parameters
#    include "CMN_DIAG"                ! 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,JJP   ) ! Surface pressure [hPa]
REAL*8, INTENT(OUT) :: RH(IIPAR,JJP   ,LLPAR) ! Rel. humidity [unitless]

```

REVISION HISTORY:

19 Aug 2010 - R. Yantosca - Initial version, based on i6_read_mod.f

1.46.5 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

1.47 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
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).

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)

1.47.1 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, IDTCH20, 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

1.47.2 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, IDTCH20, IDTPRPE, IDTMEK
USE TRACERID_MOD, ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3
USE TRACERID_MOD, ONLY : IDTSO4, IDTOCPI, IDTBCPI
```

```
# include "CMN_SIZE"          ! Size parameters
# include "CMN_03"            ! 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
```

1.47.3 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, IDTCH20, IDTPRPE, IDTMEK
USE TRACERID_MOD, ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3
USE TRACERID_MOD, ONLY : IDTSO4, IDTOCPI, IDTBCPI

```

```

# include "CMN_SIZE"          ! Size parameters
# include "CMN_03"            ! 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)

```

1.47.4 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, IDTCH20, IDTPRPE, IDTMEK
USE TRACERID_MOD,   ONLY : IDTNOx, IDTCO, IDTSO2, IDTNH3
USE TRACERID_MOD,   ONLY : IDTSO4

```

```

# include "CMN_SIZE"          ! 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

```

1.47.5 get_nei99_season_05x0666

Subroutine GET_NEI99_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
```

```
#    include "CMN_SIZE"                ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)      :: TRACER    ! Tracer number
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJP,5) ! Scale factor array
```

REVISION HISTORY:

```
30 Oct 2009 - A. van Donkelaar - Initial Version
```

1.47.6 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
```

```
#    include "CMN_SIZE"                ! Size parameters
```

```
#    include "CMN_03"                  ! 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
```

1.47.7 get_vistas_season_05x0666

Subroutine GET_VISTAS_SEASON_05x0666 returns monthly scale factors to account for monthly variations in NO_x 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
```

```
#      include "CMN_SIZE"                                ! Size parameters
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJP,5)  ! Scale factor array
```

REVISION HISTORY:

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

1.47.8 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, IDTCH20, IDTPRPE, IDTMEK
USE TRACERID_MOD, ONLY : IDTNOx,  IDTCO,   IDTSO2,  IDTNH3
USE TRACERID_MOD, ONLY : IDTSO4
```

```
#      include "CMN_SIZE"                                ! 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
```

1.47.9 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
```

```
#    include "CMN_SIZE"                ! Size parameters
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN)      :: TRACER    ! Tracer number
```

INPUT/OUTPUT PARAMETERS:

```
REAL*4,  INTENT(INOUT) :: AS(IIPAR,JJP,5) ! Scale factor array
```

REVISION HISTORY:

```
30 Oct 2009 - A. van Donkelaar - Initial Version
```

1.47.10 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
```

```
#    include "CMN_SIZE"                ! 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
```

1.47.11 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
```

```
#      include "CMN_SIZE"          ! 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
```

1.47.12 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:

```
#      include "CMN_SIZE"          ! Size parameters
```

INPUT PARAMETERS:

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

REVISION HISTORY:

```
7 Oct 2009 - A. van Donkelaar - initial version
```

1.47.13 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
```

```
#      include "CMN_SIZE"      ! Size parameters
```

REVISION HISTORY:**1.47.14 cleanup_nei2005_anthro**

Subroutine CLEANUP_NEI2005_ANTHRO deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_NEI2005_ANTHRO
```

REVISION HISTORY:**1.48 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
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
```

1.48.1 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
```

```
# include "CMN_SIZE"    ! Size parameters
# include "CMN_DIAG"    ! 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,JJPARG)
```

```
! Optical depths from met fields [unitless]
REAL*8, INTENT(IN)  :: OPTDEP(LLPAR,IIPAR,JJPARG)
```

OUTPUT PARAMETERS:

```
! Optical depth output array [unitless]
REAL*8, INTENT(OUT) :: OPTD (LLPAR,IIPAR,JJPARG)
```

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

1.49 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
```

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)

1.49.1 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:

```
#    include "CMN_SIZE"      ! Size parameters
#    include "CMN_GCTM"      ! 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,JJPARG)

! True PSurface at end    of dynamic timestep [hPa]
REAL*8,  INTENT(IN)  :: P2(IIPAR,JJPARG)

! Zonal (E-W) wind [m/s]
REAL*8,  INTENT(IN)  :: UWND(IIPAR,JJPARG,LLPAR)

! Meridional (N-S) wind [m/s]
REAL*8,  INTENT(IN)  :: VWND(IIPAR,JJPARG,LLPAR)
```

OUTPUT PARAMETERS:

```

! E-W mass fluxes [mixing ratio]
REAL*8,  INTENT(OUT) :: XMASS(IIPAR,JJPARG,LLPAR)

! N-S mass fluxes [mixing ratio]
REAL*8,  INTENT(OUT) :: YMASS(IIPAR,JJPARG,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.

1.49.2 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:

```

#    include "CMN_SIZE"  ! Size parameters
#    include "CMN"       ! STT, NTRACE, LPRT, LWINDO

```

INPUT PARAMETERS:

```

! E-W mass flux from pressure fixer
REAL*8, INTENT(IN)  :: XMASS(IIPAR,JJPARG,LLPAR)

! N-S mass flux from pressure fixer
REAL*8, INTENT(IN)  :: YMASS(IIPAR,JJPARG,LLPAR)

! Surface pressure - Ptop at current time
REAL*8, INTENT(IN)  :: PS_NOW(IIPAR,JJPARG)

! 1 / ( SINE(J+1) - SINE(J) ) -- latitude factor
REAL*8, INTENT(IN)  :: RGW_FV(JJPARG)

```

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.

1.49.3 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 geometrical 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:

```
# include "CMN_SIZE"    ! Size parameters
# include "CMN_GCTM"    ! Physical constants
```

INPUT PARAMETERS:

```
! Area of grid box (m2)
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 "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.

1.49.4 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, julio_gl:jhi_gl)

! CTM surface pressure at t1 [hPa]
REAL*8  :: pctm1(ilo_gl:ihi_gl, julio_gl:jhi_gl)

! CTM surface pressure at t1+tdt [hPa]
REAL*8  :: pctm2(ilo_gl:ihi_gl, julio_gl:jhi_gl)

! Wind velocity, x direction at t1+tdt/2 [m/s]
REAL*8  :: uu(ilo_gl:ihi_gl, julio_gl:jhi_gl, k1_gl:k2_gl)

! Wind velocity, y direction at t1+tdt/2 [m/s]
REAL*8  :: vv(ilo_gl:ihi_gl, julio_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, julio_gl:jhi_gl, k1_gl:k2_gl)

! Horizontal mass flux in N-S direction [hPa]
REAL*8  :: ymass(ilo_gl:ihi_gl, julio_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.

1.49.5 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 acos 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, julio_gl:jhi_gl)
```

```

! CTM surface pressure at t1 [hPa]
REAL*8      :: pctm1(ilo_gl:ihi_gl, julio_gl:jhi_gl)

! CTM surface pressure at t1+tdt [hPa]
REAL*8      :: pctm2(ilo_gl:ihi_gl, julio_gl:jhi_gl)

! Wind velocity, x direction at t1+tdt/2 [m/s]
REAL*8      :: uu(ilo_gl:ihi_gl, julio_gl:jhi_gl, k1_gl:k2_gl)

! Wind velocity, y direction at t1+tdt/2 [m/s]
REAL*8      :: vv(ilo_gl:ihi_gl, julio_gl:jhi_gl, k1_gl:k2_gl)

```

OUTPUT PARAMETERS:

```

! Horizontal mass flux in E-W direction [hPa]
REAL*8  :: xmass(ilo_gl:ihi_gl, julio_gl:jhi_gl, k1_gl:k2_gl)

! Horizontal mass flux in N-S direction [hPa]
REAL*8  :: ymass(ilo_gl:ihi_gl, julio_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.

1.49.6 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.

1.49.7 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.

1.49.8 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:

```

#    include "CMN_SIZE" ! Size parameters
#    include "CMN_GCTM" ! 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_g1:j2_g1)

! 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.

1.49.9 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:

```
# include "CMN_SIZE" ! Size parameters
# include "CMN_GCTM" ! Re, Pi
```

INPUT PARAMETERS:

```
! Timestep [s]
REAL*8, INTENT(IN)  :: tdt

! Cosine of grid box edges
REAL*8, INTENT(IN)  :: cose (ju1_g1:j2_g1)

! Cosine of grid box centers
REAL*8, INTENT(IN)  :: cosp (ju1_g1:j2_g1)

! Pressure thickness, the pseudo-density in a
! hydrostatic 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.

1.49.10 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_g1:j2_g1)

! 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.

1.49.11 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.

1.49.12 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.

1.49.13 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.

1.49.14 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
```

```
# include "CMN_SIZE" ! Size parameters
# include "CMN_GCTM" ! 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.

1.49.15 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.

1.50 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
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

**1.50.1 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
```

```
include "CMN_SIZE" ! 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

---

### 1.50.2 correct\_ste

Subroutine CORRECT\_STE reduces the emission of <sup>210</sup>Pb and/or <sup>7</sup>Be 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
```

---

### 1.50.3 emissRnPbBe

Subroutine EMISSRnPbBe emits <sup>222</sup>Rn and <sup>7</sup>Be 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! ND02
include "CMN_DEP" ! 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 "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 "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 high 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
-

### 1.50.4 chemRnPbBe

Subroutine CHEMRnPbBe performs loss chemistry on <sup>222</sup>Rn, <sup>210</sup>Pb, and <sup>7</sup>Be.

#### 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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
```

### 1.50.5 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

```

---

**1.51 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
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
- 

### 1.51.1 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
```

```
include "CMN_SIZE" ! 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
```

---

### 1.51.2 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

```

```

include "CMN_SIZE" ! 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 - Reformatted scale factors to a single file for all years, made necessary input changes

### 1.51.3 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

```

```

include "CMN_SIZE" ! 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,JJPARG)
```

## 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)
- 

## 1.52 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
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

---

### 1.52.1 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
```

```
include "CMN_SIZE" ! 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

---

### 1.52.2 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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

```

## 1.52.3 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! SCALE_HEIGHT
include "CMN_DIAG" ! ND44, ND65, LD65

```

#### 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,JJPARG,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 "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

```

#### 1.52.4 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 : LNLPL

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! ND44, ND65, LD65

```

## 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 tropospheric 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
-

### 1.52.5 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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 LLTR0P to dimension P24H, L24H (phs, 11/18/08)
08 Dec 2009 - R. Yantosca - Added ProTeX headers
```

---

### 1.52.6 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
```

---

## 1.53 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  
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](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](mailto: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

#### 1.53.1 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

```

```

include "CMN_SIZE" ! 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

---

### 1.53.2 init\_toms

Subroutine INIT\_TOMS allocates and zeroes all module arrays.

## INTERFACE:

```
SUBROUTINE INIT_TOMS
```

## USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR
```

```
include "CMN_SIZE" ! Size parameters
```

## REVISION HISTORY:

14 Jul 2003 - R. Yantosca - Initial version  
 01 Dec 2010 - R. Yantosca - Added ProTeX headers

---

**1.53.3 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
```

---

**1.54 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
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

### 1.54.1 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
```

```
include "CMN_SIZE"
include "comode.h"
```

#### 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

### 1.54.2 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

```

```

include "CMN_SIZE"
include "comode.h"

```

**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

---

**1.54.3 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN" ! 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

---

### 1.54.4 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

include "CMN_SIZE" ! Size parameters
include "CMN" ! 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 tropopause.  
(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,JJPARG). ARRAY needs to be of  
size (IGLOB,JGLOB). 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
-

### 1.54.5 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
```

---

### 1.54.6 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
```

---

### 1.54.7 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

```

```

include "CMN_SIZE" ! 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

```

---

**1.54.8 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

```

---



**1.54.9 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
```

---

**1.54.10 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

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! 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

### 1.54.11 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
```

```
include "CMN_SIZE"
```

**REVISION HISTORY:**

```
10 Feb 2005 - R. Yantosca - Initial version
09 Sep 2010 - R. Yantosca - Added ProTeX headers
```

---

**1.54.12 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
```

---

**1.55 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 guaranteed. 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-processor 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
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.

---

### 1.55.1 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:

```
include "CMN_GCTM" ! Physical constants etc.
```

#### 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.

---

### 1.55.2 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.
- 

### 1.55.3 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
include "CMN_GCTM"

```

#### 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.

---

#### 1.55.4 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, JUL0, 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) :: JUL0, 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, JUL0: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](mailto: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.
```

---

**1.55.5 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, JUL0, 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) :: JUL0, 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.

```

### 1.55.6 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

### 1.55.7 Set\_Jn\_Js

Subroutine Set\_Jn\_Js determines Jn and Js, by looking where Courant number is  $\geq 1$ .

## INTERFACE:

```

SUBROUTINE Set_Jn_Js(jn, js, crx, ILO, IHI, JUL0, &
 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.

---

### 1.55.8 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, JUL0, &
 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) :: JUL0, 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, JUL0:JHI)

! Average of Courant numbers from il and il+1
REAL*8, INTENT(IN) :: ua (ILO:IHI, JUL0:JHI)

! Average of Courant numbers from ij and ij+1
REAL*8, INTENT(IN) :: va (ILO:IHI, JUL0: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.
```

---

**1.55.9 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.

```

---

## 1.55.10 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.
```

---

#### 1.55.11 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, JUL0, 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.

```

---

**1.55.12 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, JUL0, &
 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) :: JUL0, 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, JUL0:JHI)

! pressure at edges in "u" (mb)
REAL*8, INTENT(IN) :: pu (iLO:IHI, JUL0:JHI)

! horizontal mass flux in E-W and N-S directions [hPa]
REAL*8, INTENT(IN) :: xmass(ILO:IHI, JUL0:JHI)
REAL*8, INTENT(IN) :: ymass(ILO:IHI, JUL0:JHI)

```

**OUTPUT PARAMETERS:**

```

! Courant numbers in E-W and N-S directions
REAL*8, INTENT(OUT) :: crx(ILO:IHI, JUL0:JHI)
REAL*8, INTENT(OUT) :: cry(ILO:IHI, JUL0:JHI)

```

**AUTHOR:**

Original code from Shian-Jiann Lin, DAO)

John Tannahill, LLNL ([jrt@llnl.gov](mailto: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.
- 

### 1.55.13 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, JUL0, 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) :: JUL0, 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, JUL0:JHI)
REAL*8 , INTENT(IN) :: ymass(ILO:IHI, JUL0: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](mailto: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.

```

**1.55.14 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, &
 JUL0, 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.

### 1.55.15 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, JUL0, &
 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) :: JUL0, JHI

! Courant number in N-S direction
REAL*8, INTENT(IN) :: cry(ILO:IHI, JUL0:JHI)
```

#### OUTPUT PARAMETERS:

```
! Average of Courant numbers from ij and ij+1
REAL*8, INTENT(OUT) :: va(ILO:IHI, JUL0: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.

### 1.55.16 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, JUL0, 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) :: JUL0, 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.

```

**1.55.17 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.

```

---

**1.55.18 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, JUL0, 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) :: JUL0, JHI

! concentration contribution from E-W advection [mixing ratio]
REAL*8, INTENT(IN) :: qqu(ILO:IHI, JUL0:JHI)
```

**OUTPUT PARAMETERS:**

```
! qqu working array [mixing ratio]
REAL*8, INTENT(OUT) :: qquwk(ILO:IHI, JUL0-2: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.

### 1.55.19 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.

---

### 1.55.20 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, JUL0, 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) :: JUL0, 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](mailto: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.

```

**1.55.21 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, &
 JUL0, 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) :: JUL0, JHI

! Concentration contribution from N-S advection [mixing ratio]
REAL*8, INTENT(IN) :: qqv(-I2/3:I2+I2/3, JUL0:JHI)

```

### OUTPUT PARAMETERS:

```

! Slope of concentration distribution in E-W direction [mixing ratio]
REAL*8, INTENT(OUT) :: dcx(-I2/3:I2+I2/3, JUL0: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.

```

---

**1.55.22 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.

---

### 1.55.23 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.

### 1.55.24 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.

---

### 1.55.25 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, JUL0, 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) :: JUL0, 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, JUL0:JHI)
```

#### OUTPUT PARAMETERS:

```
! Slope of concentration distribution in N-S direction [mixing ratio]
REAL*8, INTENT(OUT) :: dcy(ILO:IHI, JUL0:JHI)
```

#### AUTHOR:

Original code from Shian-Jiann Lin, DAO  
John Tannahill, LLNL ([jrt@llnl.gov](mailto: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.

**1.55.26 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, JUL0, 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) :: JUL0, JHI

! Concentration contribution from E-W advection [mixing ratio]
REAL*8, INTENT(IN) :: qqu(ILO:IHI, JUL0-2:JHI+2)
```

**OUTPUT PARAMETERS:**

```
! Slope of concentration distribution in N-S direction [mixing ratio]
REAL*8, INTENT(OUT) :: dcy(ILO:IHI, JUL0: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.

---

### 1.55.27 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, JUL0, &
 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) :: JUL0, JHI

! Concentration contribution from E-W advection [mixing ratio]
REAL*8, INTENT(IN) :: qqu(ILO:IHI, JUL0-2: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.
```

---

**1.55.28 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, &
 julio, 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

! I LONG ??
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](mailto: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.

```

### 1.55.29 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.

```

### 1.55.30 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, JUL0, 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) :: JUL0, 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, JUL0:JHI)

```

#### INPUT/OUTPUT PARAMETERS:

```

 ! Species density [hPa]
 REAL*8, INTENT(INOUT) :: dq1(ILO:IHI, JUL0:JHI)

 ! N-S mass flux [mixing ratio]
 REAL*8, INTENT(INOUT) :: fy (ILO:IHI, JUL0: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.

### 1.55.31 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, JUL0, 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) :: JUL0, JHI

! Dimensions in longitude & altitude ???
INTEGER, INTENT(IN) :: ilong, ivert

! Controls various options in vertical advection
```



**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.

```

**1.56 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
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.
-



**1.56.1 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
```

```
include "CMN_SIZE" ! 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.
```

---

**1.56.2 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

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! Physical constants
include "CMN_DIAG" ! NDxx flags

```

#### 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

```

---

#### 1.56.3 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 : L_FILL, 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

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! Physical constants
include "CMN_DIAG" ! NDxx flags

```

#### 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

```

---

#### 1.56.4 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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! Physical constants
include "CMN_DIAG" ! NDxx flags
```

#### 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
```

---

#### 1.56.5 do\_geos5\_window\_transport

Subroutine DO\_GEOS5\_WINDOW\_TRANSPORT is the driver program for the proper TPCORE 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 : IO_W, JO_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

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! Physical constants
include "CMN_DIAG" ! NDxx flags

```

## 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

### 1.56.6 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 : IO_W, JO_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

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! 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

---

**1.56.7 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:**

```

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! 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

---

**1.56.8 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
```

---

**1.56.9 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

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! 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 "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

### 1.56.10 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 : IO_W, JO_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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! 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

### 1.56.11 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

---

**1.57 Fortran: Module Interface upbdflex\_mod**

Module UPBDFLEX\_MOD contains subroutines which impose stratospheric boundary conditions on O3 and NOy.

**INTERFACE:**

```
MODULE UPBDFLEX_MOD
```

**USES:**

```
IMPLICIT NONE
PRIVATE
```

**PUBLIC MEMBER FUNCTIONS:**

```
PUBLIC :: DO_UPBDFLEX
PUBLIC :: UPBDFLEX_O3
PUBLIC :: UPBDFLEX_NOY
PUBLIC :: UPBDFLEX_HD
PUBLIC :: INIT_UPBDFLEX
```

**REVISION HISTORY:**

28 Jun 2001 - Q. Li, B. Field, M. Evans, R. Yantosca - Initial version  
 (1 ) Routine "upbdflex\_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 order  
       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\_UPBDFLEX. Also added lat limits for 1x1 in



UPBDFLX\_03. (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\_03 (mje, bmy, 8/15/03)
- (13) Change O3 flux for GEOS-3 to 500 Tg/yr in UPBDFLX\_03 (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

---

### 1.57.1 do\_upbdflex

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
```

```
include "CMN_SIZE" ! 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

---

### 1.57.2 upbdfx\_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
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! 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 "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 P03\_vmr that will yield 475 Tg O3/yr for various settings of IORD, JORD, KORD (rvn, bey, bmy, 12/5/00)
- \*\*\*\*\*  
 \*\*\*\*\* You must use this version of UPBDFLEX\_03 if you are \*\*\*\*\*  
 \*\*\*\*\* using the Parallel Processor TPCORE v. 7.1 \*\*\*\*\*  
 \*\*\*\*\*
- (5 ) Added to "upbdflex\_mod.f". Also updated comments and made some cosmetic changes. (bmy, 6/28/01)
  - (6 ) Now reference 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 O<sub>x</sub> (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

---

### 1.57.3 upbdflex\_NOy

Subroutine UPBDFLEX\_NOy imposes NO<sub>y</sub> (NO<sub>x</sub> + HNO<sub>3</sub>) upper boundary condition in the stratosphere. The production rates for NO<sub>y</sub> are provided by Dylan Jones, along with NO<sub>x</sub> and HNO<sub>3</sub> concentrations.

#### INTERFACE:

```
SUBROUTINE UPBDFLEX_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
```

```
include "CMN_SIZE" ! 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 [NO<sub>y</sub>] into [NO<sub>x</sub>] and [HNO<sub>3</sub>], instead of partitioning P(NO<sub>y</sub>) into P(NO<sub>x</sub>) and P(HNO<sub>3</sub>). (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(N0y) 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(N0y) 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(N0y) 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(N0y) data file. Add parallel processor DO-loops. (rvn, qli, bmy, 12/6/00)
  - (9 ) Now scale P(N0y) by 0.7 for TPCORE flags 337, in order to prevent excess N0y from building up in the stratosphere. (rvn, bmy, 12/12/00)
  - (10) Now read properly regridded P(N0y) 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,JGLOB,LGLOB). Use JGLOB,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 IDTHN03 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

#### 1.57.4 upbdfx\_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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_GCTM" ! Rdg0

```

## REMARKS:

Instead of calculating the fractionation of H<sub>2</sub> in the stratosphere (where we would have to take into account fractionation of CH<sub>4</sub>), 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

## 1.57.5 init\_upbdfx

Subroutine INIT\_UPBDFLX passes IORD, JORD, and KORD values from "input\_mod.f" to "upbdfx\_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

```

---

## 1.58 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

```

```

PRIVATE

```

## PUBLIC MEMBER FUNCTIONS:

```

public :: DO_PBL_MIX_2
!PRIVATE DATA MEMBERS:

```

```

save

```

```

integer, parameter :: plev = LLPAR, plevp = plev + 1

```

```

real*8, parameter ::
 rearth = 6.37122e6, & ! radius earth (m)
 cpwv = 1.81e3, &
 cpair = 1004.64, &
 rair = 287.04, &
 rh2o = 461., &
 zvir = rh2o/rair - 1., &
 gravit = 9.80616, &
 ra = 1./rearth, &
 epsilo = 0.622, &

```

```

latvap = 2.5104e06, &
latice = 3.336e5, &
cappa = rair/cpair, &
rhoh2o = 1.e3, &
r_g = rair / gravit, &
tfh2o = 273.16

```

---

```

... pbl constants

```

---

Prior to 12/17/10:

Declare constants with the PARAMETER attribute (bmy, 12/17/10)

```

real*8 :: &
 betam = 15., & ! constant in wind gradient expression
 betas = 5., & ! constant in surface layer gradient expression
 betah = 15., & ! constant in temperature gradient expression
 fak = 8.5, & ! constant in surface temperature excess
 g, & ! gravitational acceleration
 onet, & ! 1/3 power in wind gradient expression
 fakn = 7.2, & ! constant in turbulent prandtl number
 ricr = .3, & ! critical richardson number
 sfrac = .1, & ! surface layer fraction of boundary layer
 vk = .4, & ! von karmans constant
 ccon, & ! fak * sfrac * vk
 binm, & ! betam * sfrac
 binh ! betah * sfrac

```

---

! These are constants, so use PARAMETER tag

```

real*8, parameter :: &
 betam = 15., & ! constant in wind gradient expression
 betas = 5., & ! constant in surface layer gradient expression
 betah = 15., & ! constant in temperature gradient expression
 fak = 8.5, & ! constant in surface temperature excess
 fakn = 7.2, & ! constant in turbulent prandtl number
 ricr = .3, & ! critical richardson number
 sfrac = .1, & ! surface layer fraction of boundary layer
 vk = .4 ! 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 * sfrac * vk
 binm, & ! betam * sfrac
 binh ! betah * sfrac

```



---

```

... 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. , arvdif = .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

```

---

### 1.58.1 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:****1.58.2 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:**

---

**1.58.3 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:****1.58.4 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:**

**1.58.5 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:****1.58.6 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:**

**1.58.7 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, NTRAINED, 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, JJPARG, IDEMS, NEMIS, NCS, ND15, ND44, &
 NDRYDEP, emis_save
USE DIAG_MOD, ONLY : TURBFLUP, AD44
USE VDIFF_PRE_MOD, ONLY : IIPAR, JJPARG, 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 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
```

#### 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
```

---

#### 1.58.8 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
```

#### 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

```

## 1.59 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

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE"
include "comode.h" ! IDEMS, NEMIS, NCS
include "CMN_O3" ! EMISRR, EMISRRN
include "CMN_DIAG" ! ND15

```

```

PRIVATE

```

## PUBLIC DATA MEMBERS:

```

PUBLIC :: IIPAR, JJPAR, LLPAR ! from "CMN_SIZE"
PUBLIC :: IDEMS, NEMIS, NCS, NDRYDEP ! from "comode.h"
PUBLIC :: EMISRR, EMISRRN ! from "CMN_O3"
PUBLIC :: ND15, ND44 ! from "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

```



**1.60 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
```

```
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
```

**1.60.1 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

---

**1.60.2 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

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! FSCALYR

```

**REVISION HISTORY:**

28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial Version

---

**1.60.3 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
```

```
include "CMN_SIZE" ! Size parameters
```

**REVISION HISTORY:**

```
28 Jan 2009 - A. v. Donkelaar, P. Le Sager - Initial Version
```

---

**1.60.4 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
```

```
include "CMN_SIZE" ! 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
```

---

**1.60.5 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

```

```

include "CMN_SIZE" ! Size parameters

```

**REVISION HISTORY:**

28 Jan 2009 - P. Le Sager - Initial Version

---

**1.60.6 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

---

**1.61 Fortran: Module Interface Individual GEOS-Chem subroutines**

Here follows a list of GEOS-Chem subroutines which do not belong to any F90 module.

---

**1.61.1 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_LIQC02, 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

```

IMPLICIT NONE

```

include "CMN_SIZE" ! Size parameters
include "CMN_03" ! EMIST, EMISR, EMISRR, etc.
include "comode.h" ! IDEMS

```

## 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 CMN\_03:

```

=====
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 JJPAP, 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 IO and JO 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
- 

### 1.61.2 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
```

#### 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 ) CMN\_VOL is used to pass AIRVOL.
- (2 ) Use C-preprocessor #include statement to include CMN\_SIZE, which has IIPAR, JJPARG, LLPARG, IGLARG, JGLARG, LGLARG.
- (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 "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

---

### 1.61.3 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, LT03
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
```

IMPLICIT NONE

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! Diagnostic arrays & parameters
include "CMN_O3" ! FRAC03
include "CMN_GCTM" ! Physical constants
```

#### 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 reference 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 "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 timesteps (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 LT03 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

## 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](http://acmg.seas.harvard.edu/geos/doc/man/appendix_5.html)

---

**1.61.4 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 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 R02 consumed by H02 (*H) or NO (*N)
! CTLxR02x : # 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, CT03, CT03_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 : LSHIPS02, 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, IDTHN03
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

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE" ! Size parameters
include "CMN" ! IFLX, LPAUSE
include "CMN_DIAG" ! Diagnostic switches & arrays
include "CMN_O3" ! FMOL, XNUMOL
include "comode.h" ! IDEMS

```

## 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 ( LBPNCCH > 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 D0-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 LSHIPS02=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. (kjlw, 8/18/09)
- (88) Account for 3D AD13\_NH3\_an now (phs, 10/22/09)
- (89) NBIOMAX is now in 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"

### 1.61.5 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, CT03
USE DIAG_MOD, ONLY : LTOH, CTOH, LTOTH, CTOTH, LTNO2
USE DIAG_MOD, ONLY : CTNO2, LTHO2, CTHO2, LTNO3, CTNO3
USE DIAG_MOD, ONLY : CT03_24h, LTO3
USE DIAG_MOD, ONLY : LTLBR02H, LTLBR02N
USE DIAG_MOD, ONLY : LTLTR02H, LTLTR02N
USE DIAG_MOD, ONLY : LTLXR02H, LTLXR02N
USE DIAG_MOD, ONLY : CTLBR02H, CTLBR02N
USE DIAG_MOD, ONLY : CTLTR02H, CTLTR02N
USE DIAG_MOD, ONLY : CTLXR02H, CTLXR02N
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

```

IMPLICIT NONE

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! HR_OH1, HR_OH2, etc.

```

## 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. (rvn, 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 LT03 to accumulate O3 in ND45 at the same place as the chemistry (ccc, 7/17/09)
- 

### 1.61.6 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

IMPLICIT NONE

```
include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! Diagnostic switches & arrays
include "CMN_O3" ! SAVEOH, SAVENO
```

#### 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. (rvn, 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
-



**1.61.7 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 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)

IMPLICIT NONE

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! Diagnostic switches & arrays
include "CMN_O3" ! EMISR, EMISRR, etc...
include "comode.h" ! IHOURL

```

**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 enhancement 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 NO<sub>x</sub> 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 NO<sub>x</sub> is emitted as HNO<sub>3</sub>+10\*O<sub>3</sub> (phs, 3/4/08)
- (29) Apply spatially-varying diurnal scalars for NO<sub>x</sub> (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 NO<sub>x</sub> 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 O<sub>3</sub> or HNO<sub>3</sub>) they no longer get overwritten. (gvinken, 11/16/10)
- 19 Nov 2010 - R. Yantosca - Added ProTeX headers

### 1.61.8 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
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE"
include "CMN_03"
include "comode.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
```

#### 1.61.9 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:**

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_VEL" ! XYLAI, IJREG, IJLAND, IJUSE
include "CMN_MONOT" ! BASEMONOT
```

**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 (CMN_VEL) : Leaf Area Index of land type for current MONTH
(2) IJREG (CMN_VEL) : Number of Olson land types per grid box
(3) IJLAND+1 (CMN_VEL) : Olson land type index
(4) IJUSE (CMN_VEL) : Olson land type fraction per box (in mils)
(5) BASEMONOT (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
```

**1.61.10 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/publication>

**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
```

```
IMPLICIT NONE
```

```
include "cmn_fj.h" ! IPAR, JPAR, LPAR, CMN_SIZE
include "jv_cmn.h" ! ODMODUST, PJ
```

**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 "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 PHOT0J 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\_TOMS03 from "toms\_mod.f" at the beginning of a new month (or the first timestep) to read TOMS 03 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 PHOT0J. 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

### 1.61.11 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
```

**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

---

**1.61.12 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_S02_ac
USE DIAG_MOD, ONLY : AD13_S02_an, AD13_S02_bb, AD13_S02_bf
USE DIAG_MOD, ONLY : AD13_S02_ev, AD13_S02_nv, AD13_S04_an
USE DIAG_MOD, ONLY : AD13_S04_bf, AD13_S02_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 : CTLBR02H, CTLBR02N
USE DIAG_MOD, ONLY : CTLTR02H, CTLTR02N
USE DIAG_MOD, ONLY : CTLXR02H, CTLXR02N
USE DIAG_MOD, ONLY : AD44, AD45, LTOTH
USE DIAG_MOD, ONLY : CTOTH, AD46, AD47
USE DIAG_MOD, ONLY : AD52
USE DIAG_MOD, ONLY : AD54, CT03, CT03_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

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! NDxx flags

```

## 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 CT03 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 CT03_24h (phs, 11/17/08)
(42) Now zero AD52 for Gamma H02 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
 (kjlw, 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

```

---

### 1.61.13 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:

```

! References to F90 modules
!NBIOMAX moved to 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_S04_bf, AD13_S02_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 : LTH02, CTH02, LTNO2
USE DIAG_MOD, ONLY : CTN02, LTNO3, CTN03
! update for arom (dkh, 06/21/07)
USE DIAG_MOD, ONLY : CTLBR02H, CTLBR02N
USE DIAG_MOD, ONLY : CTLTR02H, CTLTR02N
USE DIAG_MOD, ONLY : CTLXR02H, CTLXR02N
USE DIAG_MOD, ONLY : LTLBR02H, LTLBR02N
USE DIAG_MOD, ONLY : LTLTR02H, LTLTR02N
USE DIAG_MOD, ONLY : LTLXR02H, LTLXR02N
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, CT03
USE DIAG_MOD, ONLY : AD10, AD10em, CT03_24h
! Add 03 for ND45 diag. (ccc, 8/12/09)
USE DIAG_MOD, ONLY : LT03
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

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_DIAG" ! Diagnostic switches & arrays

```

## 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 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\_S02\_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 "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\_S04\_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 CT03\_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 LT03. (ccc, 7/20/09)
  - (71) Add AD19, AD58, AD60 (kjl, 8/18/09)
  - (72) Now AD13\_S02\_an and AD13\_S04\_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 CMN\_SIZE. (fp, 2/26/10)
- 26 Aug 2010 - R. Yantosca - Added ProTeX headers

**1.61.14 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, FRAC03,
& 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

 IMPLICIT NONE

 # include "CMN_SIZE" ! Size parameters
 # include "comode.h" ! VOLUME, CSPEC, NPVERT, NLAT, NLONG

```

**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,JJP,LLPAR,N_TRACERS)

```

**OUTPUT PARAMETERS:**

```

 ! Array of O3/Ox fractions
 REAL*8, INTENT(OUT) :: FRAC03(IIPAR,JJP,LLPAR)

 ! Array of NO/NOx fractions
 REAL*8, INTENT(OUT) :: FRACNO(IIPAR,JJP,LLPAR)

 ! Array of NO2/NOx fractions
 REAL*8, INTENT(OUT) :: FRACNO2(IIPAR,JJP,LLPAR)

 ! Array of OH concentrations [molec/cm3]
 REAL*8, INTENT(OUT) :: SAVEOH(IIPAR,JJP,LLPAR)

```



```

! Array of HO2 concentrations [v/v]
REAL*8, INTENT(OUT) :: SAVEHO2(IIPAR,JJPARG,LLPAR)

! Array of NO concentrations [v/v]
REAL*8, INTENT(OUT) :: SAVENO(IIPAR,JJPARG,LLPAR)

! Array of NO2 concentrations [v/v]
REAL*8, INTENT(OUT) :: SAVENO2(IIPAR,JJPARG,LLPAR)

! Array of NO3 concentrations [v/v]
REAL*8, INTENT(OUT) :: SAVENO3(IIPAR,JJPARG,LLPAR)

```

## REVISION HISTORY:

- 27 Feb 2002 - R. Yantosca - Initial version
- (1 ) Original code from lwh, gmg, djg, 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 (rvn, 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

### 1.61.15 rdlai

Subroutine RDLAI is used for soil NOx emissions

## INTERFACE:

```
SUBROUTINE RDLAI(JDAY, MONTH, YEAR)
```

## USES:

```
USE GRID_MOD, ONLY : GET_XOFFSET, GET_YOFFSET
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE"
include "CMN_DEP"
include "CMN_VEL"
```

#### 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 IGLOB and JMX with JGLOB
19 Nov 2009 - M. Barkley - Included the simulation and LAI years
```

---

#### 1.61.16 rdland

Subroutine RDLAND reads the land types and fractions (times 1000) from the "veg-type.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 : LAVHRR_LAI
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DEP" ! FRCLND, IREG, ILAND, IUSE
include "CMN_VEL" ! IJREG, IJLAND, IJUSE
```

#### REMARKS:

Common-block variables from header file "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 "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 LAVHRLAI=T. Also updated comments and added standard GEOS-CHEM program documentation header. (bmy, 12/20/04)

02 Dec 2010 - R. Yantosca - Added ProTeX headers

**1.61.17 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
```

IMPLICIT NONE

```
include "CMN_SIZE" ! Size parameters
include "commsoil.h" ! Soil variables
```

**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

### 1.61.18 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
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_ISOP" ! SOPCOEFF
```

## 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

---

### 1.61.19 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
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
```

## 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 "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

---

### 1.61.20 readlai

Subroutine READLAI reads the leaf area indices from disk for two months. (yhw, gmg, djg, 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 : LAVHRLAI
USE LOGICAL_MOD, ONLY : LMODISLAI ! (mpb,2009)
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
include "CMN_DEP" ! IREG, ILAND, IUSE
include "CMN_VEL" ! XLAI, XLAI2
```

#### 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 IGLOB and JMX with JGLOB  
 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 LAVHRR\_LAI=T.  
                               Otherwise use the old LAI data.

---

### 1.61.21 ruralbox

Subroutine RURALBOX computes which boxes are tropospheric and which are stratospheric. SMVGEAR arrays are initialized with quantities from tropospheric boxes.

#### INTERFACE:

```
SUBROUTINE RURALBOX(AD, T, AVGW, ALBD, SUNCOS)
```

#### 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
```

```
IMPLICIT NONE
```

```
include "CMN_SIZE" ! Size parameters
include "comode.h" ! NPVERT
```

#### INPUT PARAMETERS:

```
REAL*8, INTENT(IN) :: AD(IIPAR,JJP,LLPAR) ! Air mass [kg]
REAL*8, INTENT(IN) :: T(IIPAR,JJP,LLPAR) ! Temperature [K]
REAL*8, INTENT(IN) :: AVGW(IIPAR,JJP,LLPAR) ! Mix rat. of H2O [v/v]
REAL*8, INTENT(IN) :: ALBD(IIPAR,JJP) ! Sfc albedo [unitless]
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 "CMN\_SIZE". (bmy, 2/10/00)

- (2 ) Add C-preprocessor switch LSLWJ 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 "CMN\_SIZE", don't declare it here (bmy, 7/16/01)
  - (5 ) Replace IGCMPAR,JGCMPAR,LGCMPAR with IIPAR,JJPAP,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 LSLWJ #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

### 1.61.22 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 : LNL PBL ! (Lin, 03/31/09)
USE LOGICAL_MOD, ONLY : LPRT

```

```

! NOx emissions scaling FP 15/12/09
USE EMISSIONS_MOD, ONLY : NOx_SCALING

```

```

IMPLICIT NONE

```

```

include "CMN_SIZE" ! Size parameters
include "CMN_NOX" ! GEMISNOX2
include "CMN_DIAG" ! Diagnostic flags
include "comode.h" ! IDEMS, NEMIS

```

#### INPUT PARAMETERS:

```

! CO, hydrocarbon emission [molec tracer/box/s]
REAL*8, INTENT(IN) :: EMISRR(IIPAR,JJPARG,NEMPARA+NEMPARB)

! Multi-level NOx emissions [molec NOx/box/s]
REAL*8, INTENT(IN) :: EMISRRN(IIPAR,JJPARG,NOXEXTENT)

```

#### REMARKS:

Developers: lwh, jyl, gmg, djg, bdf, bmy, 6/8/98, 6/11/08  
 (lwh, jyl, gmg, djg, 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 + IO and JREF = J + JO (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 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/ CMN\_03 (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.

---

### 1.61.23 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
```

#### 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)<sup>2</sup> 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 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 "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

```

---

#### 1.61.24 tcorr

Function TCORR applies the temperature correction for isoprene emissions, according to Guenther et al.(92)

#### INTERFACE:

```
FUNCTION TCORR(TEMP)
```

#### USES:

```
IMPLICIT NONE
```

#### 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

```