GEOS-Chem Reference
3. Diagnostic Modules

GEOS-Chem Support Team

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1 Diagnostic modules

These modules contain routines to archive various diagnostic quantities (concentrations, emissions, chemical production and loss, etc.)xfrom GEOS-Chem.

1.1 Fortran: Module Interface benchmark_mod.F

Module BENCHMARK_MOD contains routines to save out initial and final species masses which are needed for GEOS-Chem 1-month benchmark simulations

INTERFACE:

```
MODULE BENCHMARK_MOD
```

USES:

```
USE PRECISION_MOD

IMPLICIT NONE
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: STDRUN
```

PUBLIC DATA MEMBERS:

```
CHARACTER(LEN=255), PUBLIC :: INITIAL_FILE ! File w/ initial species mass
CHARACTER(LEN=255), PUBLIC :: FINAL_FILE   ! File w/ final   species mass
```

REVISION HISTORY:

```
(1 ) Now expand date & time tokens in filenames (bmy, 1/31/05)
(2 ) Now modified for GCAP grid (swu, bmy, 6/28/05)
(3 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
01 Aug 2012 - R. Yantosca - Add reference to findFreeLUN from inqure_mod.F90
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
05 Nov 2014 - M. Yannetti - PRECISION_MOD Changed REAL*8 to REAL(fp)
19 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg
29 Nov 2016 - M. Sulprizio- Convert species locally from kg/kg to kg
```

1.1.1 stdrun

Subroutine STDRUN dumps the mass of either O3 [kg] or 222Rn, 210Pb, and 7Be [kg] at the start & end of each run. This is necessary for GEOS-CHEM benchmarking.

INTERFACE:

```
SUBROUTINE STDRUN( am_I_Root, Input_Opt, State_Met, State_Chm, RC,
&                  LBEGIN )
```

USES:

```
      USE BPCH2_MOD,          ONLY : BPCH2
      USE BPCH2_MOD,          ONLY : OPEN_BPCH2_FOR_WRITE
      USE BPCH2_MOD,          ONLY : GET_HALFPOLAR
      USE BPCH2_MOD,          ONLY : GET_MODELNAME
      USE CMN_SIZE_MOD
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : GC_ERROR
      USE FILE_MOD,           ONLY : IOERROR
      USE Input_Opt_Mod,      ONLY : OptInput
      USE inquireMod,         ONLY : findFreeLUN
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      USE State_Met_Mod,      ONLY : MetState
      USE TIME_MOD,           ONLY : EXPAND_DATE
      USE TIME_MOD,           ONLY : GET_NYMD
      USE TIME_MOD,           ONLY : GET_NHMS
      USE TIME_MOD,           ONLY : GET_TAU
      USE UnitConv_Mod
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Is this the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
      LOGICAL,        INTENT(IN)    :: LBEGIN      ! =T denotes start of run
                                                   ! =F denotes end of run
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure
```

REVISION HISTORY:

```
    12 Aug 2002 - R. Yantosca - Initial version
    03 Aug 2012 - R. Yantosca - Added ProTeX headers
    (1 ) Changed name from STDRUN_Ox to STDRUN, since we now can also save out
         Rn/Pb/Be for NSRCX==1.  Also deleted obsolete code from 6/02.  Added
         LBEGIN as an argument to determine if this is the start or end of the
         run.  (bmy, 8/12/02)
    (2 ) Bundled into "benchmark_mod.f" (bmy, 7/20/04)
    (3 ) Now expand date tokens in the filename (bmy, 1/31/05)
    (4 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
         value for GEOS or GCAP grids .  Also removed references to CMN_DIAG
         and TRCOFFSET. (bmy, 6/28/05)
```

```
   (5 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
   03 Aug 2012 - R. Yantosca - Now use findFreeLUN to obtain file unit #'s
   14 Mar 2013 - M. Payer    - Replace Ox with O3 as part of removal of
                               NOx-Ox partitioning
   25 Mar 2013 - M. Payer    - Now pass State_Chm object via the arg list
   30 May 2013 - R. Yantosca - Now pass Input_Opt object via the arg list
   17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
   17 Dec 2014 - R. Yantosca - Now use State_Chm%TRACERS instead of STT
   19 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg
   16 Jun 2016 - R. Yantosca - Now use Ind_ to get species ID for O3
   30 Jun 2016 - R. Yantosca - Remove instances of STT.  Now get the advected
                               species ID from State_Chm%Map_Advect.
   11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
   29 Nov 2016 - M. Sulprizio- Convert species locally from kg/kg to kg
```

1.2 Fortran: Module Interface diag1.F

Subroutine DIAG1 accumulates diagnostic quantities on every dynamic timestep.

INTERFACE:

```
      SUBROUTINE DIAG1( am_I_Root, Input_Opt,
     &                  State_Met, State_Chm, RC )
```

USES:

```
      ! References to F90 modules
      USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_TROP
      USE CHEMGRID_MOD,       ONLY : GET_TPAUSE_LEVEL
      USE CMN_DIAG_MOD
      USE CMN_SIZE_MOD
      USE DAO_MOD,            ONLY : IS_ICE, IS_WATER, IS_LAND
      USE DIAG_MOD,           ONLY : AD33, AD35, AD54
      USE DIAG_MOD,           ONLY : AD47
#if defined( BPCH_DIAG )
      USE DIAG_MOD,           ONLY : AD30, AD31, AD45, AD57
      USE DIAG_MOD,           ONLY : AD67, AD68, AD69, LTOTH
#endif
      USE DIAG_MOD,           ONLY : AD71
      USE DIAG_MOD,           ONLY : AD71_DAY,   AD71_HR
      USE DIAG_MOD,           ONLY : AD71_LDAY,  AD71_LHR
      USE DIAG_MOD,           ONLY : AD71_COUNT, AD71_HRCT
      USE DIAG03_MOD,         ONLY : AD03_RGM, AD03_PBM, ND03
#if defined( NC_DIAG )
      USE DIAGNOSTICS_MOD,    ONLY : DiagnSpec, DiagnUpdate_Met
#endif
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : ERROR_STOP
```

```
      USE ERROR_MOD,          ONLY : SAFE_DIV
      USE GC_GRID_MOD,        ONLY : GET_AREA_M2
      USE HCO_DIAGN_MOD,      ONLY : Diagn_Update
      USE HCO_ERROR_MOD
      USE Input_Opt_Mod,      ONLY : OptInput
      USE PhysConstants
      USE PRECISION_MOD
      USE Species_Mod,        ONLY : Species
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      USE State_Met_Mod,      ONLY : MetState
      USE TIME_MOD,           ONLY : ITS_TIME_FOR_CHEM
      USE TIME_MOD,           ONLY : GET_DAY
      USE TIME_MOD,           ONLY : GET_HOUR
      USE HCO_INTERFACE_MOD,  ONLY : HcoState

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

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
```

REVISION HISTORY:

```
   (1 ) This subroutine was reconstructed from gmg's version of (10/10/97)
   (2 ) GISS-specific code has been eliminated (bmy, 3/15/99)
   (3 ) UWND, VWND, WW no longer needs to be passed (bmy, 4/7/99)
   (4 ) Use F90 syntax for declarations, etc (bmy, 4/7/99)
   (5 ) Remove counter KWACC...this is now redundant (bmy, 11/5/99)
   (6 ) ND31, ND33, ND35, ND67, and ND69 now use dynamically
        allocatable arrays declared in "diag_mod.f". (bmy, 3/9/00)
   (7 ) LTOTH is now an allocatable array in "diag_mod.f". (bmy, 3/17/00)
   (8 ) Add parallel loops over tracer where expedient (bmy, 5/4/00)
   (9 ) Updated comments and diagnostics list.  Also add more parallel
        loops for ND31 and ND68.  (bmy, 6/21/00)
   (10) Use NTRACE to dimension STT_VV instead of NNPAR (bmy, 10/17/00)
   (11) Removed obsolete code from 10/17/00 (bmy, 12/21/00)
```

```
(12) Updated diagnostic list & comments, cosmetic changes (bmy, 6/19/01)
(13) Updated diagnostic list & comments (bmy, 9/4/01)
(14) Now reference AVGW from "dao_mod.f", and make sure it is allocated
     before we reference it in the ND68 diagnostic.  Also reference PBL,
     PS, AIRDEN from "dao_mod.f". (bmy, 9/25/01)
(15) Removed obsolete code from 9/01 (bmy, 10/23/01)
(16) Renamed ND33 to "ATMOSPHERIC COLUMN SUM OF TRACER", since this is
     a sum over all levels and not just in the troposphere.  Also
     removed more obsolete code from 9/01.  Now use P(I,J)+PTOP instead
     of PS, since that is the way to ensure that we use will be used
     consistently.  Remove reference to PS from "dao_mod.f"(bmy, 4/11/02)
(17) Replaced all instances of IM with IIPAR and JM with JJPAR, in order
     to prevent namespace confusion for the new TPCORE.  Also removed
     obsolete, commented-out code.  Also now replaced reference to
     P(IREF,JREF) with P(I,J). (bmy, 6/25/02)
(18) Replaced references to P(I,J) with call to GET_PEDGE(I,J,1) from
     "pressure_mod.f"  Eliminated obsolete commented-out code from
     6/02. (dsa, bdf, bmy, 8/20/02)
(19) Now reference AD, and BXHEIGHT from "dao_mod.f".  Removed obsolete
     code.  Now refEerence IDTOX from "tracerid_mod.f". (bmy, 11/6/02)
(20) Now replace DXYP(J) with routine GET_AREA_M2 from "grid_mod.f"
     (bmy, 2/4/03)
(21) Now compute PBL top for ND67 for GEOS-4/fvDAS.  Also now include
     SCALE_HEIGHT from header file "CMN_GCTM". (bmy, 6/23/03)
(22) Now references N_TRACERS, STT, and ITS_A_FULLCHEM_SIM from
     "tracer_mod.f" (bmy, 7/20/04)
(23) Fixed ND67 PS-PBL for GCAP and GEOS-5 met fields (swu, bmy, 6/9/05)
(24) Now archive ND30 diagnostic for land/water/ice flags (bmy, 8/18/05)
(25) Now reference XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(26) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(27) Added count for time in the troposphere - array AD54 (phs, 9/22/06)
(28) Now only archive O3 in ND45 and ND47 at chem timsteps (phs, 1/24/07)
(29) Bug fix: Update ND30 for both GEOS-3 and otherwise.  Also now save
     3-D pressure edges in ND31 instead of PS-PTOP.  Revert to the !
     pre-near-land ND30 diagnostic algorithm. (bmy, 1/28/04)
(30) Use LTO3 for O3 in ND45. (ccc, 7/20/09)
(31) Add potential temperature diagnostic in ND57 (fp, 2/3/10)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
15 Feb 2011 - R. Yantosca - Added modifications for APM from G. Luo
28 Feb 2012 - R. Yantosca - Removed support for GEOS-3
01 Mar 2012 - R. Yantosca - Now use GET_AREA_M2(I,J,L) from grid_mod.F90
09 Nov 2012 - M. Payer    - Replaced all met field arrays with State_Met
                            derived type object
14 Mar 2013 - M. Payer    - Replace Ox with O3 as part of removal of
                            NOx-Ox partitioning
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
29 Aug 2013 - R. Yantosca - In ND57, we need to make ND57 !$OMP PRIVATE
```

```
06 Nov 2014 - R. Yantosca - Now use State_Met%AIRDEN(I,J,L)
07 Nov 2014 - M. Yannetti - Added PRECISION_MOD
20 Jan 2015 - R. Yantosca - Added new netCDF diagnostics
26 Feb 2015 - E. Lundgren - Replace GET_PEDGE with State_Met%PEDGE and
                            GET_PCENTER with State_Met%PMID.
24 Mar 2015 - E. Lundgren - Remove dependency on tracer_mod
25 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg
16 Apr 2015 - E. Lundgren - Add new State_Met variables to ND68
19 Oct 2015 - C. Keller   - Now use Input_Opt%ND68 instead of ND68;
                            Rename AIRDEN diagnostics to AIRDENSITY to
                            avoid name conflict with GEOS-5 model.
29 Apr 2016 - R. Yantosca - Don't initialize pointers in declaration stmts
02 May 2016 - R. Yantosca - Now declare IDTPASV locally
31 May 2016 - E. Lundgren - Replace input_opt%TRACER_MW_G with species
                            database field emMW_g (emitted species g/mol)
31 May 2016 - E. Lundgren - Remove usage of TCVV; replace with AIRMW/emMW_g
06 Jun 2016 - M. Sulprizio- Replace NTSPEC with State_Chm%nSpecies and
                            NAMEGAS with ThisSpc%Name from species database
22 Jun 2016 - R. Yantosca - Now use Ind_() to define id_PASV species ID
30 Jun 2016 - R. Yantosca - Remove instances of STT.  Now get the advected
                            species ID from State_Chm%Map_Advect.
01 Jul 2016 - R. Yantosca - Now rename species DB object ThisSpc to SpcInfo
11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
16 Sep 2016 - E. Lundgren - Remove passive species that are per total air
                            since moisture fix corrects v/v dry
20 Sep 2016 - E. Lundgren - Simplify met fields included in ND68 (8 total)
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.3 Fortran: Module Interface diag_2pm.F

Subroutine DIAG_2PM constructs the diagnostic flag arrays:

- LTJV: J-values (ND22)
- LTOH: OH concentrations (ND43)
- LTHO2: HO2 concentrations (ND43)
- LTOTH: used for tracers (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, CTJV count the number of times the diagnostics are accumulated for each grid box (i.e LTOTH is 1)

INTERFACE:

```
SUBROUTINE DIAG_2PM( State_Met )
```

USES:

```
      USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_CHEMGRID
      USE CMN_DIAG_MOD             ! HR_OH1, HR_OH2, etc.
      USE CMN_SIZE_MOD             ! Size parameters
      USE DIAG_MOD,           ONLY : LTJV,  CTJV
      USE DIAG_MOD,           ONLY : LTOH,  CTOH
#if defined( BPCH_DIAG )
      USE DIAG_MOD,           ONLY : LTOTH, CTOTH
#endif
      USE DIAG_MOD,           ONLY : LTHO2, CTHO2
      USE DIAG_MOD,           ONLY : CTO3_24h
      USE DIAG_MOD,           ONLY : CTO1D,    LTO1D
      USE DIAG_MOD,           ONLY : CTO3P,    LTO3P
      USE DIAG_MOD,           ONLY : LTLBRO2H, LTLBRO2N
      USE DIAG_MOD,           ONLY : LTLTRO2H, LTLTRO2N
      USE DIAG_MOD,           ONLY : LTLXRO2H, LTLXRO2N
      USE DIAG_MOD,           ONLY : CTLBRO2H, CTLBRO2N
      USE DIAG_MOD,           ONLY : CTLTRO2H, CTLTRO2N
      USE DIAG_MOD,           ONLY : CTLXRO2H, CTLXRO2N
      USE PRECISION_MOD            ! For GEOS-Chem Precision (fp)
      USE State_Met_Mod,      ONLY : MetState
      USE TIME_MOD,           ONLY : GET_LOCALTIME
      USE TIME_MOD,           ONLY : ITS_TIME_FOR_DIAG
      USE TIME_MOD,           ONLY : ITS_TIME_FOR_CHEM
      USE TIME_MOD,           ONLY : GET_ELAPSED_MIN
      USE TIME_MOD,           ONLY : GET_TS_DIAG

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      TYPE(MetState), INTENT(IN)  :: State_Met   ! Meteorology State object
```

REMARKS:

```
    For now use GET_LOCALTIME( I, 1, 1 ) which will be independent of J and L
    for a pure cartesian grid.  This may need to be revisited once G-C is
    interfaced into a GCM.
```

REVISION HISTORY:

```
    26 Mar 1999 - R. Yantosca - Initial version
    (1 ) Now use F90 syntax (bmy, 3/26/99)
    (2 ) Now reference LTNO2, CTNO2, LTHO2, CTHO2 arrays from "diag_mod.f".
         Updated comments, cosmetic changes.  (rvm, bmy, 2/27/02)
    (3 ) Now removed NMIN from the arg list.  Now use functions GET_LOCALTIME,
         ITS_TIME_FOR_CHEM, ITS_TIME_FOR_DYN from "time_mod.f" (bmy, 2/11/03)
    (4 ) Now rewritten using a parallel DO-loop (bmy, 7/20/04)
    (5 ) Now account for the time spent in the troposphere for ND43 and ND45
         pure O3.  Now only accumulate counter for 3D pure O3 in ND45 if
```

```
      it's a chemistry timestep. (phs, 1/24/07)
(6 ) Added 3D counter for ND65 and O3 in ND47 (phs, 11/17/08)
(7 ) Change re-initialization of ND45: only at the timestep after the
     diagnostics are accumulated. Add ITS_AFTER_DIAG and PREV_TS variables.
     (ccc, 6/12/09)
(8 ) Add LTO3 to accumulate O3 in ND45 at the same place as the
      chemistry (ccc, 7/17/09)
01 Mar 2012 - R. Yantosca - Now use GET_LOCALTIME(I,J,L) from time_mod.F90
02 Apr 2013 - M. Payer    - Remove code for LTNO, LTNO2, and LTNO3. These
                            are no longer needed because NO, NO2, and NO3
                            are now tracers.
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
08 Nov 2013 - M. Sulprizio- Removed CTO3 and LTO3. They are no longer used
                            because O3 is now a tracer.
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
```

1.4 Fortran: Module Interface diag3.F

Subroutine DIAG3 prints out diagnostics to the BINARY PUNCH format file.

INTERFACE:

```
SUBROUTINE DIAG3( am_I_Root, Input_Opt, State_Met, State_Chm, RC )
```

USES:

```
! Modules from Headers directory
USE CMN_DIAG_MOD                      ! Diagnostic switches & arrays
USE CMN_FJX_MOD                       ! Fast-JX flux diagnostics
USE CMN_O3_MOD                        ! FMOL
USE CMN_SIZE_MOD                      ! Size parameters
USE ErrCode_Mod
USE Input_Opt_Mod,      ONLY : OptInput
USE PhysConstants,      ONLY : AVO     ! Avogadro's #
USE PRECISION_MOD                     ! For GEOS-Chem Precision (fp)
USE State_Met_Mod,      ONLY : MetState
USE State_Chm_Mod,      ONLY : ChmState
USE State_Chm_Mod,      ONLY : Ind_

! Modules from GeosUtil directory
USE ERROR_MOD,          ONLY : ERROR_STOP
USE FILE_MOD
USE GC_GRID_MOD,        ONLY : GET_AREA_M2
USE GC_GRID_MOD,        ONLY : GET_YOFFSET, GET_XOFFSET
USE TIME_MOD

! Modules from GeosCore directory
USE BPCH2_MOD                         ! For binary punch I/O routines
```

```
      USE DIAG_MOD                              ! For diagnostic arrays
      USE DIAG03_MOD                            ! For Hg diagnostic
      USE DIAG04_MOD                            ! For CO2 diagnostics
      USE DIAG41_MOD                            ! For afternoon PBL diag
      USE DIAG42_MOD                            ! For SOA diag
      USE DIAG53_MOD                            ! For POPs diag
      USE DIAG56_MOD                            ! For time in tropopause diag
      USE DEPO_MERCURY_MOD                      ! For offline Hg simulation
      USE DRYDEP_MOD                            ! For dry deposition
      USE WETSCAV_MOD                           ! For wet deposition

#if   defined( TOMAS )
      USE TOMAS_MOD, ONLY : ICOMP, IDIAG, IBINS  !(win, 1/25/10)
#endif

      ! Interface w/ HEMCO
      USE HCO_TYPES_MOD, ONLY : DiagnCont
      USE HCO_DIAGN_MOD
      USE HCO_ERROR_MOD
      USE HCO_INTERFACE_MOD

      ! Species database
      USE Species_Mod,       ONLY : Species

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      LOGICAL,         INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput),  INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState),  INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState),  INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,         INTENT(OUT)   :: RC          ! Success or failure?
```

REMARKS:

```
  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  %%%  ROUTINE diag3.F SAVES TIME-AVERAGED QUANTITIES TO THE BPCH FILE.   %%%
  %%%  THE BPCH FILE FORMAT IS DEPRECATED.  DIAGNOSTIC OUTPUT WILL        %%%
  %%%  EVENTUALLY BE REPLACED BY netCDF OUTPUT IN A FUTURE RELEASE.       %%%
  %%%  FOR NOW, WE SHALL KEEP BPCH OUTPUT IN ORDER TO PRESERVE BACKWARDS  %%%
  %%%  COMPATIBILITY WITH THE EXISTING VISUALIZATION SOFTWARE.            %%%
  %%%                                                                     %%%
  %%%  ALSO NOTE: MANY EMISSIONS DIAGNOSTICS ARE NOW ARCHIVED IN HEMCO,   %%%
  %%%  AND ARE WRITTEN OUT TO BPCH FILE HERE.  THIS IS MEANT TO PRESERVE  %%%
```

```
%%%  THE EXISTING DIAGNOSTIC CAPABILITY FOR THE TIME BEING.             %%%
%%%                                                                    %%%
%%%     -- Bob Yantosca (14 Aug 2014)                                  %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

REVISION HISTORY:

(40) Bug fix: Save levels 1:LD13 for ND13 diagnostic for diagnostic categories "SO2-AC-$" and "SO2-EV-$". Now reference F90 module "tracerid_mod.f". Now reference NUMDEP from "drydep_mod.f". Now save anthro, biofuel, biomass NH3 in ND13; also fixed ND13 tracer numbers. For ND13, change scale factor from SCALESRCE to 1. Now references "wetscav_mod.f". Now also save true tracer numbers for ND38 and ND39 diagnostic. Now also write out biomass SO2. Now convert ND01, ND02, ND44 diagnostics for Rn/Pb/Be from kg to kg/s here. (bmy, 1/24/03)

(41) Now save out natural NH3 in ND13 as "NH3-NATU" (rjp, bmy, 3/23/03)

(42) Now replace DXYP(JREF) by routine GET_AREA_M2, GET_XOFFSET, and GET_YOFFSET of "grid_mod.f". Now references "time_mod.f". DIAGb, DIAGe are now local variables. Now remove obsolete statements IF (LBPNCH > 0). Removed SCALE1, replaced with SCALEDYN. (bmy, 2/24/03)

(43) Added TSKIN, PARDF, PARDR, GWET to ND67 diagnostic. For GEOS-4/fvDAS, UWND, VWND, TMPU, SPHU are A-6 fields. Adjust the ND66 scale factors accordingly. Delete KZZ from ND66. Updated comments. (bmy, 6/23/03)

(44) Bug fix: use LD68 instead of ND68 in DO-loop to avoid out-of-bounds error. (bec, bmy, 7/15/03)

(45) Now print out NTRACE drydep fluxes for tagged Ox. Also tagged Ox now saves drydep in molec/cm2/s. Now print out Kr85 prod/loss in ND03. (bmy, 8/20/03)

(46) Now use actual tracer number for ND37 diagnostic. (bmy, 1/21/04)

(47) Now loop over the actual # of soluble tracers for ND17, ND18. (bmy, 3/19/04)

(48) Now use the actual tracer # for ND17 and ND18 diagnostics. Rearrange ND44 code for clarity. (bmy, 3/23/04)

(49) Added ND06 (dust aerosol) and ND07 (carbon aerosol) diagnostics. Now scale online dust optical depths by SCALECHEM in ND21 diagnostic. (rjp, tdf, bmy, 4/5/04)

(50) Added ND08 (seasalt aerosol) diagnostic (rjp, bec, bmy, 4/20/04)

(51) Now save out SO2 from ships (if LSHIPSO2=T) (bec, bmy, 5/20/04)

(52) Added NVOC source diagnostics for ND07 (rjp, bmy, 7/13/04)

(53) Now reference "logical_mod.f", "tracer_mod.f", and "diag_pl_mod.f". Bug fix in write to DMS_BIOG. (bmy, 7/20/04)

(54) Comment out ND27 for GEOS-4. It isn't working 100% right. If you examine the flux at 200 hPa, you get the same info. (bmy, 10/15/04)

(55) Added biofuel SO4 to the bpch file under ND13. Bug fix: replace ND68 with LD68 in call to BPCH2 (auvray, bmy, 11/17/04)

(56) Now save ND03 mercury diagnostic arrays to bpch file. Also updated ND44 for tagged Hg tracers (eck, bmy, 12/14/04)

(57) Now print out extra ND21 diagnostics for crystalline sulfur tracers.
Also now save total oceanic mass of Hg0 and Hg2. Now call
WRITE_DIAG03 from "diag03_mod.f" (bmy, 1/21/05)
(58) Now call WRITE_DIAG41 from "diag41_mod.f" (bmy, 2/17/05)
(59) Add P(SO4s) to row 8 of ND05 diagnostic. Also remove special tracer
numbers for the ND67 diagnostic. Now do not save CLDMAS for ND67
for GEOS-4, since GEOS-4 convection uses different met fields.
(bec, bmy, 5/3/05)
(60) Bug fix in ND68 diagnostic: use LD68 instead of ND68 in call to BPCH2.
Now modified for GEOS-5 and GCAP met fields. Remove references to
CO-OH param simulation. Also remove references to TRCOFFSET since
that is always zero now. Now call GET_HALFPOLAR from "bpch2_mod.f"
to get the HALFPOLAR value for GEOS or GCAP grids. (swu, bmy, 6/24/05)
(61) References ND04, WRITE_DIAG04 from "diag04_mod.f". Also now updated
ND30 diagnostic for land/water/ice flags. Also remove reference
to LWI array. (bmy, 8/18/05)
(62) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(63) Added MBO as tracer #5 in ND46 diagnostic (tmf, bmy, 10/20/05)
(64) Removed duplicate variable declarations. Now remove restriction on
printing out cloud mass flux in GEOS-4 for the ND66 diagnostic.
(bmy, 3/14/06)
(65) References ND56, WRITE_DIAG56 from "diag56_mod.f" (ltm, bmy, 5/5/06)
(66) Now remove TRCOFFSET; it's obsolete. References ND42, WRITE_DIAG42
from "diag42_mod.f" (dkh, bmy, 5/22/06)
(67) Updated ND36 diagnostic for CH3I (bmy, 7/25/06)
(68) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(69) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
(bmy, 9/5/06)
(70) Now write diag 54 (time in the troposphere) if asked for (phs, 9/22/06)
(71) Now use new time counters for ND43 & ND45, Also now average between
0 and 24 UT for ND47. Bug fix in ND36. (phs, bmy, 3/5/07)
(72) Bug fix in ND65: use 3-D counter array (phs, bmy, 3/6/07)
(73) Bug fix in ND07: now save out IDTSOA4 tracer. Modifications for H2/HD
diagnostics (ND10, ND27, ND44) (tmf, phs, bmy, 9/18/07)
(74) Now save out true pressure at 3-D level edges for ND31. Change ND31
diagnostic category name to "PEDGE-$". Bug fix in ND28 diagnostic to
allow you to print out individual biomass tracers w/o having to print
all of them. (bmy, dkh, 1/24/08)
(75) Bug fix: Now divide ALBEDO in ND67 by SCALE_I6 for GEOS-3 met, but
by SCALE_A3 for all other met types (phs, bmy, 10/7/08)
(76) Fix ND65, ND47, and ozone case in ND45. Now only ND45 depends
on LD45 (phs, 11/17/08)
(77) Bug fix: Select the right index of AD34 to write. Pick the right
tracer field from AD22 if only a subset of tracers are requested
to be printed out. (ccc, 12/15/08)
(78) Added ND52 for gamma(HO2) (jaegle, 02/26/09)
(79) Updated test on ship emissions flag for AD13 (phs, 3/3/09)
(80) Add AD07_SOAGM for dicarbonyl SOA formation (tmf, 3/6/09)

```
(81) Add output in AD22 for dicarbonyl photolysis J values (tmf, 3/6/09)
(82) Add output in AD46 for biogenic C2H4 emissions (tmf, 3/6/09)
(83) Modify ND17, ND18, ND37, ND38, ND44 to output the tracers selected
      by the user. (ccc, 5/29/09)
(84) Add EFLUX output information for ND67. (lin, ccc, 5/29/09)
(85) Add test on ICOADS (cklee, 06/30/09)
(86) Add SCALE_DIAG to scale diagnostics with the number of accumulation
      steps. (ccc, 7/20/09)
(87) Add diagnostics 19, 58 and 60 for methane. (kjw, 8/18/09)
(88) Account for 3D AD13_NH3_an now (phs, 10/22/09)
(89) Added TOMAS diagnostics (win, bmy, 1/25/10)
(90) NBIOMAX is now in CMN_SIZE (hotp 7/31/09)
(91) Add SOA5 to ND07_HC, add AD57 for potential temperature. (fp, 2/3/10)
(92) Modify ND44 for tracers with several deposition tracers. (ccc, 2/3/10)
(93) Add aromatics to ND43. (dkh, 06/21/07)
(94) Add ND57 for potential temperature. (fp, 2/3/10)
(95) Re-order levels in mass fluxes diagnostics before writing them to file.
     (ND24, 25, 26). (ccc, 3/8/10)
(96) Add call to update_dep for mercury simulation at the end.(ccc, 7/19/10)
20 Aug 2010 - R. Yantosca - Added ProTeX headers
20 Aug 2010 - R. Yantosca - Now pick proper scale for ND66 for MERRA
20 Aug 2010 - R. Yantosca - Now pick proper scale for ND67 for MERRA
20 Aug 2010 - R. Yantosca - Now added SCALE_A1 for hourly data
20 Aug 2010 - R. Yantosca - Now reference GET_A1_TIME from "time_mod.f"
26 May 2011 - R. Yantosca - For ND44, omit the special treatment of
                            isoprene tracers if we are not doing fullchem
27 May 2011 - R. Yantosca - Now use SCALEDIAG for ND54 (time-in-trop) diag
08 Feb 2012 - R. Yantosca - Add modifications for GEOS-5.7.x met
08 Feb 2012 - R. Yantosca - Restructure USE statements for clarity
08 Feb 2012 - R. Yantosca - Add counter for I3 (inst 3hr) met fields
28 Feb 2012 - R. Yantosca - Removed support for GEOS-3
01 Mar 2012 - R. Yantosca - Now use GET_AREA_M2(I,J,L) from grid_mod.F90
05 Apr 2012 - R. Yantosca - Bug fix: use hourly scale for SLP in the
                            ND67 diagnostic for GEOS-5.7.x met fields
14 Mar 2013 - M. Payer    - Replace NOx and Ox with NO, NO2, and O3 as part
                            of removal of NOx-Ox partitioning
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
04 Sep 2013 - R. Yantosca - Make ND44 output consistent w/ modifications in
                            GeosCore/gamap_mod.F.
26 Sep 2013 - R. Yantosca - Renamed GEOS_57 Cpp switch to GEOS_FP
03 Dec 2013 - R. Yantosca - Change unit of PBL height to meters, this used
                            to be hPa in GEOS-1, GEOS-STRAT, GEOS-3, which
                            are no longer supported.
28 Jan 2014 - R. Yantosca - Avoid array temporaries in ND60 TOMAS diagnostic
23 Jul 2014 - R. Yantosca - Remove reference to obsolete CMN_mod.F
23 Jul 2014 - R. Yantosca - Disable obsolete ND27 diagnostic
```

```
02 Aug 2014 - C. Keller   - Connect to HEMCO diagnostics
06 Aug 2014 - C. Keller   - Added wrapper subroutine for HEMCO diagnostics
14 Aug 2014 - R. Yantosca - Corrected units for several diagnostic outputs
26 Aug 2014 - M. Sulprizio- Now get ND53 POPs emissions from HEMCO
03 Sep 2014 - R. Yantosca - Units of AD01_Rn_SOURCE and AD01_Be7_SOURCE are
                            now defined as kg/s in hcoi_gc_diagn_mod.F90
15 Oct 2014 - C. Keller   - Updated ND37 diagnostics to write out all specs
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
24 Nov 2014 - R. Yantosca - Bug fix for ND28 BC/OC: Don't multiply by area
04 Dec 2014 - R. Yantosca - No longer crashes if BIOGENIC_OCPI=0 everywhere
12 Dec 2014 - M. Yannetti - Converted HEMCO Precision updates
15 Dec 2014 - M. Sulprizio- Moved radiation diagnostic from ND71 to ND72 to
                            avoid conflicts with hourly max ppbv diagnostic.
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
23 Feb 2015 - C. Keller   - Split volcano SO2 into eruptive & degassing
02 Apr 2015 - M. Sulprizio- Now write out LIGHTNING_CLOUD_TOP diagnostic from
                            HEMCO to the ctm.bpch file. Otherwise, if will
                            save out to the HEMCO restart file.
22 Apr 2015 - M. Sulprizio- Remove the use of TRACER_COEFF to convert
                            emissions of hydrocarbon species to atomsC/cm2/s.
                            HEMCO now carries emissions for these species
                            entirely in kgC/m2/s.
21 May 2015 - R. Yantosca - Bug fix: The bpch unit string for BIOMASS_NH3
                            should be molec/cm2/s instead of atoms C/cm2/2.
22 May 2015 - R. Yantosca - Remove variables made obsolete by HEMCO
22 May 2015 - R. Yantosca - Replace NOXEXTENT with 2 in TOMAS #if blocks
07 Jul 2015 - E. Lundgren - Add marine organic aerosols (B.Gantt, M.Johnson)
05 Jan 2016 - E. Lundgren - Use GC global param AVO instead of from HEMCO
21 Apr 2016 - R. Yantosca - Fixed typo that was preventing ND29 output
29 Apr 2016 - R. Yantosca - Don't initialize pointers in declaration stmts
02 May 2016 - R. Yantosca - Now declare POPs and Rn tracer flags locally
31 May 2016 - E. Lundgren - Use species database, not XNUMOL, for molec wts
02 Jun 2016 - R. Yantosca - Now pass State_Met as an argument so that
                            we can fix the units of ND62 INST-MAP
16 Jun 2016 - R. Silvern  - Now define species ID flags locally witn Ind_
17 Jun 2016 - R. Yantosca - Renamed IDT* variables to id_*
23 Jun 2016 - R. Yantosca - Bug fix: only print out CH4 diagnostics if
                            it is an advected species
30 Jun 2016 - R. Yantosca - Remove instances of STT.  Now get the advected
                            species ID from State_Chm%Map_Advect.
01 Jul 2016 - R. Yantosca - Now rename species DB object ThisSpc to SpcInfo
18 Jul 2016 - R. Yantosca - Bug fix: look up TOMAS species ID's
11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
20 Sep 2016 - R. Yantosca - Use .eqv. instead of .eq. to compare LOGICALs
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.4.1 diag2bpch

Wrapper routine to get diagnostics from HEMCO and write them to bpch. This will look up diagnostics 'dName' and write the corresponding diagnostics array to the bpch output file.

NOTE: This is a "bridge" routine intended to provide backwards compatibility with the existing GEOS-Chem diagnostics. Eventually we will write all GEOS-Chem diagnostics to netCDF format but we are not yet at that point.

INTERFACE:

```
 SUBROUTINE DIAG2BPCH( air,       HcoState, dname,
&                      bcat,      bUnit,    bN,
&                      dAF,       dZ,       dOPTIONAL,
&                      dFACTOR,   ERR,      AreaScal  )
```

USES:

```
USE HCO_STATE_MOD,  ONLY : HCO_State
```

INPUT PARAMETERS:

```
LOGICAL,          INTENT(IN)    :: air       ! Are we on the root CPU?
TYPE(HCO_State),  POINTER       :: HcoState  ! HEMCO State object
CHARACTER(LEN=*), INTENT(IN)    :: dname     ! Diagnostics name
CHARACTER(LEN=*), INTENT(IN)    :: bCat      ! BPCH category
CHARACTER(LEN=*), INTENT(IN)    :: bUnit     ! BPCH units
INTEGER,          INTENT(IN)    :: bN        ! BPCH ID
INTEGER,          INTENT(IN)    :: dAF       ! AutoFill of diagnostic
INTEGER,          INTENT(IN)    :: dZ        ! # of vertical levels
LOGICAL,          INTENT(IN)    :: dOPTIONAL ! Optional field?
REAL(fp),         INTENT(IN)    :: dFACTOR   ! Scale factor
INTEGER,          OPTIONAL      :: AreaScal  ! Area scaling
```

INPUT/OUTPUT PARAMETERS:

```
INTEGER,          INTENT(INOUT) :: ERR       ! Return code
```

REMARKS:

```
(1) Data is multiplied by factor dFACTOR before writing to disk.
(2) dAF determines the autofill flag used for the diagnostics lookup.
(3) dZ are the number of vertical levels. Set to -1 for 2D arrays,
     otherwise a 3D array with exactly that many levels is written.
(4) dOptional determines whether or not this is an optional diagnostics.
     For optional diagnostics, zeros are written out if no corresponding
     HEMCO diagnostics could be found (because it is undefined or because
     they have never been updated). For non-optional diagnostics, the
     routine stops with an error if no HEMCO diagnostics is found.
(5) AScal can be used to multiply (1) or divide (-1) the data by the grid
     area.
```

REVISION HISTORY:

```
06 Aug 2014 - C. Keller   - Initial version
13 Aug 2014 - R. Yantosca - Added ProTeX headers; cosmetic changes
13 Aug 2014 - R. Yantosca - Bug fix, # of vertical levels in call to BPCH2
                            was 1 but should have been LEVS.  Now fixed.
29 Apr 2016 - R. Yantosca - Don't initialize pointers in declaration stmts
```

1.5 Fortran: Module Interface diag_mod.F

Module DIAG_MOD contains declarations for allocatable arrays for use with GEOS-CHEM diagnostics.

INTERFACE:

```
      MODULE DIAG_MOD
```

USES:

```
      USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

      IMPLICIT NONE
      PUBLIC
```

PUBLIC MEMBER FUNCTIONS:

```
      PUBLIC :: CLEANUP_DIAG
```

PUBLIC DATA MEMBERS:

```
#if defined( BPCH_DIAG )
      ! For ND01 -- Pb emissions (Rn, Be now tracked thru HEMCO)
      REAL*4,  ALLOCATABLE :: AD01(:,:,:)

      ! For ND02 -- Rn, Pb, Be decay
      REAL*4,  ALLOCATABLE :: AD02(:,:,:,:)
#endif

      ! For ND05 -- Sulfate prod/loss diagnostics
      REAL*4,  ALLOCATABLE :: AD05(:,:,:,:)

      ! For ND07 -- Carbon aerosol emission
      REAL*4,  ALLOCATABLE :: AD07_BC(:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_OC(:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_HC(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD07_SOAGM(:,:,:,:)

      ! For ND09 -- HCN / CH3CN simulation
      REAL*4,  ALLOCATABLE :: AD09(:,:,:,:)
```

```
      REAL*4,  ALLOCATABLE :: AD09_em(:,:,:)

      ! For ND12 -- boundary layer multiplication factor
      REAL*4,  ALLOCATABLE :: AD12(:,:,:)

      ! For ND14 -- wet convection mass flux diagnostic
      REAL(fp),  ALLOCATABLE :: CONVFLUP(:,:,:,:)

      ! For ND15 -- BL mixing mass flux diagnostic
      REAL(fp),  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(fp),  ALLOCATABLE :: DIAGCHLORO(:,:,:,:)

#if defined( BPCH_DIAG )
      ! For ND24 -- E/W transport mass flux diagnostic
      REAL(fp),  ALLOCATABLE, TARGET :: MASSFLEW(:,:,:,:)

      ! For ND25 -- N/S transport mass flux diagnostic
      REAL(fp),  ALLOCATABLE, TARGET :: MASSFLNS(:,:,:,:)

      ! For ND26 -- UP/DOWN transport mass flux diagnostic
      REAL(fp),  ALLOCATABLE, TARGET :: MASSFLUP(:,:,:,:)

      ! For ND30 -- land / water / ice flags
      REAL*4,  ALLOCATABLE :: AD30(:,:)
```

```
      ! For ND31 -- surface pressures
      REAL*4,  ALLOCATABLE :: AD31(:,:,:)
#endif

      ! For ND33 -- tropopsheric sum of tracer
      REAL*4,  ALLOCATABLE :: AD33(:,:,:)

      ! For ND35 -- 500 mb tracer
      REAL*4,  ALLOCATABLE :: AD35(:,:,:)

      ! For ND37 -- Fraction of tracer scavenged in cloud updrafts
      REAL*4,  ALLOCATABLE :: AD37(:,:,:,:)

#if defined( BPCH_DIAG )
      ! For ND38 -- Rainout in moist convection diagnostic
      REAL*4,  ALLOCATABLE :: AD38(:,:,:,:)

      ! For ND39 -- Washout in aerosol wet deposition diagnostic
      REAL*4,  ALLOCATABLE :: AD39(:,:,:,:)
#endif

      ! For ND43 -- OH and HO2 chemical diagnostics
      REAL*4,  ALLOCATABLE :: AD43(:,:,:,:)
      INTEGER, ALLOCATABLE :: LTOH(:,:)
      INTEGER, ALLOCATABLE :: CTOH(:,:,:)
      INTEGER, ALLOCATABLE :: LTHO2(:,:)
      INTEGER, ALLOCATABLE :: CTHO2(:,:,:)
      ! Added for stratospheric chem. (SDE 2013-07-15)
      INTEGER, ALLOCATABLE :: LTO1D(:,:)
      INTEGER, ALLOCATABLE :: CTO1D(:,:,:)
      INTEGER, ALLOCATABLE :: LTO3P(:,:)
      INTEGER, ALLOCATABLE :: CTO3P(:,:,:)
      ! update for arom (dkh, 06/21/07)
      INTEGER, ALLOCATABLE :: CTLBRO2H(:,:,:)
      INTEGER, ALLOCATABLE :: CTLBRO2N(:,:,:)
      INTEGER, ALLOCATABLE :: CTLTRO2H(:,:,:)
      INTEGER, ALLOCATABLE :: CTLTRO2N(:,:,:)
      INTEGER, ALLOCATABLE :: CTLXRO2H(:,:,:)
      INTEGER, ALLOCATABLE :: CTLXRO2N(:,:,:)
      INTEGER, ALLOCATABLE :: LTLBRO2H(:,:)
      INTEGER, ALLOCATABLE :: LTLBRO2N(:,:)
      INTEGER, ALLOCATABLE :: LTLTRO2H(:,:)
      INTEGER, ALLOCATABLE :: LTLTRO2N(:,:)
      INTEGER, ALLOCATABLE :: LTLXRO2H(:,:)
      INTEGER, ALLOCATABLE :: LTLXRO2N(:,:)

#if defined( BPCH_DIAG )
      ! 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(:,:)
#endif

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

      ! For ND47(O3) / ND65 -- 24-h tracer diagnostic
      INTEGER, ALLOCATABLE :: CTO3_24h(:,:,:)

      ! Dynamically allocatable array -- local only to DIAG50.F
      REAL(fp),  ALLOCATABLE :: STT_TEMPO2(:,:,:,:)

      ! For ND52 -- gamma HO2 diagnostic
      REAL*4,  ALLOCATABLE :: AD52(:,:,:)

      ! For ND54 -- tropopause diagnostics
      REAL*4,  ALLOCATABLE :: AD54(:,:,:)

#if defined( BPCH_DIAG )
      ! For ND55 -- tropopause diagnostics
      REAL*4,  ALLOCATABLE :: AD55(:,:,:)

      ! For ND57 -- theta, potential temp (FP 6/2009)
      REAL*4,  ALLOCATABLE :: AD57(:,:,:)
#endif

      ! -- for methane simulation diagnostics
      REAL*4,  ALLOCATABLE :: AD19(:,:,:)
      REAL*4,  ALLOCATABLE :: AD58(:,:,:)
      REAL*4,  ALLOCATABLE :: AD60(:,:)

#if   defined( TOMAS )
      ! For ND59 -- Size-resolved primary aerosol emissions
      REAL*4,  ALLOCATABLE :: AD59_NUMB(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_SULF(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_SALT(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_ECIL(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_ECOB(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_OCIL(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_OCOB(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD59_DUST(:,:,:,:)

      ! For ND60 -- TOMAS condensation rate diagnostic
```

```
      REAL*4,  ALLOCATABLE :: AD60_COND(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD60_COAG(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD60_NUCL(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD60_AQOX(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD60_ERROR(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD60_SOA(:,:,:,:)

      ! For ND61 -- 3D TOMAS rate diagnostic
      REAL*4,  ALLOCATABLE :: AD61(:,:,:,:)
      REAL*4,  ALLOCATABLE :: AD61_inst(:,:,:,:)
#endif

      ! For ND64 -- radiative flux from FAST-JX
      REAL*4,  ALLOCATABLE :: AD64(:,:,:,:,:)

      ! For ND65 -- production/loss rates
      REAL*4,  ALLOCATABLE :: AD65(:,:,:,:)

#if defined( BPCH_DIAG )
      ! 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(:,:,:)
#endif

      ! For ND71 -- Surface peak tracer conc. diagnostic
      REAL*4,  ALLOCATABLE :: AD71(:,:,:)
      REAL*4,  ALLOCATABLE :: AD71_HR(:,:,:)
      REAL*4,  ALLOCATABLE :: AD71_DAY(:,:,:)
      INTEGER              :: AD71_COUNT
      INTEGER              :: AD71_HRCT
      INTEGER              :: AD71_LHR
      INTEGER              :: AD71_LDAY

      ! For ND72 -- Radiation output diagnostic
      REAL*4,  ALLOCATABLE :: AD72(:,:,:)
```

REVISION HISTORY:

```
   30 Nov 1999 - A. Fiore - Initial version
   (1 ) DIAG_MOD is written in Fixed-Format F90.
   (2 ) Call subroutine CLEANUP at the end of the MAIN program to deallocate
```

```
      the memory before the run stops.  It is always good style to free
      any memory we have dynamically allocated when we don't need it
      anymoren
(3 ) Added ND13 arrays for sulfur emissions (bmy, 6/6/00)
(4 ) Moved ND51 arrays to "diag51_mod.f" (bmy, 11/29/00)
(5 ) Added AD34 array for biofuel burning emissions (bmy, 3/15/01)
(6 ) Eliminated old commented-out code (bmy, 4/20/01)
(7 ) Added AD12 array for boundary layer emissions in routine "setemis.f".
      (bdf, bmy, 6/15/01)
(8 ) Added CHEML24, DRYDL24, CTCHDD for archiving daily mean chemical
      and drydep loss in chemo3 and chemo3.f (amf, bmy, 7/2/01)
(9 ) Add ND43 arrays LTNO2, CTNO2, LTHO2, CTHO2 (rvm, bmy, 2/27/02)
(10) Add AD01, AD02 arrays for Rn-Pb-Be simulation (hyl, bmy, 8/7/02)
(11) Add AD05 array for sulfate P-L diagnostic (rjp, bdf, bmy, 9/20/02)
(12) Added subroutine CLEANUP_DIAG...moved code here from "cleanup.f",
      so that it is internal to "diag_mod.f".  Added arrays AD13_NH3_bb,
      AD13_NH3_bf, AD13_NH3_an for NH3 emissons in ND13.  Deleted obsolete
      allocatable arrays CHEML24, DRYDL24, CTCHDD.  Now also added LTNO3
      and CTNO3 arrays for ND43 diagnostic.  Added AD13_SO2_bf array for
      SO2 biofuel. (bmy, 1/16/03)
(13) Added array AD13_NH3_na for ND13 diagnostic (rjp, bmy, 3/23/03)
(14) Removed P24H and L24H -- these are now defined w/in "tagged_ox_mod.f"
      Also added AD03 array for Kr85 prod/loss diag. (jsw, bmy, 8/20/03)
(15) Added ND06 (dust emission) and ND07 (carbon aerosol emission)
      diagnostic arrays (rjp, tdf, bmy, 4/5/04)
(16) Added AD13_SO2_sh diagnostic array for ND13 (bec, bmy, 5/20/04)
(17) Added AD07_HC diagnostic array for ND07 (rjp, bmy, 7/13/04)
(18) Moved AD65 & FAMPL to "diag65_mod.f" (bmy, 7/20/04)
(19) Added array AD13_SO4_bf (bmy, 11/17/04)!
(20) Added extra arrays for ND03 mercury diagnostics (eck, bmy, 12/7/04)
(21) Added extra ND21 array for crystalline sulfur tracers.  Also remove
      ND03 and ND48 arrays; they are obsolete (bmy, 1/21/05)
(22) Removed AD41 and AFTTOT arrays; they're obsolete (bmy, 2/17/05)
(23) Added AD09, AD09_em arrays for HCN/CH3CN simulation (xyp, bmy, 6/27/05)
(24) Added AD30 array for land/water/ice output (bmy, 8/18/05)
(25) Added AD54 array for time spend in the troposphere (phs, 9/22/06)
(26) Added CTO3 counter. Convert ND43 counter arrays from 2D to 3D, for
      the variable tropopause. (phs, 1/19/07)
(27) Added AD10 and AD10em arrays for ND10 H2-HD-sim diag (phs, 9/18/07)
(28) Added CTO3_24h to account for time in the troposphere for O3 in
      ND47 (phs, 11/17/08)
(29) Added AD52 for Gamma HO2 diagnostic. (jaegle, ccc, 2/26/09)
(30) Updated to save out GLYX production of SOAG in ND07.
     (tmf, 3/6/09)
(31) Add LTO3 for ND45 diag. (ccc, 7/20/09)
(32) Add AD19, AD58, AD60 for CH4 (kjw, 8/18/09)
(33) AD13_NH3_an is 3D now (phs, 10/22/09)
(34) Add AD59_NUMB, AD59_SULF, AD59_SALT, AD59_ECOB, AD59_ECIL, AD59_OCOB,
```

```
      AD59_OCIL, and AD59_DUST for size-resolved emission  (win, 1/25/10)
(35) Add AD60_COND, AD60_COAG, AD60_NUCL, AD60_AQOX, AD60_SOA, and
      AD60_ERROR for TOMAS process rate diagnostics (win, 1/25/10)
(36) Add AD61 and AD61_INST for saving 3-D TOMAS rate (win, 1/25/10)
(37) Add counter for aromatics SOA and add AD57 diagnostic for potential
     temperature. (fp, 2/3/10)
26 Aug 2010 - R. Yantosca - Added ProTeX headers
02 Apr 2013 - M. Payer    - Removed *NO, *NO2, and *NO3 arrays for ND43
                            diagnostic. These are no longer needed because
                            NO, NO2, and NO3 are now tracers.
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
08 Nov 2013 - M. Sulprizio- Removed CTO3 and LTO3. They are no longer used
                            because O3 is now a tracer.
15 Aug 2014 - R. Yantosca - Remove diagnostics now tracked by HEMCO
21 Aug 2014 - R. Yantosca - AD01 is now only a 3-D array (for Pb emissions)
12 Nov 2014 - M. Yannetti - Added PRECISION_MOD
20 Jan 2015 - R. Yantosca - Added DIAGINIT_TRACER_CONC routine
15 Apr 2015 - R. Yantosca - Add TARGET spec to MASSFLEW, MASSFLNS, MASSFLUP
20 Jan 2016 - M. Sulprizio- Remove AD06, AD07, and AD08 arrays since these
                            diagnostics are tracked by HEMCO
23 Jun 2016 - R. Yantosca - Remove references to APM code; it is no longer
                            compatible with the FlexChem implementation
02 Aug 2016 - M. Sulprizio- Move AD65 array here from diag_pl_mod.F
03 Oct 2016 - R. Yantosca - Bug fix: scalars cannot be ALLOCATABLE
```

1.5.1 cleanup_diag

Subroutine CLEANUP_DIAG deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG
```

REVISION HISTORY:

```
13 Dec 2002 - R. Yantosca - Initial version
(1 ) Now also deallocate AD13_NH3_an, AD13_NH3_bb, AD13_NH3_bf arrays
      for the ND13 diagnostic.  (bmy, 12/13/02)
(2 ) Now also deallocate AD13_NH3_na array for ND13 (rjp, bmy, 3/23/03)
(3 ) Removed P24H and L24H, these are now defined within "tagged_ox_mod.f".
     Now also deallocate AD03 array for Kr85 prod/loss (jsw, bmy, 8/20/03)
(4 ) Now also deallocate AD06 and AD07* arrays (rjp, bdf, bmy, 4/5/04)
(5 ) Now also deallocate AD08 array (rjp, bec, bmy, 4/20/04)
(6 ) Now also deallocaes AD13_SO2_sh array (bec, bmy, 5/20/04)
(7 ) Now also deallocates AD07_HC array (rjp, bmy, 7/13/04)
(8 ) Now also deallocate AD13_SO4_bf array (bmy, 11/17/04)
(9 ) Now deallocate extra arrays for ND03 diagnostics (eck, bmy, 12/7/04)
(10) Now deallocates AD21_cr array.  Remove reference to arrays for ND03
```

```
      and ND48 diagnostics, they're obsolete. (cas, sas, bmy, 1/21/05)
(11) Removed AD41 and AFTTOT arrays; they're obsolete (bmy, 2/17/05)
(12) Now also deallocate AD09 and AD09_em (bmy, 6/27/05)
(13) Now deallocate AD30 (bmy, 8/18/05)
(14) Now deallocate CTO3, AD10, AD10em arrays (phs, 9/18/07)
(15) Now deallocate TOMAS related arrays (win, bmy, 1/25/10)
15 Feb 2011 - R. Yantosca - Add modifications for APM microphysics
15 Aug 2014 - R. Yantosca - Remove diagnostics now tracked by HEMCO
 3 Oct 2016 - R. Yantosca - Bug fix: Don't deallocate ND71 scalar variables
```

1.6 Fortran: Module Interface diag03_mod.F

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

INTERFACE:

```
MODULE DIAG03_MOD
```

USES:

```
USE PRECISION_MOD   ! For GEOS-Precision (fp)

IMPLICIT NONE
PRIVATE
```

DEFINED PARAMETERS:

```
INTEGER, PUBLIC, PARAMETER   :: PD03    = 22         ! Dim of AD03 array
INTEGER, PUBLIC, PARAMETER   :: PD03_PL = 13         ! # of PL-HG2 diags
```

PUBLIC DATA MEMBERS:

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

! Arrays
REAL*4,  PUBLIC, ALLOCATABLE :: AD03(:,:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_Hg0(:,:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_Br(:,:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_OH(:,:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_Hg2_O3(:,:,:,:)
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(:,:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_RGM(:,:,:)
```

```
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_PBM(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD03_RIV(:,:)
```

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 ) RGM a.k.a. Hg(II)gas  : Reactive (oxidized) gaseous mercury
(4 ) PBM a.k.a. Hg(II)P    : Reactive (oxidized) 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(1e+0_fp) w/ 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(6 ) Updates to mercury simulation (ccc, 5/17/10)
(7 ) Added mercury tagged tracers (eds 9/2/10)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
07 Feb 2012 - E. Corbitt  - Added new diagnostics for tagged simulation.
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
07 Nov 2014 - M. Yannetti - Added PRECISION_MOD
10 Aug 2015 - J. Fisher   - Add polar Br/BrO/O3 diagnostics
11 Aug 2015 - J. Fisher   - Add snow, deposition diagnostics
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.6.1 zero_diag03

Subroutine ZERO_DIAG03 zeroes all module arrays.

INTERFACE:

```
SUBROUTINE ZERO_DIAG03
```

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)
(3 ) Now zeros RGM and PBM diagnostics. (hma 20100219)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
12 Aug 2015 - Add Arctic river Hg diagnostic
```

1.6.2 write_diag03

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

INTERFACE:

```
SUBROUTINE WRITE_DIAG03( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE BPCH2_MOD,          ONLY : BPCH2
USE BPCH2_MOD,          ONLY : GET_MODELNAME
USE BPCH2_MOD,          ONLY : GET_HALFPOLAR
USE CMN_SIZE_MOD
USE CMN_DIAG_MOD
USE ErrCode_Mod
USE FILE_MOD,           ONLY : IU_BPCH
USE GC_GRID_MOD,        ONLY : GET_XOFFSET
USE GC_GRID_MOD,        ONLY : GET_YOFFSET
USE Input_Opt_Mod,      ONLY : OptInput
USE State_Chm_Mod,      ONLY : ChmState
USE TIME_MOD,           ONLY : GET_CT_EMIS
USE TIME_MOD,           ONLY : GET_DIAGb
USE TIME_MOD,           ONLY : GET_DIAGe
USE TIME_MOD,           ONLY : GET_CT_CHEM
USE TIME_MOD,           ONLY : GET_CT_DIAG, GET_Hg2_DIAG !H Amos, 20100218
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
```

INPUT/OUTPUT PARAMETERS:

```
TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

REMARKS:

```
 # : Field    : Description                    : Units    : Scale factor
-----------------------------------------------------------------------
The following list is outdated and not reliable (cdh, 7/5/11)
(1 ) HG-SRCE  : Anthropogenic HG0 emission     : kg       : 1
(2 ) HG-SRCE  : Total mass of oceanic Hg0      : kg       : 1
(3 ) HG-SRCE  : Oceanic Hg0 emission           : kg       : 1
(4 ) HG-SRCE  : Land reemission                : kg       : 1
(5 ) HG-SRCE  : Land natural emission          : kg       : 1
(6 ) HG-SRCE  : Anthropogenic Hg2 emission     : kg       : 1
(7 ) HG-SRCE  : Total mass of oceanic Hg2      : kg       : 1
(8 ) HG-SRCE  : Mass of Hg2 sunk in the ocean  : kg       : 1
(9 ) HG-SRCE  : Anthropogenic HgP emission     : kg       : 1
(10) HG-SRCE  : Henry's law piston velocity Kw : cm/h     : em timesteps  (anls, redo)
(11) HG-SRCE  : Mass of Hg(P)                  : kg       : 1
(12) HG-SRCE  : Converted to Particulate       : 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) HG-SRCE  : Snow emission of Hg0           : kg       : 1
(19) HG-SRCE  : Delivery of snow Hg2 to ocean  : kg       : 1
(20) HG-SRCE  : Hg2/HgP deposition to ocean    : kg       : 1
(21) HG-SRCE  : Hg2/HgP deposition to snow/ice : kg       : 1
( 1) PL-HG2-$ : Production of Hg2 from Hg0     : kg       : 1
( 2) PL-HG2-$ : Production of Hg2 from rxn w/OH : kg      : 1
( 3) PL-HG2-$ : Production of Hg2 from rxn w/O3 : kg      : 1
( 4) PL-HG2-$ : Loss of Hg2 from rxn w/ seasalt : kg      : 1
( 5) PL-HG2-$ : Loss of Hg2 from rxn w/ seasalt : 1/s     : 1
( 6) PL-HG2-$ : Prod of Hg2 form rxn w/ Br     : kg       : 1
( 7) PL-HG2-$ : Br concentration               : molec/cm3: 1
( 8) PL-HG2-$ : BrO concentration              : molec/cm3: 1
( 9) PL-HG2-$ : Reactive gaseous mercury       : pptv     : 1
(10) PL-HG2-$ : Reactive particule mercury     : pptv     : 1
(11) PL-HG2-$ : Polar Br concentration         : pptv     : 1
(12) PL-HG2-$ : Polar BrO concentration        : pptv     : 1
(13) PL-HG2-$ : Polar O3 concentration         : ppbv     : 1
NOTES:
```

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(1e+0_fp) 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
23 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
25 Apr 2016 - R. Yantosca - Now pass State_Chm via the arg list
```

1.6.3 init_diag03

Subroutine INIT_DIAG03 allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG03( State_Chm )
```

USES:

```
USE CMN_SIZE_MOD
USE ERROR_MOD,          ONLY : ALLOC_ERR
USE State_Chm_Mod,      ONLY : ChmState
```

INPUT/OUTPUT PARAMETERS:

```
TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

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
(3 ) Adapted for tagged tracers (eds 2/7/12)
```

1.6.4 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)
(2 ) Now deallocates AD03_PBM, AD03_RGM (hma 20100216)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.7 Fortran: Module Interface diag04_mod.F

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

INTERFACE:

```
MODULE DIAG04_MOD
```

USES:

```
USE PRECISION_MOD     ! For GEOS-Chem Precision (fp)

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
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
07 Nov 2014 - M. Yannetti - Added PRECISION_MOD
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.7.1 zero_diag04

Subroutine ZERO_DIAG04 zeroes the ND04 diagnostic array.

INTERFACE:

```
SUBROUTINE ZERO_DIAG04
```

USES:

```
USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

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

1.7.2 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 GC_GRID_MOD, ONLY : GET_XOFFSET, GET_YOFFSET
USE TIME_MOD,    ONLY : GET_CT_EMIS, GET_DIAGb,  GET_DIAGe

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

REMARKS:

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

REVISION HISTORY:

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

1.7.3 init_diag04

Subroutine INIT_DIAG04 allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG04
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

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

1.7.4 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
```

1.8 Fortran: Module Interface diag20_mod.F

Module DIAG20_MOD contains variables and routines which are used to compute the production and loss of O3 for use in the tagged O3 simulation

INTERFACE:

```
MODULE DIAG20_MOD
```

USES:

```
USE PRECISION_MOD

IMPLICIT NONE
PRIVATE
```

PUBLIC DATA MEMBERS:

```
REAL(fp), ALLOCATABLE, PUBLIC :: POx(:,:,:) ! Ox prod [molec/cm3/s]
REAL(fp), ALLOCATABLE, PUBLIC :: LOx(:,:,:) ! Ox loss [molec/cm3/s]
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: DIAG20
PUBLIC  :: CLEANUP_DIAG20
PUBLIC  :: INIT_DIAG20
```

PRIVATE MEMBER FUNCTIONS:

```
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)
(10) Make public FAM_NAME and H2SO4RATE (win, 1/25/10)
16 Sep 2010 - R. Yantosca - Added ProTeX headers
06 Aug 2012 - R. Yantosca - Make IU_ND20 a local module variable
12 Nov 2014 - M. Yannetti - Added PRECISION_MOD
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
07 Jul 2015 - R. Yantosca - Added fixes for several minor issues
09 Aug 2016 - M. Sulprizio- Moved code specific to ND20 from obsolete
                            diag_pl_mod.F to new module diag20_mod.F
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.8.1 diag20

Subroutine DIAG20 computes production and loss rates of O3, and then calls subroutine WRITE20 to save the these rates to disk. By saving the production and loss rates from a full-chemistry run, a user can use these archived rates to perform a quick O3 chemistry run at a later time.

INTERFACE:

```
SUBROUTINE DIAG20( am_I_Root, Input_Opt, State_Chm, State_Met,
&                  RC )
```

USES:

```
USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_CHEMGRID
USE CMN_DIAG_MOD
USE CMN_SIZE_MOD
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : ERROR_STOP
USE Input_Opt_Mod,      ONLY : OptInput
USE PhysConstants,      ONLY : AVO
USE State_Chm_Mod,      ONLY : ChmState
USE State_Chm_Mod,      ONLY : Ind_
USE State_Met_Mod,      ONLY : MetState
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 TIME_MOD,           ONLY : GET_LOCALTIME
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)    :: am_I_Root   ! Is this the root CPU?
TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

REMARKS:

```
If you want to archive the prod and loss of ozone from one of the full-
chemistry simulations (e.g. tropchem, UCX, SOA), then the PROD & LOSS MENU
in your input.geos file should look similar to this:

    %%% PROD & LOSS MENU %%%:
    Turn on P/L (ND65) diag?: T
    # of levels for ND65    : 47
    Save O3 P/L (ND20)?     : T

POx and LOx values for ND20 are obtained from KPP in flexchem_mod.F.
#############################################################################
#####    NOTE: BINARY PUNCH INPUT IS BEING PHASED OUT.  THIS DATA    #####
#####    WILL EVENTUALLY BE WRITTEN TO netCDF FILES FOR HEMCO!       #####
#####       -- Bob Yantosca (05 Mar 2015)                            #####
#############################################################################
```

REVISION HISTORY:

```
09 Jun 1999 - I. Bey      - Initial version
(1 ) Now bundled into "diag20_mod.f" (bmy, 7/20/04)
(2 ) Now also write to disk when it is the last timestep before the end of
     the run.  Now references GET_TAUE from "time_mod.f". (bmy, 11/15/04)
(3 ) Now call function ITS_TIME_FOR_WRITE20 to determine if the next
     chemistry timestep is the start of a new day.  Remove reference
     to GET_TAUe and GET_TS_CHEM.  Now archive P(Ox) and L(Ox) first
     and then test if we have to save the file to disk. (bmy, 3/3/05)
(4 ) Now references XNUMOL from "tracer_mod.f" (bmy, 10/25/05)
(5 ) Now use LLTROP_FIX instead of LLTROP (phs, 1/22/07)
(6 ) Now use LD65 instead of LLTROP_FIX (phs, bmy, 12/4/07)
(7 ) Now take care of boxes that switch b/w stratospheric and tropospheric
     regimes (phs, 11/17/08)
(8 ) Bug fix: Now just zero arrays w/o loop indices (dbj, bmy, 10/26/09)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
30 Jul 2012 - R. Yantosca - Now accept am_I_Root as an argument when
                            running with the traditional driver main.F
14 Mar 2013 - M. Payer    - Replace Ox with O3 as part of removal of
                            NOx-Ox partitioning
25 Mar 2013 - M. Payer    - Now pass State_Chm object + RC via the arg list
04 Apr 2013 - R. Yantosca - Now pass the Input_Opt object
06 Jul 2015 - R. Yantosca - Zero P_Ox and L_Ox variables at start of loop
06 Jul 2015 - R. Yantosca - Now skip computations if we are not in the
                            chemgrid (where JLOOP == 0)
08 Jul 2015 - R. Yantosca - Now save POx as kg/m3/s and LOx as 1/m3/s,
```

```
                            for compatibility with HEMCO
31 May 2016 - E. Lundgren - Use molec wt from species database rather than
                            Input_Opt%XNUMOL
09 Aug 2016 - M. Sulprizio- Move routine from diag_pl_mod.F to diag20_mod.F;
                            Obtain prod/loss rates from KPP via the POx and
                            LOx arrays set in flex_chemdr.F
10 Aug 2016 - M. Sulprizio- Remove State_Chm%Tracers from LOx calculation and
                            replace with State_chm%Species. Convert from
                            molec/cm3 to molec using BOXVL.
```

1.8.2 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 CMN_SIZE_MOD      ! Size parameters
USE CMN_DIAG_MOD      ! LD65
USE GC_GRID_MOD, ONLY : GET_XOFFSET,   GET_YOFFSET
USE inquireMod,  ONLY : findFreeLUN
```

REMARKS:

```
WRITE20 assumes that ND65 (P-L diagnostics) have been turned on.
#############################################################################
#####    NOTE: BINARY PUNCH INPUT IS BEING PHASED OUT.  THIS DATA    #####
#####    WILL EVENTUALLY BE WRITTEN TO netCDF FILES FOR HEMCO!       #####
#####       -- Bob Yantosca (05 Mar 2015)                            #####
#############################################################################
```

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
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
06 Jul 2015 - R. Yantosca - Now do not use parallel loops for casting
```

```
06 Jul 2015 - R. Yantosca - Bug fix: restore missing JFIRST assignment
08 Jul 2015 - R. Yantosca - Now save out as per m3 instead of per cm3
09 Aug 2016 - M. Sulprizio- Move routine from diag_pl_mod.F to diag20_mod.F
```

1.8.3 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(f8), 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
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
06 Jul 2015 - R. Yantosca - Now use TAU+CHEM >= TAUe to test for end of run
09 Aug 2016 - M. Sulprizio- Move routine from diag_pl_mod.F to diag20_mod.F
```

1.8.4 init_diag20

Subroutine INIT_DIAG20 takes values read from the GEOS-Chem input file and saves to module variables w/in "diag20_mod.f"

INTERFACE:

```
SUBROUTINE INIT_DIAG20( am_I_Root, Input_Opt, RC )
```

USES:

```
USE CMN_SIZE_MOD
USE CMN_DIAG_MOD
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : ALLOC_ERR
USE Input_Opt_Mod,      ONLY : OptInput
```

INPUT PARAMETERS:

```
LOGICAL,           INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput),    INTENT(IN)  :: Input_Opt   ! Input Options object
```

OUTPUT PARAMETERS:

```
INTEGER,           INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
09 Aug 2016 - M. Sulprizio- Initial version
```

1.8.5 cleanup_diag20

Subroutine CLEANUP_DIAG20 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG20
```

REVISION HISTORY:

```
09 Aug 2016 - M. Sulprizio- Initial version
```

1.9 Fortran: Module Interface diag41_mod.F

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

INTERFACE:

```
MODULE DIAG41_MOD
```

USES:

```
USE PRECISION_MOD           ! For GEOS-Chem Precision (fp)

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
01 Mar 2012 - R. Yantosca - Use updated GET_LOCALTIME from time_mod.F
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.9.1 zero_diag41

Subroutine ZERO_DIAG41 zeroes the ND41 diagnostic arrays.

INTERFACE:

```
      SUBROUTINE ZERO_DIAG41
```

USES:

```
      USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

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

1.9.2 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 GC_GRID_MOD, ONLY : GET_XOFFSET
      USE GC_GRID_MOD, ONLY : GET_YOFFSET
      USE TIME_MOD,    ONLY : GET_CT_EMIS
      USE TIME_MOD,    ONLY : GET_DIAGb
      USE TIME_MOD,    ONLY : GET_DIAGe

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

REMARKS:

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

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

REVISION HISTORY:

```
17 Feb 2005 - R. Yantosca - Initial version
(1 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
     value for GEOS or GCAP grids. (bmy, 6/28/05)
(2 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(3 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
```

1.9.3 diag41

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

INTERFACE:

```
      SUBROUTINE DIAG41
```

USES:

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

      USE CMN_SIZE_MOD    ! Size parameters
```

REVISION HISTORY:

```
18 Nov 1999 - A. Fiore, S. Wu - Initial version
(1 ) DIAG41 is written in Fixed-Format F90.
(2 ) XTRA2 must be computed by turning TURBDAY on first.  Also,
      XTRA2 is a global-size array, so use window offsets IREF, JREF
      to index it correctly. (bmy, 11/18/99)
(3 ) Do a little rewriting so that the DO-loops get executed
      in the correct order (J first, then I). (bmy, 11/18/99)
(4 ) AD41 is now declared allocatable in "diag_mod.f". (bmy, 12/6/99)
(5 ) AFTTOT is now declared allocatable in "diag_mod.f". (bmy, 3/17/00)
(6 ) Remove NYMD from the argument list -- it wasn't used (bmy, 6/22/00)
(7 ) XTRA2(IREF,JREF,5) is now XTRA2(I,J).  Also updated comments.
      (bmy, 9/25/01)
(8 ) Removed obsolete code from 9/01 (bmy, 10/23/01)
(9 ) Now reference BXHEIGHT from "dao_mod.f".  Also removed obsolete
      code. (bmy, 9/18/02)
(10) Now use function GET_LOCALTIME from "dao_mod.f" (bmy, 2/11/03)
(11) Bug fix in DO-loop for calculating local time (bmy, 7/9/03)
(12) For GEOS-4, PBL depth is already in meters, so we only have to
      multiply that by the GOOD array.  Also now references PBL array
      from "dao_mod.f".  Bug fix: now use barometric law to compute PBL
      height in meters for GEOS-1, GEOS-STRAT, GEOS-3.  This eliminates an
      overprediction of the PBL height. (swu, bmy, 11/6/03)
02 Dec 2010 - R. Yantosca - Added ProTeX headers
01 Mar 2012 - R. Yantosca - Now use GET_LOCALTIME(I,J,L) from time_mod.F90
```

1.9.4 init_diag41

Subroutine CLEANUP_DIAG41 allocates and zeroes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG41
```

USES:

```
USE ERROR_MOD, ONLY : ALLOC_ERR

USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

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

1.9.5 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
```

1.10 Fortran: Module Interface diag42_mod.F

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

INTERFACE:

```
MODULE DIAG42_MOD
```

USES:

```
USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

IMPLICIT NONE
PRIVATE
```

DEFINED PARAMETERS:

```
! Maximum number of output:
INTEGER, PUBLIC, PARAMETER   :: PD42 = 20
```

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
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.10.1 diag42

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

INTERFACE:

```
SUBROUTINE DIAG42( Input_Opt, State_Met, State_Chm )
```

USES:

```
USE AEROSOL_MOD,        ONLY : BCPI, BCPO, OCPI, OCPO, OCPISOA
USE AEROSOL_MOD,        ONLY : SALA, SALC, SOILDUST
USE AEROSOL_MOD,        ONLY : SO4,  NH4,  NIT
USE AEROSOL_MOD,        ONLY : TSOA, ISOA, ASOA, OPOA
USE AEROSOL_MOD,        ONLY : PM25, SOAG, SOAM
USE AEROSOL_MOD,        ONLY : OCFPOA, OCFOPOA
USE CARBON_MOD,         ONLY : BETANOSAVE
USE CMN_SIZE_MOD             ! Size parameters
USE CMN_DIAG_MOD             ! NDxx flags
USE Input_Opt_Mod,      ONLY : OptInput
USE PhysConstants,      ONLY : ATM
USE State_Chm_Mod,      ONLY : ChmState
USE State_Chm_Mod,      ONLY : Ind_
USE State_Met_Mod,      ONLY : MetState
```

INPUT PARAMETERS:

```
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(MetState), INTENT(IN)  :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

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
09 Nov 2012 - M. Payer    - Replaced all met field arrays with State_Met
                            derived type object
25 Mar 2013 - M. Payer    - Now pass State_Chm object via the arg list
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
26 Feb 2015 - E. Lundgren - Remove dependency on pressure_mod (not used)
25 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg
06 Jan 2016 - E. Lundgren - Use global physical parameter ATM
16 Jun 2016 - K. Yu       - Now define species ID's with the Ind_ function
17 Jun 2016 - R. Yantosca - Now only define species ID's on the first call
30 Jun 2016 - R. Yantosca - Remove instances of STT.  Now get the advected
                            species ID from State_Chm%Map_Advect.
11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
01 Sep 2016 - M. Sulprizio- Add PM2.5 concentrations to index 18
18 Nov 2016 - M. Sulprizio- Move code for calculating concentrations to
                            AEROSOL_CONC (in aerosol_mod.F) so it is in a
                            single location
```

1.10.2 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
```

1.10.3 write_diag42

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

INTERFACE:

```
SUBROUTINE WRITE_DIAG42( Input_Opt )
```

USES:

```
USE BPCH2_MOD,          ONLY : BPCH2
```

```
USE BPCH2_MOD,          ONLY : GET_MODELNAME
USE BPCH2_MOD,          ONLY : GET_HALFPOLAR
USE CMN_DIAG_MOD             ! TINDEX
USE CMN_SIZE_MOD             ! Size parameters
USE FILE_MOD,           ONLY : IU_BPCH
USE GC_GRID_MOD,        ONLY : GET_XOFFSET
USE GC_GRID_MOD,        ONLY : GET_YOFFSET
USE Input_Opt_Mod,      ONLY : OptInput
USE TIME_MOD,           ONLY : GET_CT_DIAG
USE TIME_MOD,           ONLY : GET_DIAGb
USE TIME_MOD,           ONLY : GET_DIAGe
```

INPUT PARAMETERS:

```
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
```

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
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
```

1.10.4 init_diag42

Subroutine INIT_DIAG42 allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG42( am_I_Root, Input_Opt, RC )
```

USES:

```
USE CMN_SIZE_MOD
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : ALLOC_ERR
USE Input_Opt_Mod,      ONLY : OptInput
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
22 May 2006 - D. Henze, R. Yantosca - Initial version
02 Dec 2010 - R. Yantosca - Added ProTeX headers
23 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
```

1.10.5 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
```

1.11 Fortran: Module Interface diag49_mod.F

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

INTERFACE:

```
MODULE DIAG49_MOD
```

USES:

```
USE inquireMod,    ONLY : findFreeLUN ! (ewl, 6/16/15)
USE PhysConstants
USE PRECISION_MOD       ! For GEOS-Chem Precision (fp)

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:

```
NOTE by Melissa Sulprizio, 26 May 2015
------------------------------------------------------------------------------
The emission options in the timeseries diagnostics were removed
from v10-01 since HEMCO now handles the emission diagnostics. To
utilize the diagnostics capability from HEMCO and output hourly
isoprene emissions, you can follow these steps:
  1. At the top of your HEMCO_Config.rc file, set DiagnFreq to Hourly
     and add a line for DiagnFile:
        DiagnPrefix: HEMCO_Diagnostics
        DiagnFreq: Hourly
        DiagnFile: DiagnFile.rc
  2.  Create a new text file in your run directory named DiagnFile.rc
      and list the emission fields that you would like to be saved out.
      For example:
        # Name        Spec ExtNr Cat Hier Dim OutUnit
        ISOP_BIOG     ISOP 108    1   1   2   kg/m2/s
      NOTE: The ExtNr, Cat, Hier, and Dim values listed above were
      obtained from the MEGAN entries in the HEMCO_Config.rc file.
  3. You can then run GEOS-Chem as usual. HEMCO will write out the
     specified diagnostics in a netCDF file named
     HEMCO_Diagnostics.YYYYMMDDHHmm.nc. I recommend running a short
     1-day simulation to make sure the diagnostic output is what
     you expect.
For more details on the HEMCO diagnostics, please see this post
in the HEMCO Users Guide:
     http://wiki.geos-chem.org/The_HEMCO_User%27s_Guide#Diagnostics
ND49 tracer numbers:
==============================================================================
1 - nAdvect   : GEOS-CHEM advected species              [v/v        ]
151           : OH concentration                        [molec/cm3  ]
152           : NOy concentration                       [v/v        ]
153           : Relative Humidity                       [%          ]
154           : 3-D Cloud fractions                     [unitless   ]
155           : Column optical depths                   [unitless   ]
156           : Cloud top heights                       [hPa        ]
157           : Air density                             [molec/cm3  ]
158           : Total seasalt tracer concentration      [unitless   ]
159           : PBL heights                             [m          ]
160           : PBL heights                             [levels     ]
161           : Grid box heights                        [m          ]
162           : PEDGE-$ (Pressure @ level edges         [hPa        ]
163           : Sea level pressure                      [hPa        ]
```

```
164           : Zonal wind (a.k.a. U-wind)               [m/s        ]
165           : Meridional wind (a.k.a. V-wind)          [m/s        ]
166           : Temperature                              [K          ]
167           : Sulfate aerosol optical depth            [unitless   ]
168           : Black carbon aerosol optical depth       [unitless   ]
169           : Organic carbon aerosol optical depth     [unitless   ]
170           : Accumulation mode seasalt optical depth  [unitless   ]
171           : Coarse mode seasalt optical depth        [unitless   ]
172           : Total dust optical depth                 [unitless   ]
173-179       : Size resolved dust optical depth         [unitless   ]
180           : PAR direct                               [hPa        ]
181           : PAR diffuse                              [hPa        ]
182           : Daily LAI                                [hPa        ]
183           : Temperature at 2m                        [K          ]
184           : Accumulated precip.                      [mm/day     ]
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Bug fix: get I0, J0 properly for nested grids (bmy, 11/9/04)
(2 ) Now references "pbl_mix_mod.f" (bmy, 2/16/05)
(3 ) Now saves 3-D cld frac & grid box height (bmy, 4/20/05)
(4 ) Remove TRCOFFSET since it's always zero  Also now get HALFPOLAR for
     both GCAP and GEOS grids.  (bmy, 6/28/05)
(5 ) Bug fix: do not save SLP if it's not allocated (bmy, 8/2/05)
(6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(7 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(8 ) Modified INIT_DIAG49 to save out transects (cdh, bmy, 11/30/06)
(9 ) Bug fix: accumulate into Q(X,Y,K) for dust OD (qli, bmy, 4/30/07)
(10) Minor bug fixes in DIAG49 (cdh, bmy, 2/11/08)
(11) Bug fix: replace "PS-PTOP" with "PEDGE-$"
(12) Modified to archive O3, NO, NOy as tracers 89, 90, 91  (tmf, 9/26/07)
(13) Bug fix DIAG49 for diagnostic output of SLP (tai, bmy, 10/13/09)
(14) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
(15) Bug fix in ITS_TIME_TO_CLOSE: compare HR1 to 00 not 24. (ccc, 11/11/10)
(16) Now do not scale AOD output (recalculated in RDAER AND DUST_MOD)
     (skim, 02/02/11)
12 Nov 2010 - R. Yantosca - Changed tracer 99 to be PEDGE-$ (pressure at
                            level edges) instead of Psurface-PTOP.
02 Dec 2010 - R. Yantosca - Added ProTeX headers
13 Aug 2013 - M. Sulprizio- Add farnesene emissions for updated SOA (H. Pye)
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
19 Mar 2014 - M. Sulprizio- Updated to allow for more than 75 tracers
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
22 Jun 2016 - M. Yannetti - Replace TCVV with spec db and physical const
```

1.11.1 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( am_I_Root, Input_Opt,
     &                   State_Met, State_Chm, RC )
```

USES:

```
      USE BPCH2_MOD,          ONLY : BPCH2,   OPEN_BPCH2_FOR_WRITE
      USE CMN_FJX_MOD,        ONLY : ODAER, ODMDUST, NRH, NDUST
      USE CMN_FJX_MOD,        ONLY : IWVSELECT, ACOEF_WV, BCOEF_WV
      USE CMN_O3_MOD            ! SAVEOH
      USE ErrCode_Mod
      USE FILE_MOD,           ONLY : IOERROR
      USE GC_GRID_MOD,        ONLY : GET_XOFFSET,        GET_YOFFSET
      USE Input_Opt_Mod,      ONLY : OptInput
      USE inquireMod,         ONLY : findFreeLun
      USE MODIS_LAI_MOD,      ONLY : ISOLAI => GC_LAI
      USE PhysConstants            ! XTRA2, XNUMOLAIR
      USE PBL_MIX_MOD,        ONLY : GET_PBL_TOP_L,      GET_PBL_TOP_m
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      USE State_Met_Mod,      ONLY : MetState
      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
      USE TIME_MOD,           ONLY : TIMESTAMP_STRING
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

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
11 Apr 2012 - R. Yantosca - Replace lai_mod.F with modis_lai_mod.F90
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
07 Aug 2012 - R. Yantosca - Now print LUN used to open file
09 Nov 2012 - M. Payer    - Replaced all met field arrays with State_Met
                            derived type object
14 Mar 2013 - M. Payer    - Replace NOx and Ox with NO, NO2, and O3 as part
                            of removal of NOx-Ox partitioning
13 Aug 2013 - M. Sulprizio- Add farnesene emissions for updated SOA (H. Pye)
25 Jul 2014 - R. Yantosca - Remove reference to commsoil_mod.F90
06 Nov 2014 - R. Yantosca - Now use State_Met%AIRDEN(I,J,L)
06 Nov 2014 - R. Yantosca - Now use State_Met%CLDF(I,J,L)
06 Nov 2014 - R. Yantosca - Now use State_Met%OPTD(I,J,L)
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
26 Feb 2015 - E. Lundgren - Replace GET_PEDGE with State_Met%PEDGE.
                            Remove dependency on pressure_mod.
24 Mar 2015 - E. Lundgren - Remove dependency on tracer_mod
25 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg and
                            remove AD pointer
15 Apr 2015 - M. Sulprizio- Comment out emission diagnostics for now. These
                            are now handled by the HEMCO.
24 Jun 2015 - E. Lundgren - Add code to print out mass conservation output,
                            blocked off by #if defined( MASSCONS )
17 Nov 2015 - E. Lundgren - Bug fix in masscons kg calculation: use AD
16 Jun 2016 - K. Yu       - Now define species ID's with the Ind_ function
17 Jun 2016 - R. Yantosca - Only define species ID's on the first call
```

```
22 Jun 2016 - R. Yantosca - Now make species ID's module variables
22 Jun 2016 - R. Yantosca - Rename IDTPASV to id_PASV.  Also move the
                            initializations of the id_ flags before the
                            first mass conservation test.
30 Jun 2016 - R. Yantosca - Remove instances of STT.  Now get the advected
                            species ID from State_Chm%Map_Advect.
11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.11.2 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
13 Mar 2015 - M. Sulprizio- Bug fix: Allow for temporal resolution finer
                            than 60 min (E. Marais)
```

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

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
```

1.11.4 get_i

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

INTERFACE:

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

USES:

```
USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

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

RETURN VALUE:

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

REVISION HISTORY:

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

1.11.5 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 CMN_SIZE_MOD       ! Size parameters
      USE ERROR_MOD,    ONLY : ERROR_STOP
      USE GC_GRID_MOD,  ONLY : GET_XOFFSET
      USE GC_GRID_MOD,  ONLY : GET_YOFFSET
      USE GC_GRID_MOD,  ONLY : ITS_A_NESTED_GRID
```

INPUT PARAMETERS:

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

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    (1 ) Now get I0 and J0 correctly for nested grid simulations (bmy, 11/9/04)
    (2 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
         value for GEOS or GCAP grids. (bmy, 6/28/05)
    (3 ) Now allow ND49_IMIN to be equal to ND49_IMAX and ND49_JMIN to be
         equal to ND49_JMAX.  This will allow us to save out longitude
         or latitude transects.  (cdh, bmy, 11/30/06)
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
    29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.12 Fortran: Module Interface diag50_mod.F

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

INTERFACE:

```
MODULE DIAG50_MOD
```

USES:

```
USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

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 - nAdvect   : GEOS-CHEM advected species               [v/v      ]
151           : OH concentration                         [molec/cm3]
152           : NOy concentration                        [v/v      ]
153           : Relative Humidity                        [%        ]
154           : 3-D Cloud fractions                      [unitless ]
155           : Column optical depths                    [unitless ]
156           : Cloud top heights                        [hPa      ]
157           : Air density                              [molec/cm3]
158           : Total seasalt tracer concentration       [unitless ]
159           : PBL heights                              [m        ]
160           : PBL heights                              [levels   ]
161           : Grid box heights                         [m        ]
162           : PEDGE-$ (Pressure @ level edges          [hPa      ]
163           : Sea level pressure                       [hPa      ]
164           : Zonal wind (a.k.a. U-wind)               [m/s      ]
165           : Meridional wind (a.k.a. V-wind)          [m/s      ]
166           : Temperature                              [K        ]
167           : Sulfate aerosol optical depth            [unitless ]
168           : Black carbon aerosol optical depth       [unitless ]
169           : Organic carbon aerosol optical depth     [unitless ]
170           : Accumulation mode seasalt optical depth  [unitless ]
171           : Coarse mode seasalt optical depth        [unitless ]
172           : Total dust optical depth                 [unitless ]
173-179       : Size resolved dust optical depth         [unitless ]
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Rewritten for clarity and to save extra quantities (bmy, 7/20/04)
(2 ) Added COUNT_CHEM to count the chemistry timesteps per day, since some
     quantities are only archived after a fullchem call (bmy, 10/25/04)
(3 ) Bug fix: Now get I0 and J0 properly for nested grids (bmy, 11/9/04)
(4 ) Now only archive AOD's once per chemistry timestep (bmy, 1/14/05)
(5 ) Now references "pbl_mix_mod.f" (bmy, 2/16/05)
(6 ) Now save cloud fractions & grid box heights (bmy, 4/20/05)
(7 ) Remove TRCOFFSET since it's always zero.  Also now get HALFPOLAR for
     both GCAP and GEOS grids. (bmy, 6/24/05)
(8 ) Bug fix: don't save SLP unless it is allocated (bmy, 8/2/05)
(9 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(10) Modified INIT_DIAG49 to save out transects (cdh, bmy, 11/30/06)
(11) Now use 3D timestep counter for full chem in the trop (phs, 1/24/07)
(12) Renumber RH diagnostic in WRITE_DIAG50 (bmy, 2/11/08)
(13) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, 10/7/08)
(14) Modified to archive O3, NO, NOy as tracers 89, 90, 91  (tmf, 9/26/07)
(15) Updates & bug fixes in WRITE_DIAG50 (ccc, tai, bmy, 10/13/09)
(16) Updates to AOD output.  Also have the option to write to HDF
     (amv, bmy, 12/21/09)
(17) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
02 Dec 2010 - R. Yantosca - Added ProTeX headers
03 Feb 2011 - S. Kim      - Now do not scale the AOD output
                            (recalculated in RDAER AND DUST_MOD)
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
06 Aug 2012 - R. Yantosca - Now make IU_ND50 a local module variable
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
19 Mar 2014 - M. Sulprizio- Updated to allow for more than 75 tracers
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.12.1 DIAG50

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

INTERFACE:

```
SUBROUTINE DIAG50( am_I_Root, Input_Opt, State_Met, State_Chm, RC)
```

USES:

```
      USE ErrCode_Mod
      USE Input_Opt_Mod,      ONLY : OptInput
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Met_Mod,      ONLY : MetState
      USE State_Met_Mod,      ONLY : MetState
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
    25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
    06 Nov 2014 - R. Yantosca - Now use State_Met%AIRDEN(I,J,L)
```

1.12.2 accumulate_diag50

Subroutine ACCUMULATE_DIAG50 accumulates tracers into the Q array.

INTERFACE:

```
      SUBROUTINE ACCUMULATE_DIAG50( am_I_Root, Input_Opt,
     &                              State_Met, State_Chm, RC )
```

USES:

```
      USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_CHEMGRID
      USE CMN_FJX_MOD,        ONLY : ODAER, ODMDUST, NRH, NDUST
      USE CMN_FJX_MOD,        ONLY : IWVSELECT, ACOEF_WV, BCOEF_WV
      USE CMN_O3_MOD               ! SAVEOH
      USE ErrCode_Mod
      USE Input_Opt_Mod,      ONLY : OptInput
      USE PhysConstants            ! SCALE_HEIGHT, XNUMOLAIR
      USE PBL_MIX_MOD,        ONLY : GET_PBL_TOP_L, GET_PBL_TOP_m
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      USE State_Met_Mod,      ONLY : MetState
      USE TIME_MOD,           ONLY : GET_ELAPSED_MIN, GET_TS_CHEM
      USE TIME_MOD,           ONLY : TIMESTAMP_STRING, GET_TS_DYN
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Rewrote to remove hardwiring and for better efficiency.  Added extra
     diagnostics and updated numbering scheme.  Now scale aerosol & dust
     optical depths to 400 nm. (rvm, aad, bmy, 7/20/04)
(2 ) Now reference GET_ELAPSED_MIN and GET_TS_CHEM from "time_mod.f".
     Also now use extra counter COUNT_CHEM to count the number of
     chemistry timesteps since NO, NO2, OH, O3 only when a full-chemistry
     timestep happens. (bmy, 10/25/04)
(3 ) Only archive AOD's when it is a chem timestep (bmy, 1/14/05)
(4 ) Remove reference to "CMN".  Also now get PBL heights in meters and
     model layers from GET_PBL_TOP_m and GET_PBL_TOP_L of "pbl_mix_mod.f".
     (bmy, 2/16/05)
(5 ) Now reference CLDF and BXHEIGHT from "dao_mod.f".  Now save 3-D
     cloud fraction as tracer #79 and box height as tracer #93.  Now
     remove references to CLMOSW, CLROSW, and PBL from "dao_mod.f".
     (bmy, 4/20/05)
(6 ) Remove references to TRCOFFSET because it's always zero (bmy, 6/24/05)
(7 ) Now do not save SLP data if it is not allocated (bmy, 8/2/05)
(8 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(9 ) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(10) Now account for time spent in the trop for non-tracers (phs, 1/24/07)
(11) IS_CHEM check is not appropriate anymore. Keep COUNT_CHEM3D for
     species known in troposphere only (ccc, 8/12/09)
(12) Output AOD at 3rd jv_spec.dat row wavelength.  Include all seven dust
     bin's individual AOD (amv, bmy, 12/21/09)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
02 Dec 2010 - R. Yantosca - Added ProTeX headers
09 Nov 2012 - M. Payer    - Replaced all met field arrays with State_Met
                            derived type object
14 Mar 2013 - M. Payer    - Replace NOx and Ox with NO, NO2, and O3 as part
                            of removal of NOx-Ox partitioning
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
06 Nov 2014 - R. Yantosca - Now use State_Met%CLDF(I,J,L)
06 Nov 2014 - R. Yantosca - Now use State_Met%OPTD(I,J,L)
```

```
26 Feb 2014 - E. Lundgren - Replace GET_PEDGE with State_Met%PEDGE.
24 Mar 2015 - E. Lundgren - Remove dependency on tracer_mod
25 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg
17 May 2016 - M. Sulprizio- Add IS_CHEM logical for incrementing COUNT_CHEM3D
16 Jun 2016 - K. Yu       - Now define species ID's with the Ind_ function
17 Jun 2016 - R. Yantosca - Only define species ID's on the first call
22 Jun 2016 - M. Yannetti - Replace TCVV with spec db and physical const
28 Jun 2016 - M. Sulprizio- Replace NPVERT with LLPAR to remove dependence
                            on comode_loop_mod.F
30 Jun 2016 - R. Yantosca - Remove instances of STT.  Now get the advected
                            species ID from State_Chm%Map_Advect.
11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
```

1.12.3 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
```

1.12.4 write_diag50

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

INTERFACE:

```
SUBROUTINE WRITE_DIAG50( am_I_Root, Input_Opt, State_Chm, RC )
```

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 CMN_SIZE_MOD             ! Size Parameters
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : ALLOC_ERR
      USE GC_GRID_MOD,        ONLY : GET_XOFFSET
      USE GC_GRID_MOD,        ONLY : GET_YOFFSET
      USE Input_Opt_Mod,      ONLY : OptInput
      USE inquireMod,         ONLY : findFreeLUN
      USE State_Chm_Mod,      ONLY : ChmState
      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

#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
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?!
```

REVISION HISTORY:

```
    20 Jul 2004 - R. Yantosca - Initial version
    (1 ) Rewrote to remove hardwiring and for better efficiency.  Added extra
         diagnostics and updated numbering scheme. (bmy, 7/20/04)
    (2 ) Now only archive NO, NO2, OH, O3 on every chemistry timestep (i.e.
         only when fullchem is called).  Also remove reference to FIRST.
         (bmy, 10/25/04)
```

```
(3 ) Now divide tracers 82-87 (i.e. various AOD's) by GOOD_CT_CHEM since
     these are only updated once per chemistry timestep (bmy, 1/14/05)
(4 ) Now save grid box heights as tracer #93.  Now save 3-D cloud fraction
     as tracer #79. (bmy, 4/20/05)
(5 ) Remove references to TRCOFFSET because it's always zero (bmy, 6/24/05)
(6 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(7 ) DIVISOR is now a 3-D array.  Now zero COUNT_CHEM3D.  Now zero Q
     array with array assignment statement. (phs, 1/24/07)
(8 ) RH should be tracer #17 under "TIME-SER" category (bmy, 2/11/08)
(9 ) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, 10/7/08)
(10) Change timestamp for filename.  Now save SLP under tracer #18 in
     "DAO-FLDS".  Also set unit to 'K' for temperature field.
     (ccc, tai, bmy, 10/13/09)
(11) Now have the option of saving out to HDF5 format.  NOTE: we have to
     bracket HDF-specific code with an #ifdef statement to avoid problems
     if the HDF5 libraries are not installed. (amv, bmy, 12/21/09)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
02 Dec 2010 - R. Yantosca - Added ProTeX headers
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
07 Aug 2012 - R. Yantosca - Now print LUN used to open file
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC args
```

1.12.5 get_i

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

INTERFACE:

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

USES:

```
USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

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

RETURN VALUE:

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

REMARKS:

REVISION HISTORY:

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

1.12.6 init_diag50

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

INTERFACE:

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

USES:

```
USE BPCH2_MOD,    ONLY : GET_MODELNAME
USE BPCH2_MOD,    ONLY : GET_HALFPOLAR
USE CMN_SIZE_MOD
USE ERROR_MOD,    ONLY : ALLOC_ERR
USE ERROR_MOD,    ONLY : ERROR_STOP
USE GC_GRID_MOD,  ONLY : GET_XOFFSET
USE GC_GRID_MOD,  ONLY : GET_YOFFSET
USE GC_GRID_MOD,  ONLY : ITS_A_NESTED_GRID
USE TIME_MOD,     ONLY : GET_TAUb
```

INPUT PARAMETERS:

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

REMARKS:

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
(1 ) Now get I0 and J0 correctly for nested grid simulations (bmy, 11/9/04)
(2 ) Now call GET_HALFPOLAR from "bpch2_mod.f" to get the HALFPOLAR flag
     value for GEOS or GCAP grids. (bmy, 6/28/05)
(3 ) Now allow ND50_IMIN to be equal to ND50_IMAX and ND50_JMIN to be
```

```
        equal to ND50_JMAX.  This will allow us to save out longitude
        or latitude transects.  Now allocate COUNT_CHEM3D array.
        (cdh, phs, 1/24/07)
    02 Dec 2010 - R. Yantosca - Added ProTeX headers
```

1.12.7 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
```

1.13 Fortran: Module Interface diag51b_mod.F

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:

```
USE PhysConstants, ONLY : AIRMW
USE PRECISION_MOD       ! For GEOS-Chem Precision (fp)

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:

```
NOTE by Melissa Sulprizio, 26 May 2015
------------------------------------------------------------------------------
The emission options in the timeseries diagnostics were removed
from v10-01 since HEMCO now handles the emission diagnostics. To
utilize the diagnostics capability from HEMCO and output hourly
isoprene emissions, you can follow these steps:
  1. At the top of your HEMCO_Config.rc file, set DiagnFreq to Hourly
     and add a line for DiagnFile:
        DiagnPrefix: HEMCO_Diagnostics
        DiagnFreq: Hourly
        DiagnFile: DiagnFile.rc
  2.  Create a new text file in your run directory named DiagnFile.rc
      and list the emission fields that you would like to be saved out.
      For example:
        # Name        Spec ExtNr Cat Hier Dim OutUnit
        ISOP_BIOG     ISOP 108    1   1   2   kg/m2/s
      NOTE: The ExtNr, Cat, Hier, and Dim values listed above were
      obtained from the MEGAN entries in the HEMCO_Config.rc file.
  3. You can then run GEOS-Chem as usual. HEMCO will write out the
     specified diagnostics in a netCDF file named
     HEMCO_Diagnostics.YYYYMMDDHHmm.nc. I recommend running a short
     1-day simulation to make sure the diagnostic output is what
     you expect.
For more details on the HEMCO diagnostics, please see this post
in the HEMCO Users Guide:
     http://wiki.geos-chem.org/The_HEMCO_User%27s_Guide#Diagnostics
ND51b tracer numbers:
==============================================================================
1 - nAdvect   : GEOS-CHEM advected species               [v/v        ]
151           : OH concentration                         [molec/cm3  ]
152           : NOy concentration                        [v/v        ]
153           : Relative Humidity                        [%          ]
154           : 3-D Cloud fractions                      [unitless   ]
155           : Column optical depths                    [unitless   ]
156           : Cloud top heights                        [hPa        ]
157           : Air density                              [molec/cm3  ]
158           : Total seasalt tracer concentration       [unitless   ]
159           : PBL heights                              [m          ]
160           : PBL heights                              [levels     ]
161           : Grid box heights                         [m          ]
162           : PEDGE-$ (Pressure @ level edges          [hPa        ]
163           : Sea level pressure                       [hPa        ]
```

```
164           : Zonal wind (a.k.a. U-wind)               [m/s       ]
165           : Meridional wind (a.k.a. V-wind)          [m/s       ]
166           : Temperature                              [K         ]
167           : Sulfate aerosol optical depth            [unitless  ]
168           : Black carbon aerosol optical depth       [unitless  ]
169           : Organic carbon aerosol optical depth     [unitless  ]
170           : Accumulation mode seasalt optical depth  [unitless  ]
171           : Coarse mode seasalt optical depth        [unitless  ]
172           : Total dust optical depth                 [unitless  ]
173-179       : Size resolved dust optical depth         [unitless  ]
180           : PAR direct                               [hPa       ]
181           : PAR diffuse                              [hPa       ]
182           : Daily LAI                                [hPa       ]
183           : Temperature at 2m                        [K         ]
```

REVISION HISTORY:

```
(1 ) Rewritten for clarity (bmy, 7/20/04)
(2 ) Added extra counters for NO, NO2, OH, O3.  Also all diagnostic counter
     arrays are 1-D since they only depend on longitude. (bmy, 10/25/04)
(3 ) Bug fix: Now get I0 and J0 properly for nested grids (bmy, 11/9/04)
(4 ) Now only archive AOD's once per chemistry timestep (bmy, 1/14/05)
(5 ) Now references "pbl_mix_mod.f" (bmy, 2/16/05)
(6 ) Now save cld frac and grid box heights (bmy, 4/20/05)
(7 ) Remove TRCOFFSET since it's always zero  Also now get HALFPOLAR for
     both GCAP and GEOS grids.  (bmy, 6/28/05)
(8 ) Bug fix: do not save SLP if it's not allocated (bmy, 8/2/05)
(9 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(10) Now references XNUMOLAIR from "tracer_mod.f" (bmy, 10/25/05)
(11) Modified INIT_DIAG51 to save out transects (cdh, bmy, 11/30/06)
(12) Now use 3D timestep counter for full chem in the trop (phs, 1/24/07)
(13) Renumber RH in WRITE_DIAG50 (bmy, 2/11/08)
(14) Bug fix: replace "PS-PTOP" with "PEDGE-$" (bmy, phs, 10/7/08)
(15) Bug fix in GET_LOCAL_TIME (ccc, 12/10/08)
(16) Modified to archive O3, NO, NOy as tracers 89, 90, 91  (tmf, 9/26/07)
(17) Updates in WRITE_DIAG51b (ccc, tai, bmy, 10/13/09)
(18) Updates to AOD output.  Also have the option to write to HDF
     (amv, bmy, 12/21/09)
(19) Added MEGAN species (mpb, bmy, 12/21/09)
(20) Modify AOD output to wavelength specified in jv_spec_aod.dat
     (clh, 05/07/10)
12 Nov 2010 - R. Yantosca - Now save out PEDGE-$ (pressure at level edges)
                            rather than Psurface - PTOP
03 Feb 2011 - S. Kim      - Now do not scale the AOD output
                            (recalculated in RDAER AND DUST_MOD)
01 Mar 2012 - R. Yantosca - Use updated GET_LOCALTIME from time_mod.F
06 Aug 2012 - R. Yantosca - Now make IU_ND51b a local module variable
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
19 Mar 2014 - M. Sulprizio- Updated to allow for more than 75 tracers
```

```
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
15 Apr 2015 - M. Sulprizio- Comment out emission diagnostics for now. These
                            are now handled by the HEMCO.
22 Jun 2016 - M. Yannetti - Replace TCVV with spec db and physical const
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.13.1 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( am_I_Root, Input_Opt,
     &                    State_Met, State_Chm, RC )
```

USES:

```
      USE ErrCode_Mod
      USE Input_Opt_Mod,      ONLY : OptInput
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Met_Mod,      ONLY : MetState
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

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
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
```

1.13.2 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 CMN_SIZE_MOD   ! Size parameters
USE TIME_MOD, ONLY : GET_LOCALTIME
USE TIME_MOD, ONLY : GET_TS_DYN
```

REMARKS:

```
For now use GET_LOCALTIME( I, 1, 1 ) which will be independent of J and L
for a pure cartesian grid.  This may need to be revisited once G-C is
interfaced into a GCM.
```

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(fp) 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
01 Mar 2012 - R. Yantosca - Now use GET_LOCALTIME(I,J,L) from time_mod.F90
```

1.13.3 accumulate_diag51

Subroutine ACCUMULATE_DIAG51 accumulates tracers into the Q array.

INTERFACE:

```
SUBROUTINE ACCUMULATE_DIAG51( am_I_Root, Input_Opt,
&                             State_Met, State_Chm, RC )
```

USES:

```
      USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_CHEMGRID
      USE CMN_FJX_MOD,        ONLY : ODAER, ODMDUST, NRH, NDUST
      USE CMN_FJX_MOD,        ONLY : IWVSELECT, ACOEF_WV, BCOEF_WV
      USE CMN_O3_MOD               ! SAVEOH
      USE ErrCode_Mod
      USE Input_Opt_Mod,      ONLY : OptInput
      USE MODIS_LAI_MOD,      ONLY : ISOLAI => GC_LAI
      USE PhysConstants            ! SCALE_HEIGHT, XNUMOLAIR
      USE PBL_MIX_MOD,        ONLY : GET_PBL_TOP_L,    GET_PBL_TOP_m
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      USE State_Met_Mod,      ONLY : MetState
      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
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

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
11 Apr 2012 - R. Yantosca - Replace lai_mod.F with modis_lai_mod.F
09 Nov 2012 - M. Payer    - Replaced all met field arrays with State_Met
                            derived type object
14 Mar 2013 - M. Payer    - Replace NOx and Ox with NO, NO2, and O3 as part
                            of removal of NOx-Ox partitioning
06 Nov 2014 - R. Yantosca - Now use State_Met%AIRDEN(I,J,L)
06 Nov 2014 - R. Yantosca - Now use State_Met%CLDF(I,J,L)
06 Nov 2014 - R. Yantosca - Now use State_Met%OPTD(I,J,L)
26 Feb 2015 - E. Lundgren - Replace GET_PEDGE with State_Met%PEDGE.
24 Mar 2015 - E. Lundgren - Remove dependency on tracer_mod
25 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg and
                            remove AD pointer
16 Jun 2016 - K. Yu       - Now define species ID's with the Ind_ function
17 Jun 2016 - R. Yantosca - Only define species ID's on the first call
11 Aug 2016 - R. Yantosca - Remove temporary tracer-removal code
```

1.13.4 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 ERROR_MOD, ONLY : GEOS_CHEM_STOP
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
```

OUTPUT PARAMETERS:

```
      REAL(fp), 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
```

1.13.5 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( am_I_Root, Input_Opt,
     &                         State_Chm, TAU_W, RC )
```

USES:

```
      USE BPCH2_MOD,          ONLY : BPCH2
      USE BPCH2_MOD,          ONLY : OPEN_BPCH2_FOR_WRITE
      USE CMN_SIZE_MOD             ! Size Parameters
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : ALLOC_ERR
      USE Input_Opt_Mod,      ONLY : OptInput
      USE inquireMod,         ONLY : findFreeLUN
      USE State_Chm_Mod,      ONLY : ChmState
      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

#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
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
REAL(fp),       INTENT(IN)  :: TAU_W       ! TAU value at time of write
```

INPUT/OUTPUT PARAMETERS:

```
TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

Arguments as Input:

```
=============================================================================
(1 ) TAU_W (REAL(fp)) : 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
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
07 Aug 2012 - R. Yantosca - Now print LUN used to open file
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
```

1.13.6 get_i

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

INTERFACE:

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

USES:

```
USE CMN_SIZE_MOD   ! Size parameters
```

INPUT PARAMETERS:

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

RETURN VALUE:

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

REVISION HISTORY:

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

1.13.7 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 CMN_SIZE_MOD       ! Size parameters
 USE ERROR_MOD,    ONLY : ALLOC_ERR
 USE ERROR_MOD,    ONLY : ERROR_STOP
 USE GC_GRID_MOD,  ONLY : GET_XOFFSET
 USE GC_GRID_MOD,  ONLY : GET_YOFFSET
 USE GC_GRID_MOD,  ONLY : ITS_A_NESTED_GRID
 USE TIME_MOD,     ONLY : GET_TAUb
```

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(fp),             INTENT(IN) :: HR1,    HR2
REAL(fp),             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
```

1.13.8 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
```

1.14 Fortran: Module Interface diag53_mod.F

Module DIAG53_MOD contains arrays and routines for archiving the ND53 diagnostic – POPS emissions, mass, and production. (eck 9/20/10)

INTERFACE:

```
MODULE DIAG53_MOD
```

USES:

```
USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

IMPLICIT NONE
PRIVATE
```

DEFINED PARAMETERS:

```
INTEGER, PUBLIC, PARAMETER   :: PD53 = 29  ! # of AD53 diags
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: ZERO_DIAG53
PUBLIC :: WRITE_DIAG53
PUBLIC :: INIT_DIAG53
PUBLIC :: CLEANUP_DIAG53
```

PUBLIC DATA MEMBERS:

```
! Scalars
INTEGER, PUBLIC              :: ND53  ! ND53 on/off flag
INTEGER, PUBLIC              :: LD53  ! # of levels

! Arrays
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_PG_OC_NEG(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_PG_OC_POS(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_PG_BC_NEG(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_PG_BC_POS(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPG_OH(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_OCPO_O3(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_OCPI_O3(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_BCPO_O3(:,:,:)
REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_BCPI_O3(:,:,:)
```

```
      REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_OCPO_NO3(:,:,:)
      REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_OCPI_NO3(:,:,:)
      REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_BCPO_NO3(:,:,:)
      REAL*4,  PUBLIC, ALLOCATABLE :: AD53_POPP_BCPI_NO3(:,:,:)
```

REMARKS:

```
Nomenclature:
============================================================================
(1 ) POPG                  : Gas phase POP
(2 ) POPP                  : Particulate phase POP
```

REVISION HISTORY:

```
20 Sep 2010 - N.E. Selin  - Initial Version based on DIAG03_MOD
27 Nov 2012 - M. Payer    - Added ProTeX headers
26 Aug 2014 - M. Sulprizio- Remove AD53 array, POPs emissions are now
                            tracked by HEMCO
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.14.1 zero_diag53

Subroutine ZERO_DIAG53 zeroes all module arrays.

INTERFACE:

```
      SUBROUTINE ZERO_DIAG53
```

USES:

```
      USE CMN_SIZE_MOD  ! Size parameters
```

REVISION HISTORY:

```
20 Sep 2010 - N.E. Selin  - Initial Version
27 Nov 2012 - M. Payer    - Added ProTeX headers
```

1.14.2 write_diag53

Subroutine WRITE_DIAG53 writes the ND53 diagnostic arrays to the binary punch file at the proper time.

INTERFACE:

```
      SUBROUTINE WRITE_DIAG53
```

USES:

```
      USE BPCH2_MOD,    ONLY : BPCH2, GET_MODELNAME, GET_HALFPOLAR
      USE FILE_MOD,     ONLY : IU_BPCH
      USE GC_GRID_MOD,  ONLY : GET_XOFFSET, GET_YOFFSET
      USE TIME_MOD,     ONLY : GET_CT_EMIS, GET_DIAGb,  GET_DIAGe
      USE TIME_MOD,     ONLY : GET_CT_CHEM ! CDH for sea salt loss rate

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

REMARKS:

```
 # : Field    : Description                    : Units    : Scale factor
-------------------------------------------------------------------------
(1 ) PG-SRCE  : POP emissions                  : kg       : 1
(2 ) PG-PP-$  : Gas phase POP reacted with OH  : kg       : 1
                or partitioned
```

REVISION HISTORY:

```
20 Sep 2010 - N.E. Selin  - Initial Version
27 Nov 2012 - M. Payer    - Added ProTeX headers
26 Aug 2014 - M. Sulprizio- Now track POPs emissions through HEMCO and
                            write to bpch in diag3.F
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
```

1.14.3 init_diag53

Subroutine INIT_DIAG53 allocates all module arrays.

INTERFACE:

```
      SUBROUTINE INIT_DIAG53
```

USES:

```
      USE ERROR_MOD,    ONLY : ALLOC_ERR

      USE CMN_SIZE_MOD
```

REVISION HISTORY:

```
20 Sep 2010 - N.E. Selin  - Initial Version
27 Nov 2012 - M. Payer    - Added ProTeX headers
```

1.14.4 cleanup_diag53

Subroutine CLEANUP_DIAG53 deallocates all module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_DIAG53
```

REVISION HISTORY:

```
20 Sep 2010 - N.E. Selin  - Initial Version
27 Nov 2012 - M. Payer    - Added ProTeX headers
```

1.15 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:

```
USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

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 = 4

! 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
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
02 Apr 2015 - M. Sulprizio- Increase PD56 from 3 to 4 so we can save out the
                            lightning cloud top heights from HEMCO.
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.15.1 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
```

1.15.2 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 GC_GRID_MOD,  ONLY : GET_XOFFSET, GET_YOFFSET
USE TIME_MOD,     ONLY : GET_CT_A6, GET_CT_A3, GET_CT_I3
USE TIME_MOD,     ONLY : GET_DIAGb,  GET_DIAGe

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

REMARKS:

```
 # : Field    : Description              : Units          : Scale factor
-----------------------------------------------------------------------
(1 ) LFLASH-$ : Lightning flash rate     : flashes/min/km2 : SCALE_A6
(2 ) LFLASH-$ : Intra-cloud flash rate   : flashes/min/km2 : SCALE_A6
(3 ) LFLASH-$ : Cloud-ground flash rate  : flashes/min/km2 : SCALE_A6
```

REVISION HISTORY:

```
11 May 2006 - R. Yantosca - Initial version
(1 ) Replace TINY(1d0) with 1d-32 to avoid problems on SUN 4100 platform
     (bmy, 9/5/06)
(2 ) Now scale AD56 by the # of A-6 timesteps (ltm, bmy, 3/7/07)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
26 Sep 2013 - R. Yantosca - Renamed GEOS_57 Cpp switch to GEOS_FP
17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
```

1.15.3 init_diag56

Subroutine INIT_DIAG56 allocates all module arrays, 5/11/06)

INTERFACE:

```
SUBROUTINE INIT_DIAG56
```

USES:

```
USE ERROR_MOD,    ONLY : ALLOC_ERR

USE CMN_SIZE_MOD
```

REVISION HISTORY:

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

1.15.4 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
```

1.16 Fortran: Module Interface diag63_mod.F

Module DIAG63_MOD contains variables and routines to save out the fraction of NOx remaining and integrated OPE to disk (gvinken, 25/02/11)

INTERFACE:

```
MODULE DIAG63_MOD
```

USES:

```
USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

IMPLICIT NONE
PRIVATE
```

PUBLIC DATA MEMBERS:

```
LOGICAL, PUBLIC :: DO_SAVE_DIAG63
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC :: DIAG63
PUBLIC :: ITS_TIME_FOR_DIAG63
PUBLIC :: INIT_DIAG63
```

REMARKS:

```
ND63 tracer numbers:
============================================================================
1  : Fraction of NOx remaining  [unitless]
2  : Integrated OPE             [molec O3 produced / molec NOx lost]
```

REVISION HISTORY:

```
25 Feb 2011 - G. Vinken   - Initial version based on the orig. diag49_mod.f
07 Feb 2012 - M. Payer    - Added ProTeX headers
24 Feb 2012 - M. Payer    - Rename module from diag59_mod to diag63_mod.
                            Diag59 is used by TOMAS. Fix this throughout.
06 Aug 2012 - R. Yantosca - Now make IU_ND63 a local module variable
10 Nov 2014 - M. Yannetti - Added PRECISION_MOD
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.16.1 diag63

Subroutine DIAG63 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 DIAG63 ( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
      USE BPCH2_MOD,          ONLY : BPCH2,   OPEN_BPCH2_FOR_WRITE
      USE CMN_O3_MOD       ! Pure O3, SAVENO2
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : SAFE_DIV, ERROR_STOP
      USE GC_GRID_MOD,        ONLY : GET_XOFFSET,     GET_YOFFSET
      USE HCO_DIAGN_MOD
      USE HCO_ERROR_MOD
      USE HCO_TYPES_MOD,      ONLY : DiagnCont
      USE HCO_INTERFACE_MOD,  ONLY : HcoState
      USE Input_Opt_Mod,      ONLY : OptInput
      USE inquireMod,         ONLY : findFreeLUN
      USE PhysConstants
      USE PBL_MIX_MOD,        ONLY : GET_PBL_TOP_L,   GET_PBL_TOP_m
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      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 TIME_MOD,           ONLY : GET_TAUb
!INPUT ARGUMENTS
      LOGICAL,        INTENT(IN   )       :: am_I_Root
      TYPE(OptInput), INTENT(IN   )       :: Input_Opt  ! Input opts
!INPUT/OUTPUT ARGUMENTS
      TYPE(ChmState), INTENT(INOUT)       :: State_Chm  ! Chemistry State object

      INTEGER,        INTENT(INOUT)       :: RC
```

REVISION HISTORY:

```
 25 Feb 2011 - G. Vinken   - Initial version based on DIAG49
 07 Feb 2012 - M. Payer    - Added ProTeX headers
 11 Apr 2012 - R. Yantosca - Remove reference to lai_mod.F, it's not needed
 03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
 17 Dec 2014 - R. Yantosca - Leave time/date variables as 8-byte
 26 Feb 2015 - E. Lundgren - Remove pressure_mod from use list (not used)
 29 Apr 2016 - R. Yantosca - Don't initialize pointers in declaration stmts
 31 May 2016 - E. Lundgren - Use TCVV instead of XNUMOL for molecular wts
 22 Jun 2016 - M. Yannetti - Replaced references to TCVV, now takes in
                             State_Chm for spec db access
```

1.16.2 its_time_to_close_file

Function ITS_TIME_TO_CLOSE_FILE returns TRUE if it's time to close the ND63 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
```

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_diag63

Function ITS_TIME_FOR_DIAG63 returns TRUE if ND63 is turned on and it is time to call DIAG63 – or FALSE otherwise.

INTERFACE:

```
FUNCTION ITS_TIME_FOR_DIAG63() RESULT( ITS_TIME )
```

USES:

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

RETURN VALUE:

```
LOGICAL :: ITS_TIME
```

REVISION HISTORY:

```
25 Feb 2011 - G. Vinken   - Initial version based on ITS_TIME_FOR_DIAG49
07 Feb 2012 - M. Payer    - 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:

```
USE CMN_SIZE_MOD         ! Size parameters
```

INPUT PARAMETERS:

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

RETURN VALUE:

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

REVISION HISTORY:

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

1.16.5 init_diag63

Subroutine INIT_DIAG63 allocates and zeroes all module arrays. It also gets values for module variables from "input_mod.f".

INTERFACE:

```
SUBROUTINE INIT_DIAG63( DO_ND63, N_ND63, TRACERS, IMIN,
&                       IMAX,    JMIN,   JMAX,    FREQ,
&                       FILE )
```

USES:

```
USE BPCH2_MOD,   ONLY : GET_MODELNAME
USE BPCH2_MOD,   ONLY : GET_HALFPOLAR
USE CMN_SIZE_MOD      ! Size parameters
USE GC_GRID_MOD, ONLY : GET_XOFFSET
USE GC_GRID_MOD, ONLY : GET_YOFFSET
USE GC_GRID_MOD, ONLY : ITS_A_NESTED_GRID
USE ERROR_MOD,   ONLY : ERROR_STOP
```

INPUT PARAMETERS:

```
! DO_ND63 : Switch to turn on ND63 timeseries diagnostic
! N_ND63  : Number of ND63 read by "input_mod.f"
! TRACERS : Array w/ ND63 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"
! FREQ    : Frequency for saving to disk [min]
! FILE    : ND63 output file name read by "input_mod.f"
LOGICAL,            INTENT(IN) :: DO_ND63
```

```
      INTEGER,            INTENT(IN) :: N_ND63, TRACERS(100)
      INTEGER,            INTENT(IN) :: IMIN,   IMAX
      INTEGER,            INTENT(IN) :: JMIN,   JMAX
      INTEGER,            INTENT(IN) :: FREQ
      CHARACTER(LEN=255), INTENT(IN) :: FILE
```

REVISION HISTORY:

```
25 Feb 2011 - G. Vinken   - Initial version based on INIT_DIAG49
07 Feb 2012 - M. Payer    - Added ProTeX headers
```

1.16.6 diagoh.F

Subroutine DIAGOH saves chemical diagnostic quantities for the ND43 chemical diagnostics.

INTERFACE:

```
      SUBROUTINE DIAGOH
```

USES:

```
      USE DIAG_MOD, ONLY: AD43, LTOH, LTHO2
      USE DIAG_MOD, ONLY: LTO1D, LTO3P

      USE CMN_SIZE_MOD  ! Size parameters
      USE CMN_O3_MOD    ! SAVEOH
      USE CMN_DIAG_MOD  ! Diagnostic switches & arrays

      USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

      IMPLICIT NONE
```

REVISION HISTORY:

```
01 May 1998 - R. Yantosca - Initial version
(1 ) Now use F90 syntax for declarations (bmy, 3/29/99)
(2 ) Cosmetic changes (bmy, 3/29/99)
(3 ) AD43 and DIAGCHLORO are now declared allocatable in "diag_mod.f".
      Also eliminate obsolete code. (bmy, 11/29/99)
(4 ) LTNO, LTOH are now allocatable arrays in "diag_mod.f" (bmy, 3/17/00)
(5 ) Don't save OH into STT(:,:,:NTRACER+2) anymore.  The SAVEOH
      array is now used to save OH concentrations for diagnostics.
      Also revised out-of-date comments. (bmy, 4/24/00)
(6 ) Also save out NO2 and HO2 for use w/ the ND43 diagnostic.
      Now also reference LTNO2, LTHO2 arrays from "diag_mod.f".
      Updated comments, cosmetic changes. (rvm, bmy, 2/27/02)
```

```
(7 ) Removed obsolete reference to DIAGCHLORO (bmy, 8/2/02)
(8 ) Now save NO3 [molec/cm3] as AD43(:,:,:,5) (bmy, 1/13/03)
(9 ) Corrected typo in comments (bmy, 8/10/09)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
29 Mar 2013 - M. Payer    - Removed NO, NO2, and NO3 from ND43. These are
                            now tracers.
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
15 Aug 2013 - S.D. Eastham- Added O1D (for strat-chem)
29 Aug 2013 - S.D. Eastham- Added O3P (for strat-chem)
12 Nov 2014 - M. Yannetti - Added PRECISION_MOD
```

1.17 Fortran: Module Interface diag_oh_mod.F

Module DIAG_OH_MOD contains routines and variables to archive OH mass and air mass concentrations. These are then used to print out the mass-weighted mean OH concentration in 1e5 molec/cm3. This is a metric of how certain chemisry simulations are performing.

INTERFACE:

```
MODULE DIAG_OH_MOD
```

USES:

```
USE PRECISION_MOD    ! For GEOS-Chem Precision (fp)

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)
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
12 Nov 2014 - M. Yannetti - Added PRECISION_MOD
19 Dec 2014 - R. Yantosca - Need to keep some variables as REAL*8
```

1.17.1 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( State_Met, State_Chm )
```

USES:

```
USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_NOCHEMGRID
USE CMN_SIZE_MOD
USE State_Chm_Mod,      ONLY : ChmState
USE State_Met_Mod,      ONLY : MetState
```

INPUT PARAMETERS:

```
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
TYPE(MetState), INTENT(IN)  :: State_Met   ! Meteorology State object
```

REVISION HISTORY:

```
07 Jul 2004 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
19 Dec 2014 - R. Yantosca - Use REAL*8 variables to avoid precision loss
19 Dec 2014 - R. Yantosca - Remove FIRST & XLOSS; they aren't used anymore
18 Dec 2015 - M. Sulprizio- Remove references to CSPEC and get OH directly
                            from State_Chm%Species
21 Dec 2015 - M. Sulprizio- Get air density and box volume directly from
                            State_Met object
23 Jun 2016 - R. Yantosca - Remove references to tracerid_mod.F, now
                            store species ID in module variable id_OH
```

1.17.2 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,
&                   XCH4LOSS, XCH4TROPMASS, XCH4EMIS, XCH4MASS )
```

USES:

INPUT PARAMETERS:

```
INTEGER,  INTENT(IN) :: I            ! Longitude index
INTEGER,  INTENT(IN) :: J            ! Latitude index
INTEGER,  INTENT(IN) :: L            ! Level index
REAL(fp), INTENT(IN) :: XOHMASS      ! OH Mass  (from global_ch4_mod.f)
REAL(fp), INTENT(IN) :: XAIRMASS     ! Air mass (from global_ch4_mod.f)
REAL(fp), INTENT(IN) :: XLOSS        ! Loss of ch3ccl3 by OH
REAL(fp), INTENT(IN) :: XCH4LOSS     ! Loss of ch4 by OH
```

```
REAL(fp), INTENT(IN) :: XCH4MASS      ! CH4 Mass  (from global_ch4_mod.f)
REAL(fp), INTENT(IN) :: XCH4TROPMASS  ! CH4 Mass  (from global_ch4_mod.f)
REAL(fp), INTENT(IN) :: XCH4EMIS      ! CH4 emissions
```

REVISION HISTORY:

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

1.17.3 print_diag_oh

Subroutine PRINT_DIAG_OH prints the mass-weighted OH concentration at the end of a simulation.

INTERFACE:

```
SUBROUTINE PRINT_DIAG_OH( am_I_Root, Input_Opt, RC )
```

USES:

```
USE ErrCode_Mod
USE Input_Opt_Mod,      ONLY : OptInput
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
21 Oct 2003 - R. Yantosca - Initial version
15 Sep 2010 - R. Yantosca - Added ProTeX headers
25 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
25 Jun 2014 - R. Yantosca - Now remove references to tracer_mod.F
08 Jan 2015 - M. Yannetti - Set variables to F8 as needed
```

1.17.4 init_diag_oh

Subroutine INIT_DIAG_OH initializes all module arrays.

INTERFACE:

```
SUBROUTINE INIT_DIAG_OH( am_I_Root, Input_Opt, RC )
```

USES:

```
      USE CMN_SIZE_MOD
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : ALLOC_ERR
      USE ERROR_MOD,          ONLY : ERROR_STOP
      USE Input_Opt_Mod,      ONLY : OptInput
      USE State_Chm_Mod,      ONLY : Ind_
  !INPUT VARIABLES:
      LOGICAL,        INTENT(IN)  :: am_I_Root
      TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

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
    23 Jun 2014 - R. Yantosca - Removed reference to logical_mod.F
    23 Jun 2014 - R. Yantosca - Removed reference to tracer_mod.F
    23 Jun 2016 - R. Yantosca - Now use Ind_() function for species ID's
    23 Jun 2016 - R. Yantosca - Now define species ID for OH in the INIT phase
    23 Jun 2016 - R. Yantosca - Bug fix: exit unless it's a fullchem or CH4 sim
```

1.17.5 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
```

1.18 Fortran: Module Interface gamap_mod.F

Module GAMAP_MOD contains routines to create GAMAP "tracerinfo.dat" and "diaginfo.dat" files which are customized to each particular GEOS-Chem simulation.

INTERFACE:

```
MODULE GAMAP_MOD
```

USES:

```
USE CMN_SIZE_MOD        ! Dimensions of arrays
USE CMN_DIAG_MOD        ! Diagnostic parameters
USE inquireMod,    ONLY : findFreeLUN
USE PRECISION_MOD       ! For GEOS-Chem Precision (fp)

IMPLICIT NONE
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
PUBLIC  :: DO_GAMAP
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: CREATE_DINFO
PRIVATE :: CREATE_TINFO
PRIVATE :: WRITE_TINFO
PRIVATE :: WRITE_SEPARATOR
PRIVATE :: INIT_DIAGINFO
PRIVATE :: INIT_TRACERINFO
PRIVATE :: INIT_GAMAP
PRIVATE :: CLEANUP_GAMAP
```

REMARKS:

```
For more information, please see the GAMAP Online Users' Manual:
 http://acmg.seas.harvard.edu/gamap/doc/index.html
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
(1 ) Minor bug fix for Rn/Pb/Be simulations (bmy, 5/11/05)
(2 ) Added ND09 diagnostic for HCN/CH3CN simulation. (bmy, 6/30/05)
(3 ) Added ND04 diagnostic for CO2 simulation (bmy, 7/25/05)
(4 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(5 ) Add MBO to ND46 diagnostic (tmf, bmy, 10/20/05)
(6 ) Updated for tagged Hg simulation (cdh, bmy, 4/6/06)
(7 ) Updated for ND56 lightning flash diagnostics (ltm, bmy, 5/5/06)
(8 ) Updated for ND42 SOA concentration diagnostics (dkh, bmy, 5/22/06)
(9 ) Updated for ND36 CH3I simulation diagnostics (bmy, 7/25/06)
(10) Remove support for GEOS-1 and GEOS-STRAT met fields (bmy, 8/4/06)
(11) Add routines INIT_DIAGINFO, INIT_TRACERINFO for clarity.  Added new
      entries for biomass burning (ND28) and time in tropopshere (ND54)
      in INIT_DIAGINFO and INIT_TRACERINFO. (phs, bmy, 10/17/06)
(12) Now write GPROD & APROD info to diaginfo.dat, tracerinfo.dat files,
      for the SOA restart files (tmf, havala, bmy, 2/6/07)
(13) Added ND10 diagnostic for H2/HD simulation. (phs, 9/18/07)
```

```
(14) Change category name for ND31 diagnostic (bmy, 11/16/07)
(15) Add to tracerinfo.dat file for timeseries and Rn-Pb-Be (bmy, 2/22/08)
(16) Added ND52 diagnostic for gamma HO2 (jaegle 02/26/09)
(17) Add gamap info for dicarbonyl simulation (tmf, 3/10/09)
(18) Add C2H4 in ND46 (ccc, 3/10/09)
(19) Add EFLUX to ND67 (lin, ccc, 5/29/09)
(20) Minor bug fixes (bmy, phs, 10/9/09)
(20) Minor bug fixes (dkh, bmy, 11/19/09)
(21) Include second satellite overpass diagnostic.  Adjust AOD name to 550
     nm from 400 nm.  Add additional dust AOD bins.  Output values to
     hdf_mod. (amv, bmy, 12/1/09)
(22) Increase MAXTRACER from 120 to 325 (win, 6/25/09)
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
07 Feb 2012 - E. Corbitt  - Added diagnostic info for tagged Hg simulation.
08 Feb 2012 - R. Yantosca - Add modifications for GEOS-5.7.x
01 Aug 2012 - R. Yantosca - Add reference to findFreeLUN from inqure_mod.F90
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
09 Apr 2014 - R. Yantosca - Increase MAXCAT to 160
13 Nov 2014 - M. Yannetti - Added PRECISION_MOD
06 Aug 2015 - J. Fisher   - Add non-reducible snowpack Hg reservoir
                            (orig. 29/11/11)
20 Jun 2016 - R. Yantosca - Now define species ID flags as module variables
                            that are defined only in the INIT phase
```

1.18.1 do_gamap

Subroutine DO_GAMAP is the driver program for creating the customized GAMAP files "diaginfo.dat" and "tracerinfo.dat".

INTERFACE:

```
SUBROUTINE DO_GAMAP( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE ErrCode_Mod
USE Input_Opt_Mod,      ONLY : OptInput
USE State_Chm_Mod,      ONLY : ChmState
USE TIME_MOD,           ONLY : SYSTEM_TIMESTAMP
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
03 Aug 2010 - R. Yantosca - Added ProTeX headers
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
25 Jun 2014 - R. Yantosca - Now get SIM_NAME from Input_Opt
25 Jun 2014 - R. Yantosca - Remove all references to tracer_mod.F
03 Sep 2015 - R. Yantosca - Now get State_Chm as an argument
```

1.18.2 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
```

REVISION HISTORY:

```
03 May 2005 - R. Yantosca - Initial version
03 Aug 2010 - R. Yantosca - Added ProTeX headers
01 Aug 2012 - R. Yantosca - Add reference to findFreeLUN from inqure_mod.F90
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
```

1.18.3 create_tinfo

Subroutine CREATE_TINFO writes information about tracers to a customized tracer-info.dat" file.

INTERFACE:

```
SUBROUTINE CREATE_TINFO( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
      USE ErrCode_Mod
      USE FILE_MOD,           ONLY : IOERROR
      USE Input_Opt_Mod,      ONLY : OptInput
      USE State_Chm_Mod,      ONLY : ChmState
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
      TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
    21 Apr 2005 - R. Yantosca - Initial version
    (1 ) Now write out tracers in ug/m3 (dkh, bmy, 5/22/06)
    (2 ) Now write out GPROD & APROD info (tmf, havala, bmy, 2/6/07)
    08 Dec 2009 - R. Yantosca - Added ProTeX headers
    01 Aug 2012 - R. Yantosca - Add reference to findFreeLUN from inqure_mod.F90
    03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
    31 Oct 2012 - R. Yantosca - Now save out info about soil NOx restart file
    25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
```

1.18.4 write_tinfo

Subroutine WRITE_TINFO writes one line to the customized "tracerinfo.dat" file.

INTERFACE:

```
      SUBROUTINE WRITE_TINFO( IU_FILE, NAME, FNAME,
     &                        MWT, MOLC, SCALE, UNIT, N )
```

USES:

```
      USE FILE_MOD, ONLY : IOERROR
```

INPUT PARAMETERS:

```
      INTEGER,          INTENT(IN) :: IU_FILE ! Logical unit number
      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
```

1.18.5 write_separator

Subroutine WRITE_SEPARATOR writes a separator block to the customized "tracer-info.dat" file.

INTERFACE:

```
SUBROUTINE WRITE_SEPARATOR( IU_FILE, DIAG )
```

USES:

```
USE FILE_MOD, ONLY : IOERROR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: IU_FILE
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
31 Oct 2012 - R. Yantosca - Add write statement for soil NOx restart file
```

1.18.6 init_diaginfo

Subroutine INIT_DIAGINFO initializes the CATEGORY, DESCRIPT, and OFFSET variables, which are used to define the "diaginfo.dat" file for GAMAP.

INTERFACE:

```
SUBROUTINE INIT_DIAGINFO
```

REVISION HISTORY:

```
17 Oct 1996 - R. Yantosca - Initial version
(1 ) Split this code off from INIT_GAMAP, for clarity.  Now declare biomass
      burning emissions w/ offset of 45000.  Now declare time in the
      troposphere diagnostic with offset of 46000. (phs, bmy, 10/17/06)
(2 ) Now add IJ-GPROD & IJ-APROD w/ offset of SPACING*6, for the SOA
      GPROD & APROD restart file. (tmf, havala, bmy, 2/6/07)
```

```
(3 ) Now declare H2-HD sources w/ offset of 48000. Now declare H2-HD
     production/loss w/ offset of 47000. (phs, 9/18/07)
(4 ) Change diagnostic category for ND31 diagnostic from "PS-PTOP"
     to "PEDGE-$" (bmy, 11/16/07)
(5 ) Add categories CH4-LOSS, CH4-EMISS and WET-FRAC (kjw, 8/18/09)
(6 ) Add potential temperature category. (fp, 2/26/10)
21 May 2010 - C. Carouge  - Add diagnostic for mercury simulation
03 Aug 2010 - R. Yantosca - Added ProTeX headers
21 Sep 2010 - R. Yantosca - Remove duplicate definitions of CV-FLX-$,
                            TURBMC-$, EW-FLX-$, NS-FLX-$, UP-FLX-$
21 Oct 2010 - R. Yantosca - Bug fix: MC-FRC-$ should have an offset of
                            SPACING*3 since it has units of kg/s.
31 Oct 2012 - R. Yantosca - Save soil NOx restart quantities as SPACING*60
14 Mar 2013 - M. Payer    - Replace NOx emissions with NO emissions as part
                            of removal of NOx-Ox partitioning
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
03 Sep 2013 - R. Yantosca - Restored PS-PTOP to avoid issues when using
                            diaginfo.dat, tracerinfo.dat w/ REGRIDH_RESTART
30 Jan 2014 - R. Yantosca - Add ND60 TOMAS diagnostic catetories
06 Aug 2015 - J. Fisher   - Add non-reducible snowpack Hg reservoir
                            (orig. 29/11/11)
```

1.18.7 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( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE CMN_DIAG_MOD,       ONLY : PD64
USE CMN_DIAG_MOD,       ONLY : PD72R
USE CMN_FJX_MOD,        ONLY : NSPECRADMENU, STRWVSELECT
USE DIAG03_MOD,         ONLY : ND03, PD03, PD03_PL
USE DIAG04_MOD,         ONLY : ND04
USE DIAG41_MOD,         ONLY : ND41
USE DIAG42_MOD,         ONLY : ND42
USE DIAG48_MOD,         ONLY : DO_SAVE_DIAG48
USE DIAG49_MOD,         ONLY : DO_SAVE_DIAG49
USE DIAG50_MOD,         ONLY : DO_SAVE_DIAG50
USE DIAG51_MOD,         ONLY : DO_SAVE_DIAG51
USE DIAG51b_MOD,        ONLY : DO_SAVE_DIAG51b
USE DIAG53_MOD,         ONLY : ND53, PD53
USE DIAG56_MOD,         ONLY : ND56
```

```
      USE DIAG63_MOD,         ONLY:  DO_SAVE_DIAG63
      USE ErrCode_Mod
      USE Input_Opt_Mod,      ONLY : OptInput
      USE Species_Mod,        ONLY : Species
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
#if   defined( TOMAS )
      USE TOMAS_MOD,          ONLY : IBINS, ICOMP,   IDIAG  !(win, 7/14/09)
#endif
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(ChmState), INTENT(IN)    :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

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)
   (9 ) Add iniformation for ND61 (win, 7/9/09)
   (10) Manually add info for ND44 when TOMAS aerosols dry deposition because
        only numbers are real drydep species while the mass species just
        tag along but we need them to show up in diagnostic too.  Reference
        to TOMAS_MOD and use IDTNK1 from TRACERID_MOD (win, 7/14/09)
   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.
   09-Dec-2010 - H. Amos     - Added RGM and PBM  tracers for the
```

```
                            mercury simulation
09-Dec-2010 - H. Amos     - fix spacing and #s for PL-HG2-$ diagnostics
12 Nov 2010 - R. Yantosca - Need to save out surface pressure line to
                            tracerinfo.dat for the timeseries diagnostics
22 Mar 2011 - C. Friedman - Added POPs
24 Jan 2012 - M. Payer    - Change scale factors for Rn-Pb-Be simulation so
                            units are in mBq/SCM
08 Feb 2012 - R. Yantosca - Treat GEOS-5.7.x in the same way as MERRA
19 Mar 2012 - M. Payer    - Remove ACETdl and ACETgr from ND11 diagnostic.
                            Acetone from dry leaf matter and grasses is now
                            included in the direct emissions (ACETbg).
                            (E. Fischer)
14 Mar 2013 - M. Payer    - Replace NOx and Ox with NO and O3 as part of
                            removal of NOx-Ox partitioning. Removed code for
                            storing pure O3 as N_TRACERS+1.
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
13 Aug 2013 - M. Sulprizio- Add modifications for updated SOA and SOA +
                            semivolatile POA simulations (H. Pye)
04 Sep 2013 - R. Yantosca - Fix ND44 tracer listing
04 Sep 2013 - R. Yantosca - Now also reference everything in tracerid_mod.F
04 Sep 2013 - R. Yantosca - Bug fix: # of ND46 tracers should be 20
26 Sep 2013 - R. Yantosca - Renamed GEOS_57 Cpp switch to GEOS_FP
31 Jan 2014 - R. Yantosca - Now save out tracerinfo.dat properly for TOMAS
25 Apr 2014 - M. Sulprizio- Now include J-values for ACET in ND22
27 May 2014 - M. Sulprizio- Now include J-values for ALD2, MVK, MACR, HAC,
                            and GLYC in ND22
25 Jun 2014 - R. Yantosca - Now pass Input_Opt to GET_FAM_MWT function
15 Dec 2014 - M. Sulprizio- Moved radiation diagnostic from ND71 to ND72 to
                            avoid conflicts with hourly max ppbv diagnostic.
12 Aug 2015 - J. Fisher   - Add cryosphere Hg diagnostics
25 Apr 2016 - R. Yantosca - Now get N_HG_CATS from State_Chm
17 May 2016 - R. Yantosca - Now get MolecRatio from the species database
25 May 2016 - E. Lundgren - Replace Input_Opt%TRACER_MW_KG with converted
                            species database emMW_g (emitted species g/mol)
16 Jun 2016 - E. Lundgren - Remove dependency on tracerid_mod
18 Jul 2016 - M. Sulprizio- Remove special handling of ISOPN and MMN for
                            ND44. Family tracers have been eliminated.
```

1.18.8 init_gamap

Subroutine INIT_GAMAP allocates and initializes all module variables.

INTERFACE:

```
SUBROUTINE INIT_GAMAP( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE ErrCode_Mod
USE ERROR_MOD,     ONLY : ALLOC_ERR
USE HDF_MOD,       ONLY : INIT_HDF
USE HDF_MOD,       ONLY : HDFCATEGORY
USE HDF_MOD,       ONLY : HDFDESCRIPT
USE HDF_MOD,       ONLY : HDFNAME
USE HDF_MOD,       ONLY : HDFFNAME
USE HDF_MOD,       ONLY : HDFUNIT
USE HDF_MOD,       ONLY : HDFMOLC
USE HDF_MOD,       ONLY : HDFMWT
USE HDF_MOD,       ONLY : HDFSCALE
USE Input_Opt_Mod, ONLY : OptInput
USE State_Chm_Mod, ONLY : ChmState
USE State_Chm_Mod, ONLY : Ind_
USE TIME_MOD,      ONLY : EXPAND_DATE, GET_NHMSb, GET_NYMDb
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

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
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
```

1.18.9 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
```

1.18.10 initialize.F

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( am_I_Root, Input_Opt, IFLAG, RC )
```

USES:

```
! Modules from Headers subdirectory
USE CMN_SIZE_MOD
USE CMN_DIAG_MOD
USE ErrCode_Mod
USE Input_Opt_Mod, ONLY : OptInput
USE PRECISION_MOD

! Modules from GeosCore subdirectory
USE DIAG_MOD
USE DIAG03_MOD
USE DIAG04_MOD
USE DIAG41_MOD
USE DIAG42_MOD
USE DIAG53_MOD
USE DIAG56_MOD
USE ERROR_MOD
USE TIME_MOD

IMPLICIT NONE
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object


! 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
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

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 0e+0_fp instead of 0.0.
(3 ) Also zero the mass flux arrays from TPCORE (bmy, 4/26/99)
(4 ) Only zero allocatable arrays that are turned on. (bmy, 11/29/99)
(5 ) Added arrays for ND13 diagnostic -- sulfur emissions.
      Also updated comments (bmy, 6/21/00)
(6 ) Remove SAVEJ and SAVEL -- we don't call DIAG0 anymore (bmy, 9/8/00)
(7 ) Add array AD32_bf for ND32 NOx biofuel diagnostic (bmy, 9/12/00)
(8 ) Also zero the FAMPL array for ND65 (bmy, 12/5/00)
(9 ) Now initialize AD34 array for biofuel emissions (bmy, 3/15/01)
(10) Now initialize AD12 array for boundary layer emissions in "setemis.f".
      Also made cosmetic changes & updated comments. (bdf, bmy, 6/15/01)
(11) Now initialize AD11 array for acetone diagnostic (bmy, 8/1/01)
(12) Remove reference to AVGF -- it is obsolete.  Also, AVGW is now
      included in "dao_mod.f", and is initialized there. (bmy, 9/25/01)
(13) Removed obsolete code from 9/01 (bmy, 10/24/01)
(14) Make sure FAMPL is allocated before we reference it (bmy, 1/15/02)
(15) Eliminated obsolete code from 1/02.  Now also zero CTNO2, CTHO2
      counter arrays. (bmy, 2/27/02)
(16) Bug fix: CTHO2 and CTNO2 should be zeroed if ND43 > 0, not if
      ND45 > 0.  Fix this typo. (bmy, 4/19/02)
(17) Now also zero AD01, AD02 arrays (bmy, 8/7/02)
(18) Remove reference to arrays P, SIG, SIGE from "CMN", since we now
      use floating pressure + the hybrid grid. (dsa, bdf, bmy, 8/21/02)
(19) Now zero the AD05 array for sulfate P-L (rjp, bdf, bmy, 9/20/02)
(20) Now we no longer have to zero the T array.  Also reference ERROR_STOP
      from "error_mod.f". Now also initialize AD13_NH3_an, AD13_NH3_bb,
```

```
      AD13_NH3_bf. (bmy, 12/13/02)
(21) Now also zero AD13_NH3_na array for ND13 (rjp, bmy, 3/23/03)
(22) Now references "time_mod.f" (bmy, 3/27/03)
(23) Now zeroes AD03 array for Kr85 prod/loss diag. (jsw, bmy, 8/20/03)
(24) Now also zeroes AD06 and AD07* arrays (rjp, tdf, bmy, 4/5/04)
(25) Now also zeroes AD08 array (rjp, bec, bmy, 4/20/04)
(26) Now also initialize AD13_SO2_sh array (bec, bmy, 5/20/04)
(27) Now also initialize AD07_HC array (rjp, bmy, 7/13/04)
(28) Now references AD65 & FAM_PL from "diag_pl_mod.f".  Now remove
      reference to DIAGCHLORO, it's obsolete. (bmy, 7/20/04)
(29) Now initialize extra arrays for ND03 mercury diag.  Also remove
      reference to obsolete TOFDY0 variable. (eck, bmy, 12/7/04)
(30) Now initialize AD21_cr array for ND21 diag.  Also references
      LCRYST from "logical_mod.f"  Now call ZERO_DIAG03 from "diag03_mod.f"
      to zero ND03 arrays (bmy, 1/21/05)
(31) Now call ZERO_DIAG41 from "diag41_mod.f".  Also removed references
      to AD41 and AFTTOT. (bmy, 2/17/05)
(32) Now zero AD09 and AD09_em for HCN simulation (xyp, bmy, 6/27/05)
(33) Now references ND04, ZERO_DIAG04 from "diag04_mod.f".  Also remove
      reference to "CMN" and XTRA2.  Now zeroes AD30 array (bmy, 8/18/05)
(34) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(35) Now resets SET_CT_XTRA at the beginning of the run. (tmf, 10/20/05)
(36) Now references ND56, ZERO_DIAG56 from "diag56_mod.f" (ltm, bmy, 5/5/06)
(37) Now references ND42, ZERO_DIAG42 from "diag42_mod.f" (dkh, bmy,5/22/06)
(38) take care of AD54 (time in the troposphere diagnostic) (phs, 10/17/06)
(39) Now also zero CTO3 array.  Bug fix: ZERO_DIAG42 is now called when
      ND42 is turned on. (phs, bmy, 1/30/07)
(40) Now zero AD10 and AD10em for H2HD simulation (phs, 9/18/07)
(41) Now zero CTO3_24h (phs, 11/17/08)
(42) Now zero AD52 for Gamma HO2 diag. (ccc, jaegle, 2/26/09)
(43) Updated to diagnose GLYX production of SOAG in ND07. (tmf, 1/7/09)
(44) Add initialization of counter for diag time steps. (ccc, 7/20/09)
(45) Define new diagnostics, ND19, ND58, ND60 for methane
     (kjw, 8/18/09)
(46) Add ND59 and ND60 for initialization (win, 7/28/09)
(47) Add potential temperature diagnostic. (fp, 06/09)
(48) Add TOMAS diags using ifdefs. (sfarina, 01/13)
25 Aug 2010 - R. Yantosca - Added ProTeX headers
25 Aug 2010 - R. Yantosca - Now also reset the counter for A1 timesteps
08 Feb 2012 - R. Yantosca - Rewrote USE statements, for clarity
08 Feb 2012 - R. Yantosca - Now also reset the counter for I3 timesteps
15 Oct 2012 - R. Yantosca - Bug fix, make sure Counter arrays CTLBRO2H etc.
                            are allocated before we use them
02 Apr 2013 - M. Payer    - Remove code for CTNO, CTNO2, and CTNO3. These
                            are no onger needed because NO, NO2, and NO3
                            are now tracers.
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
08 Nov 2013 - M. Sulprizio- Removed CTO3. It is no longer used because O3
```

```
                              is now a tracer.
   15 Aug 2014 - R. Yantosca - Remove diagnostics now tracked by HEMCO
   17 Sep 2014 - M. Sulprizio- Now initialize AD61 for TOMAS
   14 Nov 2014 - M. Yannetti - Added PRECISION_MOD
   17 Nov 2014 - C. Keller   - Now reset ND45 if IFLAG is set to 2.
   20 Jan 2016 - M. Sulprizio- Remove AD06, AD07, and AD08. These diagnostics
                              are tracked by HEMCO.
```

1.18.11 ndxx_setup.F

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( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
      USE CMN_DIAG_MOD
      USE CMN_SIZE_MOD
      USE DIAG_MOD
      USE DIAG63_MOD,         ONLY : DO_SAVE_DIAG63
      USE DIAG_OH_MOD,        ONLY : INIT_DIAG_OH
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : ALLOC_ERR,   ERROR_STOP
      USE Input_Opt_Mod,      ONLY : OptInput
      USE PLANEFLIGHT_MOD,    ONLY : SETUP_PLANEFLIGHT
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Chm_Mod,      ONLY : Ind_
      USE State_Met_Mod,      ONLY : MetState
#if   defined( TOMAS )
      USE TOMAS_MOD,          ONLY : IBINS, ICOMP, IDIAG   !(win, 7/9/09)
#endif

      IMPLICIT NONE
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)     :: am_I_Root   ! Are we on the root CPU?
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(OptInput), INTENT(INOUT)  :: Input_Opt   ! Input Options object
      TYPE(ChmState), INTENT(INOUT)  :: State_Chm   ! Chemistry state object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)    :: RC          ! Success or failure?
```

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_SO2_sh array for ND13 (bec, bmy, 5/20/04)
(47) Now allocate AD07_HC array for ND07 (rjp, bmy, 7/13/04)
(48) Now references "tracer_mod.f" and "logical_mod.f" instead of "CMN"
```

```
      and "CMN_SETUP".  Now references INIT_DIAG_OH from "diag_oh_mod.f"
      Adjust TRCOFFSET for various aerosol simulations. (bmy, 7/20/04)
(49) Make sure ND21 only goes from 1-LLTROP (bmy, 9/28/04)
(50) Now allocate AD13_SO4_bf array (bmy, 11/17/04)
(51) Now allocate extra arrays for ND03 mercury diag.  Also set up for
      mercury tracers in ND44 diagnostic. (bmy, 12/14/04)
(52) Added separate ND21 array for cryst sulfur tracers.  Now reinstated
      AD03 array for mercury simulation.  Now move ND03 diagnostics into
      a separate module.  Remove TCOBOX reference, it's obsolete.
      (cas, sas, bmy, 1/21/05)
(53) Now remove references to AD41 & AFTTOT.  Now call SETUP_PLANEFLIGHT
      for non-full-chemistry runs in main.f -- this will allow it to look
      for flight files for each day (bmy, 3/24/05)
(54) Now use PD05=10 to dimension AD05 array (bmy, 4/13/05)
(55) Now also allocates AD09 and AD09_em (bmy, 6/27/05)
(56) Now allocates AD30 (bmy, 8/18/05)
(57) Removed duplicate variable declarations (bmy, 2/6/06)
(58) Now remove NBIOTRCE; it's obsolete.  Replace w/ NBIOMAX (bmy, 4/5/06)
(59) Now remove TRCOFFSET; it's obsolete (bmy, 5/16/06)
(60) Added the ND54 for time spend in the troposphere (phs, 10/17/06)
(61) Now allocate ND43 and ND45 counter arrays as 3-D (phs, 1/19/07)
(62) For ND20 diagnostic, reset ND65 diagnostic with LLTROP_FIX instead of
      LLTROP.  Added ND10 diagnostic setup.  Added modifications for H2-HD
      simulation. (phs, bmy, 9/18/07)
(63) Now save true pressure edges for ND31 diagnostic (bmy, 11/16/07)
(64) Now stop the run if ND20 is defined but ND65 isn't (bmy, 12/4/07)
(65) Allocate CTO3_24h (phs, 11/18/08)
(66) We don't need to set LD65=1 here anymore, we now call NDXX_SETUP!
      after DIAG_PL_MOD. (phs, bmy, 12/18/08)
(67) Added ND52 for GAMMA HO2 diagnostic. (ccc, jaegle, 2/26/09)
(68) Add AD07_SOAGM (tmf, 1/7/09)
(67) Added ND52 for GAMMA HO2 diagnostic. (ccc, jaegle, 2/26/09)
(68) Add AD07_SOAGM (tmf, 1/7/09)
(69) Now always allocate Mass Flux arrays (phs, 4/15/09)
(70) Allocate LTO3. (ccc, 7/20/09)
(71) Add AD19, AD58, AD60 (kjw, 8/18/09)
(72) Now AD13_SO2_an and AD13_SO4_an have NOXLEVELS levels to accomodate
   NEI 2005 (amv, 10/9/09)
(73) AD13_NH3_an is 3D now (phs, 10/22/09)
(74) Add new diagnostic ND59, ND60, ND61 (win, 7/9/09)
(75) Increase size for AD44 for TOMAS aerosol mass (win, 7/14/09)
(76) Initialize values for LD59, LD60, and LD61 (win, 8/10/09)
(77) NBIOMAX is now in CMN_SIZE. (fp, 2/26/10)
26 Aug 2010 - R. Yantosca - Added ProTeX headers
16 Feb 2011 - R. Yantosca - Add modifications for APM from G. Luo
09 Nov 2012 - R. Yantosca - Added GIGC-specific modifications
29 Mar 2013 - R. Yantosca - Pass objects to GET_WETDEP_NMAX
02 Apr 2013 - M. Payer    - Remove allocation of *NO, *NO2, and *NO3 arrays
```

```
                            for ND43. These are no longer needed because NO,
                            NO2, and NO3 are now tracers.
13 Aug 2013 - M. Sulprizio- Modify AD07_HC for updated SOA (H. Pye)
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
12 Sep 2013 - M. Sulprizio- Modify AD06 to include dust alkalinity tracers
                            (T.D. Fairlie)
08 Nov 2013 - M. Sulprizio- Removed CTO3 and LTO3. They are no longer used
                            because O3 is now a tracer.
15 Aug 2014 - R. Yantosca - Removed reference to biofuel_mod.F
15 Aug 2014 - R. Yantosca - Now reference all arrays in diag_mod.F
22 May 2015 - R. Yantosca - Removed variables made obsolete by HEMCO
03 Sep 2015 - R. Yantosca - Now pass State_Chm to this routine so that
                            we can take advantage of the species database
20 Jan 2016 - M. Sulprizio- Remove code to allocate the AD06, AD07, and AD08
                            arrays. These diagnostics are tracked by HEMCO.
23 Jun 2016 - R. Yantosca - Remove references to APM code; it is no longer
                            compatible with the FlexChem implementation
20 Jul 2016 - R. Yantosca - Remove references to NNPAR (now use nAdvect)
20 Sep 2016 - R. Yantosca - Bug fix for Gfortran: Make sure the IT_IS_*
                            variables are declared as LOGICAL, not INTEGER
 3 Oct 2016 - R. Yantosca - Bug fix: don't allocate ND71 scalar variables
```

1.18.12 ohsave.F

Subroutine OHSAVE stores the concentrations of OH and HO2 for the ND43 diagnostic.

INTERFACE:

```
SUBROUTINE OHSAVE( State_Met, State_Chm )
```

USES:

```
USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_NOCHEMGRID
USE CMN_O3_MOD,         ONLY : SAVEOH, SAVEHO2, SAVEO1D, SAVEO3P
USE CMN_SIZE_MOD
USE State_Chm_Mod,      ONLY : ChmState
USE State_Chm_Mod,      ONLY : Ind_
USE State_Met_Mod,      ONLY : MetState
USE PRECISION_MOD            ! For GEOS-Chem Precision (fp)

IMPLICIT NONE
```

INPUT PARAMETERS:

```
TYPE(ChmState), INTENT(IN) :: State_Chm   ! Chemistry State object
TYPE(MetState), INTENT(IN) :: State_Met   ! Meteorology State object
```

REVISION HISTORY:

```
27 Feb 2002 - R. Yantosca - Initial version
(1 ) Original code from lwh, gmg, djj, jyl, etc, 1990's.  Modified for
     GEOS-CHEM by Bob Yantosca et al.
(2 ) Added comment header and F90 declaration syntax.  Also now specify
     the units of each variable for clarity.
(3 ) Deleted NTRACER, it is not used.  Also added FRACNO2 and SAVEHO2
     variables.  Updated comments, cosmetic changes (rvm, bmy, 2/27/02)
(4 ) Bug fix: swap the order of the lines where TMPNOX is computed.
     Also deleted obsolete code from 2/02. (bmy, 7/31/02)
(5 ) Now reference IDTOX, IDTNOX, etc from "tracerid_mod.f". (1/13/03)
(6 ) Added OpenMP parallelization commands (bmy, 8/1/03)
(7 ) Now compute quantities for mean OH in "diag_oh_mod.f".  Now also
     references STT from "tracer_mod.f".  Added N_TRACERS to the arg list.
     Now dimension args XNUMOL, STT w/ N_TRACERS and not NNPAR.
     (bmy, 7/20/04)
(8 ) Now make sure all USE statements are USE, ONLY (bmy, 10/3/05)
(9 ) Reset FRAC* and SAVE* arrays, so that we don't carry dubious data
     over from boxes that used to be in the tropopause but aren't anymore.
     (phs, 1/19/07)
15 Sep 2010 - R. Yantosca - Added ProTeX headers
14 Mar 2013 - M. Payer    - FRACO3, FRACNO, and FRACNO2 are no longer needed
                            because O3, NO, and NO2 are now tracers.
29 Mar 2013 - M. Payer    - Removed SAVENO, SAVENO2, SAVENO3.
31 May 2013 - R. Yantosca - Extra cleanup, remove N_TRACERS, XNUMOL, STT
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
17 Nov 2014 - M. Yannetti - Added PRECISION_MOD
21 Dec 2015 - M. Sulprizio- Get air density directly from State_Met object
16 Jun 2016 - J. Sheng    - Add index retriever
20 Jun 2016 - R. Yantosca - Now only define species ID's on the first call
20 Jun 2016 - R. Yantosca - Add checks to prevent array-OOB errors
```

1.19 Fortran: Module Interface planeflight_mod.F

Module PLANEFLIGHT_MOD contains variables and routines which are used to "fly" a plane through the GEOS-Chem model simulation. This is useful for comparing model results with aircraft observations.

INTERFACE:

```
MODULE PLANEFLIGHT_MOD
```

USES:

```
USE inquireMod,    ONLY : findFreeLUN
USE PRECISION_MOD       ! For GEOS-Chem Precision (fp)

IMPLICIT NONE
PRIVATE
```

PUBLIC MEMBER FUNCTIONS:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
 Prior to 5/12/16:
 This routine does not work with the FlexChem implementation. We need to
 rewrite this code to get the necessary information from KPP (mps, 5/12/16)
      PUBLIC  :: ARCHIVE_RXNS_FOR_PF
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
     PUBLIC  :: CLEANUP_PLANEFLIGHT
     PUBLIC  :: PLANEFLIGHT
     PUBLIC  :: SETUP_PLANEFLIGHT
     PUBLIC  :: SET_PLANEFLIGHT
```

PRIVATE MEMBER FUNCTIONS:

```
PRIVATE :: AN_SETUP
PRIVATE :: INIT_PLANEFLIGHT
PRIVATE :: NOY_SETUP
PRIVATE :: READ_VARIABLES
PRIVATE :: READ_POINTS
PRIVATE :: RO2_SETUP
PRIVATE :: TEST_VALID
PRIVATE :: WRITE_VARS_TO_FILE
```

REMARKS:

```
The quantities that are saved to disk by the planeflight diagnostic were
requested by GEOS-Chem users.  If you would like to save out a new quantity,
then you will have to make your own modifications in this module.
```

REVISION HISTORY:

```
(1 ) Now references "pressure_mod.f" (dsa, bdf, bmy, 8/21/02)
(2 ) Now reference AD from "dao_mod.f".  Now also references "error_mod.f".
      (bmy, 10/15/02)
(3 ) Bug fix: replace missing commas in FORMAT statement (bmy, 3/23/03)
(4 ) Now references "time_mod.f". (bmy, 3/27/03)
(5 ) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
(6 ) Bug fix: use NAMEGAS instead of NAMESPEC (lyj, bmy, 7/9/03)
(7 ) Bug fix: avoid referencing JLOP for non-SMVGEAR runs (bmy, 7/18/03)
(8 ) Bug fix: Use T instead of T3 for GMAO temperature.  Also replace
      NAMESPEC w/ NAMEGAS in RO2_SETUP.  Now locate reordered rxn
      numbers for SMVGEAR II.(tdf, mje, bmy, 8/1/03)
(9 ) Now print out N2O5 hydrolysis rxn as a special case.   Also rename
      output file. (bmy, 8/8/03)
(10) Changed "DAO" to "GMAO" for met field variable names.  Now can save
      aerosol optical depths.  Bug fix in TEST_VALID. (bmy, 4/23/03)
(11) Now references "tracer_mod.f" (bmy, 7/20/04)
(12) Bug fix in READ_VARIABLES (1/7/05)
(13) Modified the plane flight diagnostic so that it writes output files
      for each day where flight track files are defined. (bmy, 3/24/05)
```

```
(14) Minor bug fix in ARCHIVE_RXNS_FOR_PF (bmy, 5/20/05)
(15) Now split AOD's into column AOD's and AOD's below plane.  Also scale
     AOD's to 400nm. (bmy, 10/25/05)
(16) Bug fixes in READ_VARIABLES (bmy, 10/16/06)
(17) Bug fix in PLANEFLIGHT (cdh, bmy, 12/12/06)
(18) Bug fix in RO2_SETUP (tmf, bmy, 4/23/07)
(19) Set very small values to zero.  (tmf, 1/7/09)
(20) Add new RO2 species according to 'globchem.dat' (tmf, 1/7/09)
(21) Make sure we have 3 spaces in the exponential format (phs, 7/13/09)
(22) Output the grid cell indexes (kjw, 8/18/09)
(23) Add AN and NOy species. (fp, 3/10/10)
(24) Now scale AODs to wavelength specified in jv_spec_aod.dat(clh, 5/14/09)
29 Jul 2011 - R. Yantosca - Now also archive MERRA SEAICExx fields
29 Jul 2011 - R. Yantosca - Added ProTeX headers
03 Aug 2012 - R. Yantosca - Move calls to findFreeLUN out of DEVEL block
20 Aug 2013 - R. Yantosca - Removed "define.h", this is now obsolete
19 Nov 2014 - M. Yannetti - Added PRECISION_MOD
29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90
```

1.19.1 setup_planeflight

Subroutine SETUP_PLANEFLIGHT reads information from the input file in order to initialize the planeflight diagnostic. Also calls INIT_PLANEFLIGHT to allocate and zero module arrays.

INTERFACE:

```
SUBROUTINE SETUP_PLANEFLIGHT( am_I_Root, Input_Opt, State_Chm,
&                             RC )
```

USES:

```
USE ErrCode_Mod
USE FILE_MOD,           ONLY : FILE_EXISTS
USE FILE_MOD,           ONLY : IOERROR
USE Input_Opt_Mod,      ONLY : OptInput
USE State_Chm_Mod,      ONLY : ChmState
USE TIME_MOD,           ONLY : EXPAND_DATE
USE TIME_MOD,           ONLY : GET_NYMD
USE TIME_MOD,           ONLY : GET_NHMS
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Is this the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REMARKS:

REVISION HISTORY:

```
30 Jul 2002 - M. Evans    - Initial version
(1 ) Rename from "plane.dat" to "plane.log", since "*.dat" implies an input
     file name. (bmy, 8/8/03)
(2 ) Add fancy output string (bmy, 4/26/04)
(3 ) Now references GET_NYMD, GET_NHMS, and EXPAND_DATE from "time_mod.f".
     Now also replaces date & time tokens in the filenames. (bmy, 7/20/04)
(4 ) Now references FILE_EXISTS from "file_mod.f".  Modified so that we
     check if a flight track file exists on each day.  Open file for
     output on each day and write header. (bmy, 3/25/05)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
30 Jul 2012 - R. Yantosca - Now accept am_I_Root as an argument when
                            running with the traditional driver main.F
06 Aug 2012 - R. Yantosca - Now use local IU_PLANE and not from file_mod.F
07 Aug 2012 - R. Yantosca - Now print LUN used to open file
25 Jun 2014 - R. Yantosca - Now accept Input_Opt & RC via the arg list
25 Jun 2014 - R. Yantosca - Now remove references to tracer_mod.F
```

1.19.2 read_variables

Subroutine READ_VARIABLES reads the list of variables (chemical species, rxn rates, GMAO met fields, or GEOS-Chem species) to be printed out and sorts the information into the appropriate module variables.

INTERFACE:

```
SUBROUTINE READ_VARIABLES( am_I_Root, Input_Opt, State_Chm,
&                          IU_FILE,   RC )
```

USES:

```
USE CMN_SIZE_MOD                  ! Size parameters
USE ErrCode_Mod
USE ERROR_MOD,  ONLY : GEOS_CHEM_STOP
USE FILE_MOD,   ONLY : IOERROR
USE Input_Opt_Mod,      ONLY : OptInput
USE Species_Mod,        ONLY : Species
USE State_Chm_Mod,      ONLY : ChmState
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root  ! Is this the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt  ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm  ! Chemistry State object
INTEGER,        INTENT(IN)  :: IU_FILE    ! Logical unit # for ASCII read
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC         ! Success or failure?
```

REVISION HISTORY:

```
30 Jul 2002 - M. Evans    - Initial version
(1 ) Now references GEOS_CHEM_STOP from "error_mod.f", which frees all
     allocated memory before stopping the run. (bmy, 10/15/02)
(2 ) Bug fix: replace missing commas in FORMAT statement (bmy, 3/23/03)
(3 ) Bug fix: replace NAMESPEC w/ NAMEGAS for SMVGEAR II (lyj, bmy, 7/9/09)
(4 ) Now locate reordered rxn numbers for SMVGEAR II. (mje, bmy, 8/1/03)
(5 ) Now flag N2O5 hydrolysis rxn as a special case (bmy, 8/8/03)
(6 ) Changed variable name prefix "DAO" to "GMAO".  Also added aerosol
     optical depths w/ tracer offset 2000. (bmy, 4/23/04)
(7 ) Now references N_TRACERS & ITS_A_FULLCHEM_SIM from "tracer_mod.f"
     (bmy, 7/20/04)
(8 ) Bug fix: extract tracer # when reading rxn rates (bmy, 1/7/05)
(9 ) Now computes column AOD's and AOD's below plane (bmy, 10/24/05)
(10) We need to trim NAMEGAS before comparing to LINE so that comparisons
     for species like "O3" will work.  Also set NCS=NCSURBAN at the top
     of the subroutine, to avoid out of bounds error. (dbm, bmy, 10/16/06)
(11) Add tracer TMS_?? for TOMAS microphysics rate diagnostic (win, 7/28/09)
29 Jul 2011 - R. Yantosca - Also search for MERRA SEAICExx met fields
29 Jul 2011 - R. Yantosca - Added ProTeX headers
30 Jul 2012 - R. Yantosca - Now accept am_I_Root as an argument when
                            running with the traditional driver main.F
25 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
20 Jun 2016 - M. Sulprizio- Replace NTSPEC with State_Chm%nSpecies and
                            NAMEGAS with SpcInfo%Name from species database
```

1.19.3 read_points

Subroutine READ_POINTS reads the information (ID, date, time, lat, lon, pressure) for each measurement listed in the input file, and sorts these into the appropriate module variables.

INTERFACE:

```
SUBROUTINE READ_POINTS( am_I_Root, Input_Opt, IU_FILE, RC )
```

USES:

```
USE BPCH2_MOD,          ONLY : GET_TAU0
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : GEOS_CHEM_STOP
USE FILE_MOD,           ONLY : IOERROR
USE Input_Opt_Mod,      ONLY : OptInput
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Is this the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
INTEGER,        INTENT(IN)  :: IU_FILE     ! Logical unit # of file
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
30 Jul 2002 - M. Evans    - Initial version
(1 ) Now references GEOS_CHEM_STOP from "error_mod.f", which frees all
     allocated memory before stopping the run. (bmy, 10/15/02)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
30 Jul 2012 - R. Yantosca - Now accept am_I_Root as an argument when
                            running with the traditional driver main.F
```

1.19.4 ro2_setup

Subroutine RO2_SETUP saves the species indices of RO2 constituents in the PRO2 array. Also computes the count NPRO2.

INTERFACE:

```
SUBROUTINE RO2_SETUP( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE CMN_SIZE_MOD
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : GEOS_CHEM_STOP
USE Input_Opt_Mod,      ONLY : OptInput
USE Species_Mod,        ONLY : Species
USE State_Chm_Mod,      ONLY : ChmState
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
01 Aug 2003 - M. Evans    - Initial version
(1 ) Now references GEOS_CHEM_STOP from "error_mod.f", which frees all
     allocated memory before stopping the run. (bmy, 10/15/02)
(2 ) Now replace NAMESPEC w/ NAMEGAS for SMVGEAR II (bmy, 8/1/03)
(3 ) Now references ITS_A_FULLCHEM_SIM from "tracer_mod.f" (bmy, 7/20/04)
(4 ) Bug fix: PO3 should be PO2 (tmf, bmy, 4/23/07)
(5 ) NOTE: PO3 was a bug, that should have been PO2 (tmf, 2/10/09)
(6 ) Add new RO2 species according to 'globchem.dat' (tmf, 3/10/09)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
25 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
25 Jun 2014 - R. Yantosca - Removed references to tracer_mod.F
20 Jun 2016 - M. Sulprizio- Replace NTSPEC with State_Chm%nSpecies and
                            NAMEGAS with SpcInfo%Name from species database
```

1.19.5 noy_setup

Subroutine NOY_SETUP saves the species indices of NOy constituents in the PNOY array. Also computes the count NPNOY.

INTERFACE:

```
SUBROUTINE NOY_SETUP( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE CMN_SIZE_MOD
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : GEOS_CHEM_STOP
USE Input_Opt_Mod,      ONLY : OptInput
USE Species_Mod,        ONLY : Species
USE State_Chm_Mod,      ONLY : ChmState
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
01 Jun 2009 - F. Paulot   - Initial version
29 Jul 2011 - R. Yantosca - Added ProTeX headers
25 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
25 Jun 2014 - R. Yantosca - Removed references to tracer_mod.F
20 Jun 2016 - M. Sulprizio- Replace NTSPEC with State_Chm%nSpecies and
                            NAMEGAS with SpcInfo%Name from species database
```

1.19.6 an_setup

Subroutine AN_SETUP saves the species indices of AN constituents in the P_AN array. Also computes the count NPAN.

INTERFACE:

```
SUBROUTINE AN_SETUP( am_I_Root, Input_Opt, State_Chm, RC )
```

USES:

```
USE CMN_SIZE_MOD
USE ErrCode_Mod
USE ERROR_MOD,          ONLY : GEOS_CHEM_STOP
USE Input_Opt_Mod,      ONLY : OptInput
USE Species_Mod,        ONLY : Species
USE State_Chm_Mod,      ONLY : ChmState
```

INPUT PARAMETERS:

```
LOGICAL,        INTENT(IN)  :: am_I_Root   ! Are we on the root CPU?
TYPE(OptInput), INTENT(IN)  :: Input_Opt   ! Input Options object
TYPE(ChmState), INTENT(IN)  :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
INTEGER,        INTENT(OUT) :: RC          ! Success or failure?
```

REVISION HISTORY:

```
01 Jun 2009 - F. Paulot   - Initial version
29 Jul 2011 - R. Yantosca - Added ProTeX headers
25 Jun 2014 - R. Yantosca - Now accept am_I_Root, Input_Opt, RC
25 Jun 2014 - R. Yantosca - Removed references to tracer_mod.F
20 Jun 2016 - M. Sulprizio- Replace NTSPEC with State_Chm%nSpecies and
                            NAMEGAS with SpcInfo%Name from species database
```

1.19.7 planeflight

Subroutine PLANEFLIGHT saves concentrations to disk at locations corresponding to a flight track.

INTERFACE:

```
SUBROUTINE PLANEFLIGHT( am_I_Root, Input_Opt,
&                       State_Met, State_Chm, RC )
```

USES:

```
      USE BPCH2_MOD,          ONLY : GET_TAU0
      USE CHEMGRID_MOD,       ONLY : ITS_IN_THE_CHEMGRID
      USE CMN_DIAG_MOD,       ONLY : NDUST, NAER
      USE CMN_FJX_MOD,        ONLY : ODAER, QAA, QAA_AOD, ODMDUST
      USE CMN_FJX_MOD,        ONLY : IWVSELECT, ACOEF_WV, BCOEF_WV
      USE CMN_SIZE_MOD
#if   defined( TOMAS )
      USE DIAG_MOD,           ONLY : AD61_INST   ! (win, 7/28/09)
#endif
      USE ErrCode_Mod
      USE ERROR_MOD,          ONLY : GEOS_CHEM_STOP
      USE Input_Opt_Mod,      ONLY : OptInput
      USE OCEAN_MERCURY_MOD,  ONLY : Fg !eds 10/27/11
      USE OCEAN_MERCURY_MOD,  ONLY : OMMFp => Fp
      USE PhysConstants,      ONLY : CONSVAP, AIRMW
      USE State_Chm_Mod,      ONLY : ChmState
      USE State_Met_Mod,      ONLY : MetState
      USE TIME_MOD
```

INPUT PARAMETERS:

```
      LOGICAL,        INTENT(IN)    :: am_I_Root   ! Are we on the root CPU?
      TYPE(OptInput), INTENT(IN)    :: Input_Opt   ! Input Options object
      TYPE(MetState), INTENT(IN)    :: State_Met   ! Meteorology State object
```

INPUT/OUTPUT PARAMETERS:

```
      TYPE(ChmState), INTENT(INOUT) :: State_Chm   ! Chemistry State object
```

OUTPUT PARAMETERS:

```
      INTEGER,        INTENT(OUT)   :: RC          ! Success or failure?
```

REVISION HISTORY:

```
    08 Jul 2002 - M. Evans    - Initial version
    (1 ) Now reference AD from "dao_mod.f".  Now references GEOS_CHEM_STOP from
         "error_mod.f", which frees memory before stopping. (bmy, 10/15/02)
    (2 ) Now uses functions GET_TAU, GET_TS_CHEM from "time_mod.f".
         (bmy, 3/27/03)
    (3 ) Updated comments, cosmetic changes (bmy, 7/18/03)
    (4 ) Now references T from "dao_mod.f", so that we can save out temperature
         for non-SMVGEAR runs. (bmy, 8/1/03)
    (5 ) Now references UWND and VWND from "dao_mod.f".  Now references
         GET_PEDGE from "pressure_mod.f".  Added CASEs for surface pressure,
         UWND, VWND to the CASE statement (bmy, 4/23/04)
    (6 ) Now references STT & TCVV from "tracer_mod.f" (bmy, 7/20/04)
    (7 ) Now return if DO_PF = .FALSE. (bmy, 3/24/05)
    (8 ) Now compute column AOD's and AOD's below plane.  Also now scale
         AOD's to 400nm. (bmy, 10/24/05)
    (9 ) Bug fix: exit if PTAU(M) == PTAUE, so that we write out on the next !
```

```
      planeflight timestep (cdh, bmy, 12/12/06)
(10) Change planeflight output time step. (ccc, 8/27/09)
(11) Add case matching for TOMAS rates (win, 7/28/09)
(12) Modify PTAUE calculation w/ ref to GET_TS_DYN  (win, 7/28/09)
(13) Now scale AOD's to jv_spec_aod.dat wavelength. (clh, 5/14/09)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
09 Feb 2012 - R. Yantosca - Treat GEOS-5.7.x in the same way as MERRA
09 Nov 2012 - M. Payer    - Replaced all met field arrays with State_Met
                            derived type object
25 Mar 2013 - R. Yantosca - Now accept am_I_Root, Input_Opt, State_Chm, RC
26 Sep 2013 - R. Yantosca - Renamed GEOS_57 Cpp switch to GEOS_FP
19 Nov 2014 - M. Yannetti - Edited OCEAN_MERCURY_MOD Fp to OMMFP
12 Jan 2015 - L. Schiferl - Allow for more precision in TAUE computation
26 Feb 2015 - E. Lundgren - Replace GET_PEDGE with State_Met%PEDGE.
                            Remove dependency on pressure_mod.
25 Mar 2015 - E. Lundgren - Change tracer units from kg to kg/kg
12 Aug 2015 - R. Yantosca - Add support for MERRA2 meteorology
21 Dec 2015 - M. Sulprizio- Get air density directly from State_Met object
22 Dec 2015 - M. Sulprizio- Replace CSPEC with State_Chm%Species
21 Apr 2016 - M. Sulprizio- Get CONSVAP from PhysConstants instead of
                            computing locally
17 May 2016 - M. Sulprizio- Remove PCHEM, IJLOOP and use IS_FULLCHEM instead
22 Jun 2016 - M. Yannetti - Replaced references to TCVV with spec db
```

1.19.8 test_valid

Subroutine TEST_VALID tests to see if we are w/in the tropopause, which is where chemistry is done.

INTERFACE:

```
SUBROUTINE TEST_VALID( IND, I, J, L, Input_Opt, State_Met )
```

USES:

```
USE CMN_SIZE_MOD
USE GC_GRID_MOD,        ONLY : GET_XOFFSET
USE GC_GRID_MOD,        ONLY : GET_YOFFSET
USE Input_Opt_Mod,      ONLY : OptInput
USE State_Met_Mod,      ONLY : MetState
```

INPUT PARAMETERS:

```
INTEGER,        INTENT(IN) :: IND         ! # of the flight track point
TYPE(OptInput), INTENT(IN) :: Input_Opt   ! Input Options object
TYPE(MetState), INTENT(IN) :: State_Met   ! Meteorology State object
```

OUTPUT PARAMETERS:

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

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) Now use GET_PEDGE of "pressure_mod.f" to return the pressure at the
     bottom edge of box (I,J,L), for hybrid grid. (dsa, bdf, bmy, 8/21/02)
(2 ) Since JLOP is not allocated for non-SMVGEAR runs, set PCHEM=F and
     JLOOP=0 even if we are in the troposphere. (bmy, 7/18/03)
(3 ) Bug fix: add 0.5 in expression for I so that the rounding will
     be done correctly.  Also make sure that I is computed correctly
for points near the date line.  (bmy, 4/23/04)
(4 ) Now references ITS_A_FULLCHEM_SIM from "tracer_mod.f" (bmy, 7/20/04)
(5 ) Now references ITS_IN_THE_TROP from "tropopause_mod.f" (bmy, 8/22/05)
(6 ) Reference GET_XOFFSET and GET_YOFFSET from "grid_mod.f" and also
     add for the case of nested-grid simulation (win, 7/28/09)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
08 Sep 2011 - L. Schiferl - Added correct definitions for I and J
                            based on nested regions
26 Feb 2015 - E. Lundgren - Replace GET_PEDGE with State_Met%PEDGE.
                            Remove dependency on pressure_mod.
17 May 2016 - M. Sulprizio- Remove PCHEM and JLOOP arguments
```

1.19.9 write_vars_to_file

Subroutine WRITE_VARS_TO_FILE writes the values of all the variables for a given flight track point to the output file.

INTERFACE:

```
SUBROUTINE WRITE_VARS_TO_FILE( IND, VARI )
```

USES:

```
USE FILE_MOD, ONLY : IOERROR
```

INPUT PARAMETERS:

```
INTEGER, INTENT(IN) :: IND           ! # of the flight track point
REAL(fp),  INTENT(IN) :: VARI(NPVAR)   ! Values to print to file
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) The max line length for output seems to be 1024 characters.  Adjust
     MAXVARS accordingly so that we don't exceed this. (bmy, 7/8/02)
```

```
(2 ) Now do not write file header -- this is now done in subroutine
     SETUP_PLANEFLIGHT at the start of each day (bmy, 3/25/05)
(3 ) Bug fix: make sure we have 3 spaces in exponential (phs, 7/13/09)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.19.10 set_planeflight

Subroutine SET_PLANEFLIGHT is used to pass values read in from the GEOS-Chem input file to "planeflight_mod.f".

INTERFACE:

```
SUBROUTINE SET_PLANEFLIGHT( PF, IN_FILE, OUT_FILE )
```

INPUT PARAMETERS:

```
LOGICAL,            INTENT(IN) :: PF         ! Turn on planeflight diag?
CHARACTER(LEN=255), INTENT(IN) :: IN_FILE    ! Input file to read
CHARACTER(LEN=255), INTENT(IN) :: OUT_FILE   ! Output file to write
```

REVISION HISTORY:

```
20 Jul 2004 - R. Yantosca - Initial version
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```

1.19.11 init_planeflight

Subroutine INIT_PLANEFLIGHT reads the input file to compute the number of variables and flight track points to print out. Also allocates all module arrays.

INTERFACE:

```
SUBROUTINE INIT_PLANEFLIGHT( am_I_Root )
```

USES:

```
USE CMN_SIZE_MOD    ! Size Parameters
USE ERROR_MOD, ONLY : ALLOC_ERR
USE ERROR_MOD, ONLY : GEOS_CHEM_STOP
USE FILE_MOD,  ONLY : IOERROR
```

INPUT PARAMETERS:

```
LOGICAL, INTENT(IN) :: am_I_Root   ! Is this the root CPU?
```

REVISION HISTORY:

```
08 Jul 2002 - M. Evans    - Initial version
(1 ) Now reference GEOS_CHEM_STOP from "error_mod.f", which frees all
      allocated memory before stopping the run.  Also reference ALLOC_ERR
      from "error_mod.f" (bmy, 10/15/02)
(2 ) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
(3 ) INIT_PLANEFLIGHT is now called each day but the arrays are only
      allocated once.  Arrays are now allocated to the maximum size.
      (bmy, 3/25/05)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
30 Jul 2012 - R. Yantosca - Now accept am_I_Root as an argument when
                            running with the traditional driver main.F
20 Jun 2016 - M. Sulprizio- Change PRRATE array dimensions from
                            (ITLOOP,NPREAC) to (IIPAR,JJPAR,LLPAR,NPREAC)
```

1.19.12 cleanup_planeflight

Subroutine CLEANUP_PLANEFLIGHT deallocates all allocatable module arrays.

INTERFACE:

```
SUBROUTINE CLEANUP_PLANEFLIGHT
```

REVISION HISTORY:

```
01 Jul 2001 - M. Evans    - Initial version
(1 ) Renamed PRATE to PRRATE to avoid conflict w/ SMVGEAR II (bmy, 4/1/03)
29 Jul 2011 - R. Yantosca - Added ProTeX headers
```