GEOS-Chem Reference
5. Makefiles

GEOS-Chem Support Team

20 Dec 2016

Contents

1 Routine/Function Prologues

1.1 Module Interface Makefile (Main-level)

This is a "router" makefile. It calls the main GEOS-Chem Makefile (in the GeosCore sub-directory) to direct the Unix "make" utility how to build the GEOS-Chem source code.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
GEOSDIR    Specifies the directory where GEOS-Chem "core" routines are found
GTMM       Specifies the directory where the GTMM routines are found
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 24 Nov 2009 - R. Yantosca - Now call libbpch and libcore targets in
                             the Makefile in the GeosCore sub-directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 25 Jan 2010 - R. Yantosca - Added Makefile targets for TOMAS microphysics
 16 Feb 2011 - R. Yantosca - Added Makefile targets for APM microphysics
 04 Nov 2011 - R. Yantosca - Remove ESMF targets, those are not needed
 24 Jan 2012 - R. Yantosca - Also add libnc target to build netCDF utils
 11 May 2012 - R. Yantosca - Now make sure that all targets of the
                             GeosCore/Makefile are pointed to properly
 20 Aug 2013 - R. Yantosca - Make sure Makefile names are consistent
 18 Sep 2013 - R. Yantosca - Remove GeosTomas, that is now gone
 18 Sep 2013 - M. Long     - Add Makefile target "hpc"
 15 Jan 2014 - R. Yantosca - Updated comments
 19 Mar 2014 - R. Yantosca - Add more visible comment section dividers
 04 Jun 2015 - R. Yantosca - Now add "wipeout" and "debug" targets
 23 Jun 2016 - R. Yantosca - Remove references to GeosApm
```

1.1.1 Makefile_header.mk

This sub-makefile defines the variables which specify compilation options for the different supported compiler/platform combinations. Also, the default makefile compilation rules are specified here.

REMARKS:

```
To build the programs, call "make" with the following syntax:

.

  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
To display a complete list of options, type "make help".

.

The following variables are exported to the main-level Makefile:

.

Variable   Description
--------   -----------
CC         Contains the default C compilation commands (for PGI only)
F90        Contains the Fortran compilation commands
FREEFORM   Contains the command to force F90 "free format" compilation
LD         Contains the command to link to libraries & make executable
LINK       Contains the commands to link to GEOS-Chem built libraries
R8         Contains the command to force REAL -> REAL*8
SHELL      Contains the default Unix shell to use when building code
NCL        Contains the default netCDF library link commands

.

FFLAGS is a local variable that is not returned to the "outside world",
but is only used locally.  COMPILER, HDF5, and OMP are all input via the
command line or via environment variables.

.

NOTE: We now use SHELL :=/bin/bash as the default Unix shell.  This allows
us to extend the Makefile ifeq statements so that we can test for more than
one string.  The following example is used to ensure that the met field name
selected by the user is case-insensitive:

  # %%%%% GEOS-5 %%%%%
  REGEXP    :=((^[Gg][Ee][Oo][Ss])?5|.5)
  ifeq ($(shell [[ "$(MET)" =~ $(REGEXP) ]] && echo true),true)
  USER_DEFS += -DGEOS_5
  endif

.

The [[ ]] in bash is an evaluation.  The above ifeq statement uses regular
expressions to test if the MET variable matches the string "GEOS" (case-
insensitive) and either "5" or "any character and then a 5".  This will
return true (via the "echo true" statement) for combinations like "GEOS-5",
"geos5", "Geos-5", "GeOs.5", etc.  This is a robust way of evaluating
the user's input, and will make errors less likely.
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 22 Sep 2009 - R. Yantosca - Bug fix, added -I$(HDR) to F90 compilation lines
 24 Sep 2009 - R. Yantosca - added NONUMA option for PGI compiler
 07 Oct 2009 - R. Yantosca - Replaced .SUFFIXES section w/ pattern rules
 19 Nov 2009 - R. Yantosca - Now use OMP variable to determine whether to
                             turn on OpenMP parallelization options
 23 Nov 2009 - R. Yantosca - Now use -module $(MOD) instead of -I$(MOD) to
```

```
                            specify the directory for *.mod files on both
                            IFORT and PGI compilers.
23 Nov 2009 - R. Yantosca - Now use -moddir=$(MOD) and -M$(MOD) instead of
                            -I$(MOD) to specify the directory for *.mod
                            files on the SunStudio compiler.
23 Nov 2009 - R. Yantosca - Change DEBUG to allow for new version of
                            Totalview which doesn't choke when debugging
                            parallel code (Totalview 8.6.1-1)
02 Dec 2009 - R. Yantosca - Added SUN32 switch for building 32-bit
                            executbable on the SunStudio compiler
11 Dec 2009 - R. Yantosca - Now define SHELL here and export to other
                            Makefiles, so as to have a single place where
                            the Unix shell name is defined.
21 Dec 2009 - R. Yantosca - Add H5I and H5L variables to specify the
                            HDF5 library and include paths.  Also set
                            the default to not link to the HDF5 libraries.
21 Dec 2009 - R. Yantosca - Now pass LINK back to the outside world, so
                            that the Makefile that builds the executable
                            can reference it.
19 Jan 2010 - R. Yantosca - Minor fix, add -m64 if SUN32 is not defined.
25 Jan 2010 - R. Yantosca - Now add -DTOMAS to FFLAGS if necessary
28 Jan 2010 - C. Carouge  - Add -lIsoropia to LINK, for ISORROPIA II
16 Feb 2011 - R. Yantosca - Now add -DAPM to FFLAGS if necessary
25 Aug 2011 - R. Yantosca - Add "-fp-model source" to FFLAGS for IFORT
                            compiler.  This will prevent aggressive
                            optimizations from changing numerical results.
25 Aug 2011 - R. Yantosca - Add -CU (check for uninit'd variables) to
                            FFLAGS when using IFORT w/ the DEBUG option.
26 Aug 2011 - R. Yantosca - Allow for deactivation of the "-fp-model source"
                            option by using the PRECISE=no env variable
24 Jan 2012 - R. Yantosca - If NETCDF=yes, GEOS-Chem will link and include
                            to the netCDF dir paths that are specified
24 Jan 2012 - R. Yantosca - Now use := for makefile assignment statements
10 Feb 2012 - R. Yantosca - When compiling with NETCDF=yes or HDF5=yes,
                            we must also add the flags -mcmodel=medium
                            -i-dynamic to FFLAGS in order to avoid memory
                            errors (for IFORT only)
10 Feb 2012 - R. Yantosca - Remove -CU from the DEBUG option (IFORT only)
19 Mar 2012 - R. Yantosca - Add optional NO_ISO switch, which will turn off
                            the ISORROPIA ATE package for testing
05 Apr 2012 - R. Yantosca - Now assume netCDF is always used
05 Apr 2012 - R. Yantosca - Change BL_INC_NETCDF to INC_NETCDF
05 Apr 2012 - R. Yantosca - Change BL_INC_HDF5   to INC_HDF5
05 Apr 2012 - R. Yantosca - Change BL_LIB_NETCDF to LIB_NETCDF
05 Apr 2012 - R. Yantosca - Change BL_LIB_HDF5   to LIB_HDF5
30 Apr 2012 - R. Yantosca - Add NETCDF3=[yes|no] makefile option
30 Apr 2012 - R. Yantosca - Use separate netCDF link and include paths
                            for netCDF3 and for netCDF4
```

```
30 Apr 2012 - R. Yantosca - Also add -mcmodel=medium flag for PGI compiler
09 May 2012 - R. Yantosca - Now try to get the proper linking sequence
                            for netCDF etc w/ nf-config and nc-config.
11 May 2012 - R. Yantosca - Now export NCL (netCDF linking sequence)
17 Aug 2012 - R. Yantosca - Now add RRTMG=yes option for RRTMG rad transfer
07 Sep 2012 - R. Yantosca - Now add OPT variable to set global opt levels
07 Sep 2012 - R. Yantosca - Also set TRACEBACK for PGI compiler
17 Apr 2013 - R. Yantosca - Add switch to set -DKPP_SOLVE_ALWAYS, which
                            will force KPP to get past nonconvergences
25 Feb 2013 - S. Farina   - Add flag for TOMAS40
22 Apr 2013 - R. Yantosca - TOMAS40=yes option now sets -DTOMAS -DTOMAS40
28 Apr 2013 - S. Farina   - Add flags for TOMAS15 and TOMAS12
13 Aug 2013 - R. Yantosca - Removed "define.h"; now set all GEOS-Chem
                            user options via the Make command
14 Aug 2013 - R. Yantosca - Now use regular expressions to test the
                            validity of command-line inputs
21 Aug 2013 - R. Yantosca - Improved error checking for command line inputs
26 Aug 2013 - R. Yantosca - Add -debug all as an IFORT debugging option
16 Sep 2013 - R. Yantosca - Now set GIGC Cpp switches first.  This allows
                            us to skip the GRID setting if we are using
                            EXTERNAL_GRID=yes or EXTERNAL_FORCING=yes.
18 Sep 2013 - M. Long     - Add edits for HPC Grid-Indpendent GEOS-Chem
26 Sep 2013 - R. Yantosca - MET=geosfp now sets Cpp switch w/ -DGEOS_FP
07 Nov 2013 - R. Yantosca - NEST=se to now sets CPP switch w/ -DNESTED_SE
08 Nov 2013 - R. Yantosca - Add FPEX flag to avoid conflicting with the
                            ESMF/MAPL environment variable FPE
24 Feb 2014 - R. Yantosca - Add UCX=yes flag for invoking UCX strat chem
18 Mar 2014 - R. Yantosca - Now add TAU_PROF=y flag to invoke TAU profiler
19 Mar 2014 - R. Yantosca - Move library link commands after the sections
                            that set the C-preprocessor switches
19 Mar 2014 - R. Yantosca - Restore GTMM compilation funcitonality
19 Mar 2014 - R. Yantosca - Add more visible comment section dividers
20 Mar 2014 - R. Yantosca - Bug fix: "+= -DDEBUG" instead of ":= -DDEBUG"
09 Jul 2014 - R. Yantosca - Now don't require MET or GRID if target is
                            srcdoc, utildoc, gtmmdoc, makedoc, or hemcodoc
21 Jul 2014 - R. Yantosca - Update build sequence
03 Oct 2014 - R. Yantosca - Now turn on NO_REDUCED=y for hpc target
03 Oct 2014 - R. Yantosca - Now compatible with netCDF 4.1.1 or 4.2+
17 Oct 2014 - R. Yantosca - Don't require MET or GRID to remove ESMF etc.
05 Nov 2014 - R. Yantosca - Will compile w/ 8-byte precision by default
14 Nov 2014 - R. Yantosca - Further updates for hpc compilation
21 Nov 2014 - R. Yantosca - Add special compilation command for ISORROPIA
21 Nov 2014 - R. Yantosca - Add cosmetic changes and indentation
06 Jan 2015 - R. Yantosca - Add two-way nesting options from Y. Y. Yan
09 Jan 2015 - M. Sulprizio- Now properly link to the RRTMG directory
13 Jan 2015 - R. Yantosca - Add fix for GEOS-Chem-Libraries library path
08 Apr 2015 - R. Yantosca - Bug fix: set RRTMG=yes if it passes the regexp
10 Apr 2015 - R. Yantosca - Export RRTMG_NEEDED var to be used elsewhere
```

```
10 Apr 2015 - R. Yantosca - Bug fix: -l rad should be -lrad in link var
12 May 2015 - R. Yantosca - Bug fix for PGI compiler: remove extra "-"
                            in front of $(NC_INC_CMD) in the PGI section
12 May 2015 - R. Yantosca - Now use GC_BIN, GC_INCLUDE to point to the
                            netCDF library paths and GC_F_BIN, GC_F_INCLUDE
                            to point to netCDF-Fortran library paths.
                            (In some cases, these are the same).
20 May 2015 - R. Yantosca - Test if GC_F_BIN and GC_F_INCLUDE are defined
                            as env variables before trying to use them.
29 May 2015 - R. Yantosca - Now set KPP_CHEM for KPP.  We can't redefine
                            the CHEM variable because it is an env var.
04 Jun 2015 - R. Yantosca - Now use RRTMG_NO_CLEAN=y or RRTMG_NOCLEAN=y to
                            removing RRTMG objects, modules, and libraries.
04 Jun 2015 - R. Yantosca - Bug fix: don't turn on UCX except for CHEM=UCX
15 Jun 2015 - R. Yantosca - Now define the HEMCO standalone link command
                            separately from the GEOS-Chem link command
07 Jul 2015 - M. Sulprizio- Add option for CHEM=SOA_SVPOA
17 Jul 2015 - E. Lundgren - Remove BSTATIC option when picking pgi options
                            for debug run or regular run
30 Jul 2015 - M. Yannetti - Added TIMERS.
03 Aug 2015 - M. Sulprizio- NEST=cu to now sets CPP switch w/ -DNESTED_CU for
                            custom nested grids
11 Aug 2015 - R. Yantosca - Add MERRA2 as a met field option
24 Aug 2015 - R. Yantosca - Bug fix: Add missing | when testing USER_DEFS
07 Dec 2015 - R. Yantosca - Add "realclean_except_rrtmg" target that
                            replaces the RRTMG_CLEAN variabe
10 Feb 2016 - E. Lundgren - Add BPCH restart file input and output switches
11 Feb 2016 - E. Lundgren - Change BPCH to BPCH_DIAG, NETCDF to NC_DIAG
12 Jul 2016 - E. Lundgren - Remove binary punch restart file option
19 Jul 2016 - R. Yantosca - Add more flags for enabling experimental code
20 Sep 2016 - M. Sulprizio- Remove NEST=se option. This grid was never fully
                            implemented.
12 Dec 2016 - R. Yantosca - Allow gfortran etc. to compile with TAU_PROF=y
13 Dec 2016 - R. Yantosca - Add GPROF=y to compile for GNU profiler gprof
```

1.2 Module Interface Makefile (in the HEMCO/src directory)

Calls makefiles in the subdirectories srcCore, srcExtensions, srcInterfaces to compile the HEMCO source code into library files and to create an executable.

REMARKS:

```
To build the programs, call "make" with the following syntax:
  make -jN TARGET [ OPTIONAL-FLAGS ]
To display a complete list of options, type "make help".
```

REVISION HISTORY:

```
14 Jul 2014 - R. Yantosca - Initial version
```

1.3 Module Interface Makefile (in the GeosUtil subdirectory)

This makefile compiles the various GEOS-Chem utility modules, which provide basic functionality for:

- Collapsing vertical levels in the stratosphere
- Date and time computations
- Defining data directories
- Defining the GEOS-Chem horizontal grid
- Defining the GEOS-Chem pressure coordinate grid
- Defining the logical units for GEOS-Chem file I/O
- Defining various Unix commands
- Platform-specific error handling
- Manipulating string variables
- Regridding data (horizontally) from fine to coarse resolution
- Converting gas concentration units

REMARKS:

```
To build the programs, call "make" with the following syntax:

  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

Makefile uses the following variables:

Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
```

```
MOD         Specifies the directory where module files (*.mod) are stored
AR          Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE        Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
 19 Nov 2009 - R. Yantosca - Initial version
 23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                             automatically written to the mod directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 21 Dec 2009 - R. Yantosca - If HDF5=yes, then look for hdf5.mod in the
                             HDF5 include path $(HDF5_INC).
 01 Mar 2012 - R. Yantosca - Replace grid_mod.F with grid_mod.F90, to
                             facilitate work on the GI model
 03 Apr 2012 - M. Payer    - Add new module regrid_a2a_mod.F90 (M. Cooper)
 03 Aug 2012 - R. Yantosca - Add dependency for inquireMod.F90
 19 Mar 2014 - R. Yantosca - Add more visible comment section dividers
 20 Jun 2014 - R. Yantosca - Removed unix_cmds_mod.F; it's now obsolete
 20 Jun 2014 - R. Yantosca - Removed directory_mod.F; it's now obsolete
 10 Jul 2014 - R. Yantosca - Now compile ncdf_mod.F90 in NcdfUtil/ subdir
 21 Jul 2014 - R. Yantosca - regrid_a2a_mod.F90 no longer relies on other
                             files in GeosUtil
 21 Jul 2014 - R. Yantosca - Removed regrid_1x1_mod.F; it's obsolete
 23 Jul 2014 - R. Yantosca - Removed global_grid_mod.F90; it's obsolete
 08 Jan 2015 - E. Lundgren - Add module for unit conversion
 03 Jun 2015 - R. Yantosca - Also remove *.mod, *.a files with "make clean"
 07 Dec 2015 - R. Yantosca - Restore fast "clean" command; add "slowclean"
 22 Jan 2016 - R. Yantosca - Remove linux_err.o
 29 Nov 2016 - R. Yantosca - grid_mod.F90 is now gc_grid_mod.F90, etc.
```

1.4 Module Interface Makefile (in the ISOROPIA/ subdirectory)

This makefile compiles the ISOROPIA code. Object files (*.o) are bundled into the libIsoropia.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
.
Makefile uses the following variables:
.
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
R8         Specifies the command to treat "REAL" as "REAL*8"
```

REVISION HISTORY:

```
21 Dec 2009 - C. Carouge  - Initial version
22 Aug 2011 - R. Yantosca - Add "-fp-model source" flag for IFORT compiler,
                            which prevents random numerical noise
25 Aug 2011 - R. Yantosca - Remove -fp-model source flag here, as this is
                            now added to FFLAGS in Makefile_header.mk
19 Mar 2014 - R. Yantosca - Add more visible comment section dividers
21 Nov 2014 - R. Yantosca - Compile w/o includes for ESMF, MAPL, FVdycore
04 Jun 2015 - R. Yantosca - Also remove *.mod, *.a files with "make clean"
04 Jun 2015 - R. Yantosca - Add debug target, remove help
```

1.5 Module Interface Makefile (in the GeosCore subdirectory)

This is the main GEOS-Chem makefile. It compiles the GEOS-Chem core source code files and bundles all of the object files (*.o) into the libGeosCore.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
.
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
.
To display a complete list of options, type "make help".
.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Most of the time this Makefile will be called automatically    %%%
%%% from the router Makefile in the top-level directory.  However, if    %%%
%%% you are in the ./GeosCore directory, then you can call this Makefile %%%
%%% to build the GEOS-Chem source code, libraries, and executables.      %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
.
```

```
Makefile uses the following variables:

                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root directory for the GEOS-Chem code
BIN        Specifies the directory where executable files are stored
BPCH       Specifies the directory where the G-C bpch routines are stored
DOC        Specifies the directory for generating documentation w/ ProTeX
EXE        Specifies the name of the executable file
HDR        Specifies the directory where include files are found
LIB        Specifies the directory where library files (*.a) are stored
LINK       Specifies the link commands to the GEOS-Chem library files
KPP        Specifies the directory where th KPP solver files reside
MOD        Specifies the directory where module files (*.mod) are stored
NCDF       Specifies the directory where netCDF utilities are stored
OBJ        Specifies the list of object files (*.o) to be created.
UTIL       Specifies the directory where the G-C utility modules are found
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
NTRAC      Cmd line argument; specifies either 43 or 54 tracer simulation
KPPSOLVER  Cmd line argument; specifies the type of integrator to use

                                                                             .
NOTE: CC, F90, FREEFORM, LD, R8 are included from "Makefile_header.mk".

                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% You can compile GEOS-Chem in parallel using the "make -jN" option!   %%%
%%%                                                                      %%%
%%% N = number of proceses that you want to run simultaneously (i.e.     %%%
%%% (when one file is finished compiling, "make" will immediately start  %%%
%%% on the next one).  Usually N is the # of processors on your system.  %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

                                                                             .
GEOS-Chem routines will be compiled in the following order, by directory:
-------------------------------------------------------------------------------
(1) NcdfUtil/            : NetCDF I/O modules
(2) Headers/             : Header files (i.e. CMN_SIZE_mod.F, etc.)
(3) KPP/                 : KPP solver routines
(4) GeosUtil/            : GEOS-Chem utility modules (i.e. pressure_mod.F)
(5) HEMCO/Core/          : HEMCO Core modules
(6) HEMCO/Extensions/    : HEMCO Extensions modules
(7) HEMCO/Interfaces/    : HEMCO Interface modules
(7) ISOROPIA/            : ISORROPIA aerosol thermodyn equilibrium module
(8) GeosCore/            : "Core" GEOS-Chem modules
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 18 Sep 2009 - P. Le Sager - Removed -lKppInt
```

```
21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                            display the help screen options
19 Nov 2009 - R. Yantosca - Now compile the various GEOS-Chem utility
                            modules in the GeosUtil subdirectory
19 Nov 2009 - R. Yantosca - Now compile the GEOS-Chem bpch module
                            separately in the GeosBpch subdirectory
19 Nov 2009 - R. Yantosca - Now list all object dependencies explicitly,
                            to be able to use "make -j" (parallel make)
23 Nov 2009 - R. Yantosca - Remove "main.o" explicitly form the "exe"
                            makefile target.  This will be now compiled in
                            the proper sequence given the dependency
                            ordering.  This allows "make -j" to work.
23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                            automatically written to the mod directory
23 Nov 2009 - R. Yantosca - Removed libbpch; bundled that into libutil
23 Nov 2009 - R. Yantosca - Added separate target libcore.  lib is now
                            a synonym for "libkpp libutil libcore"
01 Dec 2009 - R. Yantosca - Modified the "exe" target for SunStudio compiler
                            which chokes at link time if the list of object
                            files is not explicitly passed
02 Dec 2009 - R. Yantosca - Add conditional statements in dependencies list
                            for the SunStudio compiler
11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
21 Dec 2009 - R. Yantosca - Now get LINK from Makefile_header.mk
25 Jan 2010 - R. Yantosca - Whem making "realclean", also call "clean" in
                            the $(GEOSTOM)/Makefile.  Also make sure to
                            remove executables in the $(BIN) directory.
28 Jan 2010 - C. Carouge  - Modifications for ISORROPIA II
08 Feb 2010 - C. Carouge  - Modifications for F. Paulot's isoprene scheme
10 May 2010 - R. Yantosca - Add dependency for RD_AOD.f
14 May 2010 - C. Carouge  - Updates for mercury simulation
20 Aug 2010 - R. Yantosca - Modifications for MERRA met fields
16 Feb 2011 - R. Yantosca - Add modifications for APM (G. Luo)
05 Aug 2011 - M. Long     - Now compile module files in Headers/ directory
04 Nov 2011 - R. Yantosca - Remove references to ESMF subdirectory
08 Dec 2011 - M. Payer    - Remove obsolete GEIA biogenic emissions routines
24 Jan 2012 - R. Yantosca - Also add libnc target to build netCDF utils
25 Jan 2012 - R. Yantosca - Add ncdfcheck target to check netCDF install
05 Apr 2012 - R. Yantosca - Now assume netCDF will always be used
05 Apr 2012 - R. Yantosca - Now retire rdlai.F, readlai.F
11 Apr 2012 - R. Yantosca - Now retire obsolete lai_mod.F
11 Apr 2012 - R. Yantosca - Reference modis_lai_mod.F90 in timeseries diag
11 Apr 2012 - R. Yantosca - Remove all references to obsolete lai_mod.F
12 Apr 2012 - R. Yantosca - Remove reference to findmon.F
19 Apr 2012 - R. Yantosca - Remove reference to rd_prof.F
30 Oct 2012 - R. Yantosca - Remove reference to rdsoil.F
27 Nov 2012 - R. Yantosca - Remove reference to getifsun.F
27 Mar 2013 - S.D. Eastham- Rolled photolysis functions together
```

```
30 May 2013 - R. Yantosca - Remove reference to GEOS-3 TPCORE routines
13 Aug 2013 - M. Sulprizio- Remove reference to soaprod_mod.F (no longer
                            needed) (SOAupdate, hotp 7/25/10)
20 Aug 2013 - R. Yantosca - Make sure Makefile target names are consistent
20 Sep 2013 - R. Yantosca - Bug fix for make realclean: Don't try to make
                            clean unless we compile for target hpc
27 Jan 2014 - R. Yantosca - Add tomas_mod.o to wetscav_mod dependency list
03 Feb 2014 - R. Yantosca - Add linoz_mod.o to input_mod.o dependency list
21 Feb 2014 - M. Sulprizio- Removed reference to tropopause_mod.F. It is now
                            obsolete because of the UCX updates.
18 Mar 2014 - R. Yantosca - Add tauclean target to remove TAU profile files
19 Mar 2014 - R. Yantosca - Now restore GTMM functionality
19 Mar 2014 - R. Yantosca - Add more visible comment section dividers
11 Apr 2014 - R. Yantosca - Add modules to input_mod.o dependencies list
23 Jun 2014 - R. Yantosca - Remove references to obsolete logical_mod.o
21 Jul 2014 - R. Yantosca - Now build HEMCO emissions modules after
                            NcdfUtil and GeosUtil, but before GeosCore
22 Jul 2014 - R. Yantosca - Move hcox_paranox_mod.F90, paranox_util_mod.F90
                            and hcox_driver_mod.F90 back to HEMCO/Extensions
24 Jul 2014 - R. Yantosca - Remove canopy_nox_mod.F, readfert.F, readclim.F,
                            and readsoil.F. HEMCO makes all these obsolete.
15 Sep 2014 - M. Sulprizio- Remove global_oc_mod.F and global_bc_mod.F.
                            HEMCO makes these obsolete.
23 Sep 2014 - M. Sulprizio- Removed global_hno3_mod.F and global_no3_mod.F.
                            HEMCO makes these obsolete.
04 Jun 2015 - R. Yantosca - Add wipeout target to remove any leftover
                            library, module, or executable files
03 Sep 2015 - R. Yantosca - Add gamap_mod.o dependency to input_mod.o
03 Dec 2015 - R. Yantosca - cleanup.o now depends on geosfp_read_mod.o
                            and merra2_read_mod.o
07 Dec 2015 - R. Yantosca - Restore fast "clean" command; add "slowclean"
07 Dec 2015 - R. Yantosca - Add "realclean_except_rrtmg" target
18 May 2016 - M. Sulprizio- Remove comode_mod.F, setemis.F, and several
                            leftover routines from SMVGEAR
23 Jun 2016 - R. Yantosca - Remove references to tracerid_mod
23 Jun 2016 - R. Yantosca - Remove references to GeosApm
30 Jun 2016 - M. Sulprizio- Remove readchem.F, reader.F, jsparse.F, ksparse.F
09 Aug 2016 - M. Sulprizio- Remove diag_pl_mod and add diag20_mod
```

1.6 Module Interface Makefile (in the GTMM subdirectory)

This is main "router" makefile for the GTMM model. It compiles the GTMM code for GEOS-Chem mercury simulations. **REMARKS:**

```
To build the programs, call "make" with the following syntax:

  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
```

```
.
To display a complete list of options, type "make help".
.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the main GEOS-Chem Makefile in  %%%
%%% GeosCore directory!                                                  %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
.
Makefile uses the following variables:
.
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
DOC        Specifies the directory where GEOS-Chem documentation is found
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
16 Sep 2009 - R. Yantosca - Initial version
18 Sep 2009 - P. Le Sager - Added kppintegrator target & commented
                            "make -C int" calls
21 Sep 2009 - C. Carouge  - Adapted to use with GTMM model.
19 Mar 2014 - R. Yantosca - Add more visible comment section dividers
07 Dec 2015 - R. Yantosca - Restore fast "clean" command; add "slowclean"
```

1.7 Module Interface Makefile (in the KPP subdirectory)

This is main "router" makefile for the KPP solver. It compiles the KPP code for one of the following types of GEOS-Chem simulations:

1. GEOS-Chem "standard" simulation (43 tracers)
2. GEOS-Chem "secondary organic aerosol" simulation (54 tracers)

The KPP code will be compiled using one of the following numerical solvers:

1. rosenbrock (This is the default option.)
2. lsodes
3. radau5
4. runge_kutta

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the main GEOS-Chem Makefile in  %%%
%%% GeosCore directory!                                                  %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
DOC        Specifies the directory where GEOS-Chem documentation is found
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
NTRAC      Cmd line argument; specifies either 43 or 54 tracer simulation
KPPSOLVER  Cmd line argument; specifies the type of integrator to use
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 18 Sep 2009 - P. Le Sager - Added kppintegrator target & commented
                             "make -C int" calls
 20 Nov 2009 - P. Le Sager - Added CHEM option
 23 Nov 2009 - R. Yantosca - Added realclean target
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 16 Oct 2013 - M. Sulprizio- Remove isoprene directory from realclean target.
                             This directory has been removed because it is
                             obsolete.
 26 May 2015 - R. Yantosca - Bug fix, now point CHEM=benchmark by default
 29 May 2015 - R. Yantosca - Add tropchem as a synonym for NOX_Ox_HC_Aer_Br
 29 May 2015 - R. Yantosca - Now use KPP_CHEM instead of CHEM.  CHEM is an
                             environment variable and can't be reset.
 07 Dec 2015 - R. Yantosca - Restore fast "clean" command; add "slowclean"
 07 Dec 2015 - R. Yantosca - Also add the slowrealclean target, which can
                             be used for cleaning everything except RRTMG
 12 May 2016 - R. Yantosca - Added "firstpass" target to compile Precision,
                             Parameters, and Monitor modules first
```

1.8 Module Interface Makefile (in the KPP/[Mechanism] subdirectory)

This makefile compiles the KPP solver code for a given GEOS-Chem chemistry mechanism. Object files (*.o) are bundled into the libKpp.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                             display the help screen options
 23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                             automatically written to the mod directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 12 May 2016 - R. Yantosca - Added "firstpass" target to compile Precision,
                             Parameters, and Monitor modules first
 12 May 2016 - R. Yantosca - Updated comments and cosmetic changes
 13 Jul 2016 - M. Sulprizio- Remove gckpp_Hessian.o. Hessian is turned off
                             for the prod/loss functionality (M. Long).
```

1.9 Module Interface Makefile (in the KPP/[Mechanism] subdirectory)

This makefile compiles the KPP solver code for a given GEOS-Chem chemistry mechanism. Object files (*.o) are bundled into the libKpp.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                             display the help screen options
 23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                             automatically written to the mod directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 12 May 2016 - R. Yantosca - Added "firstpass" target to compile Precision,
                             Parameters, and Monitor modules first
 12 May 2016 - R. Yantosca - Updated comments and cosmetic changes
 13 Jul 2016 - M. Sulprizio- Remove gckpp_Hessian.o. Hessian is turned off
                             for the prod/loss functionality (M. Long).
```

1.10 Module Interface Makefile (in the KPP/[Mechanism] subdirectory)

This makefile compiles the KPP solver code for a given GEOS-Chem chemistry mechanism. Object files (*.o) are bundled into the libKpp.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                             display the help screen options
 23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                             automatically written to the mod directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 12 May 2016 - R. Yantosca - Added "firstpass" target to compile Precision,
                             Parameters, and Monitor modules first
 12 May 2016 - R. Yantosca - Updated comments and cosmetic changes
 13 Jul 2016 - M. Sulprizio- Remove gckpp_Hessian.o. Hessian is turned off
                             for the prod/loss functionality (M. Long).
```

1.11 Module Interface Makefile (in the KPP/[Mechanism] subdirectory)

This makefile compiles the KPP solver code for a given GEOS-Chem chemistry mechanism. Object files (*.o) are bundled into the libKpp.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                             display the help screen options
 23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                             automatically written to the mod directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 12 May 2016 - R. Yantosca - Added "firstpass" target to compile Precision,
                             Parameters, and Monitor modules first
 12 May 2016 - R. Yantosca - Updated comments and cosmetic changes
 13 Jul 2016 - M. Sulprizio- Remove gckpp_Hessian.o. Hessian is turned off
                             for the prod/loss functionality (M. Long).
```

1.12 Module Interface Makefile (in the KPP/[Mechanism] subdirectory)

This makefile compiles the KPP solver code for a given GEOS-Chem chemistry mechanism. Object files (*.o) are bundled into the libKpp.a library (located in the LIB directory). Module files (*.mod) are copied to the MOD directory.

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]
                                                                             .
To display a complete list of options, type "make help".
                                                                             .
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% NOTE: Normally you will not have to call this Makefile directly,     %%%
%%% it will be called automatically from the Makefile in the directory   %%%
%%% just above this one!                                                 %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                                                             .
Makefile uses the following variables:
                                                                             .
Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
ROOTDIR    Specifies the root-level directory of the GEOS-Chem code
HDR        Specifies the directory where GEOS-Chem include files are found
LIB        Specifies the directory where library files (*.a) are stored
MOD        Specifies the directory where module files (*.mod) are stored
AR         Sys var w/ name of library creator program (i.e., "ar", "ranlib")
MAKE       Sys var w/ name of Make command (i.e, "make" or "gmake")
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                             display the help screen options
 23 Nov 2009 - R. Yantosca - Now don't copy module files; they will be
                             automatically written to the mod directory
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 12 May 2016 - R. Yantosca - Added "firstpass" target to compile Precision,
                             Parameters, and Monitor modules first
 12 May 2016 - R. Yantosca - Updated comments and cosmetic changes
 13 Jul 2016 - M. Sulprizio- Remove gckpp_Hessian.o. Hessian is turned off
                             for the prod/loss functionality (M. Long).
```

1.13 Module Interface Makefile (in doc subdirectory)

Makefile for building the documentation (in PDF and PostScript formats) for the GEOS-Chem model source code, makefiles, and related scripts.

REMARKS:

```
To build the documentation, call "make" with the following syntax:

  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

You must have the LaTeX utilities (latex, dvips, dvipdf) installed
on your system in order to build the documentation.
```

REVISION HISTORY:

```
 16 Sep 2009 - R. Yantosca - Initial version
 21 Sep 2009 - R. Yantosca - Now call Makefile in help directory to
                             display the help screen options
 19 Nov 2009 - R. Yantosca - Now build documentation for Makefiles in the
                             GeosUtil and GeosCore subdirectories
 11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
 28 Jan 2010 - R. Yantosca - Now add the Makefiles in the GeosTomas and
                             ISOROPIA subdirs to the documentation
 27 Aug 2010 - R. Yantosca - Brought up to date for newly documented code
 31 Aug 2010 - R. Yantosca - Add documentation for GTMM routines
 14 Sep 2010 - R. Yantosca - Now split make commands into include files
 20 Aug 2013 - R. Yantosca - Remove GeosTomas directory, that is obsolete
 09 Jul 2014 - R. Yantosca - Now build HEMCO documentation
 21 Jul 2014 - R. Yantosca - Now look for HEMCO modules in subdirectories
 10 Jul 2015 - R. Yantosca - Added GCRT directory
 18 Nov 2016 - R. Yantosca - Updated for v11-01
```

1.13.1 Makefile_UtilDoc.mk (in doc subdirectory)

This Makefile fragment contains commands to build the documentation for the GEOS-Chem utility modules. It is inlined into the Makefile (in the doc subdirectory) by an "include" command.

REMARKS:

```
To build the documentation, call "make" with the following syntax:

  make TARGET [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".
```

```
You must have the LaTeX utilities (latex, dvips, dvipdf) installed
on your system in order to build the documentation.
```

REVISION HISTORY:

```
14 Sep 2010 - R. Yantosca - Initial version, split off from Makefile
16 Dec 2010 - R. Yantosca - Renamed output files to "GC_Ref_Vol_2.*"
19 Jul 2011 - R. Yantosca - Changed *.f* to *.F* for ESMF compatibility
03 Apr 2012 - M. Payer    - Added *.F90 so that grid_mod.F90 and
                            regrid_a2a_mod.F90 are included
15 Jan 2014 - R. Yantosca - Now only create *.pdf output
10 Jul 2015 - R. Yantosca - Use ./protex to avoid problems on some systems
18 Nov 2016 - R. Yantosca - Now use protex -sfp to increment chapters
```

1.13.2 Makefile_SrcDoc.mk (in doc subdirectory)

This Makefile fragment contains commands to build the documentation for the GEOS-Chem Source Code. It is inlined into the Makefile (in the doc subdirectory) by an "include" command.

REMARKS:

```
To build the documentation, call "make" with the following syntax:

  make TARGET [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

You must have the LaTeX utilities (latex, dvips, dvipdf) installed
on your system in order to build the documentation.
```

REVISION HISTORY:

```
14 Sep 2010 - R. Yantosca - Initial version, split off from Makefile
14 Sep 2010 - R. Yantosca - Added optdepth_mod.f to list
15 Sep 2010 - R. Yantosca - Added diag_2pm, diag_56, diagoh, ohsave
16 Sep 2010 - R. Yantosca - Added diag_pl_mod
04 Nov 2010 - R. Yantosca - Added acetone_mod
10 Nov 2010 - R. Yantosca - Added lightning_nox_mod
19 Nov 2010 - R. Yantosca - Added anthroems, RnPbBe_mod, tagged_ox_mod
19 Nov 2010 - R. Yantosca - Added tcorr, emfossil, emf_scale
01 Dec 2010 - R. Yantosca - Added global_br_mod, global_no3_mod
01 Dec 2010 - R. Yantosca - Added global_nox_mod, global_o1d_mod
01 Dec 2010 - R. Yantosca - Added global_oh_mod,  toms_mod
02 Dec 2010 - R. Yantosca - Added upbdflx_mod, diag41_mod, diag42_mod
02 Dec 2010 - R. Yantosca - Added diag03_mod, diag49_mod, diag50_mod
02 Dec 2010 - R. Yantosca - Added diag51_mod, diag51b_mod, boxvl, rdmonot
02 Dec 2010 - R. Yantosca - Added rdlight, rdland, rdsoil, emmonot
```

```
16 Dec 2010 - R. Yantosca - Renamed output files to "GC_Ref_Vol_3.*"\
21 Dec 2010 - R. Yantosca - Added comode_mod
11 Jul 2011 - R. Yantosca - Added restart_mod
19 Jul 2011 - R. Yantosca - Changed *.f* to *.F* for ESMF compatibility
29 Jul 2011 - R. Yantosca - Added planeflight_mod
22 Aug 2011 - R. Yantosca - Added retro_mod
07 Sep 2011 - R. Yantosca - Added gfed3_biomass_mod, *jv*_mod files
22 Dec 2011 - M. Payer    - Added aerosol_mod, drydep_mod, seasalt_mod,
                            and sulfate_mod
07 Feb 2012 - M. Payer    - Added paranox_mod, diag63_mod
08 Feb 2012 - R. Yantosca - Added geos57_read_mod.F90
28 Feb 2012 - R. Yantosca - Added pbl_mix_mod
05 Mar 2012 - M. Payer    - Added tracer_mod
06 Mar 2012 - R. Yantosca - Added photoj.F and set_prof.F
07 Mar 2012 - M. Payer    - Added global_ch4_mod
19 Mar 2012 - M. Payer    - Added EF_MGN20_mod
22 Mar 2012 - M. Payer    - Added c2h6_mod, olson_landmap_mod
29 Mar 2012 - R. Yantosca - Added lai_mod
29 Mar 2012 - R. Yantosca - Added modis_lai_mod and mapping_mod
09 Apr 2012 - R. Yantosca - Added modules from Headers/ directory
13 Apr 2012 - R. Yantosca - Removed findmon.F, rdlai.F, lai_mod.F
19 Apr 2012 - R. Yantosca - Added read_jv_atms_dat.F90
15 May 2012 - R. Yantosca - Added tpcore_bc_mod.F
22 May 2012 - M. Payer    - Add bromocarb_mod.F, cldice_HBrHOBr_rxn.F,
                            and ssa_bromine_mod.F
31 Jul 2012 - R. Yantosca - Added FAST-J routines etc.
03 Aug 2012 - R. Yantosca - Added benchmark_mod, etc.
06 Aug 2012 - R. Yantosca - Added gcap_read_mod, etc.
14 Aug 2012 - R. Yantosca - Added gc_environment_mod, etc.
23 Oct 2012 - R. Yantosca - Added modules in ESMF
23 Oct 2012 - R. Yantosca - Added tagged_co_mod
23 Oct 2012 - M. Payer    - Added soil NOx modules; Removed upbdflx_mod.F
27 Nov 2012 - M. Payer    - Added modules for POPs simulation
13 Dec 2012 - R. Yantosca - Added biofit, sunparam, and removed some
                            obsolete functions
22 Jul 2013 - M. Sulprizio- Added rcp_mod
01 Aug 2013 - M. Sulprizio- Added aeic_mod
20 Aug 2013 - M. Sulprizio- Added carbon_mod
20 Aug 2013 - R. Yantosca - Remove reference to "define.h"
05 Sep 2013 - M. Sulprizio- Added global_hno3_mod
15 Jan 2014 - R. Yantosca - Now only create *.pdf file output
25 Feb 2014 - M. Sulprizio- Added a3_read_mod, a6_read_mod, and i6_read_mod
25 Feb 2014 - M. Sulprizio- Added chemgrid_mod, fast_jx_mod, and ucx_mod.
                            Removed references to tropopause_mod and routines
                            for Fast-J.
08 Jul 2014 - R. Yantosca - Removed obsolete routines from the list
06 Jan 2015 - M. Sulprizio- Remove additional routines made obsolete by HEMCO
07 Jan 2015 - R. Yantosca - Added exchange_mod (i.e. 2-way nesting)
```

```
15 Jan 2015 - M. Sulprizio- Added rrtmg_rad_transfer_mod.F and set_prof_o3.F
04 Mar 2015 - R. Yantosca - Add uvalbedo_mod.F
10 Jul 2015 - R. Yantosca - Use ./protex to avoid problems on some systems
10 Jul 2015 - R. Yantosca - Updated list of files as of v11-01b
29 Aug 2016 - M. Sulprizio- Updated list of files as of v11-01g
```

1.13.3 Makefile_DiagsDoc.mk (in doc subdirectory)

This Makefile fragment contains commands to build the documentation for the GEOS-Chem diagnostics modules. It is inlined into the Makefile (in the doc subdirectory) by an "include" command.

REMARKS:

```
To build the documentation, call "make" with the following syntax:

  make TARGET [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

You must have the LaTeX utilities (latex, dvips, dvipdf) installed
on your system in order to build the documentation.
```

REVISION HISTORY:

```
18 Nov 2016 - R. Yantosca - Initial version
```

1.13.4 Makefile_MakeDoc.mk (in doc subdirectory)

This Makefile fragment contains commands to build the documentation for the GEOS-Chem Makefiles It is inlined into the Makefile (in the doc subdirectory) by an "include" command.

REMARKS:

```
To build the documentation, call "make" with the following syntax:

  make TARGET [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

You must have the LaTeX utilities (latex, dvips, dvipdf) installed
on your system in order to build the documentation.
```

REVISION HISTORY:

```
14 Sep 2010 - R. Yantosca - Initial version, split off from Makefile
16 Dec 2010 - R. Yantosca - Renamed output files to "GC_Ref_Vol_1.*"
```

```
 15 Jan 2014 - R. Yantosca - Now only create *.pdf output
 15 Jan 2014 - R. Yantosca - Now only prints prologues, avoids printing code
 10 Jul 2015 - R. Yantosca - Use ./protex to avoid problems on some systems
```

1.13.5 Makefile_Hemco.mk (in doc subdirectory)

This Makefile fragment contains commands to build the documentation for the HEMCO Source Code. It is inlined into the Makefile (in the doc subdirectory) by an "include" command.

REMARKS:

```
To build the documentation, call "make" with the following syntax:

  make TARGET [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

You must have the LaTeX utilities (latex, dvips, dvipdf) installed
on your system in order to build the documentation.
```

REVISION HISTORY:

```
 08 Jul 2014 - R. Yantosca - Initial version
 21 Jul 2014 - R. Yantosca - Now look for HEMCO modules in subdirectories
 10 Jul 2015 - R. Yantosca - Use ./protex to avoid problems on some systems
 18 Nov 2016 - R. Yantosca - Now use protex -spf to update chapters
```

1.14 Module Interface Makefile (in the help subdirectory)

Displays the makefile help screen for GEOS-Chem.

REMARKS:

```
To build the programs, call "make" with the following syntax:

  make -jN TARGET REQUIRED-FLAGS [ OPTIONAL-FLAGS ]

To display a complete list of options, type "make help".

Makefile uses the following variables:

Variable   Description
--------   -----------
SHELL      Specifies the shell for "make" to use (usually SHELL=/bin/sh)
```

REVISION HISTORY:

```
21 Sep 2009 - R. Yantosca - Initial version
24 Sep 2009 - R. Yantosca - Added info about NONUMA option for PGI
24 Sep 2009 - R. Yantosca - Now list rosenbrock as default solver
19 Nov 2009 - R. Yantosca - Updated comments
23 Nov 2009 - R. Yantosca - Updated comments
11 Dec 2009 - R. Yantosca - Now get SHELL from Makefile_header.mk
21 Dec 2009 - R. Yantosca - Added info about HDF5 option
25 Jan 2010 - R. Yantosca - Added info about TOMAS option
10 Mar 2010 - C. Carouge  - Remove info about TOMAS option. Keep info
                            about tomas target.
26 Aug 2011 - R. Yantosca - Added info about APM targets
26 Aug 2011 - R. Yantosca - Add info about the PRECISE=no option
11 May 2012 - R. Yantosca - Updated to include info about new make options
08 Apr 2015 - M. Sulprizio- Updated to include make options added in v10-01
29 May 2015 - R. Yantosca - Updated help screen for v10-01 CHEM options
05 Dec 2016 - R. Yantosca - Updated for v11-01
```