GEOS-Chem Reference, Vol. 1: Makefiles

Bob Yantosca, Michael Long, Melissa Payer and Matthew Cooper
GEOS-Chem Support Team

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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 TARGET [ 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
GEOSTOM    Specifies the directory where GEOS-Chem + TOMAS 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
```

```
# Get the Unix shell definition
include ./Makefile_header.mk

# Define variables
GEOSAPM = GeosApm
GEOSDIR = GeosCore
GEOSTOM = GeosTomas
GTMM = GTMM

#==============================================================================
# Makefile targets: type "make help" for a complete list!
#==============================================================================

.PHONY: all lib libkpp libutil exe clean realclean doc docclean help

all:
@$(MAKE) -C $(GEOSDIR) all
```

```
lib:
@$(MAKE) -C $(GEOSDIR) lib

libcore:
@$(MAKE) -C $(GEOSDIR) libcore

libkpp:
@$(MAKE) -C $(GEOSDIR) libkpp

libutil:
@$(MAKE) -C $(GEOSDIR) libutil

exe:
@$(MAKE) -C $(GEOSDIR) exe

clean:
@$(MAKE) -C $(GEOSDIR) clean

realclean:
@$(MAKE) -C $(GEOSDIR) realclean

doc:
@$(MAKE) -C $(GEOSDIR) doc

docclean:
@$(MAKE) -C $(GEOSDIR) docclean

help:
@$(MAKE) -C $(GEOSDIR) help

#=============================================================================
# Targets for TOMAS aerosol microphysics code (win, bmy, 1/25/10)
#=============================================================================

.PHONY: tomas libtomas exetomas cleantomas

tomas:
@$(MAKE) -C $(GEOSTOM) TOMAS=yes all

libtomas:
@$(MAKE) -C $(GEOSTOM) TOMAS=yes lib

exetomas:
@$(MAKE) -C $(GEOSTOM) TOMAS=yes exe

cleantomas:
@$(MAKE) -C $(GEOSTOM) TOMAS=yes clean
```

```
#============================================================================
# Targets for APM aerosol microphysics code (bmy, 2/16/11)
#============================================================================

.PHONY: apm libapm exeapm cleanapm

apm:
@$(MAKE) -C $(GEOSAPM) APM=yes all

libapm:
@$(MAKE) -C $(GEOSAPM) APM=yes lib

exeapm:
@$(MAKE) -C $(GEOSAPM) APM=yes exe

cleanapm:
@$(MAKE) -C $(GEOSAPM) APM=yes clean

#============================================================================
# Targets for mercury simulation (ccc, 6/7/10)
#============================================================================

.PHONY: hg

hg:
@$(MAKE) -C $(GEOSDIR) allhg
```

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 TARGET [ 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
                                                                             .
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: The IBM/XLF compiler has not been validated yet.          %%%
%%%                          Beta-testers welcome!                        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%       NOTE: GEOS-Chem has not yet been ported to GNU Fortran.         %%%
%%%                          Beta-testers welcome!                        %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

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


#=============================================================================
# Default settings for Makefile options
#=============================================================================

# IFORT is default compiler
ifndef COMPILER
COMPILER = ifort
endif

# OpenMP is turned on by default
ifndef OMP
OMP = yes
endif

# HDF5 output is turned off by defautl
ifndef HDF5
HDF5 = no
endif

# Use precise FP math optimization (i.e. to avoid numerical noise)
ifndef PRECISE
PRECISE=yes
endif

# TOMAS runs on single processor (at least for now!)
ifeq ($(TOMAS),yes)
OMP = no
endif

#=============================================================================
# Default values for variables
#=============================================================================

# If your system uses "/bin/sh", then uncomment this line!
SHELL = /bin/sh
```

```
# If your system uses "/bin/bash", then uncomment this line!
#SHELL = /bin/bash

# If you have HDF5 installed on your system, then define both the include
# (H5I) and library paths (H5L) here!  Otherwise leave these blank.
H5I = /home/bmy/NASA/basedir/x86_64-unknown-linux-gnu/ifort/Linux/include/hdf5
H5L = /home/bmy/NASA/basedir/x86_64-unknown-linux-gnu/ifort/Linux/lib

# Link to library files created from code in the various subdirs
# NOTE: -lGeosUtil should always be last!
LINK  = -L$(LIB) -lKpp -lIsoropia -lGeosUtil -lHeaders
LHG   = -L$(LIB) -lKpp -lIsoropia -lHg -lGeosUtil -lHeaders

# Add the HDF5 library link commands if necessary
ifeq ($(HDF5),yes)
LINK += -L$(H5L) -lhdf5_fortran -lhdf5_hl -lhdf5hl_fortran -lhdf5 -lsz -lz -lm
LHG  += -L$(H5L) -lhdf5_fortran -lhdf5_hl -lhdf5hl_fortran -lhdf5 -lsz -lz -lm
endif

ifeq ($(ESMF),yes)
LINK += -lESMF $(LIB_CHEM_BASE) $(LIB_CHEM_SHARED) $(LIB_PILGRIM) \
               $(LIB_MAPL_BASE) $(LIB_CFIO) $(LIB_GFIO) $(LIB_MPEU) \
               $(LIB_ESMF) $(LIB_SDF) \
               $(LIB_SYS) $(LIB_MPI) $(ESMF_LDFLAGS) -lmpi_cxx -lstdc++ -limf -lrt -ldl
LHG  += -lESMF
endif

#=============================================================================
# IFORT compilation options (default)
#=============================================================================
ifeq ($(COMPILER),ifort)

# Turn on -traceback option by default for debugging runs
ifdef DEBUG
TRACEBACK=yes
endif

# Pick compiler options for debug run or regular run
ifdef DEBUG
FFLAGS   = -cpp -w -O0 -auto -noalign -convert big_endian -g -CU
else
FFLAGS   = -cpp -w -O2 -auto -noalign -convert big_endian -vec-report0
endif

# Prevent any optimizations that would change numerical results
# This is needed to prevent numerical noise from ISORROPIA (bmy, 8/25/11)
ifeq ($(PRECISE),yes)
FFLAGS  += -fp-model source
```

```
endif

# Turn on OpenMP parallelization
ifeq ($(OMP),yes)
FFLAGS  += -openmp -Dmultitask
endif

# Also add TOMAS aerosol microphysics option
ifeq ($(TOMAS),yes)
FFLAGS  += -DTOMAS
endif

# Also add APM aerosol microphysics option
ifeq ($(APM),yes)
FFLAGS  += -DAPM
endif

# Add special IFORT optimization commands
ifdef IPO
FFLAGS  += -ipo -static
endif

# Add option for "array out of bounds" checking
ifdef BOUNDS
FFLAGS  += -CB
endif

# Also add traceback option
ifdef TRACEBACK
FFLAGS  += -traceback
endif

# Include options (i.e. for finding *.h, *.mod files)
INCLUDE  = -I$(HDR) -module $(MOD)

# Also append HDF5 include commands if necessary
ifeq ($(HDF5),yes)
INCLUDE += -DUSE_HDF5 -I$(H5I)
endif

# Also add ESMF linking option
ifeq ($(ESMF),yes)
FFLAGS  += -DESMF_
endif

ifeq ($(ESMF_TESTBED),yes)
FFLAGS += -DESMF_TESTBED_
INCLUDE += -I$(HDR)
```

```
endif

CC       =
F90      = ifort $(FFLAGS) $(INCLUDE)
LD       = ifort $(FFLAGS)
FREEFORM = -free
R8       = -r8

endif

#=============================================================================
# Portland Group (PGI) compilation options
#=============================================================================
ifeq ($(COMPILER),pgi)

# Pick compiler options for debug run or regular run
ifdef DEBUG
FFLAGS   = -byteswapio -Mpreprocess -Bstatic -g -O0
else
FFLAGS   = -byteswapio -Mpreprocess -Bstatic -fast
endif

# Turn on OpenMP parallelization
ifeq ($(OMP),yes)
FFLAGS  += -mp -Mnosgimp -Dmultitask
endif

# Add option for suppressing PGI non-uniform memory access (numa) library
ifeq ($(NONUMA),yes)
FFLAGS  += -mp=nonuma
endif

# Also add TOMAS aerosol microphysics option
ifeq ($(TOMAS),yes)
FFLAGS  += -DTOMAS
endif

# Also add APM aerosol microphysics option
ifeq ($(APM),yes)
FFLAGS  += -DAPM
endif

# Add option for "array out of bounds" checking
ifdef BOUNDS
FFLAGS  += -C
endif

# Include options (i.e. for finding *.h, *.mod files)
```

```
INCLUDE  = -I$(HDR) -module $(MOD)

# Also append HDF5 include commands if necessary
ifeq ($(HDF5),yes)
INCLUDE += -DUSE_HDF5 -I$(H5I)
endif

CC       = gcc
F90      = pgf90 $(FFLAGS) $(INCLUDE)
LD       = pgf90 $(FFLAGS)
FREEFORM = -Mfree
R8       = -Mextend -r8

endif

#=============================================================================
# SunStudio compilation options
#=============================================================================
ifeq ($(COMPILER),sun)

# Pick compiler options for debug run or regular run
# NOTE: -native builds in proper options for whichever chipset you have!
ifdef DEBUG
FFLAGS   = -fpp -g -O0 -stackvar -xfilebyteorder=big16:%all -native
else
FFLAGS   = -fpp -fast -stackvar -xfilebyteorder=big16:%all -native
endif

# Build Sun for 32-bit platform
ifdef SUN32
FFLAGS  += -m32
else
FFLAGS  += -m64
endif

# Turn on OpenMP parallelization
ifeq ($(OMP),yes)
FFLAGS  += -openmp=parallel -Dmultitask
endif

# Also add TOMAS aerosol microphysics option
ifeq ($(TOMAS),yes)
FFLAGS  += -DTOMAS
endif

# Also add APM aerosol microphysics option
ifeq ($(APM),yes)
FFLAGS  += -DAPM
```

```
endif

# Add option for "array out of bounds" checking
ifdef BOUNDS
FFLAGS  += -C
endif

# Include options (i.e. for finding *.h, *.mod files)
INCLUDE  = -I$(HDR) -moddir=$(MOD) -M$(MOD)

# Also append HDF5 include commands if necessary
ifeq ($(HDF5),yes)
INCLUDE += -DUSE_HDF5 -I$(H5I)
endif

CC       =
#------------------------------------------------------------------
# If your compiler is under the name "f90", use these lines!
F90      = f90 $(FFLAGS) $(INCLUDE)
LD       = f90 $(FFLAGS)
#------------------------------------------------------------------
# If your compiler is under the name "sunf90", use these lines!
#F90      = sunf90 $(FFLAGS) $(INCLUDE)
#LD       = sunf90 $(FFLAGS)
#------------------------------------------------------------------
FREEFORM = -free
R8       = -xtypemap=real:64

endif

#=============================================================================
# IBM/XLF compilation options
# NOTE: someone who runs on IBM compiler should check this !!!
#=============================================================================
ifeq ($(COMPILER),xlf)

# Default compilation options
FFLAGS = -bmaxdata:0x80000000 -bmaxstack:0x80000000 -qfixed -qsuffix=cpp=f -q64

# Add optimization options
FFLAGS += -O3 -qarch=auto -qtune=auto -qcache=auto -qmaxmem=-1 -qstrict

# Turn on OpenMP parallelization
ifeq ($(OMP),yes)
FFLAGS += -qsmp=omp:opt -WF,-Dmultitask -qthreaded
endif

# Prior to 11/19/09:
```

```
## Add more options for parallel run
#ifndef DEBUG
#FFLAGS += -qsmp=omp:opt -WF,-Dmultitask -qthreaded
#endif

# Also add TOMAS aerosol microphysics option
ifeq ($(TOMAS),yes)
FFLAGS  += -DTOMAS
endif

# Also add APM aerosol microphysics option
ifeq ($(APM),yes)
FFLAGS  += -DAPM
endif

# Add option for "array out of bounds" checking
ifdef BOUNDS
FFLAGS += -C
endif

# Include options (i.e. for finding *.h, *.mod files)
INCLUDE  = -I$(HDR) -I $(MOD)

# Also append HDF5 include commands if necessary
ifeq ($(HDF5),yes)
INCLUDE += -DUSE_HDF5 -I$(H5I)
endif

CC       =
F90      = xlf90_r $(FFLAGS) $(INCLUDE)
LD       = xlf90_r $(FFLAGS)
FREEFORM = -qrealsize=8
R8       = -r8

endif

#=============================================================================
# Specify pattern rules for compiliation
# (i.e. tell "make" how to compile different types of source code files)
#=============================================================================
%.o : %.f
$(F90) -c $<
%.o : %.F
$(F90) -c $<
%.o : %.f90
$(F90) -c $(FREEFORM) $<
%.o : %.F90
$(F90) -c $(FREEFORM) $<
```

```
%.o : %.c
$(CC) -c $*.c

#============================================================================
# Export global variables so that the main Makefile will see these
#============================================================================
export CC
export F90
export FREEFORM
export LD
export LINK
export R8
export SHELL
```

1.2 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

REMARKS:

```
To build the programs, call "make" with the following syntax:
                                                                             .
  make TARGET [ 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).
```

```
# Define variables
ROOTDIR = ..
HDR     = $(ROOTDIR)/Headers
HELP    = $(ROOTDIR)/help
LIB     = $(ROOTDIR)/lib
MOD     = $(ROOTDIR)/mod

# Include header file.  This returns CC, F90, FREEFORM, LD, R8, SHELL,
# as well as the default Makefile compilation rules for source code files.
include $(ROOTDIR)/Makefile_header.mk

#=============================================================================
# List of files to compile.  Here the order is not important,
# as we will explicity define the dependencies listing below.
#=============================================================================

# List of source files
SRC = $(wildcard *.F) $(wildcard *.F90)

# Replace .f and .f90 extensions with *.o
TMP = $(SRC:.F=.o)
OBJ = $(TMP:.F90=.o)
```

```
# Special files just for IFORT
ifeq ($(COMPILER),ifort)
OBJ += ifort_errmsg.o
endif

# Special files just for PGI
ifeq ($(COMPILER),pgi)
OBJ += linux_err.o
endif

#=============================================================================
# Makefile targets: type "make help" for a complete listing!
#=============================================================================

.PHONY: clean help

lib: $(OBJ)
$(AR) crs libGeosUtil.a $(OBJ)
mv libGeosUtil.a $(LIB)

clean:
rm -f *.o *.mod

help:
@$(MAKE) -C $(HELP)

#=============================================================================
# Dependencies listing (grep "USE " to get the list of module references!)
#
# From this list of dependencies, the "make" utility will figure out the
# correct order of compilation (so we don't have to do that ourselves).
# This also allows us to compile on multiple processors with "make -j".
#
# NOTES:
# (1) Only specify object-file dependencies that are within this directory.
#      Object files in other directories will be referenced at link-time.
# (2) For "make -j" to work, all files in this directory must have a
#      listed dependency.
#=============================================================================

bpch2_mod.o      : bpch2_mod.F      error_mod.o    file_mod.o   julday_mod.o
charpak_mod.o    : charpak_mod.F
directory_mod.o  : directory_mod.F
error_mod.o      : error_mod.F
file_mod.o       : file_mod.F       error_mod.o
grid_mod.o       : grid_mod.F       error_mod.o
ifort_errmsg.o   : ifort_errmsg.F
```

```
julday_mod.o     : julday_mod.F
linux_err.o      : linux_err.c
pressure_mod.o   : pressure_mod.F   error_mod.o
regrid_1x1_mod.o : regrid_1x1_mod.F charpak_mod.o  error_mod.o  grid_mod.o
time_mod.o       : time_mod.F       charpak_mod.o  error_mod.o  grid_mod.o  \
                                    julday_mod.o
transfer_mod.o   : transfer_mod.F   error_mod.o
unix_cmds_mod.o  : unix_cmds_mod.F

# NOTE: if HDF5=yes then we need to also look for the hdf5.mod
# in the HDF5 include path (bmy, 12/21/09)
hdf_mod.o        : hdf_mod.F       error_mod.o    grid_mod.o
ifeq ($(HDF5),yes)
$(F90) -DUSE_HDF5 -I$(HDF_INC) -c $<
endif
```

1.3 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 TARGET [ 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 c
```

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
```

```
# Define variables
SHELL   = /bin/sh
ROOTDIR = ..
HDR     = $(ROOTDIR)/Headers
HELP    = $(ROOTDIR)/help
LIB     = $(ROOTDIR)/lib
MOD     = $(ROOTDIR)/mod

# Include header file.  This returns variables CC, F90, FREEFORM, LD, R8,
# as well as the default Makefile compilation rules for source code files.
include $(ROOTDIR)/Makefile_header.mk

#=============================================================================
# List of files to compile (the order is important!).  We specify these as
# a list of object files (*.o).  For each object file, the "make" utility
# will find the corresponding source code file (*.F) and compile it.
#=============================================================================

# List of source files
SRC = $(wildcard *.F) $(wildcard *.F90)

# Replace .F and .F90 extensions with *.o
TMP = $(SRC:.F=.o)
OBJ = $(TMP:.F90=.o)

#=============================================================================
# Makefile targets: type "make help" for a complete listing!
#=============================================================================

.PHONY: clean help

lib: $(OBJ)
$(AR) crs libIsoropia.a $(OBJ)
mv libIsoropia.a $(LIB)

clean:
```

```
rm -f *.o *.mod

help:
@$(MAKE) -C $(HELP)

#============================================================================
# Dependencies listing (grep "USE " to get the list of module references!)
#
# From this list of dependencies, the "make" utility will figure out the
# correct order of compilation (so we don't have to do that ourselves!)
#============================================================================

isoropiaIIcode.o:  isoropiaIIcode.F  isrpia.inc
$(F90) $(R8) -c $<
```

1.4 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 TARGET [ 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


# Define variables
ROOTDIR = ..
DOC     = $(ROOTDIR)/doc
HDR     = $(ROOTDIR)/Headers
HELP    = $(ROOTDIR)/help
LIB     = $(ROOTDIR)/lib
MOD     = $(ROOTDIR)/mod

# Include header file.  This returns CC, F90, FREEFORM, LD, R8, SHELL,
# as well as the default Makefile compilation rules for source code files.
include $(ROOTDIR)/Makefile_header.mk

# Make the standard 43-tracer simulation the default
ifndef CHEM
CHEM = standard
endif

# Check if NTRAC option is used
ifdef NTRAC

ifeq ($(NTRAC),43)
CHEM = standard
endif
```

```
ifeq ($(NTRAC),54)
CHEM = SOA
endif

endif


# Make rosenbrock the default solver
ifndef KPPSOLVER
KPPSOLVER = rosenbrock
endif

# solver (S=Source, T=Target)
SOLVER_SFILE=./int/gckpp_Integrator_$(KPPSOLVER).F90
SOLVER_TFILE=./$(CHEM)/gckpp_Integrator.F90


#=============================================================================
# Makefile targets: type "make help" for a complete listing!
#=============================================================================

.PHONY: all lib kppintegrator clean realclean doc help

all: lib

lib: kppintegrator
@$(MAKE) -C $(CHEM)

kppintegrator:
@diff $(SOLVER_SFILE) $(SOLVER_TFILE) ;\
if [ $$? == 1 ] ; then   \
echo " copy $(SOLVER_SFILE) --> $(SOLVER_TFILE)";\
cp $(SOLVER_SFILE) $(SOLVER_TFILE) ;    \
fi

clean:
@$(MAKE) -C $(CHEM) clean

realclean:
@$(MAKE) -C standard clean
@$(MAKE) -C SOA clean
@$(MAKE) -C isoprene clean

help:
@$(MAKE) -C $(HELP)
```

1.5 Module Interface Makefile (in the KPP/43t subdirectory)

This makefile compiles the KPP solver code for the GEOS-Chem 43 tracer simulation (i.e. without secondary organic aerosol tracers). 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 TARGET [ 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
```

```
# Define variables
ROOTDIR = ../..
HDR     = $(ROOTDIR)/Headers
HELP    = $(ROOTDIR)/help
LIB     = $(ROOTDIR)/lib
```

```
MOD     = $(ROOTDIR)/mod

# Include header file.  This returns CC, F90, FREEFORM, LD, R8, SHELL,
# as well as the default Makefile compilation rules for source code files.
include $(ROOTDIR)/Makefile_header.mk

#=============================================================================
# List of files to compile.  Here the order is not important,
# as we will explicity define the dependencies listing below.
#=============================================================================

# Source code files
SRC  = $(wildcard gckpp*.F90)

# Object files
OBJ  = $(SRC:.F90=.o)

#=============================================================================
# Makefile targets: type "make help" for a complete listing!
#=============================================================================

.PHONY: clean help

lib: $(OBJ)
$(AR) crs libKpp.a $(OBJ)
mv libKpp.a $(LIB)

clean:
rm -f *.o *.mod geos

help:
@$(MAKE) -C $(HELP)

#=============================================================================
# Dependencies listing (grep "USE " to get the list of module references!)
#
# From this list of dependencies, the "make" utility will figure out the
# correct order of compilation (so we don't have to do that ourselves!)
#=============================================================================

gckpp_Function.o      : gckpp_Parameters.o

gckpp_Global.o        : gckpp_Parameters.o

gckpp_Hessian.o       : gckpp_Parameters.o      \
                        gckpp_HessianSP.o

gckpp_Initialize.o    : gckpp_Parameters.o      \
```

```
                        gckpp_Global.o          \
                        gckpp_Util.o            \
                        gckpp_Monitor.o

gckpp_Integrator.o    : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Function.o        \
                        gckpp_Rates.o           \
                        gckpp_Jacobian.o        \
                        gckpp_LinearAlgebra.o

gckpp_Jacobian.o      : gckpp_Parameters.o      \
                        gckpp_JacobianSP.o

gckpp_LinearAlgebra.o : gckpp_Parameters.o      \
                        gckpp_JacobianSP.o

gckpp_Model.o         : gckpp_Precision.o       \
                        gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Function.o        \
                        gckpp_Integrator.o      \
                        gckpp_Rates.o           \
                        gckpp_Jacobian.o        \
                        gckpp_Hessian.o         \
                        gckpp_Stoichiom.o       \
                        gckpp_Monitor.o         \
                        gckpp_Util.o            \
                        gckpp_LinearAlgebra.o

gckpp_Parameters.o    : gckpp_Precision.o

#gckpp_Rates.o         : gckpp_Parameters.o      \
#                        gckpp_Global.o          \
#                        gckpp_Monitor.o         \
#                        gckpp_comode_mod.o

gckpp_Rates.o         : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Monitor.o

gckpp_Stoichiom.o     : gckpp_Parameters.o      \
                        gckpp_StoichiomSP.o

gckpp_Util.o          : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Monitor.o
```

1.6 Module Interface Makefile (in the KPP/SOA subdirectory)

This makefile compiles the KPP solver code for the GEOS-Chem SOA simulation (with aromatic formation of secondary organic aerosol tracers). 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 TARGET [ 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
```

```
# Define variables
ROOTDIR = ../..
HDR     = $(ROOTDIR)/Headers
```

```
HELP    = $(ROOTDIR)/help
LIB     = $(ROOTDIR)/lib
MOD     = $(ROOTDIR)/mod

# Include header file.  This returns CC, F90, FREEFORM, LD, R8, SHELL,
# as well as the default Makefile compilation rules for source code files.
include $(ROOTDIR)/Makefile_header.mk

#==============================================================================
# List of files to compile.  Here the order is not important,
# as we will explicity define the dependencies listing below.
#==============================================================================

# Source code files
SRC  = $(wildcard gckpp*.F90)

# Object files
OBJ  = $(SRC:.F90=.o)

#==============================================================================
# Makefile targets: type "make help" for a complete listing!
#==============================================================================

.PHONY: clean help

lib: $(OBJ)
$(AR) crs libKpp.a $(OBJ)
mv libKpp.a $(LIB)

clean:
rm -f *.o *.mod geos

help:
@$(MAKE) -C $(HELP)

#==============================================================================
# Dependencies listing (grep "USE " to get the list of module references!)
#
# From this list of dependencies, the "make" utility will figure out the
# correct order of compilation (so we don't have to do that ourselves!)
#==============================================================================

gckpp_Function.o      : gckpp_Parameters.o

gckpp_Global.o        : gckpp_Parameters.o

gckpp_Hessian.o       : gckpp_Parameters.o      \
                        gckpp_HessianSP.o
```

```
gckpp_Initialize.o    : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Util.o            \
                        gckpp_Monitor.o

gckpp_Integrator.o    : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Function.o        \
                        gckpp_Rates.o           \
                        gckpp_Jacobian.o        \
                        gckpp_LinearAlgebra.o

gckpp_Jacobian.o      : gckpp_Parameters.o      \
                        gckpp_JacobianSP.o

gckpp_LinearAlgebra.o : gckpp_Parameters.o      \
                        gckpp_JacobianSP.o

gckpp_Model.o         : gckpp_Precision.o       \
                        gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Function.o        \
                        gckpp_Integrator.o      \
                        gckpp_Rates.o           \
                        gckpp_Jacobian.o        \
                        gckpp_Hessian.o         \
                        gckpp_Stoichiom.o       \
                        gckpp_Monitor.o         \
                        gckpp_Util.o            \
                        gckpp_LinearAlgebra.o

gckpp_Parameters.o    : gckpp_Precision.o

gckpp_Rates.o         : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Monitor.o

gckpp_Stoichiom.o     : gckpp_Parameters.o      \
                        gckpp_StoichiomSP.o

gckpp_Util.o          : gckpp_Parameters.o      \
                        gckpp_Global.o          \
                        gckpp_Monitor.o
```

1.7 Module Interface Makefile (in the GeosTomas subdirectory)

This is the main makefile for GEOS-Chem + TOMAS aerosol microphysics. It compiles the GEOS-Chem core source code files and into object files (*.o). Module files (*.mod) are copied to the MOD directory.

REMARKS:

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

                                                                             .
  make TARGET [ 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
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.  %%%
   %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

REVISION HISTORY:

```
    25 Jan 2010 - R. Yantosca - Initial version for TOMAS microphysics
    28 Jan 2010 - C. Carouge  - Modifications for ISORROPIA II
    10 May 2010 - R. Yantosca - Add dependency for RD_AOD.f
    26 Aug 2010 - R. Yantosca - Modifications for MERRA met fields
    23 Sep 2010 - R. Yantosca - Removed "tropopause.f" from compile list
    23 Sep 2010 - R. Yantosca - Updated dependencies for v9-01-01
```

```
# Define variables
ROOTDIR := ..
APM     := $(ROOTDIR)/APM
BIN     := $(ROOTDIR)/bin
BPCH    := $(ROOTDIR)/GeosBpch
CORE    := $(ROOTDIR)/GeosCore
DOC     := $(ROOTDIR)/doc
EXE     := geostomas
HDR     := $(ROOTDIR)/Headers
HELP    := $(ROOTDIR)/help
ISO     := $(ROOTDIR)/ISOROPIA
LIB     := $(ROOTDIR)/lib
KPP     := $(ROOTDIR)/KPP
MOD     := $(ROOTDIR)/mod
UTIL    := $(ROOTDIR)/GeosUtil
GTMM    := $(ROOTDIR)/GTMM
LESMF   := $(ROOTDIR)/ESMF

# This directory only contains files that are different for the TOMAS
# aerosol microphysics.  For files that are the same as for the regular
# GEOS-Chem code, look in the GeosCore directory.
VPATH   := ../GeosCore

# Include header file.  This returns CC, F90, FREEFORM, LD, R8, SHELL,
# as well as the default Makefile compilation rules for source code files.

ifeq ($(ESMF),yes)
  # Hack to force the ESMA headers work correctly with mpif90 as FC
  include $(ROOTDIR)/Makefile_header.mk
override FC := $(COMPILER)
  # End-of-hack
  include $(ESMADIR)/Config/ESMA_base.mk  # Generic stuff
  include $(ESMADIR)/Config/ESMA_arch.mk  # System dependencies
  include $(ESMADIR)/Config/GMAO_base.mk  # GMAO stuff
  include $(ROOTDIR)/Makefile_header.mk
```

```
override FC := $(ESMA_FC) # Unset hack
override LD := mpif90
else
include $(ROOTDIR)/Makefile_header.mk
endif

#==============================================================================
# List of files to compile.  We need to manually list all object files, since
# some of these will be referenced from the ../GeosCore directory.
#
# Parallel make may not work with TOMAS.  Investigate later... (bmy, 1/25/10)
#==============================================================================

OBJ =                                                                      \
BLKSLV.o                drydep_mod.o            partition.o                \
CLDSRF.o                dust_dead_mod.o         pbl_mix_mod.o              \
CO_strat_pl.o           dust_mod.o              pderiv.o                   \
EFOLD.o                 edgar_mod.o             photoj.o                   \
FLINT.o                 emep_mod.o              physproc.o                 \
GAUSSP.o                emf_scale.o             pjc_pfix_geos5_window_mod.o \
GEN.o                   emfossil.o              pjc_pfix_mod.o             \
JRATET.o                emisop.o                planeflight_mod.o          \
JVALUE.o                emisop_grass.o          precipfrac.o               \
LEGND0.o                emisop_mb.o             pulsing.o                  \
MATIN4.o                emissdr.o               rd_js.o                    \
MIESCT.o                emissions_mod.o         rd_prof.o                  \
NOABS.o                 emmonot.o               rdisopt.o                  \
OPMIE.o                 epa_nei_mod.o           rdlai.o                    \
RD_TJPL.o               fast_j.o                rdland.o                   \
RnPbBe_mod.o            fertadd.o               rdlight.o                  \
SPHERE.o                findmon.o               rdmonot.o                  \
XSEC1D.o                fjfunc.o                rdsoil.o                   \
XSECO2.o                fjx_acet_mod.o          readchem.o                 \
XSECO3.o                future_emissions_mod.o  reader.o                   \
a3_read_mod.o           fvdas_convect_mod.o     readlai.o                  \
a6_read_mod.o           fyhoro.o                restart_mod.o              \
acetone_mod.o           fyrno3.o                rpmares_mod.o              \
aerosol_mod.o           gamap_mod.o             ruralbox.o                 \
aircraft_nox_mod.o      gasconc.o               scale_anthro_mod.o         \
airmas.o                gc_biomass_mod.o        schem.o                    \
anthroems.o             gcap_convect_mod.o      seasalt_mod.o              \
arctas_ship_emiss_mod.o gcap_read_mod.o         set_aer.o                  \
arsl1k.o                geia_mod.o              set_prof.o                 \
backsub.o               get_global_ch4.o        setbase.o                  \
benchmark_mod.o         getifsun.o              setemdep.o                 \
biofit.o                gfed2_biomass_mod.o     setemis.o                  \
biofuel_mod.o           global_ch4_mod.o        setmodel.o                 \
biomass_mod.o           global_hno3_mod.o       sfcwindsqr.o               \
```

```
boxvl.o                 global_no3_mod.o        smvgear.o                   \
bravo_mod.o             global_nox_mod.o        soaprod_mod.o               \
c2h6_mod.o              global_o1d_mod.o        soilbase.o                  \
cac_anthro_mod.o        global_o3_mod.o         soilcrf.o                   \
calcrate.o              global_oh_mod.o         soilnoxems.o                \
carbon_mod.o            gwet_read_mod.o         soiltemp.o                  \
ch3i_mod.o              h2_hd_mod.o             soiltype.o                  \
chemdr.o                hcn_ch3cn_mod.o         streets_anthro_mod.o        \
chemistry_mod.o         i6_read_mod.o           subfun.o                    \
cleanup.o               icoads_ship_mod.o       sulfate_mod.o               \
co2_mod.o               initialize.o            sunparam.o                  \
comode_mod.o            inphot.o                tagged_co_mod.o             \
convection_mod.o        input_mod.o             tagged_ox_mod.o             \
dao_mod.o               isoropiaII_mod.o        tcorr.o                     \
decomp.o                jsparse.o               toms_mod.o                  \
diag03_mod.o            jv_index.o              tpcore_bc_mod.o             \
diag04_mod.o            ksparse.o               tpcore_fvdas_mod.o          \
diag1.o                 lai_mod.o               tpcore_geos5_window_mod.o   \
diag3.o                 lightning_nox_mod.o     tpcore_mod.o                \
diag41_mod.o            linoz_mod.o             tpcore_window_mod.o         \
diag42_mod.o            logical_mod.o           tracer_mod.o                \
diag48_mod.o            lump.o                  tracerid_mod.o              \
diag49_mod.o            main.o                  transport_mod.o             \
diag50_mod.o            megan_mod.o             retro_mod.o                 \
diag51_mod.o            meganut_mod.o           tropopause_mod.o            \
diag51b_mod.o           mercury_mod.o           upbdflx_mod.o               \
diag56_mod.o            mmran_16.o              update.o                    \
diag_2pm.o              ndxx_setup.o            uvalbedo_mod.o              \
diag_mod.o              nei2005_anthro_mod.o    vdiff_mod.o                 \
diag_oh_mod.o           ocean_mercury_mod.o     vdiff_pre_mod.o             \
diag_pl_mod.o           ohsave.o                vistas_anthro_mod.o         \
diagoh.o                optdepth_mod.o          wetscav_mod.o               \
xtra_read_mod.o         aero_drydep.o           tomas_mod.o                 \
tomas_tpcore_mod.o      RD_AOD.o                depo_mercury_mod.o          \
land_mercury_mod.o      global_br_mod.o         merra_a1_mod.o              \
merra_a3_mod.o          merra_cn_mod.o          merra_i6_mod.o

#=============================================================================
# Makefile targets: type "make help" for a complete listing!
#=============================================================================

.PHONY: clean realclean doc docclean help

all:
@$(MAKE) TOMAS=yes lib
@$(MAKE) TOMAS=yes exe

ifeq ($(ESMF),yes)
```

```
lib:                                                    # Build for ESMF/GEOS-5
@$(MAKE) libgc
@$(MAKE) libesmf
else ifeq ($(ESMF_TESBED),yes)
lib:                                                    # Build for ESMF/Testbed
@$(MAKE) libgc
@$(MAKE) libesmf_testbed
else
lib:                                                    # Build normal GEOS-Chem
@$(MAKE) libgc
endif

libgc:                                                  # Compile everything
@$(MAKE) libheaders
@$(MAKE) libkpp
@$(MAKE) libutil
@$(MAKE) libiso
@$(MAKE) libtomas

libtomas: $(OBJ)                                        # Build code in GeosTomas/

libiso:                                                 # Build code in ISOROPIA/
@$(MAKE) -C $(ISO)

libkpp:                                                 # Build code in KPP/
@$(MAKE) -C $(KPP)

libutil:                                                # Build code in GeosUtil/
@$(MAKE) -C $(UTIL)

libheaders:                                             # Build code in Headers/
@$(MAKE) -C $(HDR)

libesmf:                                                # Compile ESMF/GEOS-5
@$(MAKE) -C $(LESMF) ESMF=yes esmf

libesmf_testbed:                                        # Compile ESMF testbed
@$(MAKE) -C $(LESMF) ESMF_TESTBED=yes esmf

exe:                                                    # Build executable
$(LD) $(OBJ) $(LINK) -o $(EXE)
cp -f $(EXE) $(BIN)

clean:                                                  # Remove files here
rm -f *.o *.mod geos geosapm geostomas

realclean:                                              # Remove files everywhere
@$(MAKE) clean
```

```
@$(MAKE) -C $(ISO) clean
@$(MAKE) -C $(KPP) realclean
@$(MAKE) -C $(UTIL) clean
@$(MAKE) -C $(CORE) clean
@$(MAKE) -C $(GTMM) clean
@$(MAKE) -C $(HDR) clean
@$(MAKE) docclean
rm -f $(LIB)/*.a
rm -f $(MOD)/*.mod
rm -f $(BIN)/geos*

doc:                                                    # Build documentation
@$(MAKE) -C $(DOC) all

docclean:                                               # Remove documentation
@$(MAKE) -C $(DOC) clean

help:                                                   # Show help screen
@$(MAKE) -C $(HELP)

#============================================================================
# Dependencies listing (grep "USE " to get the list of module references!)
#
# From this list of dependencies, the "make" utility will figure out the
# correct order of compilation (so we don't have to do that ourselves).
# This also allows us to compile on multiple processors with "make -j".
#
# NOTES:
# (1) Only specify object-file dependencies that are within this directory.
#      Object files in other directories will be referenced at link-time.
# (2) For "make -j" to work, all files in this directory must have a
#      listed dependency.
#============================================================================

a3_read_mod.o              : a3_read_mod.F          dao_mod.o             \
                             diag_mod.o             logical_mod.o

a6_read_mod.o              : a6_read_mod.F          dao_mod.o             \
                             diag_mod.o             logical_mod.o

acetone_mod.o              : acetone_mod.F          dao_mod.o             \
                             diag_mod.o

aerosol_mod.o              : aerosol_mod.F          comode_mod.o          \
                             dao_mod.o              diag_mod.o            \
                             logical_mod.o          tracerid_mod.o        \
                             tracer_mod.o           tropopause_mod.o
```

```
aircraft_nox_mod.o          : aircraft_nox_mod.F                          \
                              dao_mod.o               diag_mod.o

airmas.o                    : airmas.F

anthroems.o                 : anthroems.F                                 \
                              future_emissions_mod.o  edgar_mod.o         \
                              geia_mod.o              logical_mod.o       \
                              scale_anthro_mod.o      tracer_mod.o        \
                              tracerid_mod.o

arctas_ship_emiss_mod.o     : arctas_ship_emiss_mod.F                     \
                              logical_mod.o           scale_anthro_mod.o  \
                              tracerid_mod.o          tracer_mod.o

arsl1k.o                    : arsl1k.F

backsub.o                   : backsub.F

benchmark_mod.o             : benchmark_mod.F                             \
                              tracerid_mod.o          tracer_mod.o

biofuel_mod.o               : biofuel_mod.F                               \
                              dao_mod.o               diag_mod.o          \
                              epa_nei_mod.o           future_emissions_mod.o \
                              logical_mod.o           streets_anthro_mod.o \
                              tracerid_mod.o          tracer_mod.o

biofit.o                    : biofit.F

biomass_mod.o               : biomass_mod.F                               \
                              diag_mod.o              gc_biomass_mod.o    \
                              gfed2_biomass_mod.o     logical_mod.o       \
                              tracerid_mod.o          tracer_mod.o

BLKSLV.o                    : BLKSLV.F

boxvl.o                     : boxvl.F               dao_mod.o

bravo_mod.o                 : bravo_mod.F                                 \
                              future_emissions_mod.o  logical_mod.o       \
                              scale_anthro_mod.o      tracerid_mod.o

c2h6_mod.o                  : c2h6_mod.F                                  \
                              biofuel_mod.o           biomass_mod.o       \
                              dao_mod.o               diag_mod.o          \
                              geia_mod.o              global_oh_mod.o     \
                              logical_mod.o           tracerid_mod.o      \
```

```
                          tracer_mod.o

cac_anthro_mod.o        : cac_anthro_mod.F                          \
                          future_emissions_mod.o  logical_mod.o     \
                          scale_anthro_mod.o      tracerid_mod.o    \
                          tracer_mod.o

calcrate.o              : calcrate.F                                \
                          comode_mod.o            dao_mod.o         \
                          diag_mod.o              drydep_mod.o      \
                          logical_mod.o           pbl_mix_mod.o     \
                          planeflight_mod.o       tracerid_mod.o

carbon_mod.o            : carbon_mod.F                              \
                          biomass_mod.o           comode_mod.o      \
                          dao_mod.o               diag_mod.o        \
                          drydep_mod.o            future_emissions_mod.o \
                          gfed2_biomass_mod.o     global_no3_mod.o  \
                          global_o3_mod.o         global_oh_mod.o   \
                          logical_mod.o           megan_mod.o       \
                          pbl_mix_mod.o           tracerid_mod.o    \
                          tracer_mod.o            tropopause_mod.o  \
                          vdiff_pre_mod.o         meganut_mod.o     \
                          tomas_mod.o

ch3i_mod.o              : ch3i_mod.F                                \
                          biofuel_mod.o           biomass_mod.o     \
                          dao_mod.o               diag_mod.o        \
                          diag_pl_mod.o           logical_mod.o     \
                          tracerid_mod.o          tracer_mod.o      \
                          uvalbedo_mod.o

chemdr.o                : chemdr.F                                  \
                          aerosol_mod.o           comode_mod.o      \
                          dao_mod.o               diag_oh_mod.o     \
                          diag_pl_mod.o           future_emissions_mod.o \
                          dust_mod.o              logical_mod.o     \
                          planeflight_mod.o       restart_mod.o     \
                          tracer_mod.o            tracerid_mod.o    \
                          tropopause_mod.o        uvalbedo_mod.o

chemistry_mod.o         : chemistry_mod.F                           \
                          acetone_mod.o           aerosol_mod.o     \
                          c2h6_mod.o              carbon_mod.o      \
                          ch3i_mod.o              comode_mod.o      \
                          dao_mod.o               drydep_mod.o      \
                          dust_mod.o              global_ch4_mod.o  \
                          h2_hd_mod.o             hcn_ch3cn_mod.o   \
```

```
                          isoropiaII_mod.o       logical_mod.o          \
                          mercury_mod.o          optdepth_mod.o         \
                          rpmares_mod.o          RnPbBe_mod.o           \
                          seasalt_mod.o          sulfate_mod.o          \
                          tagged_co_mod.o        tagged_ox_mod.o        \
                          tracerid_mod.o         tracer_mod.o           \
                          tomas_mod.o

cleanup.o                 : cleanup.F                                   \
                          acetone_mod.o          aerosol_mod.o          \
                          arctas_ship_emiss_mod.o aircraft_nox_mod.o    \
                          biomass_mod.o          biofuel_mod.o          \
                          bravo_mod.o            c2h6_mod.o             \
                          cac_anthro_mod.o       carbon_mod.o           \
                          co2_mod.o              comode_mod.o           \
                          dao_mod.o              depo_mercury_mod.o     \
                          diag_mod.o             diag03_mod.o           \
                          diag04_mod.o           diag41_mod.o           \
                          diag50_mod.o           diag51_mod.o           \
                          diag51b_mod.o          diag_oh_mod.o          \
                          diag_pl_mod.o          drydep_mod.o           \
                          dust_mod.o             dust_dead_mod.o        \
                          edgar_mod.o            emep_mod.o             \
                          epa_nei_mod.o          gc_biomass_mod.o       \
                          isoropiaII_mod.o       gfed2_biomass_mod.o    \
                          global_ch4_mod.o       global_hno3_mod.o      \
                          global_no3_mod.o       global_nox_mod.o       \
                          global_o1d_mod.o       global_oh_mod.o        \
                          h2_hd_mod.o            hcn_ch3cn_mod.o        \
                          lai_mod.o              land_mercury_mod.o     \
                          lightning_nox_mod.o    linoz_mod.o            \
                          megan_mod.o            mercury_mod.o          \
                          ocean_mercury_mod.o    pbl_mix_mod.o          \
                          pjc_pfix_mod.o         planeflight_mod.o      \
                          seasalt_mod.o          sulfate_mod.o          \
                          tagged_co_mod.o        toms_mod.o             \
                          tracer_mod.o           transport_mod.o        \
                          tropopause_mod.o       uvalbedo_mod.o         \
                          vistas_anthro_mod.o    wetscav_mod.o          \
                          icoads_ship_mod.o      tpcore_fvdas_mod.o     \
                          tpcore_geos5_window_mod.o  tomas_mod.o

CLDSRF.o                  : CLDSRF.F

co2_mod.o                 : co2_mod.F            biomass_mod.o          \
                          diag04_mod.o           tracer_mod.o           \
                    tracerid_mod.o
```

```
CO_strat_pl.o           : CO_strat_pl.F                                 \
                          dao_mod.o             tracer_mod.o            \
                          tracerid_mod.o        tropopause_mod.o

comode_mod.o            : comode_mod.F          tracer_mod.o

convection_mod.o        : convection_mod.F                              \
                          dao_mod.o             diag_mod.o              \
                          depo_mercury_mod.o    fvdas_convect_mod.o     \
                          gc_type_mod.o         gcap_convect_mod.o      \
                          logical_mod.o         mercury_mod.o           \
                          tracer_mod.o          tracerid_mod.o          \
                          wetscav_mod.o

dao_mod.o               : dao_mod.F                                     \
                          logical_mod.o         tracer_mod.o

decomp.o                : decomp.F

depo_mercury_mod.o      : depo_mercury_mod.F                            \
                          dao_mod.o             diag_mod.o              \
                          logical_mod.o         tracerid_mod.o

diag03_mod.o            : diag03_mod.F          tracerid_mod.o

diag04_mod.o            : diag04_mod.F

diag1.o                 : diag1.F                                       \
                          dao_mod.o             diag_mod.o              \
                          tracer_mod.o          tracerid_mod.o          \
                          tropopause_mod.o

diag3.o                 : diag3.F                                       \
                          biofuel_mod.o         biomass_mod.o           \
                          diag_mod.o            diag03_mod.o            \
                          diag04_mod.o          diag41_mod.o            \
                          diag42_mod.o          diag56_mod.o            \
                          diag_pl_mod.o         depo_mercury_mod.o      \
                          drydep_mod.o          logical_mod.o           \
                          tracer_mod.o          tracerid_mod.o          \
                          wetscav_mod.o         tomas_mod.o

diag41_mod.o            : diag41_mod.F          pbl_mix_mod.o

diag42_mod.o            : diag42_mod.F                                  \
                          dao_mod.o             logical_mod.o           \
                          tracerid_mod.o        tracer_mod.o
```

```
diag48_mod.o            : diag48_mod.F                                  \
                          dao_mod.o             pbl_mix_mod.o           \
                          tracerid_mod.o        tracer_mod.o

diag49_mod.o            : diag49_mod.F                                  \
                          dao_mod.o             lai_mod.o               \
                          pbl_mix_mod.o         tracerid_mod.o          \
                          tracer_mod.o

diag50_mod.o            : diag50_mod.F                                  \
                          comode_mod.o          dao_mod.o               \
                          logical_mod.o         pbl_mix_mod.o           \
                          tracerid_mod.o        tracer_mod.o            \
                          tropopause_mod.o

diag51_mod.o            : diag51_mod.F                                  \
                          dao_mod.o             lai_mod.o               \
                          logical_mod.o         pbl_mix_mod.o           \
                          tracerid_mod.o        tracer_mod.o            \
                          tropopause_mod.o

diag51b_mod.o           : diag51b_mod.F                                 \
                          dao_mod.o             lai_mod.o               \
                          logical_mod.o         pbl_mix_mod.o           \
                          tracerid_mod.o        tracer_mod.o            \
                          tropopause_mod.o

diag56_mod.o            : diag56_mod.F

diag_2pm.o              : diag_2pm.F                                    \
                          diag_mod.o            tropopause_mod.o


diag_mod.o              : diag_mod.F

diag_oh_mod.o           : diag_oh_mod.F                                 \
                          comode_mod.o          logical_mod.o           \
                          tracerid_mod.o        tracer_mod.o

diag_pl_mod.o           : diag_pl_mod.F                                 \
                          comode_mod.o          logical_mod.o           \
                          tracerid_mod.o        tracer_mod.o

drydep_mod.o            : drydep_mod.F          comode_mod.o            \
                          dao_mod.o             diag_mod.o              \
                          logical_mod.o         pbl_mix_mod.o           \
                          tracerid_mod.o        tracer_mod.o            \
                          meganut_mod.o         tomas_mod.o
```

```
diagoh.o                  : diagoh.F               diag_mod.o

dust_dead_mod.o           : dust_dead_mod.F        dao_mod.o

dust_mod.o                : dust_mod.F                                \
                            comode_mod.o           dao_mod.o          \
                            diag_mod.o             drydep_mod.o       \
                            dust_dead_mod.o        logical_mod.o      \
                            tracerid_mod.o         tracer_mod.o

edgar_mod.o               : edgar_mod.F                               \
                            future_emissions_mod.o logical_mod.o      \
                            scale_anthro_mod.o

EFOLD.o                   : EFOLD.F

emep_mod.o                : emep_mod.F                                \
                            future_emissions_mod.o logical_mod.o      \
                            scale_anthro_mod.o     tracerid_mod.o     \
                            tracer_mod.o

emf_scale.o               : emf_scale.F            tracerid_mod.o

emfossil.o                : emfossil.F                                \
                            bravo_mod.o            cac_anthro_mod.o   \
                            dao_mod.o              diag_mod.o         \
                            edgar_mod.o            emep_mod.o         \
                            epa_nei_mod.o          icoads_ship_mod.o  \
                            logical_mod.o          nei2005_anthro_mod.o \
                            streets_anthro_mod.o   tracer_mod.o       \
                            tracerid_mod.o         vistas_anthro_mod.o \
                            retro_mod.o

emisop.o                  : emisop.F               dao_mod.o          \
                            meganut_mod.o

emisop_grass.o            : emisop_grass.F         dao_mod.o

emisop_mb.o               : emisop_mb.F            dao_mod.o

emissdr.o                 : emissdr.F                                 \
                            acetone_mod.o          aircraft_nox_mod.o \
                            biofuel_mod.o          dao_mod.o          \
                            diag_mod.o             emissions_mod.o    \
      lightning_nox_mod.o   logical_mod.o        \
                            megan_mod.o            tracer_mod.o       \
                            tracerid_mod.o         meganut_mod.o
```

```
emissions_mod.o             : emissions_mod.F                              \
                              arctas_ship_emiss_mod.o biomass_mod.o        \
                              bravo_mod.o             c2h6_mod.o           \
                              cac_anthro_mod.o        carbon_mod.o         \
                              ch3i_mod.o              co2_mod.o            \
                              dust_mod.o              edgar_mod.o          \
                              emep_mod.o              epa_nei_mod.o        \
                              global_ch4_mod.o        h2_hd_mod.o          \
                              hcn_ch3cn_mod.o         icoads_ship_mod.o    \
                              logical_mod.o           mercury_mod.o        \
                              nei2005_anthro_mod.o    RnPbBe_mod.o         \
                              seasalt_mod.o           streets_anthro_mod.o \
                              sulfate_mod.o           tagged_co_mod.o      \
                              tracer_mod.o            vistas_anthro_mod.o  \
                              retro_mod.o

emmonot.o                   : emmonot.F

epa_nei_mod.o               : epa_nei_mod.F                                \
                              future_emissions_mod.o  logical_mod.o        \
                              scale_anthro_mod.o      tracerid_mod.o       \
                              tracer_mod.o

fast_j.o                    : fast_j.F                                     \
                              dao_mod.o               toms_mod.o

fertadd.o                   : fertadd.F             logical_mod.o

findmon.o                   : findmon.F

fjfunc.o                    : fjfunc.F

fjx_acet_mod.o              : fjx_acet_mod.F

future_emissions_mod.o      : future_emissions_mod.F

fvdas_convect_mod.o         : fvdas_convect_mod.F                          \
                              dao_mod.o               diag_mod.o           \
                              depo_mercury_mod.o      logical_mod.o        \
                              tracerid_mod.o          tracer_mod.o

fyhoro.o                    : fyhoro.F

fyrno3.o                    : fyrno3.F

gamap_mod.o                 : gamap_mod.F                                  \
                              diag03_mod.o            diag04_mod.o         \
```

```
                          diag41_mod.o          diag42_mod.o          \
                          diag48_mod.o          diag49_mod.o          \
                          diag50_mod.o          diag51_mod.o          \
                          diag51b_mod.o         diag56_mod.o          \
                          diag_pl_mod.o       drydep_mod.o          \
                          logical_mod.o         tracerid_mod.o        \
                          tracer_mod.o          wetscav_mod.o         \
                          tomas_mod.o
ifeq ($(COMPILER),sun)
$(F90) -O0 -c $<
endif

gasconc.o               : gasconc.F                                   \
                          comode_mod.o          dao_mod.o             \
                          drydep_mod.o          tropopause_mod.o      \
                          logical_mod.o

GAUSSP.o                : GAUSSP.F

gc_biomass_mod.o        : gc_biomass_mod.F                            \
                          future_emissions_mod.o logical_mod.o        \
                          tracerid_mod.o        tracer_mod.o

gc_type_mod.o           : gc_type_mod.F

gcap_convect_mod.o      : gcap_convect_mod.F                          \
                          dao_mod.o             diag_mod.o

gcap_read_mod.o         : gcap_read_mod.F       dao_mod.o             \
                          diag_mod.o            logical_mod.o

geia_mod.o              : geia_mod.F

GEN.o                   : GEN.F

get_global_ch4.o        : get_global_ch4.F                            \
                          future_emissions_mod.o logical_mod.o

getifsun.o              : getifsun.F            comode_mod.o

gfed2_biomass_mod.o     : gfed2_biomass_mod.F                         \
                          future_emissions_mod.o logical_mod.o        \
                          tracer_mod.o          tracerid_mod.o

global_br_mod.o         : global_br_mod.F       tropopause_mod.o

global_ch4_mod.o        : global_ch4_mod.F                            \
                          dao_mod.o             diag_mod.o            \
```

```
                        diag_oh_mod.o          diag_pl_mod.o          \
                        global_oh_mod.o        logical_mod.o          \
                        tracer_mod.o           vdiff_pre_mod.o

global_hno3_mod.o       : global_hno3_mod.F                           \
                        dao_mod.o              tracer_mod.o

global_no3_mod.o        : global_no3_mod.F

global_nox_mod.o        : global_nox_mod.F

global_o1d_mod.o        : global_o1d_mod.F

global_o3_mod.o         : global_o3_mod.F

global_oh_mod.o         : global_oh_mod.F

gwet_read_mod.o         : gwet_read_mod.F                             \
                        dao_mod.o              diag_mod.o             \
                        logical_mod.o

h2_hd_mod.o             : h2_hd_mod.F                                 \
                        biofuel_mod.o          biomass_mod.o          \
                        dao_mod.o              diag_mod.o             \
                        drydep_mod.o           geia_mod.o             \
                        global_nox_mod.o       global_o1d_mod.o       \
                        global_oh_mod.o        logical_mod.o          \
                        scale_anthro_mod.o     tagged_co_mod.o        \
                        tracerid_mod.o         tracer_mod.o           \
                        tropopause_mod.o       meganut_mod.o

hcn_ch3cn_mod.o         : hcn_ch3cn_mod.F                             \
                        biomass_mod.o          dao_mod.o              \
                        diag_mod.o             geia_mod.o             \
                        global_oh_mod.o        logical_mod.o          \
                        pbl_mix_mod.o          tracerid_mod.o

i6_read_mod.o           : i6_read_mod.F                               \
                        dao_mod.o              diag_mod.o             \
                        logical_mod.o

icoads_ship_mod.o       : icoads_ship_mod.F                           \
                        future_emissions_mod.o logical_mod.o          \
                        scale_anthro_mod.o     tracerid_mod.o         \
                        tracer_mod.o

initialize.o            : initialize.F                                \
                        diag_mod.o             diag03_mod.o           \
```

```
                          diag04_mod.o          diag41_mod.o          \
                          diag42_mod.o          diag56_mod.o          \
                          diag_pl_mod.o         logical_mod.o

inphot.o                : inphot.F

input_mod.o             : input_mod.F                               \
                          benchmark_mod.o       biofuel_mod.o         \
                          depo_mercury_mod.o    diag03_mod.o          \
                          diag04_mod.o          diag41_mod.o          \
                          diag42_mod.o        diag48_mod.o          \
                          diag49_mod.o        diag50_mod.o          \
     diag51_mod.o       diag51b_mod.o        \
     diag56_mod.o       diag_oh_mod.o        \
     diag_pl_mod.o      drydep_mod.o         \
                          emissions_mod.o       future_emissions_mod.o \
                          gamap_mod.o           land_mercury_mod.o    \
                          logical_mod.o       mercury_mod.o         \
                          ocean_mercury_mod.o   planeflight_mod.o     \
                          restart_mod.o         tpcore_bc_mod.o       \
                          tracerid_mod.o        tracer_mod.o          \
                          transport_mod.o       upbdflx_mod.o         \
                          wetscav_mod.o         tomas_mod.o

isoropiaII_mod.o        : isoropiaII_mod.F                          \
                          dao_mod.o             global_hno3_mod.o     \
                          logical_mod.o         tracerid_mod.o        \
                          tracer_mod.o          tropopause_mod.o

jsparse.o               : jsparse.F           comode_mod.o

JRATET.o                : JRATET.F            fjx_acet_mod.o

JVALUE.o                : JVALUE.F

jv_index.o              : jv_index.F

ksparse.o               : ksparse.F

lai_mod.o               : lai_mod.F           logical_mod.o

land_mercury_mod.o      : land_mercury_mod.F                        \
                          biomass_mod.o         dao_mod.o             \
                          depo_mercury_mod.o    lai_mod.o             \
                          logical_mod.o         tracerid_mod.o        \

LEGND0.o                : LEGND0.F
```

```
lightning_nox_mod.o         : lightning_nox_mod.F                          \
                              dao_mod.o              diag56_mod.o          \
                              diag_mod.o             logical_mod.o

linoz_mod.o                 : linoz_mod.F                                  \
                              dao_mod.o              tracerid_mod.o        \
                              tracer_mod.o           tropopause_mod.o

logical_mod.o               : logical_mod.F

lump.o                      : lump.F                                       \
                              comode_mod.o           tracerid_mod.o

main.o                      : main.F                                       \
                              a3_read_mod.o          a6_read_mod.o         \
                              benchmark_mod.o        chemistry_mod.o       \
                              convection_mod.o       comode_mod.o          \
                              diag_mod.o             diag41_mod.o          \
                              diag42_mod.o           diag48_mod.o          \
                              diag49_mod.o           diag50_mod.o          \
                              diag51_mod.o           diag51b_mod.o         \
                              diag_oh_mod.o          dao_mod.o             \
                              depo_mercury_mod.o     drydep_mod.o          \
                              emissions_mod.o        global_ch4_mod.o      \
                              gcap_read_mod.o        gwet_read_mod.o       \
                              i6_read_mod.o          input_mod.o           \
                              lai_mod.o              lightning_nox_mod.o   \
                              linoz_mod.o            logical_mod.o         \
                              megan_mod.o            pbl_mix_mod.o         \
                              ocean_mercury_mod.o    planeflight_mod.o     \
                              soaprod_mod.o          tpcore_bc_mod.o       \
                              tracer_mod.o           transport_mod.o       \
                              tropopause_mod.o       restart_mod.o         \
                              upbdflx_mod.o          uvalbedo_mod.o        \
                              vdiff_mod.o            wetscav_mod.o         \
                              xtra_read_mod.o        merra_cn_mod.o        \
                              merra_a1_mod.o         merra_a3_mod.o        \
                              merra_i6_mod.o

MATIN4.o                    : MATIN4.F

megan_mod.o                 : megan_mod.F          a3_read_mod.o         \
                              lai_mod.o            logical_mod.o         \
                              meganut_mod.o        merra_a1_mod.o

meganut_mod.o               : meganut_mod.F        dao_mod.o

mercury_mod.o               : mercury_mod.F                               \
```

```
                        dao_mod.o               depo_mercury_mod.o      \
                        diag03_mod.o            diag_mod.o              \
                        drydep_mod.o            global_br_mod.o         \
                        global_o3_mod.o         global_oh_mod.o         \
                        land_mercury_mod.o      lai_mod.o               \
                        logical_mod.o           ocean_mercury_mod.o     \
                        pbl_mix_mod.o           RnPbBe_mod.o            \
                        tracerid_mod.o          tracer_mod.o            \
                        tropopause_mod.o        vdiff_pre_mod.o

merra_a1_mod.o          : merra_a1_mod.F                                \
                        logical_mod.o           dao_mod.o

merra_a3_mod.o          : merra_a3_mod.F                                \
                        logical_mod.o           dao_mod.o

merra_cn_mod.o          : merra_cn_mod.F                                \
                        logical_mod.o           dao_mod.o

merra_i6_mod.o          : merra_i6_mod.F                                \
                        logical_mod.o           dao_mod.o

MIESCT.o                : MIESCT.F

ndxx_setup.o            : ndxx_setup.F                                  \
                        biofuel_mod.o           diag_mod.o              \
                        diag_oh_mod.o           drydep_mod.o            \
                        logical_mod.o           planeflight_mod.o       \
                        tracer_mod.o            tracerid_mod.o          \
                        wetscav_mod.o           tomas_mod.o

nei2005_anthro_mod.o    : nei2005_anthro_mod.F                          \
                        future_emissions_mod.o  logical_mod.o           \
                        scale_anthro_mod.o      tracerid_mod.o          \
                        tracer_mod.o

NOABS.o                 : NOABS.F

ocean_mercury_mod.o     : ocean_mercury_mod.F                           \
                        dao_mod.o               depo_mercury_mod.o      \
                        diag03_mod.o            logical_mod.o           \
                        tracerid_mod.o          tracer_mod.o

ohsave.o                : ohsave.F              comode_mod.o            \
                        diag_mod.o              tracerid_mod.o

optdepth_mod.o          : optdepth_mod.F        diag_mod.o
```

```
OPMIE.o                       : OPMIE.F

partition.o                   : partition.F                                 \
                                comode_mod.o            tracerid_mod.o

pbl_mix_mod.o                 : pbl_mix_mod.F                               \
                                dao_mod.o               diag_mod.o            \
                                logical_mod.o           tracer_mod.o

pderiv.o                      : pderiv.F

photoj.o                      : photoj.F

physproc.o                    : physproc.F                                  \
                                comode_mod.o            logical_mod.o         \
                                chemistry_mod.o

pjc_pfix_geos5_window_mod.o : pjc_pfix_geos5_window_mod.F

pjc_pfix_mod.o                : pjc_pfix_mod.F

planeflight_mod.o             : planeflight_mod.F                           \
                                comode_mod.o            dao_mod.o             \
                                tracer_mod.o            tropopause_mod.o

precipfrac.o                  : precipfrac.F          dao_mod.o

pulsing.o                     : pulsing.F

RD_AOD.o                      : RD_AOD.F

rd_js.o                       : rd_js.F

rd_prof.o                     : rd_prof.F

rdisopt.o                     : rdisopt.F

rdlai.o                       : rdlai.F

rdland.o                      : rdland.F              logical_mod.o

rdlight.o                     : rdlight.F

rdmonot.o                     : rdmonot.F

rdsoil.o                      : rdsoil.F

RD_TJPL.o                     : RD_TJPL.F
```

```
readchem.o                : readchem.F                                  \
                            diag_pl_mod.o          drydep_mod.o         \
                            logical_mod.o

reader.o                  : reader.F

readlai.o                 : readlai.F              logical_mod.o

restart_mod.o             : restart_mod.F                               \
                            comode_mod.o           dao_mod.o            \
                            logical_mod.o          tracer_mod.o

retro_mod.o               : retro_mod.F                                 \
                            future_emissions_mod.o logical_mod.o        \
                            scale_anthro_mod.o     tracerid_mod.o       \
                            tracer_mod.o

RnPbBe_mod.o              : RnPbBe_mod.F                                \
                            dao_mod.o              diag_mod.o           \
                            logical_mod.o          tracer_mod.o         \
                            tropopause_mod.o

rpmares_mod.o             : rpmares_mod.F                               \
                            dao_mod.o              global_hno3_mod.o    \
                            tracerid_mod.o         tracer_mod.o         \
                            tropopause_mod.o

ruralbox.o                : ruralbox.F                                  \
                            comode_mod.o           tropopause_mod.o

scale_anthro_mod.o        : scale_anthro_mod.F

schem.o                   : schem.F                dao_mod.o            \
                            tracerid_mod.o         tracer_mod.o         \
                            tropopause_mod.o

seasalt_mod.o             : seasalt_mod.F                               \
                            dao_mod.o              diag_mod.o           \
                            drydep_mod.o           logical_mod.o        \
                            pbl_mix_mod.o          tracerid_mod.o       \
                            tracer_mod.o           vdiff_pre_mod.o      \
                            tomas_mod.o

set_aer.o                 : set_aer.F

set_prof.o                : set_prof.F                                  \
                            dao_mod.o              toms_mod.o
```

```
setbase.o                 : setbase.F

setemdep.o                : setemdep.F             drydep_mod.o          \
                            tracer_mod.o           tracerid_mod.o

setemis.o                 : setemis.F                                    \
                            aircraft_nox_mod.o     biofuel_mod.o         \
                            biomass_mod.o          comode_mod.o          \
                            diag_mod.o             emissions_mod.o       \
                            lightning_nox_mod.o    logical_mod.o         \
                            pbl_mix_mod.o          tracerid_mod.o        \
                            tropopause_mod.o

setmodel.o                : setmodel.F

sfcwindsqr.o              : sfcwindsqr.F           dao_mod.o

smvgear.o                 : smvgear.F              comode_mod.o

soaprod_mod.o             : soaprod_mod.F                                \
                            carbon_mod.o           dao_mod.o             \
                            logical_mod.o          tracer_mod.o

soilbase.o                : soilbase.F

soilcrf.o                 : soilcrf.F

soilnoxems.o              : soilnoxems.F                                 \
                            dao_mod.o              diag_mod.o            \
                            future_emissions_mod.o logical_mod.o         \
                            meganut_mod.o

soiltemp.o                : soiltemp.F

soiltype.o                : soiltype.F

SPHERE.o                  : SPHERE.F

streets_anthro_mod.o      : streets_anthro_mod.F                         \
                            future_emissions_mod.o logical_mod.o         \
                            scale_anthro_mod.o     tracerid_mod.o        \
                            tracer_mod.o

subfun.o                  : subfun.F

sulfate_mod.o             : sulfate_mod.F                                \
                            arctas_ship_emiss_mod.o biomass_mod.o        \
```

```
                              bravo_mod.o             cac_anthro_mod.o       \
                              comode_mod.o            dao_mod.o              \
                              diag_mod.o              drydep_mod.o           \
                              edgar_mod.o             emep_mod.o             \
                              epa_nei_mod.o           future_emissions_mod.o \
                              gfed2_biomass_mod.o     global_hno3_mod.o      \
                              global_no3_mod.o        global_oh_mod.o        \
                              icoads_ship_mod.o       tomas_mod.o            \
                              logical_mod.o           nei2005_anthro_mod.o   \
                              pbl_mix_mod.o           scale_anthro_mod.o     \
                              seasalt_mod.o           streets_anthro_mod.o   \
                              tracerid_mod.o          tracer_mod.o           \
                              tropopause_mod.o        uvalbedo_mod.o         \
                              vdiff_pre_mod.o         wetscav_mod.o

sunparam.o                  : sunparam.F

tagged_co_mod.o             : tagged_co_mod.F                              \
                              biofuel_mod.o           biomass_mod.o          \
                              dao_mod.o               diag_mod.o             \
                              diag_pl_mod.o           global_nox_mod.o       \
                              global_oh_mod.o         logical_mod.o          \
                              megan_mod.o             meganut_mod.o          \
                              pbl_mix_mod.o           tracerid_mod.o         \
                              tracer_mod.o            tropopause_mod.o

tagged_ox_mod.o             : tagged_ox_mod.F                              \
                              dao_mod.o               diag_mod.o             \
                              diag_pl_mod.o           drydep_mod.o           \
                              logical_mod.o           pbl_mix_mod.o          \
                              tracerid_mod.o          tracer_mod.o           \
                              tropopause_mod.o        meganut_mod.o

tcorr.o                     : tcorr.F

toms_mod.o                  : toms_mod.F

tpcore_bc_mod.o             : tpcore_bc_mod.F                              \
                              logical_mod.o           tracer_mod.o

tpcore_geos5_window_mod.o   : tpcore_geos5_window_mod.F90
$(F90) -c $(FREEFORM) $(R8) $<

tpcore_mod.o                : tpcore_mod.F          dao_mod.o              \
                              diag_mod.o            global_ch4_mod.o       \
                              tracer_mod.o          tomas_tpcore_mod.o
$(F90) -c $(R8) $<
```

```
tpcore_window_mod.o         : tpcore_window_mod.F     dao_mod.o             \
                              diag_mod.o              global_ch4_mod.o      \
                              tracer_mod.o            tomas_mod.o
$(F90) -c $(R8) $<

tracer_mod.o                : tracer_mod.F

tracerid_mod.o              : tracerid_mod.F                                \
                              logical_mod.o           tracer_mod.o

transport_mod.o             : transport_mod.F                               \
                              dao_mod.o               diag_mod.o            \
                              logical_mod.o           pjc_pfix_mod.o        \
                              tpcore_mod.o            tpcore_bc_mod.o       \
                              tpcore_fvdas_mod.o      tpcore_window_mod.o   \
                              tracer_mod.o                                  \
                              tpcore_geos5_window_mod.o                     \
                              pjc_pfix_geos5_window_mod.o


tropopause.o                : tropopause.F                                  \
                              dao_mod.o               diag_mod.o            \
                              logical_mod.o           tropopause_mod.o

tropopause_mod.o            : tropopause_mod.F                              \
                              comode_mod.o            dao_mod.o             \
                              diag_mod.o              logical_mod.o

upbdflx_mod.o               : upbdflx_mod.F                                 \
                              dao_mod.o               linoz_mod.o           \
                              logical_mod.o           tagged_ox_mod.o       \
                              tracerid_mod.o          tracer_mod.o          \
                              tropopause_mod.o

update.o                    : update.F

vdiff_pre_mod.o             : vdiff_pre_mod.F       tracer_mod.o
ifeq ($(COMPILER),sun)
$(F90) -O3 -c $<
endif

vdiff_mod.o                 : vdiff_mod.F90                                 \
                              comode_mod.o            dao_mod.o             \
                              depo_mercury_mod.o      diag_mod.o            \
                              drydep_mod.o            logical_mod.o         \
                              ocean_mercury_mod.o     pbl_mix_mod.o         \
                              tracer_mod.o            tracerid_mod.o        \
                              vdiff_pre_mod.o
```

```
vistas_anthro_mod.o         : vistas_anthro_mod.F                          \
                              future_emissions_mod.o  epa_nei_mod.o        \
                              logical_mod.o           scale_anthro_mod.o   \
                              tracerid_mod.o          tracer_mod.o

wetscav_mod.o               : wetscav_mod.F                                \
                              dao_mod.o               diag_mod.o           \
                              depo_mercury_mod.o      logical_mod.o        \
                              mercury_mod.o           ocean_mercury_mod.o  \
                              tracerid_mod.o          tracer_mod.o         \
                              tomas_mod.o

XSEC1D.o                    : XSEC1D.F

XSEC02.o                    : XSEC02.F

XSEC03.o                    : XSEC03.F

xtra_read_mod.o             : xtra_read_mod.F       dao_mod.o            \
                              diag_mod.o            logical_mod.o        \
                              tomas_mod.o

#-----------------------------------------------------------------------------
# Dependencies of files specific to TOMAS microphysics (bmy, 1/25/10)
#-----------------------------------------------------------------------------

tomas_mod.o                 : tomas_mod.F                                  \
                      dao_mod.o               diag_mod.o             \
                              diag_pl_mod.o         logical_mod.o        \
                              tropopause_mod.o      tracer_mod.o         \
                              tracerid_mod.o

tomas_tpcore_mod.o          : tomas_tpcore_mod.F90                         \
                              tomas_mod.o           tracerid_mod.o


aero_drydep.o               : aero_drydep.F                                \
                              dao_mod.o             diag_mod.o           \
                              drydep_mod.o          dust_mod.o           \
                              logical_mod.o         pbl_mix_mod.o        \
                              tracer_mod.o          tracerid_mod.o       \
                              tropopause_mod.o      tomas_mod.o
```

1.8 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 TARGET [ 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.
```

```
# Define variables
SHELL   = /bin/sh
ROOTDIR = ..
HDR     = $(ROOTDIR)/Headers
HELP    = $(ROOTDIR)/help
LIB     = $(ROOTDIR)/lib
MOD     = $(ROOTDIR)/mod
LGTMM   = -L$(LIB) -lHg


# Include header file.  This returns variables CC, F90, FREEFORM, LD, R8,
# as well as the default Makefile compilation rules for source code files.
```

```
include $(ROOTDIR)/Makefile_header.mk

#============================================================================
# List of files to compile.  Here the order is not important,
# as we will explicity define the dependencies listing below.
#============================================================================

# Source code files
SRC  = $(wildcard *.F90)

# Object files
OBJ  = $(SRC:.F90=.o)

#============================================================================
# Makefile targets: type "make help" for a complete listing!
#============================================================================

.PHONY: clean help gtmm

lib: $(OBJ)
$(AR) crs libHg.a $(OBJ)
mv libHg.a $(LIB)

gtmm:
@$(MAKE) lib
@$(MAKE) exe

exe:
$(LD) $(OBJ) $(LGTMM) -o gtmm

clean:
rm -f *.o *.mod gtmm

help:
@$(MAKE) -C $(HELP)

#============================================================================
# Dependencies listing (grep "USE " to get the list of module references!)
#
# From this list of dependencies, the "make" utility will figure out the
# correct order of compilation (so we don't have to do that ourselves!)
#============================================================================

CleanupCASAarrays.o            : CleanupCASAarrays.F90 defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

GTMM.o                         : GTMM.F90              defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o        \
```

```
                                dorestart_mod.o       input_gtmm_mod.o

GTMM_coupled.o                : GTMM_coupled.F90      defineConstants.o     \
                                defineArrays.o        dorestart_mod.o       \
                          loadCASAinput.o       input_gtmm_mod.o

HgOutForGEOS.o                : HgOutForGEOS.F90      defineConstants.o     \
                                loadCASAinput.o       defineArrays.o        \
                                CasaRegridModule.o

assignAgeClassToRunningPool.o  : assignAgeClassToRunningPool.F90            \
                                defineConstants.o     loadCASAinput.o       \
                                defineArrays.o

assignRanPoolToAgeClass.o      : assignRanPoolToAgeClass.F90                \
                                defineConstants.o     loadCASAinput.o       \
                                defineArrays.o

defineArrays.o                : defineArrays.F90      defineConstants.o

doFPARandLAI.o                : doFPARandLAI.F90      defineConstants.o     \
                                loadCASAinput.o       defineArrays.o

doHerbCarbon.o                : doHerbCarbon.F90      defineConstants.o     \
                                loadCASAinput.o       defineArrays.o
# $(F90) -O0 -c $(FREEFORM) doHerbCarbon.F90

doHerbCarbonHg.o              : doHerbCarbonHg.F90    defineConstants.o     \
                                loadCASAinput.o       defineArrays.o
# $(F90) -O0 -c $(FREEFORM) doHerbCarbonHg.F90

doHerbivory.o                 : doHerbivory.F90       defineConstants.o     \
                                loadCASAinput.o       defineArrays.o

doHgDeposition.o              : doHgDeposition.F90    defineConstants.o     \
                                loadCASAinput.o       defineArrays.o

doLatitude.o                  : doLatitude.F90        defineConstants.o     \
                                loadCASAinput.o       defineArrays.o

doLeafRootShedding.o          : doLeafRootShedding.F90 defineConstants.o    \
                                loadCASAinput.o       defineArrays.o

doMaxHg.o                     : doMaxHg.F90           defineConstants.o     \
                                loadCASAinput.o       defineArrays.o

doNPP.o                       : doNPP.F90             defineConstants.o     \
                                loadCASAinput.o       defineArrays.o
```

```
doOptimumTemperature.o         : doOptimumTemperature.F90 defineConstants.o  \
                                 loadCASAinput.o       defineArrays.o

doPET.o                        : doPET.F90             defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

doSoilMoisture.o               : doSoilMoisture.F90    defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

doTreeCarbon.o                 : doTreeCarbon.F90      defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o
# $(F90) -O0 -c $(FREEFORM) doTreeCarbon.F90

doTreeCarbonHg.o               : doTreeCarbonHg.F90    defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o
# $(F90) -O0 -c $(FREEFORM) doTreeCarbonHg.F90

getAgeClassBF.o                : getAgeClassBF.F90     defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

getFireParams.o                : getFireParams.F90     defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

getFuelWood.o                  : getFuelWood.F90       defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

getSoilMoistParams.o           : getSoilMoistParams.F90 defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

getSoilParams.o                : getSoilParams.F90     defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o

input_gtmm_mod.o               : input_gtmm_mod.F90    defineConstants.o     \
                                 defineArrays.o

load_GC_data.o                 : load_GC_data.F90      defineConstants.o     \
                                 loadCASAinput.o       CasaRegridModule.o

loadCASAinput.o                : loadCASAinput.F90     defineConstants.o     \
                                 defineArrays.o        CasaRegridModule.o

loadHgDeposition.o             : loadHgDeposition.F90  defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o        \
                                 CasaRegridModule.o

organizeAgeClasses.o           : organizeAgeClasses.F90 defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o
```

```
processData.o                  : processData.F90       defineConstants.o     \
                                 loadCASAinput.o       defineArrays.o
# $(F90) -O0 -c $(FREEFORM) processData.F90

sort_pick_veg.o                : sort_pick_veg.F90     defineConstants.o

dorestart_mod.o                : dorestart_mod.F90     defineConstants.o     \
                                 defineArrays.o
```

1.9 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 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:

```
 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
```

```
#=============================================================================
# Initialization
#=============================================================================

# Define variables
ROOTDIR := ..
BIN     := $(ROOTDIR)/bin
BPCH    := $(ROOTDIR)/GeosBpch
```

```
CORE    := $(ROOTDIR)/GeosCore
DOC     := $(ROOTDIR)/doc
GTMM    := $(ROOTDIR)/GTMM
HDR     := $(ROOTDIR)/Headers
HELP    := $(ROOTDIR)/help
ISO     := $(ROOTDIR)/ISOROPIA
KPP     := $(ROOTDIR)/KPP
TOM     := $(ROOTDIR)/GeosTomas
UTIL    := $(ROOTDIR)/GeosUtil

# Get the Unix shell in SHELL from the Makefile_header.mk
include $(ROOTDIR)/Makefile_header.mk

#=============================================================================
# Makefile targets
#=============================================================================

.PHONY: all docclean help

all: srcdoc utildoc gtmmdoc makedoc

clean:
rm -f *.tex *.ps *.pdf

help:
@$(MAKE) -C $(HELPDIR)

#=============================================================================
# Build the GEOS-Chem documentation
#=============================================================================

# Commands to build the source code documentation
include ./Makefile_SrcDoc.mk

# Commands to build the utility module documentation
include ./Makefile_UtilDoc.mk

# Commands to build the makefile documentation
include ./Makefile_MakeDoc.mk

# Commands to build the GTMM documentation
include ./Makefile_GtmmDoc.mk
```

1.9.1 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
  7 Sep 2011 - R. Yantosca - Added gfed3_biomass_mod, *jv*_mod files
```

```
# List of source code files (order is important)
SRC1 :=                             \
./intro.geos-chem                   \
./headers.geos-chem                 \
$(HDR)/define.h                     \
$(HDR)/CMN_SIZE_mod.F               \
$(HDR)/CMN_DIAG_mod.F               \
$(HDR)/cmn_fj_mod.F                 \
$(HDR)/jv_cmn_mod.F                 \
$(HDR)/jv_mie_mod.F                 \
```

```
$(CORE)/main.F                      \
$(CORE)/acetone_mod.F               \
$(CORE)/arctas_ship_emiss_mod.F     \
$(CORE)/bravo_mod.F                 \
$(CORE)/cac_anthro_mod.F            \
$(CORE)/chemistry_mod.F             \
$(CORE)/co2_mod.F                   \
$(CORE)/comode_mod.F                \
$(CORE)/convection_mod.F            \
$(CORE)/dao_mod.F                   \
$(CORE)/depo_mercury_mod.F          \
$(CORE)/diag03_mod.F                \
$(CORE)/diag04_mod.F                \
$(CORE)/diag41_mod.F                \
$(CORE)/diag42_mod.F                \
$(CORE)/diag49_mod.F                \
$(CORE)/diag50_mod.F                \
$(CORE)/diag51b_mod.F               \
$(CORE)/diag56_mod.F                \
$(CORE)/diag_pl_mod.F               \
$(CORE)/diag_oh_mod.F               \
$(CORE)/diag_mod.F                  \
$(CORE)/dust_mod.F                  \
$(CORE)/emep_mod.F                  \
$(CORE)/emissions_mod.F             \
$(CORE)/fjx_acet_mod.F              \
$(CORE)/gamap_mod.F                 \
$(CORE)/gfed3_biomass_mod.F         \
$(CORE)/global_br_mod.F             \
$(CORE)/global_no3_mod.F            \
$(CORE)/global_nox_mod.F            \
$(CORE)/global_o1d_mod.F            \
$(CORE)/global_o3_mod.F             \
$(CORE)/global_oh_mod.F             \
$(CORE)/h2_hd_mod.F                 \
$(CORE)/icoads_ship_mod.F           \
$(CORE)/input_mod.F                 \
$(CORE)/isoropiaII_mod.F            \
$(CORE)/land_mercury_mod.F          \
$(CORE)/lightning_nox_mod.F         \
$(CORE)/linoz_mod.F                 \
$(CORE)/logical_mod.F               \
$(CORE)/megan_mod.F                 \
$(CORE)/meganut_mod.F               \
$(CORE)/merra_a1_mod.F              \
$(CORE)/merra_a3_mod.F              \
$(CORE)/merra_cn_mod.F              \
$(CORE)/merra_i6_mod.F              \
```

```
$(CORE)/nei2005_anthro_mod.F         \
$(CORE)/optdepth_mod.F               \
$(CORE)/pjc_pfix_mod.F               \
$(CORE)/planeflight_mod.F            \
$(CORE)/retro_mod.F                  \
$(CORE)/RnPbBe_mod.F                 \
$(CORE)/scale_anthro_mod.F           \
$(CORE)/tagged_ox_mod.F              \
$(CORE)/toms_mod.F                   \
$(CORE)/tropopause_mod.F             \
$(CORE)/tpcore_fvdas_mod.F90         \
$(CORE)/tpcore_geos5_window_mod.F90  \
$(CORE)/transport_mod.F              \
$(CORE)/upbdflx_mod.F                \
$(CORE)/vdiff_mod.F90                \
$(CORE)/vdiff_pre_mod.F              \
$(CORE)/vistas_anthro_mod.F          \
./subs.geos-chem                     \
$(CORE)/anthroems.F                  \
$(CORE)/boxvl.F                      \
$(CORE)/diag1.F                      \
$(CORE)/diag3.F                      \
$(CORE)/diag_2pm.F                   \
$(CORE)/diagoh.F                     \
$(CORE)/emfossil.F                   \
$(CORE)/emf_scale.F                  \
$(CORE)/emmonot.F                    \
$(CORE)/fast_j.F                     \
$(CORE)/findmon.F                    \
$(CORE)/initialize.F                 \
$(CORE)/ndxx_setup.F                 \
$(CORE)/ohsave.F                     \
$(CORE)/rdlai.F                      \
$(CORE)/rdland.F                     \
$(CORE)/rdsoil.F                     \
$(CORE)/rdlight.F                    \
$(CORE)/rdmonot.F                    \
$(CORE)/readlai.F                    \
$(CORE)/ruralbox.F                   \
$(CORE)/setemis.F                    \
$(CORE)/sfcwindsqr.F                 \
$(CORE)/tcorr.F


# Output file names
TEX1 := GC_Ref_Vol_3.tex
DVI1 := GC_Ref_Vol_3.dvi
PDF1 := GC_Ref_Vol_3.pdf
```

```
PS1  := GC_Ref_Vol_3.ps


# Make commands
srcdoc:
rm -f $(TEX1)
protex -sf $(SRC1) > $(TEX1)
latex $(TEX1)
latex $(TEX1)
latex $(TEX1)
dvipdf $(DVI1) $(PDF1)
dvips $(DVI1) -o $(PS1)
rm -f *.aux *.dvi *.log *.toc
```

1.9.2 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


# List of source code files
SRC3 := ./intro.util $(wildcard $(UTIL)/*.F)


# Output file names
TEX3 := GC_Ref_Vol_2.tex
DVI3 := GC_Ref_Vol_2.dvi
PDF3 := GC_Ref_Vol_2.pdf
PS3  := GC_Ref_Vol_2.ps
```

```
# Make commands
utildoc:
rm -f $(TEX3)
protex -sf $(SRC3) > $(TEX3)
latex $(TEX3)
latex $(TEX3)
latex $(TEX3)
dvipdf $(DVI3) $(PDF3)
dvips $(DVI3) -o $(PS3)
rm -f *.aux *.dvi *.log *.toc
```

1.9.3 Makefile_GtmmDoc.mk (in doc subdirectory)

This Makefile fragment contains commands to build the documentation for the Global Terrestrial Mercury Model (GTMM). 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_4.*"
 19 Jul 2011 - R. Yantosca - Changed *.f* to *.F* for ESMF compatibility
```

```
# List of source code files (order is important)
SRC4 :=                                 \
./intro.gtmm                            \
$(GTMM)/GTMM.F90                        \
$(GTMM)/CasaRegridModule.F90            \
$(GTMM)/defineArrays.F90                \
$(GTMM)/defineConstants.F90             \
$(GTMM)/dorestart_mod.F90               \
$(GTMM)/input_gtmm_mod.F90              \
$(GTMM)/loadCASAinput.F90               \
./subs.gtmm                             \
$(GTMM)/CleanupCASAarrays.F90           \
$(GTMM)/GTMM_coupled.F90                \
$(GTMM)/HgOutForGEOS.F90                \
```

```
$(GTMM)/assignAgeClassToRunningPool.F90    \
$(GTMM)/assignRanPoolToAgeClass.F90        \
$(GTMM)/doFPARandLAI.F90                   \
$(GTMM)/doHerbCarbon.F90                   \
$(GTMM)/doHerbCarbonHg.F90                 \
$(GTMM)/doHerbivory.F90                    \
$(GTMM)/doHgDeposition.F90                 \
$(GTMM)/doLatitude.F90                     \
$(GTMM)/doLeafRootShedding.F90             \
$(GTMM)/doMaxHg.F90                        \
$(GTMM)/doNPP.F90                          \
$(GTMM)/doOptimumTemperature.F90           \
$(GTMM)/doPET.F90                          \
$(GTMM)/doSoilMoisture.F90                 \
$(GTMM)/doTreeCarbon.F90                   \
$(GTMM)/doTreeCarbonHg.F90                 \
$(GTMM)/getAgeClassBF.F90                  \
$(GTMM)/getFireParams.F90                  \
$(GTMM)/getFuelWood.F90                    \
$(GTMM)/getSoilMoistParams.F90             \
$(GTMM)/getSoilParams.F90                  \
$(GTMM)/loadHgDeposition.F90               \
$(GTMM)/load_GC_data.F90                   \
$(GTMM)/organizeAgeClasses.F90             \
$(GTMM)/processData.F90                    \
$(GTMM)/sort_pick_veg.F90


# Output file names
TEX4 := GC_Ref_Vol_4.tex
DVI4 := GC_Ref_Vol_4.dvi
PDF4 := GC_Ref_Vol_4.pdf
PS4  := GC_Ref_Vol_4.ps


# Make commands
gtmmdoc:
rm -f $(TEX4)
protex -sf $(SRC4) > $(TEX4)
latex $(TEX4)
latex $(TEX4)
latex $(TEX4)
dvipdf $(DVI4) $(PDF4)
dvips $(DVI4) -o $(PS4)
rm -f *.aux *.dvi *.log *.toc
```

1.9.4 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.*"
```

```
# List of source code files (order is important)
SRC2 :=                         \
./intro.make                    \
$(ROOTDIR)/Makefile             \
$(ROOTDIR)/Makefile_header.mk   \
$(UTIL)/Makefile                \
$(ISO)/Makefile                 \
$(CODE)/Makefile                \
$(KPP)/Makefile                 \
$(KPP)/standard/Makefile        \
$(KPP)/SOA/Makefile             \
$(TOM)/Makefile                 \
$(GTMM)/Makefile                \
$(DOC)/Makefile                 \
$(DOC)/Makefile_SrcDoc.mk       \
$(DOC)/Makefile_UtilDoc.mk      \
$(DOC)/Makefile_GtmmDoc.mk      \
$(DOC)/Makefile_MakeDoc.mk      \
$(HELP)/Makefile


# Output file names
TEX2 := GC_Ref_Vol_1.tex
DVI2 := GC_Ref_Vol_1.dvi
PDF2 := GC_Ref_Vol_1.pdf
PS2  := GC_Ref_Vol_1.ps
```

```
# Make command
makedoc:
rm -f $(TEX2)
protex -fS $(SRC2) > $(TEX2)
latex $(TEX2)
latex $(TEX2)
latex $(TEX2)
dvipdf $(DVI2) $(PDF2)
dvips $(DVI2) -o $(PS2)
rm -f *.aux *.dvi *.log *.toc
```

1.10 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 TARGET [ 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
```

```
# Get the Unix shell (in SHELL variable) from Makefile_header.mk
```

```
ROOTDIR = ..
include $(ROOTDIR)/Makefile_header.mk

help:
@echo '%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%'
@echo '%%%      GEOS-Chem Help Screen      %%%'
@echo '%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%'
@echo
@echo 'Usage: make TARGET [ OPTIONAL-FLAGS ]'
@echo ''
@echo 'TARGET may be one of the following:'
@echo 'all             Default target (synonym for "lib exe")'
@echo 'lib             Builds GEOS-Chem source code'
@echo 'libheaders      Builds GEOS-Chem objs & libs only in GeosHeaders/'
@echo 'libcore         Builds GEOS-Chem objs & libs only in GeosCore/'
@echo 'libutil         Builds GEOS-Chem objs & libs only in GeosUtil/'
@echo 'libkpp          Builds GEOS-Chem objs & libs only in KPP/'
@echo 'exe             Creates GEOS-Chem executable'
@echo 'clean           Removes *.o, *.mod files in source code subdirs only'
@echo 'realclean       Removes all *.o, *mod, *.lib *.a, *.tex, *ps, *pdf files everywhere'
@echo 'doc             Builds GEOS-Chem documentation (*.ps, *.pdf) in doc/'
@echo 'docclean        Removes *.tex, *.pdf, *,ps from doc/'
@echo 'help            Displays this help screen'
@echo ''
@echo 'Special targets for TOMAS aerosol microphysics:'
@echo 'tomas           Builds GEOS-Chem + TOMAS (synonym for "libtomas exetomas")'
@echo 'libtomas        Builds GEOS-Chem + TOMAS objs & libs in GeosTomas/'
@echo 'exetomas        Creates GEOS-Chem + TOMAS executable'
@echo 'cleantomas      Removes *.o *.mod files only in GeosTomas/'
@echo ''
@echo 'Special targets for APM aerosol microphysics:'
@echo 'apm             Builds GEOS-Chem + APM (synonym for libapm exeapm)'
@echo 'libapm          Builds GEOS-Chem + APM objs & libs in GeosApm/ subdir'
@echo 'exeapm          Creates GEOS-Chem + APM executable in GeosApm/'
@echo 'cleanapm        Removes *.o *.mod files only in GeosApm/'
@echo ''
@echo 'Special target for mercury simulation:'
@echo 'hg              Builds GEOS-Chem + GTMM for mercury simulation'
@echo ''
@echo 'OPTIONAL-FLAGS may be:'
@echo 'COMPILER=___    Options: ifort pgi sun xlf (default is ifort)'
@echo 'PRECISE=no      Disable precise floating point math optimization (for speed)'
@echo 'HDF5=yes        Enables writing diagnostic timeseries output to HDF5 files'
@echo 'DEBUG=yes       Builds GEOS-Chem for a debugger (with -g -O0)'
@echo 'BOUNDS=yes      Turns on subscript-array checking (for debug)'
@echo 'OMP=[yes|no]    Turns OpenMP parallelization on/off (default is yes)'
@echo 'IPO=yes         Turns on optmization options -ipo -static (ifort only)'
@echo 'TRACEBACK=yes   Turns on -traceback option (ifort only)'
```

```
@echo 'NONUMA=yes     Turns on -mp=nonuma option (pgi only)'
@echo 'CHEM=___       Specifies which simulation is done. Options: standard SOA'
@echo 'NTRAC=[43|54]  Specifies # of tracers for KPP chemical solver. Should use CHEM flag ins
@echo 'KPPSOLVER=___  Specifies the integrator used w/ KPP:'
@echo '               Options: lsodes radau5 rosenbrock runge_kutta (default is rosenbrock)'
@echo '               (NOTE: This is set by default if you use "make tomas")
```