Notes on Downloading, Compiling, and Running MPAS-A

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CONTENS

1. Downloading and Compiling MPAS

1.1 Setting up the Environment

Before installing and compiling MPAS, ensure all necessary environments and dependencies, such as zlib, pio, hdf5, netcdf, and pnetcdf, are prepared.

```
#pnetcdf
mkdir ~/[your environments path]/pnetcdf
cd ~/[your environments path]/pnetcdf
wget https://parallel-netcdf.github.io/Release/parallel-netcdf-1.8.1.tar.gz
tar -zxvf parallel-netcdf-1.8.1.tar.gz
cd parallel-netcdf-1.8.1
./configure --prefix=~/[your environments path]/pnetcdf
make check
make install

#zlib
mkdir ~/[your environments path]/zlib
cd ~/[your environments path]/zlib
wget http://www.zlib.net/zlib-1.2.11.tar.gz
tar -xvzf zlib-1.2.11.tar.gz
cd zlib-1.2.10
./configure --prefix=~/[your environments path]/zlib
make
make install

#hdf5
mkdir ~/[your environments path]/hdf5
cd ~/[your environments path]/hdf5
wget https://github.com/HDFGroup/hdf5/archive/refs/heads/develop.zip
unzip develop.zip
cd hdf5-develop
./configure --prefix=~/[your environments path]/hdf5 --with-zlib=~/[your
environments path]/zlib -enable-fortran -enable-cxx
make -j 4
make check
make install
make check-install

#pio
cd ~/[your environments path]
```

```
git clone https://github.com/NCAR/ParallelIO.git
cd ParallelIO
make
make check
make install

#netcdf-f
mkdir ~/[your environments path]/netcdff
cd ~/[your environments path]/netcdff
wget https://github.com/Unidata/netcdf-fortran/archive/refs/heads/main.zip
unzip main.zip
cd netcdf-fortran-main
./configure --enable-parallel-tests --disable-zstandard-plugin --prefix=~/[your environments path]/netcdff --host=x86_64
make all
make install

#netcdf-c
mkdir ~/[your environments path]/netcdfc
cd ~/[your environments path]/netcdfc
wget https://downloads.unidata.ucar.edu/netcdf-c/4.9.2/netcdf-c-4.9.2.tar.gz
tar -xzvf netcdf-c-4.9.2.tar.gz
cd netcdf-c-4.9.2
./configure --enable-parallel-tests --prefix=~/[your environments path]/netcdfc --host=x86_64
make check
make
make install
```

I have also set up the required environment for MPAS compilation in the path "/work/ess-liuzj/apps". If you are the user of "TaiYi" HPC at Southern University of Science and Technology, then feel free to load all the required environment directly by following these steps:

（1）Copy the following commands into your ~/.bashrc file:

```
export HDF5DIR=/work/ess-liuzj/apps/software/hdf5-1.10.9
export ZLIBDIR=/work/ess-liuzj/apps/software/zlib1.2.11
export UDUNITSDIR=/work/ess-liuzj/apps/software/udunits-2.2.28
export NCVIEWDIR=/work/ess-liuzj/apps/software/ncview
export METISDIR=/work/ess-liuzj/apps/software/metis-5.1.0
export JASPERDIR=/work/ess-liuzj/apps/software/jasper-1.900.1
export LIBPNGDIR=/work/ess-liuzj/apps/software/libpng-1.2.50
```

```
export CMAKEDIR=/work/ess-liuzj/apps/cmake-3.24.2
export XTERMDIR=/work/ess-liuzj/apps/software/xterm
export BLASDIR=/work/ess-liuzj/apps/software/blas
export LAPACKDIR=/work/ess-liuzj/apps/software/lapack
export PATH=${HDF5DIR}/bin:$PATH
export PATH=${ZLIBDIR}/bin:$PATH
export PATH=/work/ess-liuzj/apps/convert_mpas/convert_mpas:$PATH
export PATH=/work/ess-liuzj/apps/MPAS-Tools/mesh_tools/grid_rotate:$PATH
export PATH=/work/ess-liuzj/apps/convert_mpas:$PATH
export PATH=/work/ess-liuzj/apps/MPAS-Limited-Area/create_region:$PATH
export PATH=${UDUNITSDIR}/bin:$PATH
export PATH=${NCVIEWDIR}/bin:$PATH
export PATH=${METISDIR}/bin:$PATH
export PATH=${JASPERDIR}/bin:$PATH
export PATH=${LIBPNGDIR}/bin:$PATH
export PATH=${CMAKEDIR}/bin:$PATH
export PATH=${XTERMDIR}/bin:$PATH
export LD_LIBRARY_PATH=${ZLIBDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${HDF5DIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${UDUNITSDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${METISDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${JASPERDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${LIBPNGDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${XTERMDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${BLASDIR}/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH=${LAPACKDIR}/lib:$LD_LIBRARY_PATH
export INCLUDE=${ZLIBDIR}/include:$INCLUDE
export INCLUDE=${HDF5DIR}/include:$INCLUDE
export INCLUDE=${UDUNITSDIR}/include:$INCLUDE
export INCLUDE=${METISDIR}/include:$INCLUDE
export INCLUDE=${JASPERDIR}/include:$INCLUDE
export INCLUDE=${LIBPNGDIR}/include:$INCLUDE
export INCLUDE=${LAPACKDIR}/include:$INCLUDE
#pnetcdf
export PNETCDFDIR=/work/ess-liuzj/apps/software/pnetcdf-1.12.2
export PATH=$PNETCDFDIR/bin:$PATH
export LD_LIBRARY_PATH=$PNETCDFDIR/lib:$LD_LIBRARY_PATH
export LIBRARY_PATH=$PNETCDFDIR/lib:$LIBRARY_PATH
export LD_RUN_PATH=$PNETCDFDIR/lib:$LD_RUN_PATH
export INCLUDE=$PNETCDF/include:$INCLUDE
export C_INCLUDE_PATH=$PNETCDFDIR/include:$C_INCLUDE_PATH
export
CPLUS_INCLUDE_PATH=$PNETCDFDIR/include:$CPLUS_INCLUDE_PATH
export CPPFLAGS=-I$PNETCDF/include
```

```
export CPPINCLUDES=-I$PNETCDF/include
export FCINCLUDES=-I$PNETCDFDIR/include
#PIO
export PIO=/work/ess-liuzj/apps/software/pio-2.5.9
export LD_LIBRARY_PATH=$PIO/lib:$LD_LIBRARY_PATH
export LIBRARY_PATH=$PIO/lib:$LIBRARY_PATH
export LD_RUN_PATH=$PIO/lib:$LD_RUN_PATH
export INCLUDE=$PIO/include:$INCLUDE
export C_INCLUDE_PATH=$PIO/include:$C_INCLUDE_PATH
export CPLUS_INCLUDE_PATH=$PIO/include:$CPLUS_INCLUDE_PATH
export CPPFLAGS=-I$PIO/include
export CPPINCLUDES=-I$PIO/include
export FCINCLUDES=-I$PIO/include
export PIO_LIB=-L$PIO/lib
#netcdf
export ENV_NETCDF=/work/ess-liuzj/apps/software/netcdf
export PATH=$ENV_NETCDF/bin:$PATH
export LD_LIBRARY_PATH=$ENV_NETCDF/lib:$LD_LIBRARY_PATH
export LIBRARY_PATH=$ENV_NETCDF/lib:$LIBRARY_PATH
export LD_RUN_PATH=$ENV_NETCDF/lib:$LD_RUN_PATH
export INCLUDE=$ENV_NETCDF/include:$INCLUDE
export C_INCLUDE_PATH=$ENV_NETCDF/include:$C_INCLUDE_PATH
export
CPLUS_INCLUDE_PATH=$ENV_NETCDF/include:$CPLUS_INCLUDE_PATH
export CPPFLAGS=-I$ENV_NETCDF/include
export CPPINCLUDES=-I$NETCDF/include
export FCINCLUDES=-I$NETCDF/include

ulimit -s unlimited
```

（2） Then, run source ~/.bashrc to apply the environment settings.

（3） To verify, run nc-config --all to check if netcdf is successfully loaded. Taking netcdf as an example, if the following information appears on the screen, it means that netcdf has been loaded successfully.

```
[ess-liuzj@login05 ~]$ nc-config --all

This netCDF 4.7.4 has been built with the following features:

  --cc            -> mpiicc
  --cflags        -> -I/work/ess-liuzj/apps/software/netcdf/include -I/work/ess-liuzj/apps/software/hdf5-1.10.9/include
 -I/work/ess-liuzj/apps/software/zlib1.2.11/include
  --libs          -> -L/work/ess-liuzj/apps/software/netcdf/lib -lnetcdf
  --static        -> -lhdf5_hl -lhdf5 -lm -lz

  --has-c++       -> no
  --cxx           ->

  --has-c++4      -> no
  --cxx4          ->

  --has-fortran   -> yes
  --fc            -> mpiifort
  --fflags        -> -I/work/ess-liuzj/apps/software/netcdf/include -I/work/ess-liuzj/apps/software/netcdf/include
  --flibs         -> -L/work/ess-liuzj/apps/software/netcdf/lib -lnetcdff
  --has-f90       ->
  --has-f03       -> yes

  --has-dap       -> no
  --has-dap2      -> no
  --has-dap4      -> no
  --has-nc2       -> yes
  --has-nc4       -> yes
  --has-hdf5      -> yes
  --has-hdf4      -> no
  --has-logging   -> no
  --has-pnetcdf   -> no
  --has-szlib     -> no
  --has-cdf5      -> yes
  --has-parallel4 -> no
  --has-parallel  -> no

  --prefix        -> /work/ess-liuzj/apps/software/netcdf
  --includedir    -> /work/ess-liuzj/apps/software/netcdf/include
  --libdir        -> /work/ess-liuzj/apps/software/netcdf/lib
  --version       -> netCDF 4.7.4
```

1.2 Downloading MPAS Source Code

After successfully loading the required environment, the next step is to download the MPAS source code (using version MPAS-A v7.3 as an example). It is recommended to create a directory named “MPAS-Model” in the root directory, where all operations for this section will be conducted. The steps are as follows:

```
cd ~
mkdir MPAS-Model
cd MPAS-Model
```

Next, download the MPAS source code. You can download any available version from either the MPAS-A website, Zenodo or GitHub:

• MPAS-A Website: https://mpas-dev.github.io/

• GitHub: https://github.com/MPAS-Dev/

After downloading the source code, unzip the files and enter into the directory with the following commands:

```
wget https://zenodo.org/records/10464525/files/MPAS-Model-7.3.tar.gz
tar -xzvf MPAS-Model-7.3.tar.gz
cd MPAS-Model-7.3
```

1.3 Compiling MPAS

Before compiling MPAS, you need to specify the compiler you used. To do this, modify lines 138 to 161 in the Makefile file as follows:

```
ifort:
	( $(MAKE) all \
	"FC_PARALLEL = mpiifort" \
	"CC_PARALLEL = mpiicc" \
	"CXX_PARALLEL = mpiicpc" \
	"FC_SERIAL = mpiifort" \
	"CC_SERIAL = mpiicc" \
	"CXX_SERIAL = mpiicpc" \
	"FFLAGS_PROMOTION = -real-size 64" \
	"FFLAGS_OPT = -O3 -convert big_endian -free -align array64byte" \
	"CFLAGS_OPT = -O3" \
	"CXXFLAGS_OPT = -O3" \
	"LDFLAGS_OPT = -O3" \
	"FFLAGS_DEBUG = -g -convert big_endian -free -CU -CB -check all -fpe0 -traceback" \
	"CFLAGS_DEBUG = -g -traceback" \
	"CXXFLAGS_DEBUG = -g -traceback" \
	"LDFLAGS_DEBUG = -g -fpe0 -traceback" \
	"FFLAGS_OMP = -qopenmp" \
	"CFLAGS_OMP = -qopenmp" \
	"CORE = $(CORE)" \
	"DEBUG = $(DEBUG)" \
	"USE_PAPI = $(USE_PAPI)" \
	"OPENMP = $(OPENMP)" \
	"CPPFLAGS = $(MODEL_FORMULATION) -D_MPI" )
```

Next, add absolute paths for PIO, NetCDF, and PNetCDF in the Makefile. To do this, modify lines 463 to 506 with the following steps:

```
# Check if libpio.* exists and link -lpio if so, but we make an exception for
# libpio.settings (a file added in PIO2), which is not a library to link
ifneq ($(wildcard $(PIO_LIB)/libpio\.a), )
        # Makefiles don't support "and" operators so we have nested "if" instead
        ifneq "$(wildcard $(PIO_LIB)/libpio\.a)" "$(PIO_LIB)/libpio.settings"
                LIBS += -lpio
        endif
endif

ifneq ($(wildcard $(PIO_LIB)/libpiof\.so), )
        LIBS += -lpiof
endif
ifneq ($(wildcard $(PIO_LIB)/libpioc\.*), )
        LIBS += -lpioc
endif
ifneq ($(wildcard $(PIO_LIB)/libgptl\.*), )
        LIBS += -lgptl
endif
LIBS += -L/work/ess-liuzj/apps/software/pio-2.5.9/lib -lpiof -lpioc
ifneq "$(NETCDF)" ""
        CPPINCLUDES += -I$(NETCDF)/include
        FCINCLUDES += -I$(NETCDF)/include
        LIBS += -L$(NETCDF)/lib
        NCLIB = -lnetcdf
        NCLIBF = -lnetcdff
        ifneq ($(wildcard $(NETCDF)/lib/libnetcdff.*), ) # CHECK FOR NETCDF4
                LIBS += $(NCLIBF)
        endif # CHECK FOR NETCDF4
        ifneq "$(NETCDFF)" ""
                FCINCLUDES += -I$(NETCDFF)/include
                LIBS += -L$(NETCDFF)/lib
                LIBS += $(NCLIBF)
        endif
        LIBS += $(NCLIB)
endif
LIBS += -L/work/ess-liuzj/apps/software/netcdf/lib -lnetcdff -lnetcdf

ifneq "$(PNETCDF)" ""
        CPPINCLUDES += -I$(PNETCDF)/include
        FCINCLUDES += -I$(PNETCDF)/include
        LIBS += -L$(PNETCDF)/lib -lpnetcdf
endif
LIBS += -L/work/ess-liuzj/apps/software/pnetcdf-1.12.2/lib -lpnetcdf
RM = rm -f
CPP = cpp -P -traditional
RANLIB = ranlib
```

Next, navigate to the src directory:

```
cd src
```

In the Makefile located in this directory, you'll need to replace the relative paths for directories such as externals, frame, ops, dycore, and driver with absolute paths. This adjustment is typically done around line 18.

```
mpas: $(AUTOCLEAN_DEPS) externals frame ops dycore drver
	$(LINKER) $(LDFLAGS) -o $(EXE_NAME) ~/MPAS-Model/MPAS-Model-7.3/src/driver/*.o -L. -ldycore -lops -lframework $(LIBS) -I./exter
nal/esmf_time_f90 -L./external/esmf_time_f90 -lesmf_time
```

After saving and exiting the Makefile in the src directory, return to the previous (parent) directory

```
cd ..
```

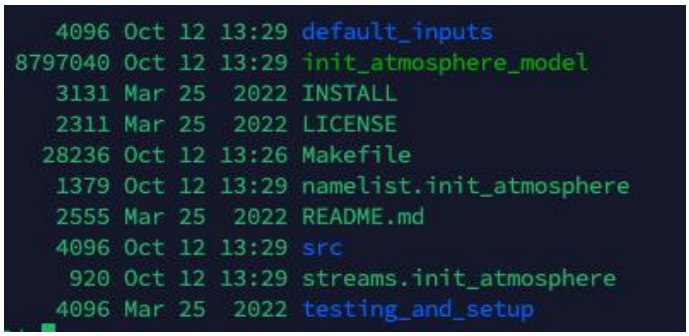
Now, to start compiling the init_atmosphere core, enter the following command:

```
make ifort CORE=init_atmosphere USE_PIO2=true PRECISION=single
```

This command uses the Intel Fortran compiler (ifort), specifies the init_atmosphere core, enables PIO (Parallel IO), and sets the precision to single. The compilation should take a few minutes.

```
*********************************************************************************
MPAS was built with default single-precision reals.
Debugging is off.
Parallel version is on.
Papi libraries are off.
TAU Hooks are off.
MPAS was built without OpenMP support.
MPAS was built with .F files.
The native timer interface is being used
Using the PIO 2 library.
*********************************************************************************
```

If the compilation is successful, you'll see a new executable file named init_atmosphere_model in the current directory.



Note: If this step fails, you'll need to clean the current build for the init_atmosphere core before trying again. Use the following command to clean up:

make clean CORE=init_atmosphere

Next, let us compile the atmosphere core. Before starting the compilation, clean the current directory with the following command:：

make clean CORE=atmosphere

After cleaning the directory, enter the following compilation command to build the atmosphere core:

make ifort CORE=atmosphere USE_PIO2=true PRECISION=single

```
*********************************************************************************
MPAS was built with default single-precision reals.
Debugging is off.
Parallel version is on.
Papi libraries are off.
TAU Hooks are off.
MPAS was built without OpenMP support.
MPAS was built with .F files.
The native timer interface is being used
Using the PIO 2 library.
*********************************************************************************
```

This command compiles the atmosphere core with Intel Fortran (ifort), enables PIO (Parallel IO), and sets the precision to single. If the compilation is successful, you will see the atmosphere_model executable file generated in the current directory, along with any necessary associated files.

```
-Model-7.3]$ ll

ess-dongl 15625768 Oct 12 13:43 atmosphere_model
ess-dongl  1639008 Oct 12 13:43 build_tables
ess-dongl       64 Oct 12 13:42 CAM_ABS_DATA.DBL -> ./src/core_atmosphere/physics/physics_wrf/files/CAM_ABS_DATA.DBL
ess-dongl       67 Oct 12 13:42 CAM_AEROPT_DATA.DBL -> ./src/core_atmosphere/physics/physics_wrf/files/CAM_AEROPT_DATA.DBL
ess-dongl     4096 Oct 12 13:43 default_inputs
ess-dongl       59 Oct 12 13:42 GENPARM.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/GENPARM.TBL
ess-dongl  8797040 Oct 12 13:29 init_atmosphere_model
ess-dongl     3131 Mar 25  2022 INSTALL
ess-dongl       59 Oct 12 13:42 LANDUSE.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/LANDUSE.TBL
ess-dongl     2311 Mar 25  2022 LICENSE
ess-dongl    28236 Oct 12 13:26 Makefile
ess-dongl     1774 Oct 12 13:43 namelist.atmosphere
ess-dongl     1379 Oct 12 13:29 namelist.init_atmosphere
ess-dongl       61 Oct 12 13:42 OZONE_DAT.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/OZONE_DAT.TBL
ess-dongl       61 Oct 12 13:42 OZONE_LAT.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/OZONE_LAT.TBL
ess-dongl       62 Oct 12 13:42 OZONE_PLEV.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/OZONE_PLEV.TBL
ess-dongl     2555 Mar 25  2022 README.md
ess-dongl       61 Oct 12 13:42 RRTMG_LW_DATA -> ./src/core_atmosphere/physics/physics_wrf/files/RRTMG_LW_DATA
ess-dongl       65 Oct 12 13:42 RRTMG_LW_DATA.DBL -> ./src/core_atmosphere/physics/physics_wrf/files/RRTMG_LW_DATA.DBL
ess-dongl       61 Oct 12 13:42 RRTMG_SW_DATA -> ./src/core_atmosphere/physics/physics_wrf/files/RRTMG_SW_DATA
ess-dongl       65 Oct 12 13:42 RRTMG_SW_DATA.DBL -> ./src/core_atmosphere/physics/physics_wrf/files/RRTMG_SW_DATA.DBL
ess-dongl       60 Oct 12 13:42 SOILPARM.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/SOILPARM.TBL
ess-dongl     4096 Oct 12 13:43 src
ess-dongl     1203 Oct 12 13:43 stream_list.atmosphere.diagnostics
ess-dongl      927 Oct 12 13:43 stream_list.atmosphere.output
ess-dongl        9 Oct 12 13:43 stream_list.atmosphere.surface
ess-dongl     1571 Oct 12 13:43 streams.atmosphere
ess-dongl      920 Oct 12 13:29 streams.init_atmosphere
ess-dongl     4096 Mar 25  2022 testing_and_setup
ess-dongl       59 Oct 12 13:42 VEGPARM.TBL -> ./src/core_atmosphere/physics/physics_wrf/files/VEGPARM.TBL
```

If this step completes successfully, it indicates that the MPAS-A compilation is finished. You should now have the init_atmosphere_model and atmosphere_model executable files in your directory, along with other required configuration and support files. These files are now ready for running simulations with the MPAS-A model.

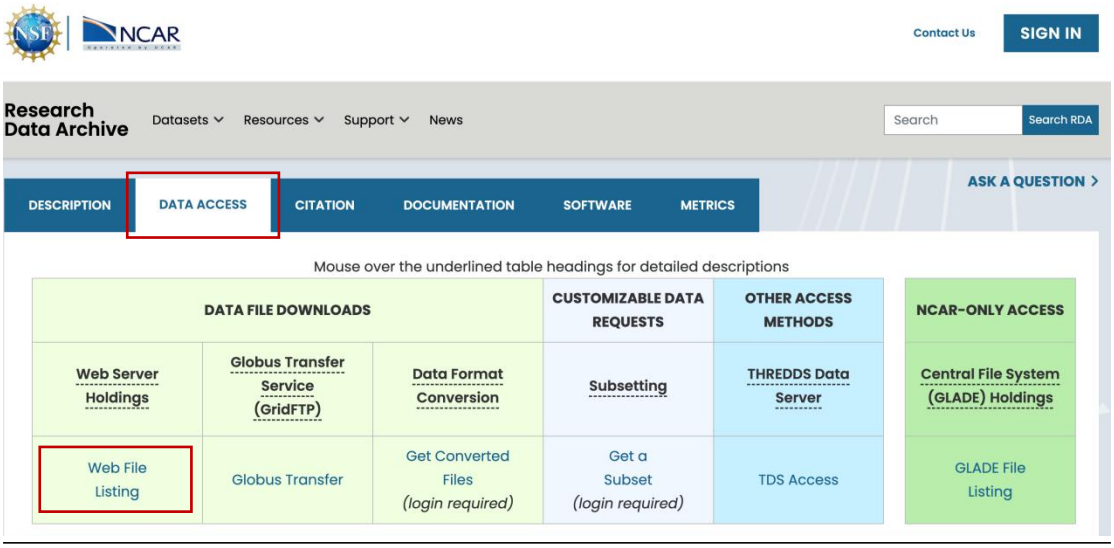
2. Data Download and Preprocessing

2.1 Downloading Forcing Data

Before running MPAS, we should download specific driving data. Here, we take the GFS 0.25-degree product driving MPAS simulation from July 19 to 23, 2021 as an example to show the data download process.

Enter the GFS product website: http://rda.ucar.edu/datasets/ds084.1/

Click "DATA ACCESS" and "Web File Listing" accordingly. As follows:



2.2 Preprocessing Data

After downloading the GFS grib data, it must be decoded and preprocessed. The preprocessing requires the WRF Pre-Processing System (WPS). Below is a brief introduction to installing and compiling WPS.

```
cd ~/MPAS-Model
wget https://github.com/wrf-model/WRF/archive/v4.1.1.tar.gz
tar -xzvf v4.1.1.tar.gz
cd WPS-4.1.1
./configure
```

```
[ess-zhucy@login05 WPS-4.1]$ ./configure
Will use NETCDF in dir: /work/ess-liuzj/WRF/Build_WRF/LIBRARIES/netcdf
Using WRF I/O library in WRF build identified by $WRF_DIR: /work/ess-liuzj/WRFtest/WRF-4.1.2
Found Jasper environment variables for GRIB2 support...
  $JASPERLIB = /work/ess-liuzj/apps/software/grib2/lib
  $JASPERINC = /work/ess-liuzj/apps/software/grib2/include
------------------------------------------------------------------------
Please select from among the following supported platforms.

   1.  Linux x86_64, gfortran    (serial)
   2.  Linux x86_64, gfortran    (serial_NO_GRIB2)
   3.  Linux x86_64, gfortran    (dmpar)
   4.  Linux x86_64, gfortran    (dmpar_NO_GRIB2)
   5.  Linux x86_64, PGI compiler   (serial)
   6.  Linux x86_64, PGI compiler   (serial_NO_GRIB2)
   7.  Linux x86_64, PGI compiler   (dmpar)
   8.  Linux x86_64, PGI compiler   (dmpar_NO_GRIB2)
   9.  Linux x86_64, PGI compiler, SGI MPT   (serial)
  10.  Linux x86_64, PGI compiler, SGI MPT   (serial_NO_GRIB2)
  11.  Linux x86_64, PGI compiler, SGI MPT   (dmpar)
  12.  Linux x86_64, PGI compiler, SGI MPT   (dmpar_NO_GRIB2)
  13.  Linux x86_64, IA64 and Opteron    (serial)
  14.  Linux x86_64, IA64 and Opteron    (serial_NO_GRIB2)
  15.  Linux x86_64, IA64 and Opteron    (dmpar)
  16.  Linux x86_64, IA64 and Opteron    (dmpar_NO_GRIB2)
  17.  Linux x86_64, Intel compiler    (serial)
  18.  Linux x86_64, Intel compiler    (serial_NO_GRIB2)
  19.  Linux x86_64, Intel compiler    (dmpar)
  20.  Linux x86_64, Intel compiler    (dmpar_NO_GRIB2)
  21.  Linux x86_64, Intel compiler, SGI MPT    (serial)
  22.  Linux x86_64, Intel compiler, SGI MPT    (serial_NO_GRIB2)
  23.  Linux x86_64, Intel compiler, SGI MPT    (dmpar)
  24.  Linux x86_64, Intel compiler, SGI MPT    (dmpar_NO_GRIB2)
  25.  Linux x86_64, Intel compiler, IBM POE    (serial)
  26.  Linux x86_64, Intel compiler, IBM POE    (serial_NO_GRIB2)
  27.  Linux x86_64, Intel compiler, IBM POE    (dmpar)
  28.  Linux x86_64, Intel compiler, IBM POE    (dmpar_NO_GRIB2)
  29.  Linux x86_64 g95 compiler     (serial)
  30.  Linux x86_64 g95 compiler     (serial_NO_GRIB2)
  31.  Linux x86_64 g95 compiler     (dmpar)
```

Select 17 and press Enter.

```
./compile
```

If the executable file ungrib.exe appears, the compilation was successful.

```
iuzj ess-dongl      4795 Apr 13  2019 compile
iuzj ess-dongl      1765 Apr 13  2019 clean
iuzj ess-dongl      4096 Apr 13  2019 arch
iuzj ess-dongl      3377 Oct 14 11:43 configure.wps
iuzj ess-dongl        21 Oct 14 11:45 ungrib.exe -> ungrib/src/ungrib.exe
iuzj ess-dongl      4096 Oct 14 11:45 ungrib
iuzj ess-dongl      4096 Oct 14 11:45 util
```

Now, edit the “namelist.wps” file located in the ~/MPAS-Model/WPS-4.1 directory as follows:

```
&share
 wrf_core = 'ARW',
 max_dom = 2,
 start_date = '2021-07-19_00:00:00','2021-07-19_00:00:00',
 end_date   = '2021-07-22_00:00:00','2021-07-22_00:00:00',
 interval_seconds = 21600
 io_form_geogrid = 2,
/
```

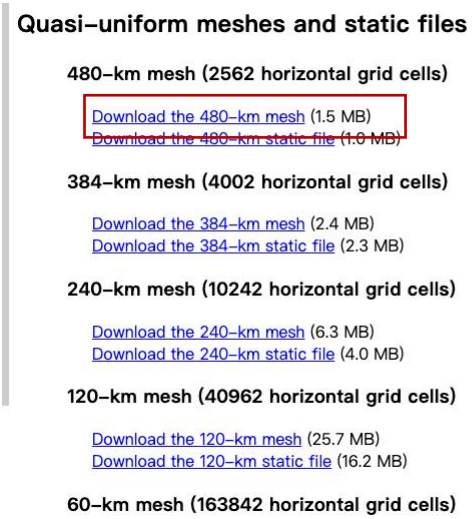
```
&ungrib
 out_format = 'WPS',
 prefix = 'GFS',
/
```

In this step, we only need to modify the “share” and “ungrib” sections of the namelist.wps file. After making and saving these changes, proceed with the following steps to link the downloaded GFS data:

```
./link_grib.csh  ~/MPAS_data/gfs/gfs.0p25.2021071900.f0*
ln -sf ungrib/Variable_Tables/Vtable.GFS Vtable
./ungrib.exe
```

2.3 Downloading Mesh data

MPAS apphorizontal unstructured grids in the horizontal direction, so we need to download specific mesh files. The MPAS official website provides a range of variable-resolution and quasi-uniform resolution meshes.
(Visit https://mpas-dev.github.io/ and navigate to “MPAS-Atmosphere download” > “MPAS-Atmosphere meshes”).
Here, we will demonstrate the process for downloading a quasi-uniform 480 km mesh and a variable-resolution 92 km to 25 km mesh.




```
cd  ~/MPAS_data/mesh
mkdir 480km
mkdir 92_25km
cd 480km
wget https://www2.mmm.ucar.edu/projects/mpas/atmosphere_meshes/x1.2562.tar.gz
wget https://www2.mmm.ucar.edu/projects/mpas/atmosphere_meshes/x1.2562_static.tar.gz
tar -xzvf x1.2562.tar.gz
tar -xzvf x1.2562_static.tar.gz
cd ../92_25km
wget https://www2.mmm.ucar.edu/projects/mpas/atmosphere_meshes/x4.163842.tar.gz
tar -xzvf x4.163842.tar.gz
```

2.4 Downloading Geographic Data

The MPAS website provides terrain data, which can be downloaded directly by

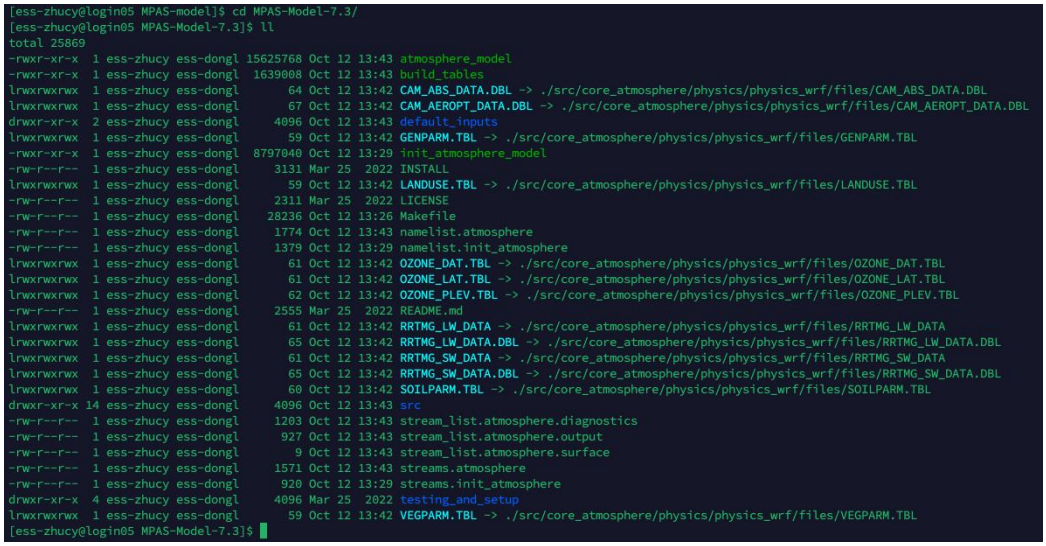
clicking or by using wget. (Visit https://mpas-dev.github.io/ and go to "MPAS-Atmosphere download" > "Static geographical datasets"). Alternatively, you can use the terrain data available in the /data/ess-liuzj/geog directory.

After downloading the terrain data, upload it to the ~/MPAS-data/geog directory.

3. Running Global Quasi-uniform Resolution Simulatin

Before running a global quasi-uniform resolution MPAS simulation, ensure the following steps are completed:

MPAS-A has been successfully compiled, with the path set to ~/MPAS-Model/MPAS-Model-7.3



The driving data has been decoded, with files located in ~/MPAS_data/gfs

```
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_00
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_03
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_06
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_09
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_12
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_15
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_18
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-19_21
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_00
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_03
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_06
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_09
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_12
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_15
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_18
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-20_21
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_00
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_03
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_06
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_09
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_12
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_15
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_18
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-21_21
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_00
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_03
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_06
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_09
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_12
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_15
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_18
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-22_21
ess-liuzj ess-dongl 818178824 Dec 20  2022 GFS:2021-07-23_00
```

The mesh data have been downloaded and are located in ~/MPAS_data/mesh/480km and ~/MPAS_data/mesh/92_25km.

```
otal 13824
rw-r--r-- 1 ess-zhucy ess-dongl  140827 Sep 19  2014 x1.2562.graph.info
rw-r--r-- 1 ess-zhucy ess-dongl    5555 Sep 19  2014 x1.2562.graph.info.part.12
rw-r--r-- 1 ess-zhucy ess-dongl    6091 Sep 19  2014 x1.2562.graph.info.part.16
rw-r--r-- 1 ess-zhucy ess-dongl    5124 Sep 19  2014 x1.2562.graph.info.part.2
rw-r--r-- 1 ess-zhucy ess-dongl    5124 Sep 19  2014 x1.2562.graph.info.part.4
rw-r--r-- 1 ess-zhucy ess-dongl    5124 Sep 19  2014 x1.2562.graph.info.part.6
rw-r--r-- 1 ess-zhucy ess-dongl    5124 Sep 19  2014 x1.2562.graph.info.part.8
rw-r--r-- 1 ess-zhucy ess-dongl 3508132 Jun 12  2023 x1.2562.grid.nc
rw-r--r-- 1 ess-zhucy ess-dongl 4894200 Jun 29 22:39 x1.2562.static.nc
rw-r--r-- 1 ess-zhucy ess-dongl 1387702 Jul  6 05:19 x1.2562_static.tar.gz
rw-r--r-- 1 ess-zhucy ess-dongl 1514620 Jun 12  2023 x1.2562.tar.gz
rw-r--r-- 1 ess-zhucy ess-dongl 1514620 Jun 12  2023 x1.2562.tar.gz.1
ess-zhucy@login05 480km]$
```

```
[ess-zhucy@login05 92_25km]$ ll
total 360448
-rw-r--r-- 1 ess-zhucy ess-dongl   9011227 Jun 14  2013 x4.163842.graph.info
-rw-r--r-- 1 ess-zhucy ess-dongl    641601 Jun 14  2013 x4.163842.graph.info.part.1024
-rw-r--r-- 1 ess-zhucy ess-dongl    354986 Jun 14  2013 x4.163842.graph.info.part.12
-rw-r--r-- 1 ess-zhucy ess-dongl    514568 Jun 14  2013 x4.163842.graph.info.part.128
-rw-r--r-- 1 ess-zhucy ess-dongl    389090 Jun 14  2013 x4.163842.graph.info.part.16
-rw-r--r-- 1 ess-zhucy ess-dongl    561570 Jun 14  2013 x4.163842.graph.info.part.192
-rw-r--r-- 1 ess-zhucy ess-dongl    423236 Jun 14  2013 x4.163842.graph.info.part.24
-rw-r--r-- 1 ess-zhucy ess-dongl    584961 Jun 14  2013 x4.163842.graph.info.part.256
-rw-r--r-- 1 ess-zhucy ess-dongl    440303 Jun 14  2013 x4.163842.graph.info.part.32
-rw-r--r-- 1 ess-zhucy ess-dongl    608443 Jun 14  2013 x4.163842.graph.info.part.384
-rw-r--r-- 1 ess-zhucy ess-dongl    457393 Jun 14  2013 x4.163842.graph.info.part.48
-rw-r--r-- 1 ess-zhucy ess-dongl    620219 Jun 14  2013 x4.163842.graph.info.part.512
-rw-r--r-- 1 ess-zhucy ess-dongl    465936 Jun 14  2013 x4.163842.graph.info.part.64
-rw-r--r-- 1 ess-zhucy ess-dongl    631915 Jun 14  2013 x4.163842.graph.info.part.768
-rw-r--r-- 1 ess-zhucy ess-dongl    474470 Jun 14  2013 x4.163842.graph.info.part.96
-rw-r--r-- 1 ess-zhucy ess-dongl 224139172 Jun 14  2023 x4.163842.grid.nc
-rw-r--r-- 1 ess-zhucy ess-dongl 127922914 Jun 14  2023 x4.163842.tar.gz
[ess-zhucy@login05 92_25km]$
```

3.1 Generating Static Files

```
cd ~
mkdir MPAS_simulations
cd MPAS_simulations
mkdir 480km_simulation
mkdir 92_25km_simulation
cd 480km_simulation
ln -s  ~/MPAS_Model/MPAS-Model-7.3/init_atmosphere_model .
ln -s  ~/MPAS_Model/MPAS-Model-7.3/atmosphere_model .
ln -s  ~/MPAS_data/gfs/2023_09-07_08/GFS\:2023-09-0* .
ln -s  ~/MPAS_data/mesh/480km/x1.2562.grid.nc .
cp  ~/MPAS_Model/MPAS-Model-7.3/stream_list.atmosphere.* .
cp  ~/MPAS_Model/MPAS-Model-7.3/namelist.* .
cp  ~/MPAS_Model/MPAS-Model-7.3/streams.* .
ln -s  ~
/MPAS_Model/MPAS-Model-7.3/src/core_atmosphere/physics/physics_wrf/files/* .
```

Now edit the namelist.init_atmosphere file as follows:

```
&nhyd_model
    config_init_case = 7
    config_start_time = '2021-07_19_00:00:00'
    config_stop_time = '2021-07-22_00:00:00'
    config_theta_adv_order = 3
    config_coef_3rd_order = 0.25
/
&dimensions
    config_nvertlevels = 55
    config_nsoillevels = 4
    config_nfglevels = 38
    config_nfgsoillevels = 4
/
&data_sources
    config_geog_data_path = '/data/ess-liuzj/geog/WPS_GEOG/'
    config_met_prefix = 'CFSR'
    config_sfc_prefix = 'SST'
    config_fg_interval = 86400
    config_landuse_data = 'MODIFIED_IGBP_MODIS_NOAH'
    config_topo_data = 'GMTED2010'
    config_vegfrac_data = 'MODIS'
    config_albedo_data = 'MODIS'
    config_maxsnowalbedo_data = 'MODIS'
    config_supersample_factor = 3
    config_use_spechumd = false
/
&vertical_grid
    config_ztop = 30000.0
    config_nsmterrain = 1
    config_smooth_surfaces = true
    config_dzmin = 0.3
    config_nsm = 30
    config_tc_vertical_grid = true
    config_blend_bdy_terrain = false
/
&interpolation_control
    config_extrap_airtemp = 'linear'
/
```

```
/
&interpolation_control
    config_extrap_airtemp = 'linear'
/
&preproc_stages
    config_static_interp = true
    config_native_gwd_static = true
    config_vertical_grid = false
    config_met_interp = false
    config_input_sst = false
    config_frac_seaice = false
/
&io
    config_pio_num_iotasks = 0
    config_pio_stride = 1
/
&decomposition
    config_block_decomp_file_prefix = 'x1.2562.graph.info.part.'
/
```

Please take note of some key variables:

- config_start_time: Start time of the simulation
- config_end_time: End time of the simulation
- config_nvertlevels: Number of vertical levels
- config_geog_data_path: Path to the terrain data
- config_landuse_data: Path to the landuse data
- config_block_decomp_file_prefix:

Path to the task decomposition file required for parallel computation

Now edit the streams.init_atmosphere file as follows:

```
<streams>
<immutable_stream name="input"
                  type="input"
                  filename_template="x1.2562.grid.nc"
                  input_interval="initial_only" />

<immutable_stream name="output"
                  type="output"
                  filename_template="x1.2562.static.nc"
                  packages="initial_conds"
                  output_interval="initial_only" />


</streams>
~
```

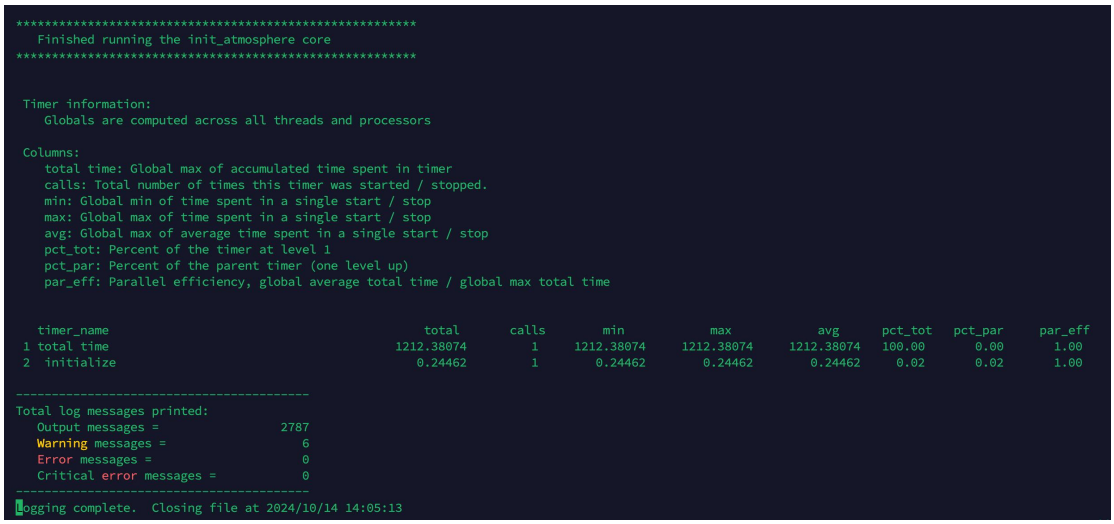
Note that the input section should specify the grid data, while the output section is set to generate static data.

Now, run the following command to begin generating the static file (the & at the end runs the task in the background):

```
./init_atmosphere &
```

You can monitor the process in the log file named log.init_atmosphere.0000.out (referred to as the “log file” below).

After approximately 30 minutes, the log file should display the following message at the end, indicating successful completion.



```
*****************************************************
   Finished running the init_atmosphere core
*****************************************************


 Timer information:
    Globals are computed across all threads and processors

 Columns:
    total time: Global max of accumulated time spent in timer
    calls: Total number of times this timer was started / stopped.
    min: Global min of time spent in a single start / stop
    max: Global max of time spent in a single start / stop
    avg: Global max of average time spent in a single start / stop
    pct_tot: Percent of the timer at level 1
    pct_par: Percent of the parent timer (one level up)
    par_eff: Parallel efficiency, global average total time / global max total time


   timer_name                                      total       calls        min          max          avg      pct_tot   pct_par     par_eff
 1 total time                                   1212.38074         1     1212.38074   1212.38074   1212.38074   100.00      0.00        1.00
 2  initialize                                     0.24462         1        0.24462      0.24462      0.24462     0.02      0.02        1.00

-----------------------------------------
Total log messages printed:
   Output messages =                2787
   Warning messages =                  6
   Error messages =                    0
   Critical error messages =           0
-----------------------------------------
Logging complete.  Closing file at 2024/10/14 14:05:13
```

3.2 Generating Init Files

Next, update the preproc_stages module and simulation timing information in the namelist.init_atmosphere file as follows:

```
&nhyd_model
    config_init_case = 7
    config_start_time = '2021-07-19_00:00:00'
    config_stop_time =  '2021-07-22_00:00:00'
    config_theta_adv_order = 3
    config_coef_3rd_order = 0.25
/
&dimensions
    config_nvertlevels = 55
    config_nsoillevels = 4
    config_nfglevels = 38
    config_nfgsoillevels = 4
/
&data_sources
    config_geog_data_path = '/data/ess-liuzj/geog/WPS_GEOG/'
    config_met_prefix = 'GFS'
    config_sfc_prefix = 'SST'
    config_fg_interval = 86400
    config_landuse_data = 'MODIFIED_IGBP_MODIS_NOAH'
    config_topo_data = 'GMTED2010'
    config_vegfrac_data = 'MODIS'
    config_albedo_data = 'MODIS'
    config_maxsnowalbedo_data = 'MODIS'
    config_supersample_factor = 3
    config_use_spechumd = false
/
&vertical_grid
    config_ztop = 30000.0
    config_nsmterrain = 1
    config_smooth_surfaces = true
    config_dzmin = 0.3
    config_nsm = 30
    config_tc_vertical_grid = true
    config_blend_bdy_terrain = false
/
&interpolation_control
    config_extrap_airtemp = 'linear'
/
```

```
&vertical_grid
    config_ztop = 30000.0
    config_nsmterrain = 1
    config_smooth_surfaces = true
    config_dzmin = 0.3
    config_nsm = 30
    config_tc_vertical_grid = true
    config_blend_bdy_terrain = false
/
&interpolation_control
    config_extrap_airtemp = 'linear'
/
&preproc_stages
    config_static_interp = false
    config_native_gwd_static = false
    config_vertical_grid = true
    config_met_interp = true
    config_input_sst = false
    config_frac_seaice = true
/
&io
    config_pio_num_iotasks = 0
    config_pio_stride = 1
/
&decomposition
    config_block_decomp_file_prefix = 'x1.2562.graph.info.part.'
/
```

Modify the streams.init_atmosphere file as follows:

```
<streams>
<immutable_stream name="input"
                  type="input"
                  filename_template="x1.2562.static.nc"
                  input_interval="initial_only" />

<immutable_stream name="output"
                  type="output"
                  filename_template="x1.2562.init.nc"
                  packages="initial_conds"
                  output_interval="initial_only" />


</streams>
~
~
~
```

Note that in this configuration, input data should be set to the static data, and output

data should be set to generate the init data.
Run the following command to begin generating the init file:

```
./init_atmosphere &
```

This process should take about one minute to complete. Upon success, an x1.2562.init.nc file will be created in the current directory. You can also check the last entries in the log file to confirm successful completion.

3.3 Running the Simulation

Now edit the namelist.atmosphere file as follows:

```
&nhyd_model
    config_time_integration_order = 2
    config_dt = 720.0
    config_start_time = '2021-07-19_00:00:00'
    config_run_duration = '3_00:00:00'
    config_split_dynamics_transport = true
    config_number_of_sub_steps = 2
    config_dynamics_split_steps = 3
    config_h_mom_eddy_visc2 = 0.0
    config_h_mom_eddy_visc4 = 0.0
    config_v_mom_eddy_visc2 = 0.0
    config_h_theta_eddy_visc2 = 0.0
    config_h_theta_eddy_visc4 = 0.0
    config_v_theta_eddy_visc2 = 0.0
    config_horiz_mixing = '2d_smagorinsky'
    config_len_disp = 480000.0
    config_visc4_2dsmag = 0.05
    config_w_adv_order = 3
    config_theta_adv_order = 3
    config_scalar_adv_order = 3
    config_u_vadv_order = 3
    config_w_vadv_order = 3
    config_theta_vadv_order = 3
    config_scalar_vadv_order = 3
    config_scalar_advection = true
    config_positive_definite = false
    config_monotonic = true
    config_coef_3rd_order = 0.25
    config_epssm = 0.1
    config_smdiv = 0.1
/
&damping
    config_zd = 22000.0
    config_xnutr = 0.2
/
&limited_area
    config_apply_lbcs = false
/
&io
    config_pio_num_iotasks = 0
```

```
&io
    config_pio_num_iotasks = 0
    config_pio_stride = 1
/
&decomposition
    config_block_decomp_file_prefix = 'x1.2562.graph.info.part.'
/
&restart
    config_do_restart = false
/
&printout
    config_print_global_minmax_vel = true
    config_print_detailed_minmax_vel = false
/
&IAU
    config_IAU_option = 'off'
    config_IAU_window_length_s = 21600.
/
&physics
    config_sst_update = false
    config_sstdiurn_update = false
    config_deepsoiltemp_update = false
    config_radtlw_interval = '00:30:00'
    config_radtsw_interval = '00:30:00'
    config_bucket_update = 'none'
    config_physics_suite = 'mesoscale_reference'
/
&soundings
    config_sounding_interval = 'none'
/
```

Please pay attention to some key variables:

• config_dt: Time step for integration

Note: When the resolution is increased, the time step must be appropriately reduced, or the simulation may fail. The following are recommended time step choices for reference:

For a resolution of 3 km, choose a time step of 15 seconds.

For a resolution of 15 km, choose a time step of 90 seconds.

For a resolution of 60 km, choose a time step of 360 seconds.

For resolutions of 120 km or higher, choose a time step of 720 seconds.

• config_time_integration_order: Order of the integration method

• config_start_time: Start time of the simulation

• config_run_duration: Duration of the simulation
• config_len_disp: Grid spacing
• config_apply_lbcs: Whether to enable regional simulation
• config_do_restart: Whether this is a restart simulation
• config_physics_suite: Chosen parameterization scheme suite
• config_block_decomp_file_prefix:
Path to the task partition file required for parallel computing (this affects whether parallel computation is successfully used in subsequent integrations)

Other important variables can be found in detail in the official MPAS_user_guide document, and will not be discussed here.

Now edit the streams.atmosphere file as follows:

```
<streams>
<immutable_stream name="input"
                  type="input"
                  filename_template="x1.2562.init.nc"
                  input_interval="initial_only" />

<immutable_stream name="restart"
                  type="input;output"
                  filename_template="restart.$Y-$M-$D_$h.$m.$s.nc"
                  input_interval="initial_only"
                  output_interval="1_00:00:00" />

<stream name="output"
        type="output"
        filename_template="history.$Y-$M-$D_$h.$m.$s.nc"
        output_interval="6:00:00" >

        <file name="stream_list.atmosphere.output"/>
</stream>

<stream name="diagnostics"
        type="output"
        filename_template="diag.$Y-$M-$D_$h.$m.$s.nc"
        output_interval="3:00:00" >

        <file name="stream_list.atmosphere.diagnostics"/>
</stream>


</streams>
~
~
```

Note that the input is the init data, and the output consists of the diag data and the history data. You can set the diagnostic output interval to any desired time, for example: output every 1 hour, every 3 hours, etc. Feel free to add or delete any variables you want in the stream_list.atmosphere.output file

After modifying the namelist.atmosphere file and the streams.atmosphere file, write and submit the job script. The steps are as follows:

```
touch test.rsl
```

```
#!/bin/bash
#BSUB -q debug
#BSUB -J atmosphere_model
#BSUB -n 10
#BSUB -e %J.err
#BSUB -o %J.out
#BSUB -R "span[ptile=40]"

mpirun -n 10 ./atmosphere_model
```

```
bsub < test.rsl
```

```
[ess-zhucy@login05 480km]$ bjobs
JOBID      USER    STAT  QUEUE      FROM_HOST   EXEC_HOST   JOB_NAME   SUBMIT_TIME
7451819    ess-zhu PEND  debug      login05                 *ere_model Oct 14 15:15
[ess-zhucy@login05 480km]$ bjobs
JOBID      USER    STAT  QUEUE      FROM_HOST   EXEC_HOST   JOB_NAME   SUBMIT_TIME
7451819    ess-zhu RUN   debug      login05     10*r13n45   *ere_model Oct 14 15:15
[ess-zhucy@login05 480km]$ ll
```

After completing simulation, a series of netcdf data files starting with ‘diag’ and ‘history’ will appear, as shown below.

```
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:15 diag.2021-07-19_00.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:15 diag.2021-07-19_03.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:15 diag.2021-07-19_06.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:15 diag.2021-07-19_09.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:15 diag.2021-07-19_12.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:15 diag.2021-07-19_15.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-19_18.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-19_21.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_00.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_03.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_06.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_09.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_12.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_15.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_18.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-20_21.00.00.nc
- 1 ess-zhucy ess-dongl  1146328 Oct 14 15:16 diag.2021-07-21_00.00.00.nc
```

```
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:15 history.2021-07-19_00.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:15 history.2021-07-19_06.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:15 history.2021-07-19_12.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:16 history.2021-07-19_18.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:16 history.2021-07-20_00.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:16 history.2021-07-20_06.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:16 history.2021-07-20_12.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:16 history.2021-07-20_18.00.00.nc
r-- 1 ess-zhucy ess-dongl 28230860 Oct 14 15:16 history.2021-07-21_00.00.00.nc
```

If the following summary information is output at the end of the log file, it indicates that the simulation run was successful and has ended.

Note that the error information must be 0. Additionally, please make sure to save the computational core hours and storage size used for this simulation.

```
  timer_name                                 total       calls       min         max         avg      pct_tot   pct_par     par_eff
1 total time                              105.68636           1    105.68624   105.68636   105.68628   100.00      0.00        1.00
2  initialize                               0.82919           1      0.81551     0.82919     0.81813     0.78      0.78        0.99
2  time integration                        87.28709         360      0.09471     0.49328     0.24238    82.59     82.59        1.00
3   physics driver                         45.59163         360      0.00736     0.35390     0.09699    43.14     52.23        0.77
4    calc_cldfraction                       0.02887         144      0.00009     0.00021     0.00015     0.03      0.06        0.74
4    RRTMG_sw                              26.47477         144      0.00001     0.22962     0.11088    25.05     58.07        0.60
4    RRTMG_lw                              16.71059         144      0.09525     0.11925     0.10941    15.81     36.65        0.94
4    Monin-Obukhov                          0.04877         360      0.00009     0.00026     0.00012     0.05      0.11        0.90
4    Noah                                   0.08130         360      0.00003     0.00032     0.00011     0.08      0.18        0.49
4    YSU                                    0.53311         360      0.00126     0.00209     0.00142     0.50      1.17        0.96
4    bl_ysu_gwdo                            0.15247         360      0.00028     0.00053     0.00036     0.14      0.33        0.85
4    New_Tiedtke                            1.95063         360      0.00350     0.00622     0.00475     1.85      4.28        0.88
3   atm_rk_integration_setup                0.18725         360      0.00046     0.00134     0.00050     0.18      0.21        0.97
3   atm_compute_moist_coefficients          0.15495         360      0.00037     0.00053     0.00040     0.15      0.18        0.94
3   physics_get_tend                        0.36572         360      0.00085     0.00252     0.00100     0.35      0.42        0.98
3   atm_compute_vert_imp_coefs              0.19156        1080      0.00016     0.00043     0.00017     0.18      0.22        0.98
3   atm_compute_dyn_tend                    5.52701        3240      0.00132     0.00352     0.00167     5.23      6.33        0.98
3   small_step_prep                         0.50329        3240      0.00012     0.00061     0.00015     0.48      0.58        0.97
3   atm_advance_acoustic_step               1.53927        4320      0.00031     0.00111     0.00035     1.46      1.76        0.98
3   atm_divergence_damping_3d               0.72595        4320      0.00013     0.00041     0.00016     0.69      0.83        0.98
3   atm_recover_large_step_variables        1.47887        3240      0.00034     0.00162     0.00044     1.40      1.69        0.96
3   atm_compute_solve_diagnostics           2.02045        3240      0.00048     0.00160     0.00060     1.91      2.31        0.97
3   atm_rk_dynamics_substep_finish          0.27291        1080      0.00015     0.00059     0.00025     0.26      0.31        0.97
3   atm_advance_scalars                     2.82530         720      0.00364     0.00551     0.00381     2.67      3.24        0.97
3   atm_advance_scalars_mono                2.07322         360      0.00528     0.00644     0.00562     1.96      2.38        0.98
3   microphysics                           14.21107         360      0.02320     0.04273     0.03391    13.45     16.28        0.86
4    WSM6                                  13.66588         360      0.02162     0.03960     0.03249    12.93     96.16        0.86

----------------------------------------
Total log messages printed:
   Output messages =                5119
   Warning messages =                  3
   Error messages =                    0
   Critical error messages =           0
----------------------------------------
Logging complete.  Closing file at 2024/10/14 15:17:20
```

4. Running Global Variable-resolution Simulation

4.1 Creating the Mesh with Regional Resolution Refinement

Firstly, navigate to the 92_25km_simulation directory:

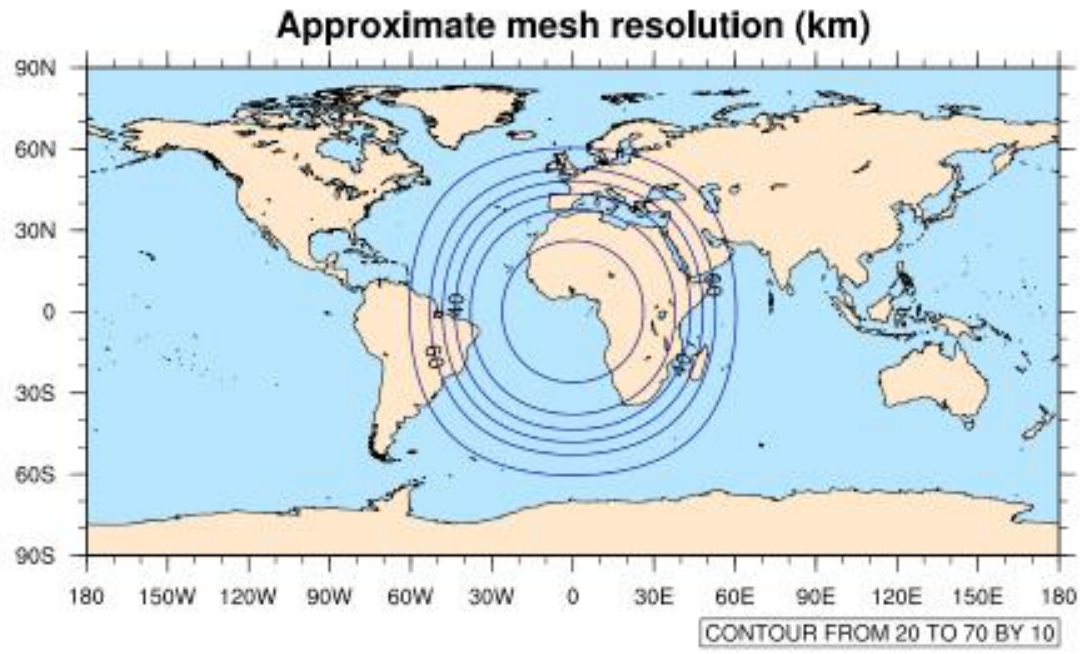
```
cd ~/MPAS_simulations/92_25km_simulation
ln -s   ~/MPAS_Model/MPAS-Model-7.3/init_atmosphere_model .
ln -s   ~/MPAS_Model/MPAS-Model-7.3/atmosphere_model .
ln -s   ~/MPAS_data/gfs/2023_09-07_08/GFS\:2023-09-0* .
ln -s   ~/MPAS_data/mesh/92_25km/x4.163842.grid.nc .
cp   ~/MPAS_Model/MPAS-Model-7.3/stream_list.atmosphere.* .
cp   ~/MPAS_Model/MPAS-Model-7.3/namelist.* .
cp   ~/MPAS_Model/MPAS-Model-7.3/streams.* .
ln -s   ~
/MPAS_Model/MPAS-Model-7.3/src/core_atmosphere/physics/physics_wrf/files/* .
```

Now, you need to roughly check the grid spacing distribution of the variable-resolution mesh, i.e., how the grid spacing is distributed in x4.163842.grid.nc. Copy the mesh_resolution.ncl script from the /data/ess-liuzj/mpas_tutorial/ncl_scripts directory to the current path:

```
cp /data/ess-liuzj/mpas_tutorial/ncl_scripts/mesh_resolution.ncl .
export FNAME=x4.163842.grid.nc
ncl mesh_resolution.ncl
```

Please note that you need to load the NCAR Command Language (NCL) first.

A mesh_resolution.pdf file will appear in the current directory as follows:



This figure shows the global distribution of horizontal grid resolution. By default, the grid resolution is refined over western Africa, but MPAS supports shifting the center of grid refinement to any location. Now, we will use Zhengzhou, Henan, as an example for grid refinement. The steps are as follows:

Create a file named namelist.input:

```
&input
   config_original_latitude_degrees = 0
   config_original_longitude_degrees = 0

   config_new_latitude_degrees =  34.0
   config_new_longitude_degrees = 113.0
   config_birdseye_rotation_counter_clockwise_degrees = 90
/
```

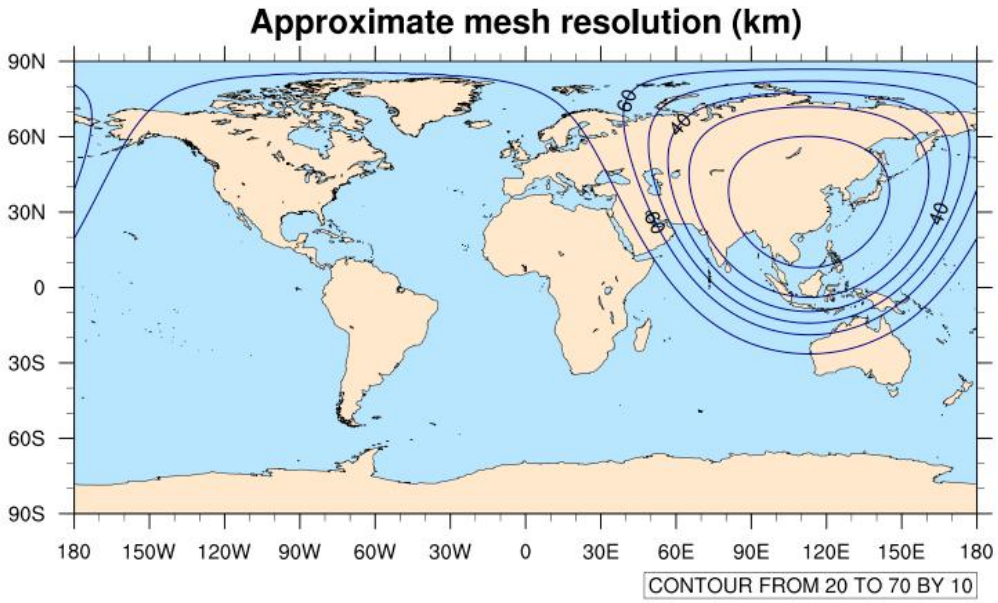
Note: 34.0 and 113.0 represent the latitude and longitude for the refinement. The first two variables are set to 0, indicating that the refinement type is a regular circular refinement. If other values are used, it indicates an elliptical refinement.

Run the following command to shift the refinement center.

```
grid_rotate x4.163842.grid.nc henan.grid.nc
```

A henan.grid.nc file will appear in the current path. Now, let's check the approximate grid spacing distribution in henan.grid.nc.

```
export FNAME=henan.grid.nc
ncl mesh_resolution.ncl
```



4.2 Creating Static, Init files and Running the Simulations

Please note that for global variable-resolution simulations, after completing 'Creating the Mesh with Regional Resolution Refinement,' the remaining steps align with the content in Sections 3.1–3.3. If you want more details on creating static files, init files, or doing the simulations, the information in Sections 3.1–3.3 is entirely sufficient.