MPAS
Model for Prediction Across Scales

Running MPAS Part 1: Creating Initial Conditions and Running a Basic Global Simulation

MPAS
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Outline

Real-data Initial Conditions

- Processing time-invariant fields ("static" file generation)
- Interpolating atmospheric and land-surface fields
- Producing SST and sea-ice update files

Running a basic simulation

Creating idealized initial conditions

- 3-d baroclinic wave test case
- 3-d supercell test case
- 2-d mountain wave test case

There will, of course, be digressions along the way…

Real-data ICs: processing static fields

Before beginning the process of creating real-data ICs, we need an SCVT mesh!

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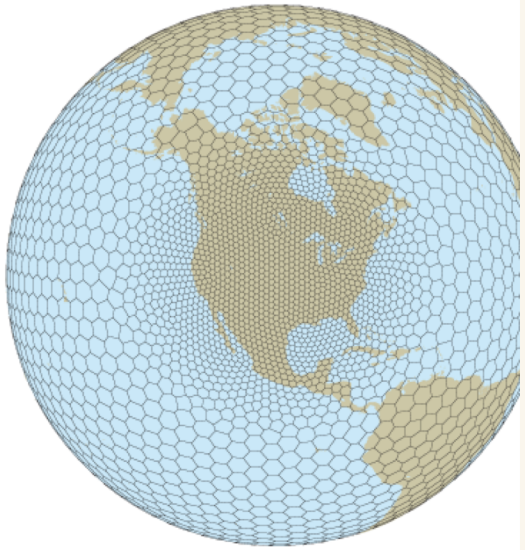
MPAS Atmosphere 7.0 was released on 8 June 2019.

***As of September 2018**, official support for MPAS-Atmosphere has migrated from the Google Groups forum to a web forum hosted by NCAR's Mesoscale and Microscale Meteorology. Users are encouraged to post any questions related to building and running MPAS-Atmosphere to the appropriate sub-topic in the MPAS-Atmosphere forum at http://forum.mmm.ucar.edu/phpBB3/. Posting to the forum requires the creation of an account, but no account is needed to browse the forum.*

First...

MPAS Atmosphere 7.0 release notes
MPAS source code download
MPAS-Atmosphere Users' Guide
MPAS-Atmosphere tutorial presentations
MPAS-Atmosphere meshes
Next...
Configurations for idealized test cases
Sample input files for real-data simulations



A variable resolution MPAS Voronoi mesh

Real-data ICs: processing static fields

The mesh download page has meshes that have been well-tested

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MPAS Mesh Specification

MPAS-Atmosphere Meshes

Several resolutions of quasi-uniform meshes, plus one refined mesh, are available for download. Each download provides an SCVT mesh on the unit sphere, the mesh connectivity (graph.info) file for the mesh, and partitionings of the mesh (e.g., graph.info.part.32) for various MPI task counts. Other meshes may be available upon request from the MPAS-Atmosphere developers by sending mail to *mpas-atmosphere-help* **AT** *googlegroups.com*.

All mesh files supplied here use double-precision real values. However, running MPAS-Atmosphere in single-precision requires the user to begin with single-precision SCVT mesh files, and all pre-processing steps must be run using a single-precision version of *init_atmosphere_model* with these mesh files. The double-precision mesh files provided here may be run through the double_to_float_grid converter program to produce a single-precision mesh file.

Quasi-uniform meshes

480-km mesh (2562 horizontal grid cells)

Download the 480-km mesh (1.6 MB)

384-km mesh (4002 horizontal grid cells)

Download the 384-km mesh (5.4 MB)

240-km mesh (10242 horizontal grid cells)

Download the 240-km mesh (6.6 MB)

120-km mesh (40962 horizontal grid cells)

Download the 120-km mesh (26.9 MB)

60-km mesh (163842 horizontal grid cells)

Download the 60-km mesh (111 MB)

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Real-data ICs: processing static fields

Some of the meshes that are found on the download page include:

```
x1.40962
x1.163842
x1.655362
x1.2621442
x1.5898242
x4.163842
x4.535554
x5.6488066
```

How does one interpret these cryptic names?

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Real-data ICs: processing static fields

Some of the meshes that are found on the download page include:

```
x1.40962
x1.163842
x1.655362
x1.2621442
x1.5898242
x4.163842
x4.535554
x5.6488066
```

Refinement factor:

x1 = no refinement (quasi-uniform)

x4 = refinement by a factor of 4

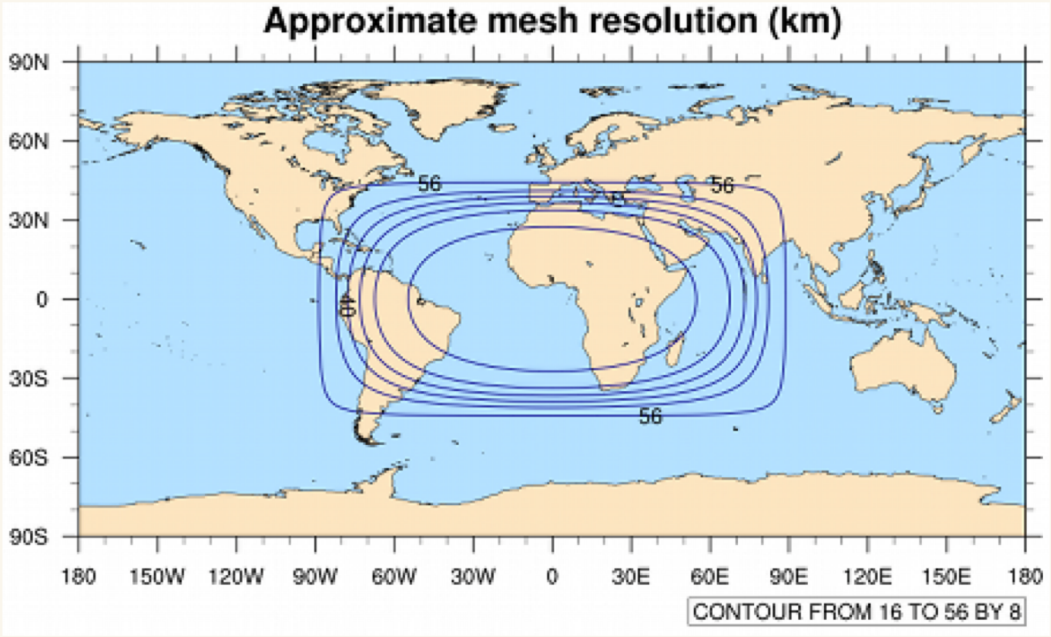
x5 = refinement by a factor of 5

Real-data ICs: processing static fields

Some of the meshes that are found on the download page include:

```
x1.40962
x1.163842
x1.655362
x1.2621442
x1.5898242
x4.163842
x4.535554
x5.6488066
```

Total number of cells in the mesh



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Real-data ICs: processing static fields

When downloading a mesh, you'll get the mesh itself as well as various *mesh (graph) partition files*.

For example, the x1.40962 mesh (about 120-km resolution) is provided with the following files:

`x1.40962.grid.nc` – the mesh itself
`x1.40962.graph.info` – the mesh connectivity graph
`x1.40962.graph.info.part.2` – pre-computed partitioning for 2 MPI tasks
`x1.40962.graph.info.part.8` – pre-computed partitioning for 8 MPI tasks
`x1.40962.graph.info.part.16` – pre-computed partitioning for 16 MPI tasks
...

We'll say more about partition files when talking about running the model, and also when talking about MPAS meshes

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Real-data ICs: processing static fields

Recall from the previous talk that there are two executables we need to initialize and run an MPAS-Atmosphere simulation:

`init_atmosphere_model`

- Handles all stages of processing real-data initial conditions
- Handles processing of SST and sea-ice update files
- Handles generation of various idealized initial conditions
- Handles generation of lateral boundary conditions

`atmosphere_model`

- The model itself, responsible for performing integration/simulation given any source of initial conditions

Real-data ICs: processing static fields

How does the 'init_atmosphere' core manage to combine all of this functionality into one program!?

- The key idea is that `init_atmosphere_model` may be run in stages using different options

```
&nhyd_model
    config_init_case = 7
    ...
/

&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
/
```

2 = ideal baroclinic wave
4 = ideal squall line
5 = ideal supercell
6 = ideal mountain wave
7 = real-data initialization
8 = surface update file creation (like sst_update=1 in WRF)
9 = lateral boundary conditions

Only used for real-data cases to control, e.g., whether we interpolate static fields, compute fields for GWDO scheme, interpolate meteorological data, etc.

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Real-data ICs: processing static fields

Generally, there are two files that must be edited every time the `init_atmosphere_model` program is run:

`namelist.init_atmosphere`

- Fortran namelist file
- Determines which "case" will be prepared (e.g., idealized cases, real-data case)
- Determines sub-options for the selected initialization case

`streams.init_atmosphere`

- XML file
- Specifies which netCDF files will be read and written by the `init_atmosphere_model` program

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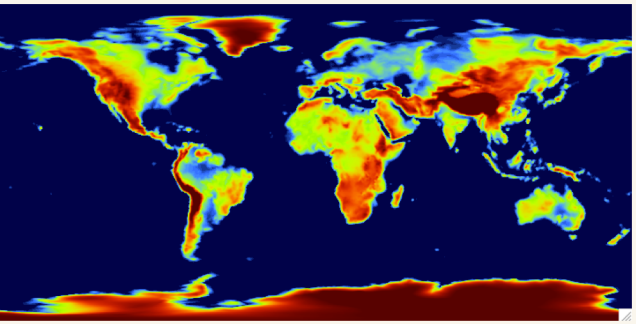
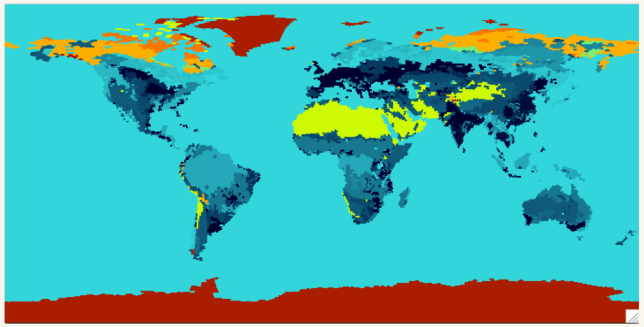
Real-data ICs: processing static fields

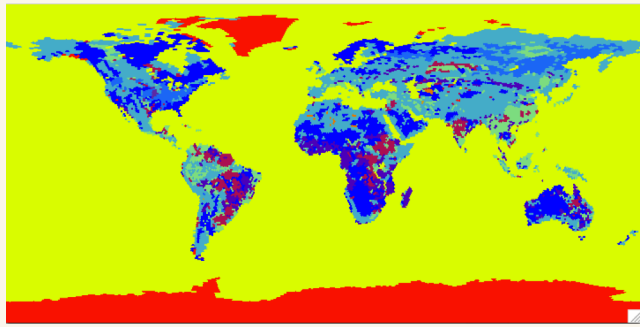
When we talk about time-invariant, “static” fields, what do we mean, exactly?



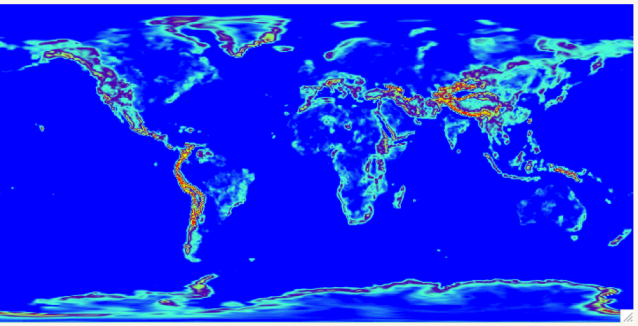
Terrain elevation



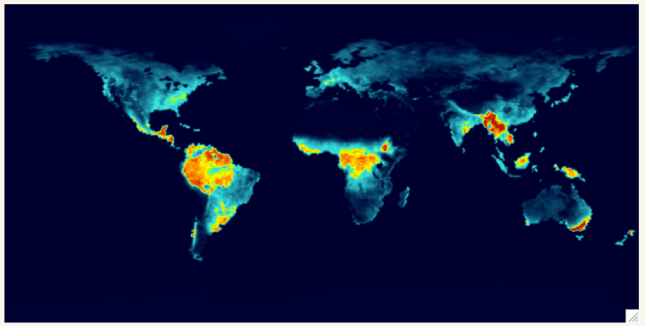
Dominant land cover category



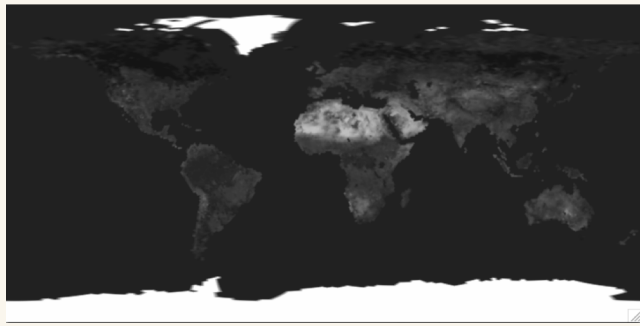
Dominant soil category



Sub-grid-scale terrain variance



Climatological monthly vegetation fraction



Climatological monthly surface albedo

These fields can be interpolated once and re-used for any real-data simulation

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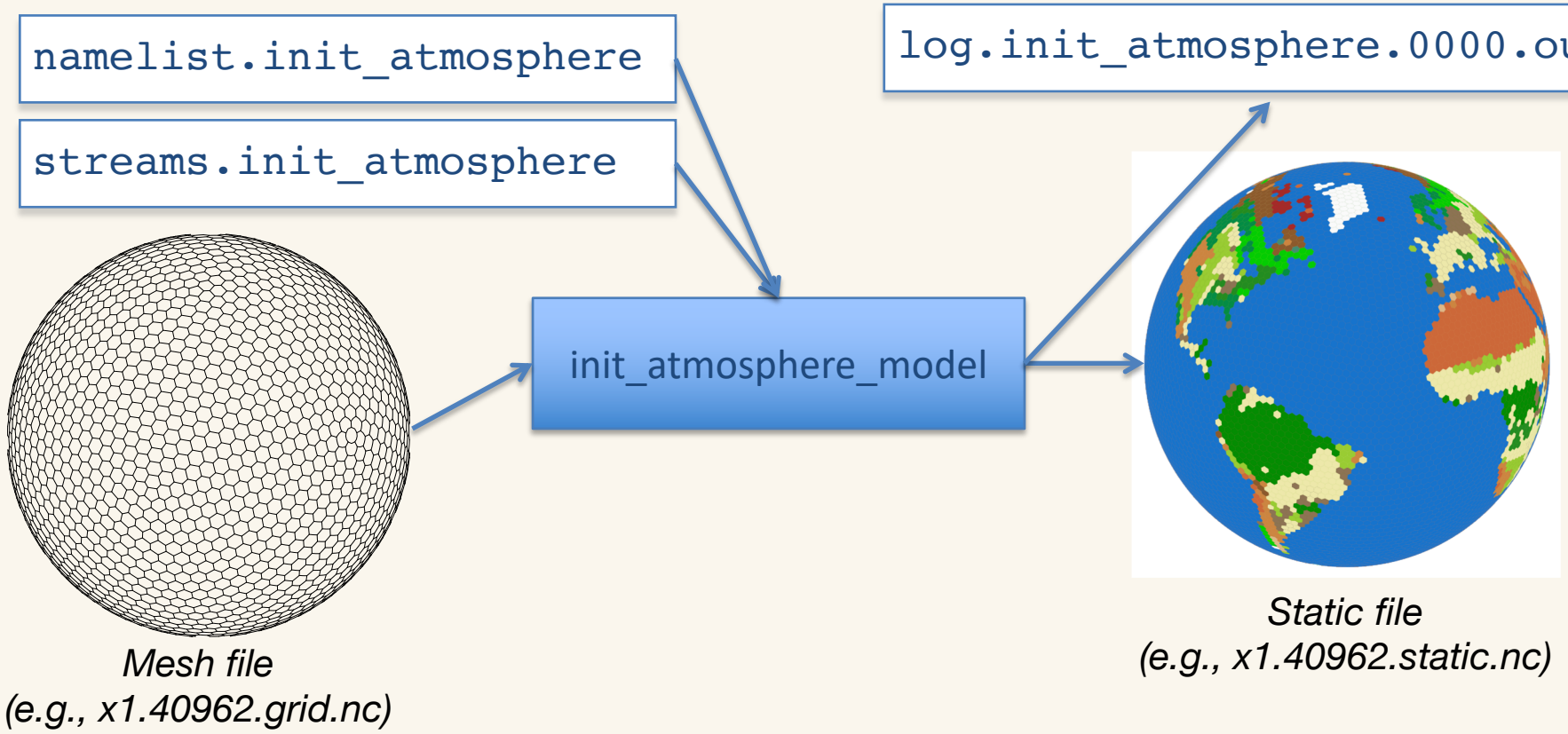
Real-data ICs: processing static fields

From where do we obtain the datasets for these “static” fields?

- These are the same datasets as are used by the WRF model

Real-data ICs: processing static fields

Input and output files when producing a “static” file:



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Real-data ICs: processing static fields

Key settings in the `namelist.init_atmosphere` file:

```
&nhyd_model
    config_init_case = 7
/
&data_sources
    config_geog_data_path = '/glade/work/wrfhelp/WPS_GEOG/'
    config_landuse_data = 'MODIFIED_IGBP_MODIS_NOAH'
    config_topo_data = 'GMTED2010'
    config_vegfrac_data = 'MODIS'
    config_albedo_data = 'MODIS'
    config_maxsnowalbedo_data = 'MODIS'
/
&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
/
```

Real-data ICs: processing static fields

Key settings in the `streams.init_atmosphere` file:

```
<immutable_stream name="input"
                  type="input"
                  filename_template="x1.40962.grid.nc"
                  input_interval="initial_only" />


<immutable_stream name="output"
                  type="output"
                  filename_template="x1.40962.static.nc"
                  packages="initial_conds"
                  output_interval="initial_only" />
```

Real-data ICs: processing static fields

The result should be a “static” netCDF file with

- terrain
- land use category
- soil category
- climatological albedo
- climatological vegetation fraction
- sub-grid-scale orography statistics for the GWDO scheme

Also, the radius of the SCVT mesh should be 6371229.0 m!

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Real-data ICs: processing static fields

Look for messages like the following in the `log.init_atmosphere.0000.out` file:

```
--- enter subroutine init_atm_static:
Using GMTED2010 terrain dataset
/shared/WPS_GEOG/topo_gmted2010_30s/00001-01200.00001-01200
/shared/WPS_GEOG/topo_gmted2010_30s/01201-02400.00001-01200
/shared/WPS_GEOG/topo_gmted2010_30s/02401-03600.00001-01200
```

```
Computing GWDO static fields on the native MPAS mesh

--- Using GMTED2010 terrain dataset for GWDO static fields
```

```
-----------------------------------------
Total log messages printed:
   Output messages =                 3067
   Warning messages =                  10
   Error messages =                     0
   Critical error messages =            0
-----------------------------------------
```

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Digression: “intermediate” data files

Time-varying meteorological and land-surface fields in MPAS-Atmosphere are interpolated from *intermediate* files produced by the ungrib component of the WRF Pre-processing System.

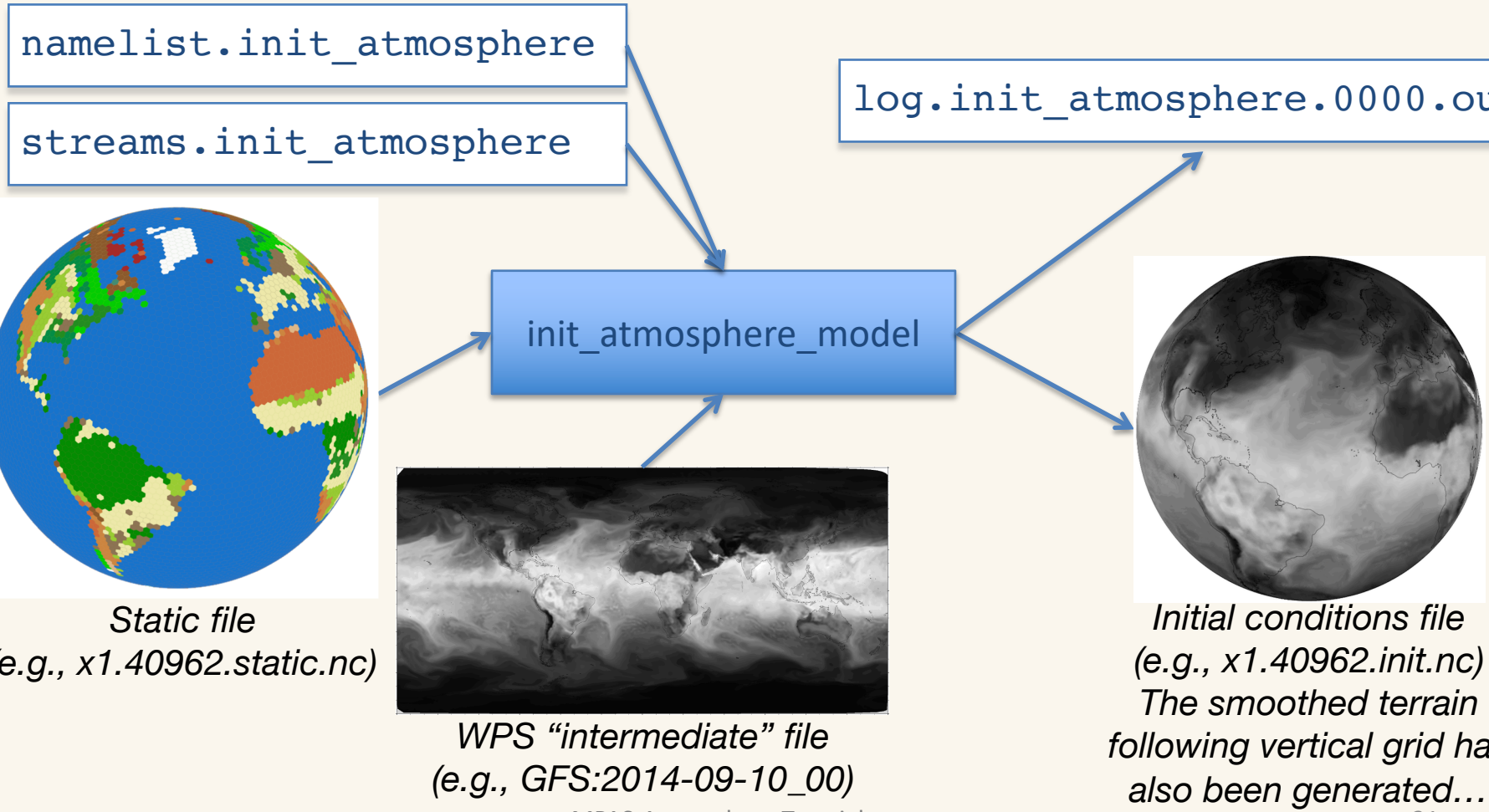
We’ll assume in this tutorial that these files have already been prepared!

- Additional details may be found in the links, below

WRF Model web page: http://www2.mmm.ucar.edu/wrf/users/
WRF Users’ guide:
http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_v4/v4.0/contents.html
WPS source code:
http://www2.mmm.ucar.edu/wrf/src/WPSV4.0.TAR.gz
Tutorial slides for running ungrib:
http://www2.mmm.ucar.edu/wrf/users/tutorial/201801/wps_general.pdf

Real-data ICs: interpolating meteorological fields

Input and output files when producing an “init” file:



Real-data ICs: interpolating meteorological fields

Key settings in the `namelist.init_atmosphere` file:

```
&nhyd_model
    config_init_case = 7
    config_start_time = '2014-09-10_00:00:00'
/
&dimensions
    config_nvertlevels = 55
    config_nsoillevels = 4
    config_nfglevels = 38
    config_nfgsoillevels = 4
/
&data_sources
    config_met_prefix = 'GFS'
    config_use_spechumd = false
/
```

Real-data ICs: interpolating meteorological fields

Key settings in the `namelist.init_atmosphere` file (*cont.*):

```
&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
/
&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
/
```

Real-data ICs: interpolating meteorological fields

Key settings in the `streams.init_atmosphere` file:

```
<immutable_stream name="input"
                  type="input"
                  filename_template="x1.40962.static.nc"
                  input_interval="initial_only" />


<immutable_stream name="output"
                  type="output"
                  filename_template="x1.40962.init.nc"
                  packages="initial_conds"
                  output_interval="initial_only" />
```

Real-data ICs: interpolating meteorological fields

The result should be a “init” netCDF file with

- *everything from the “static” file*
- 3-d vertical grid information
- 3-d potential temperature (*theta*)
- 3-d winds (*u* and *w*)
- 3-d water vapor mixing ratio (q_v)
- 2-d soil moisture
- 2-d soil temperature

Real-data ICs: processing static fields

Look for messages like the following in the `log.init_atmosphere.0000.out` file:

```
 real-data GFS test case
Using option 'linear' for vertical extrapolation of temperature
max ter = 5393.19321458650
Setting up vertical levels as in 2014 TC experiments


--- config_tc_vertical_grid = T
--- als   = 0.750000000000000E-01
--- alt   = 1.70000000000000
--- zetal = 0.750000000000000
```

```
Interpolating TT at 27 1000.00000000000
Interpolating U at 27 1000.00000000000
Interpolating V at 27 1000.00000000000
Interpolating RH at 27 1000.00000000000
Interpolating GHT at 27 1000.00000000000
*********************************************
Found 27 levels in the first-guess data
*********************************************
```

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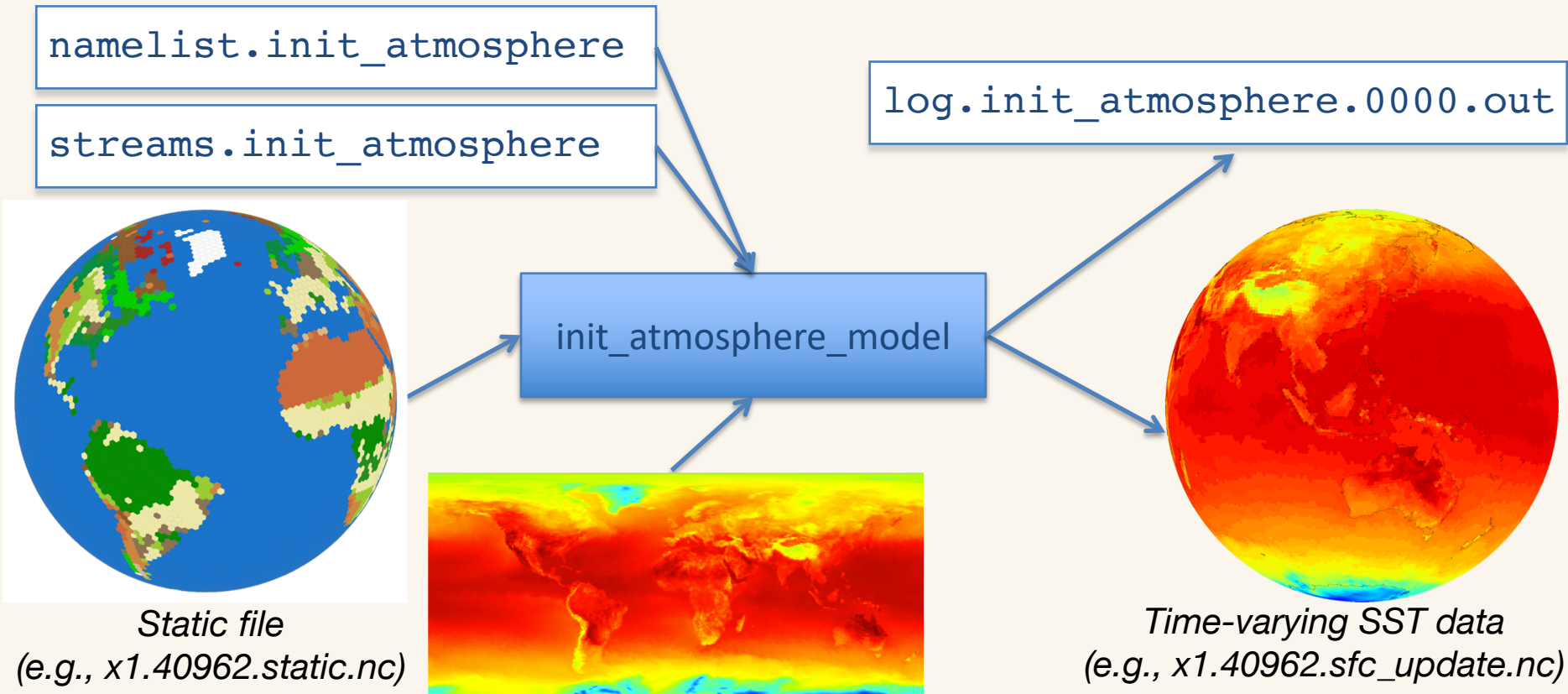
- 2-d mountain wave test case

Producing SST and sea-ice update files

Input and output files when producing an SST update file:



Producing SST and sea-ice update files

Key settings in the `namelist.init_atmosphere` file:

```
&nhyd_model
    config_init_case = 8
    config_start_time = '2014-09-10_00:00:00'
    config_stop_time = '2014-09-20_00:00:00'
/
&data_sources
    config_sfc_prefix = 'SST'
    config_fg_interval = 86400
/
&preproc_stages
    config_static_interp = false
    config_native_gwd_static = false
    config_vertical_grid = false
    config_met_interp = false
    config_input_sst = true
    config_frac_seaice = true
/
```

Producing SST and sea-ice update files

Key settings in the `streams.init_atmosphere` file:

```
<immutable_stream name="input"
                  type="input"
                  filename_template="x1.40962.static.nc"
                  input_interval="initial_only" />

<immutable_stream name="surface"
                  type="output"
                  filename_template="x1.40962.sfc_update.nc"
                  filename_interval="none"
                  packages="sfc_update"
                  output_interval="86400" />
```

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Real-data ICs: processing static fields

Look for messages like the following in the `log.init_atmosphere.0000.out` file:

```
real-data surface (SST) update test case
Processing file SST:2014-09-10_00
Processing file SST:2014-09-11_00
Processing file SST:2014-09-12_00
Processing file SST:2014-09-13_00
Processing file SST:2014-09-14_00
Processing file SST:2014-09-15_00
Processing file SST:2014-09-16_00
Processing file SST:2014-09-17_00
Processing file SST:2014-09-18_00
Processing file SST:2014-09-19_00
Processing file SST:2014-09-20_00
```

```
----------------------------------------
Total log messages printed:
   Output messages =                  144
   Warning messages =                   0
   Error messages =                     0
   Critical error messages =            0
----------------------------------------
```

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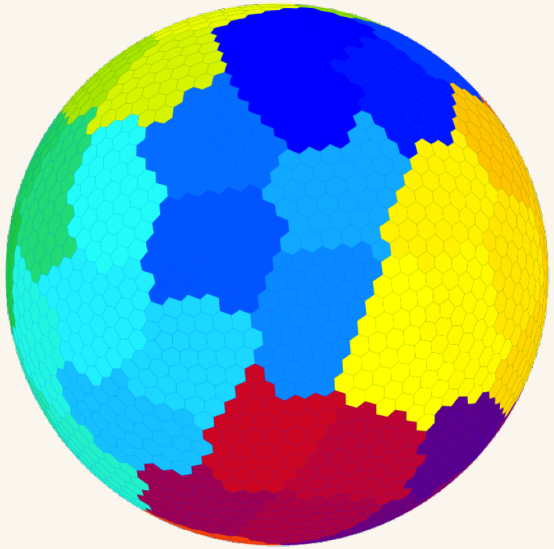
Digression: Mesh partition files

MPAS meshes must be partitioned using *Metis* in order for MPAS to be run in parallel



However, the meshes available from the MPAS-Atmosphere download page are provided with several pre-computed partition files

- **In many cases, it may not be necessary for you to run Metis yourself; just use a pre-computed partitioning**

For example, the x1.40962 mesh (about 120-km resolution) is provided with the following files:

`x1.40962.grid.nc` – the mesh itself
`x1.40962.graph.info` – the mesh connectivity graph
`x1.40962.graph.info.part.2` – pre-computed partitioning for 2 MPI tasks
`x1.40962.graph.info.part.8` – pre-computed partitioning for 8 MPI tasks
`x1.40962.graph.info.part.16` – pre-computed partitioning for 16 MPI tasks
...

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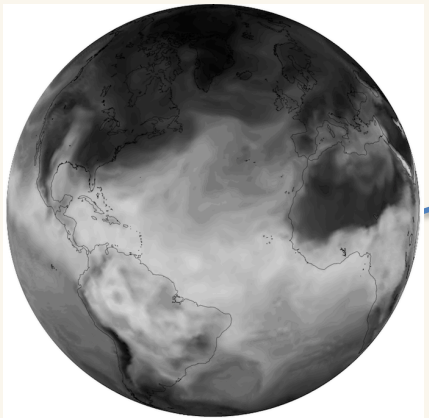
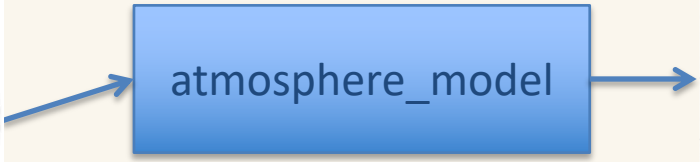
Running the MPAS-Atmosphere model

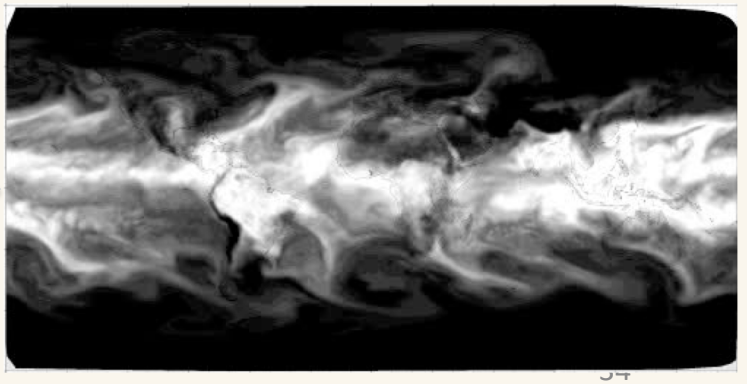
The same `atmosphere_model` executable can be used for either real-data or idealized simulations

Given initial conditions (e.g., `x1.40962.init.nc`), all that is needed to run the model is to:

1. Edit the `namelist.atmosphere` file to set model timestep, mixing and damping parameters, physics options, etc.
2. Edit the `streams.atmosphere` file to specify the name of the input initial conditions file and the frequency of model history files
3. Ensure that the proper mesh partition file (e.g., `x1.40962.graph.info.part.64`) is present
4. Run `atmosphere_model`







Running the MPAS-Atmosphere model

Before running the model itself (`atmosphere_model`), verify that the following namelist options have been properly set:

- **config_start_time –** The starting time of the simulation, which should either match the time in the initial conditions files or a *model restart file*.
- **config_dt** – The model timestep, in seconds; with MPAS v5.0, try starting with a timestep of between 5 and 6 times the minimum model grid spacing in kilometers; also ensure that model output interval is evenly divided by the timestep
- **config_len_disp –** The length-scale for explicit horizontal mixing; set this to the minimum grid distance (in meters) in the mesh

Besides these crucial namelist options, ensure that the names of input and output files are correctly set in the `streams.atmosphere` file!

Running the MPAS-Atmosphere model

As the model runs, information about the progress of the model is written to the file `log.atmosphere.0000.out`

- This is the equivalent of the WRF `rsl.error.0000` file

One can *tail* this file to check on model progress, e.g.,

```
$ tail -f log.atmosphere.0000.out
```

```
Begin timestep 2017-06-12_01:00:00
--- time to run the LW radiation scheme L_RADLW = T
--- time to run the SW radiation scheme L_RADSW = T
--- time to run the convection scheme L_CONV    = T
--- time to apply limit to accumulated rainc and rainnc L_ACRAIN   = F
--- time to apply limit to accumulated radiation diags. L_ACRADT   = F
--- time to calculate additional physics_diagnostics               = F
 split dynamics-transport integration             3

global min, max w  -0.4467210       1.098162
global min, max u   -89.13145       88.83957
Timing for integration step:    0.3368 s
```

Above: Example output for a timestep in the log file from a typical model run.

MPAS
Model for Prediction Across Scales

One final, important note…

If there are any errors reported in the `log.init_atmosphere.0000.out` or `log.atmosphere.0000.out` files, look for `log.*.err` files, and have a closer look!

```
 ----------------------------------------
 Total log messages printed:
    Output messages =                   46
    Warning messages =                   0
    Error messages =                     0
    Critical error messages =            1
 ----------------------------------------
```

```
-------------------------------------------------------------------------
Beginning MPAS-init_atmosphere Error Log File for task    0 of    1
    Opened at 2018/07/27 16:35:58
-------------------------------------------------------------------------


CRITICAL ERROR: Could not open input file 'x1.40926.static.nc' to read
mesh fields
Logging complete.  Closing file at 2018/07/27 16:35:58
```