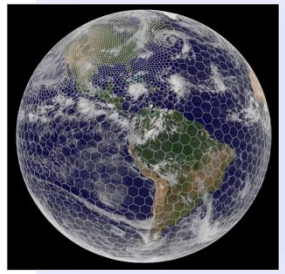


Regional-MPAS
Prepare mesh, Create initial and boundary conditions

Michael Duda Ming Chen

Weather Modeling and Research Section

Mesoscale & Microscale Meteorology Laboratory

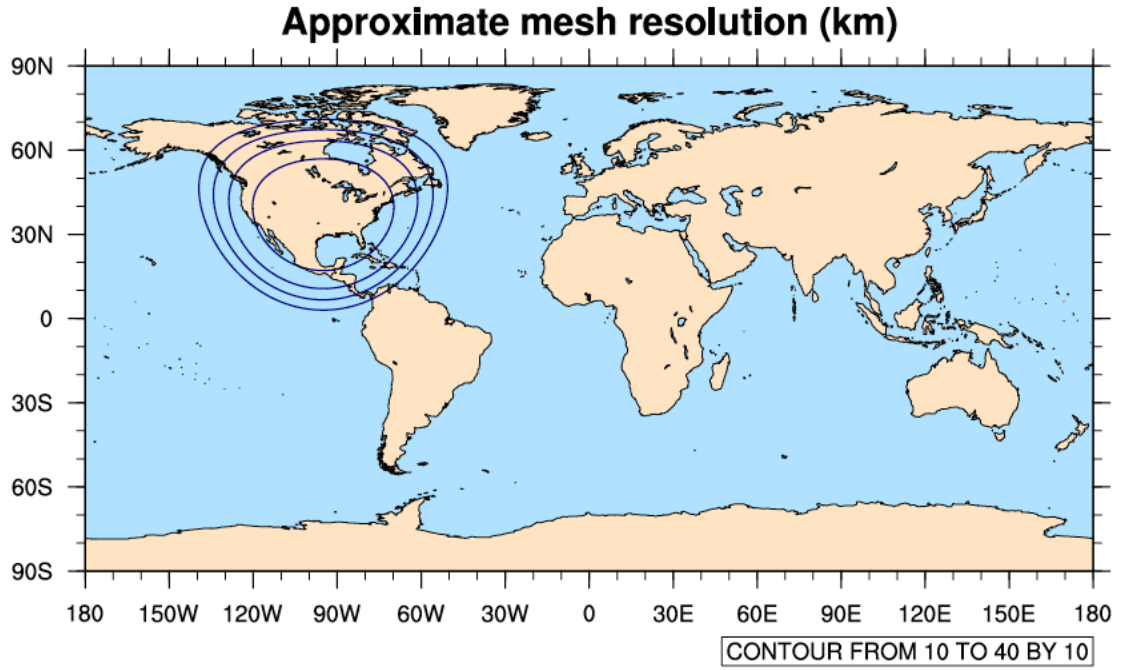
National Center for Atmospheric Research

This material is based upon work sponsored by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977

Regional-MPAS: prepare mesh, create initial and boundary conditions

- **A limited-area domain must be defined, and a mesh must be created**
- **The mesh must be partitioned for parallel execution**
- **Initial and boundary conditions must be generated for the domain**

(see Sections 4.3 and 8.2 in the User's Guide)



60-3km mesh centered over CONUS

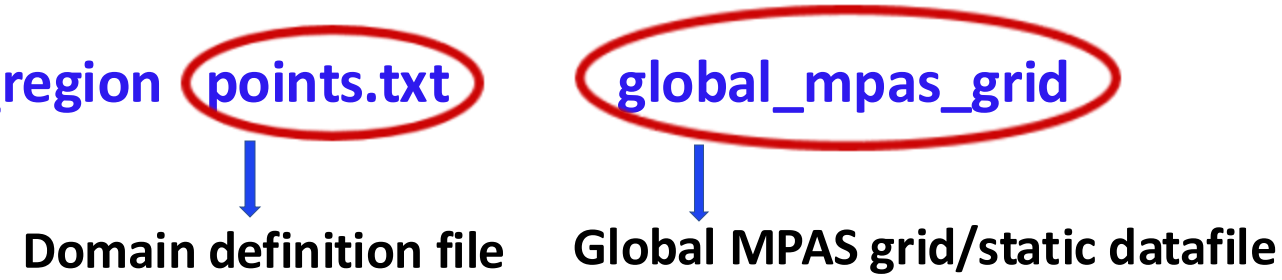
Regional-MPAS: preparing mesh using MPAS_limited_area tool

MPAS Limited-Area: a python tool to produces a regional area grid

- **Download and Installing**
  - git clone https://github.com/MPAS-Dev/MPAS-Limited-Area.git
  - setenv PATH ${PATH}:/path/to/MPAS-Limited-Area

- **Run the create_region command-line script**

  - **create_region points.txt global_mpas_grid**

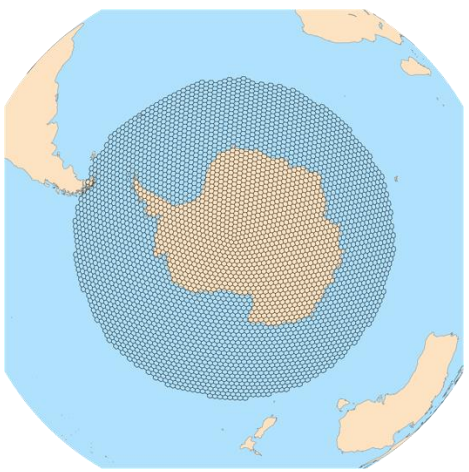


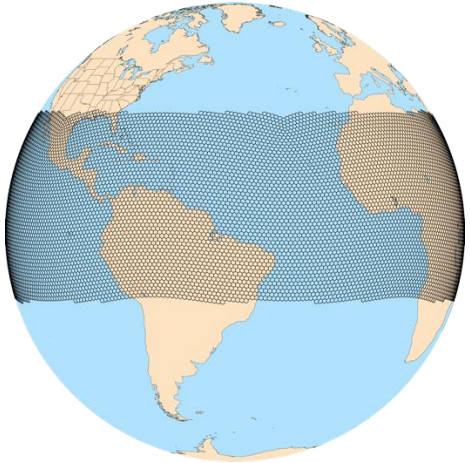
(Sample points.txt files can be found in docs/points-examples)

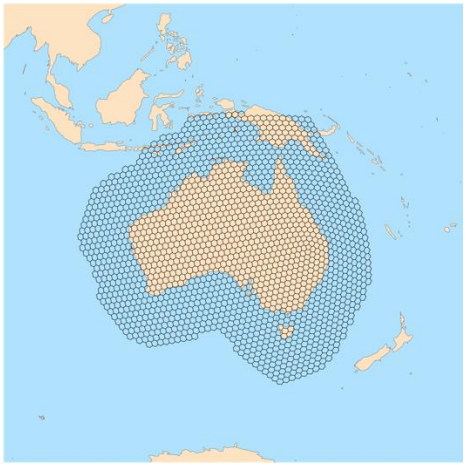
Regional-MPAS: how to create mesh over a regional domain

- MPAS supports various types of region: Circles, ellipses, channels, and polygons
- Required inputs: a parent mesh and a region definition file
- It is easy to add new region types using python

(https://github.com/MPAS-Dev/MPAS-Limited-Area.git)







Regional-MPAS: how to create mesh over a regional domain

Points.txt

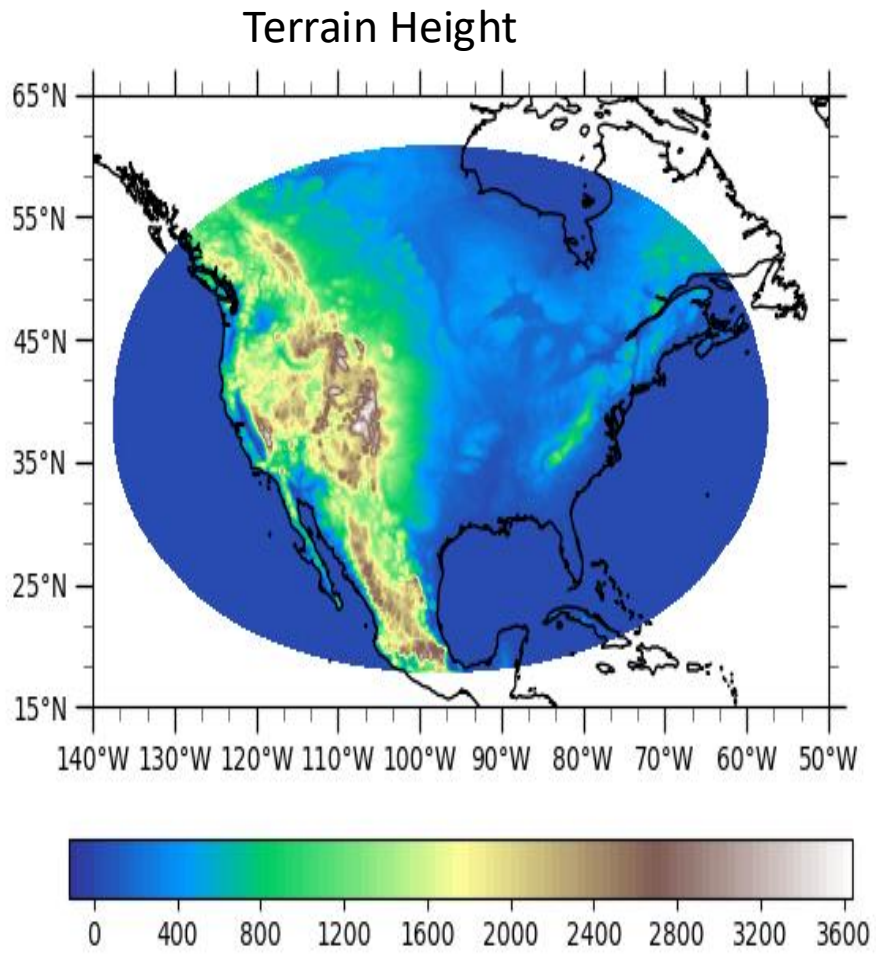
Name: CONUS
Type: circle
Point: 37.5, -95.0
radius: 4000

Command usage line:

Create_region points.txt x1.10242.static.nc

Output:

CONUS.static.nc and CONUS.graph.info



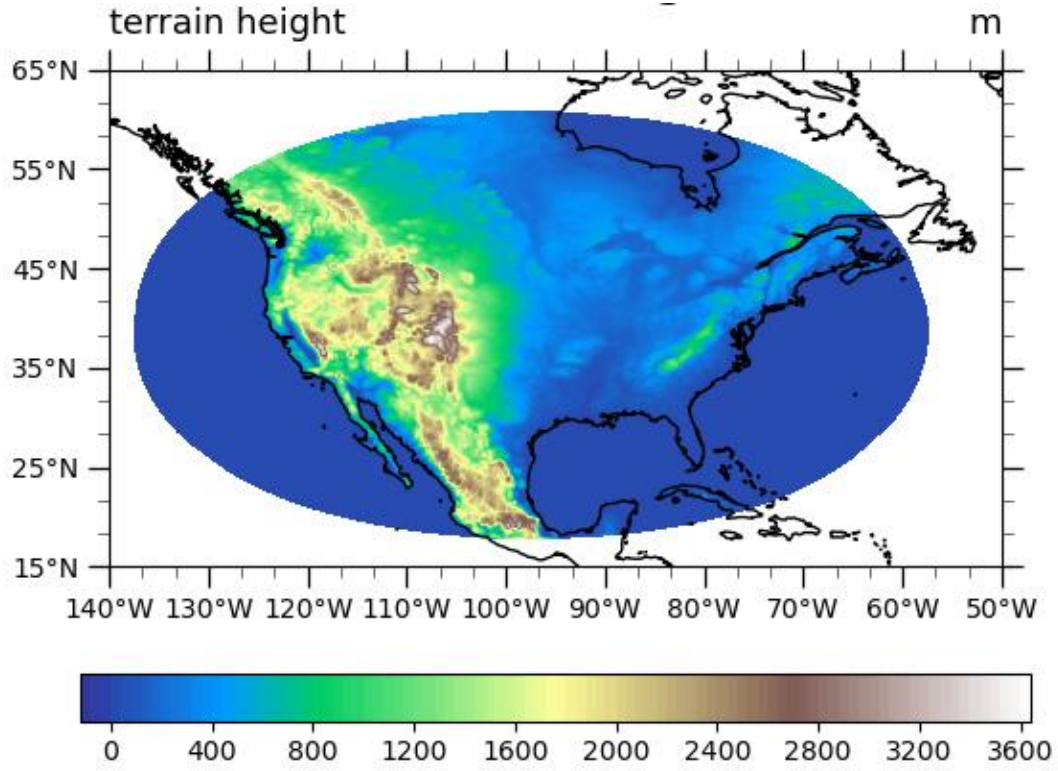
Regional-MPAS: how to create mesh over a regional domain

The ellipse method

Points.txt

Name: CONUS
Type: ellipse
Point: 37.5, -95.0
Semi-major-axis: 4500000.
Semi-minor-axis: 3200000.
Orientation-angle: 90.0

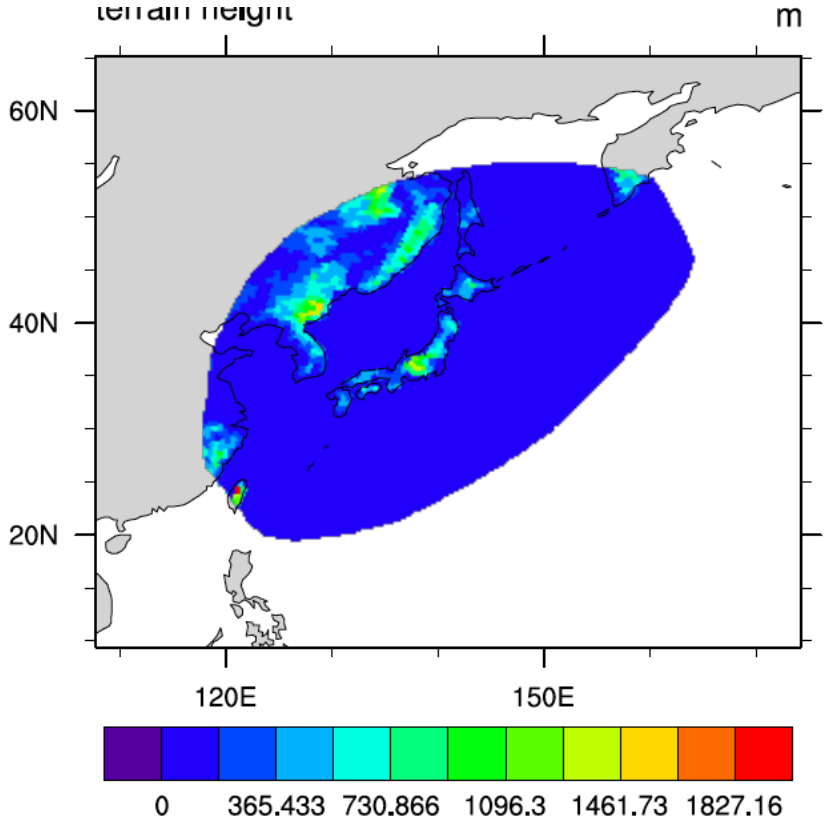
Terrain Height



Regional-MPAS: how to create mesh over a regional domain

Points.txt

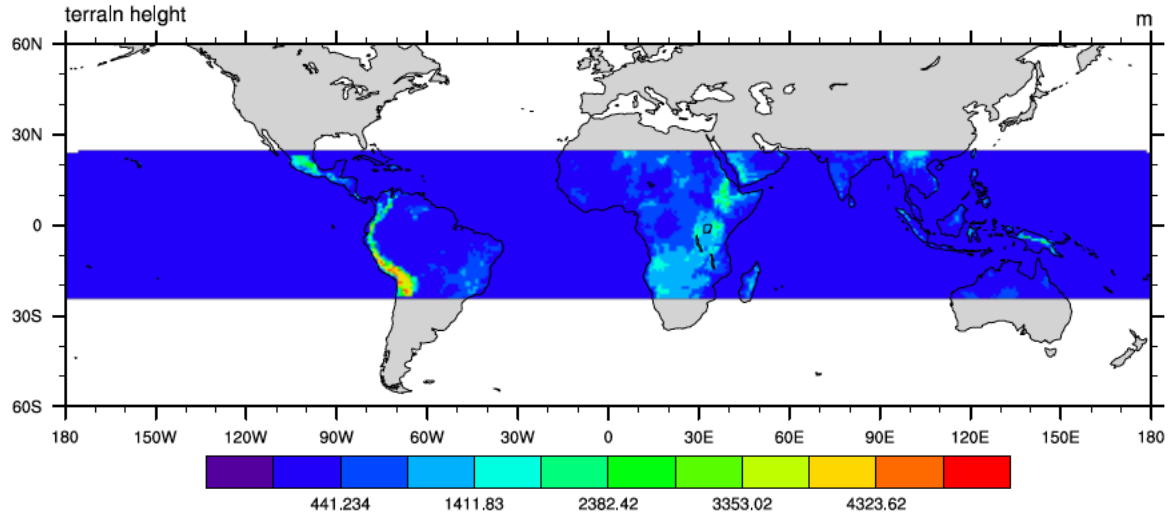
Name: Japan
Type: ellipse
Point: 38.0, 138.0
Semi-major-axis: 2000000
Semi-minor-axis: 1000000
Orientation-angle: 45



Regional-MPAS: how to create mesh over a regional domain

Points.txt

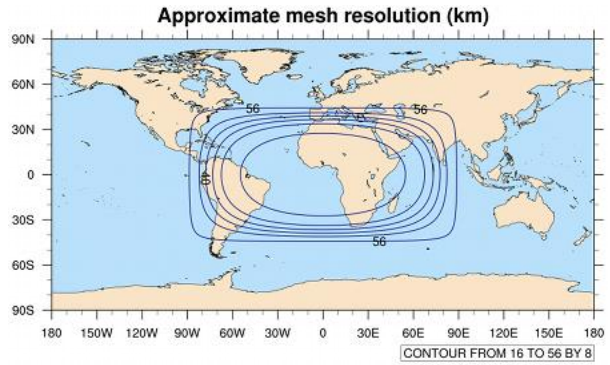
Name: Tropics
Type: channel
ulat: 20.4
llat: -20.4



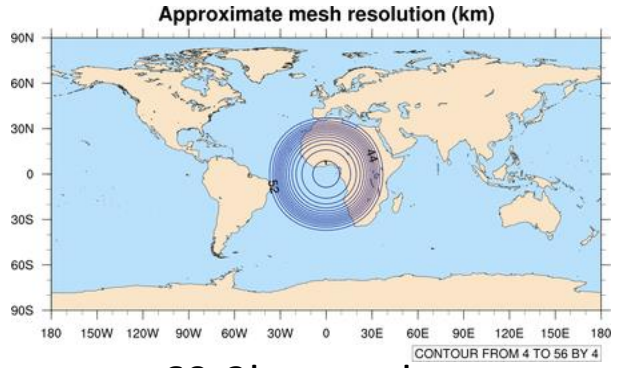
The equatorial channel

Regional-MPAS: how to create mesh over a regional domain

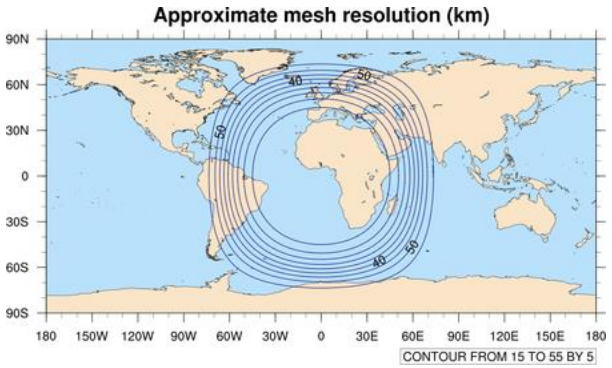
Creating limited-area meshes from variable-resolution “parent” meshes works equally well
Available MPAS global meshes (http://mpas-dev.github.io).



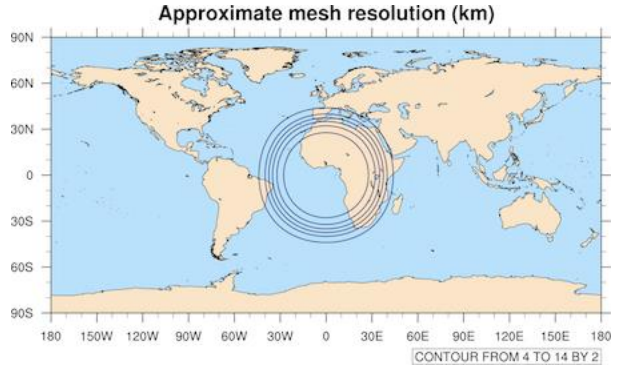
60-15km mesh



60-3km mesh



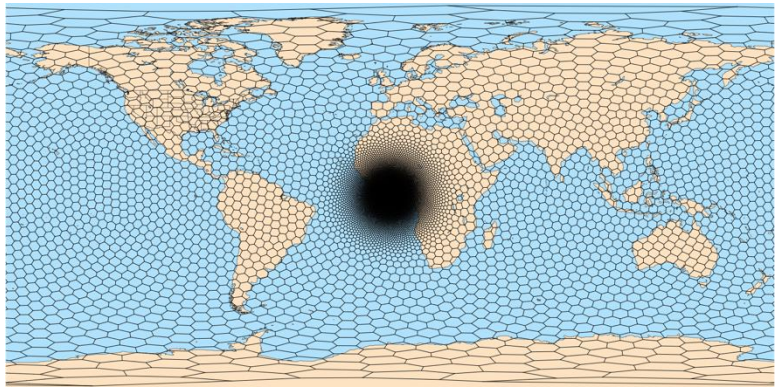
60-10km mesh



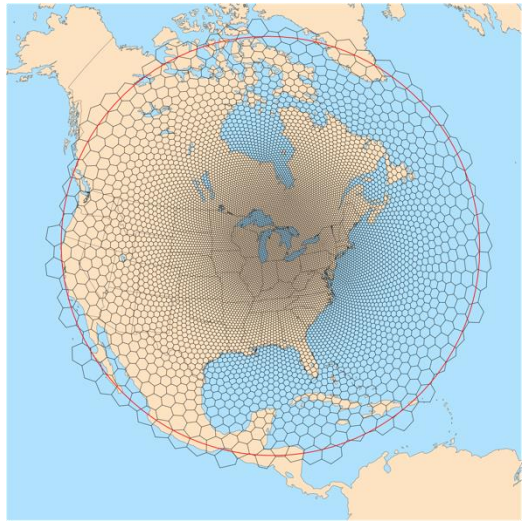
46-12km mesh

Regional-MPAS: how to create mesh over a regional domain

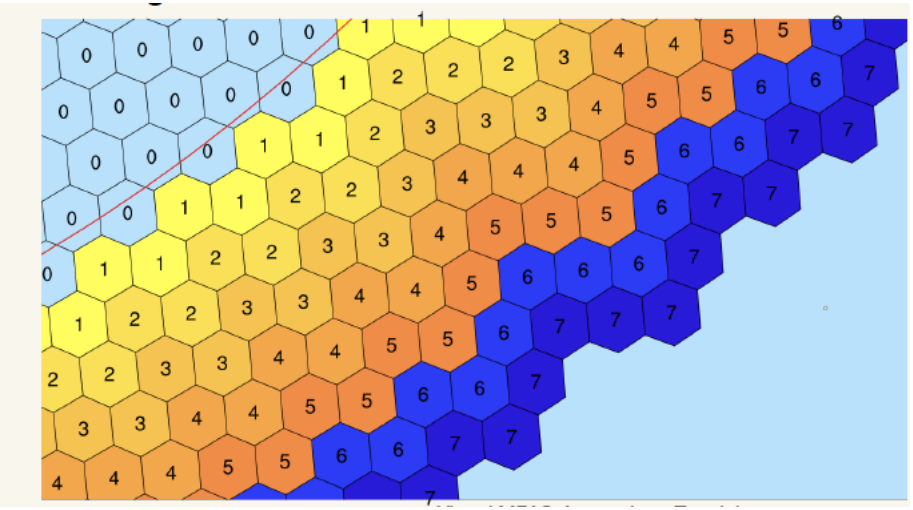
Step I: run grid-rotate to relocate the refinement to the area of interests



Step II: run mpas_limited_area tool to produce limited-area mesh



Regional-MPAS: Lateral Boundary



In MPAS, the lateral boundary includes

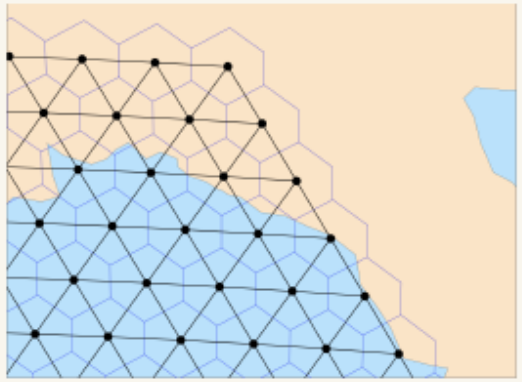
- **Five layers of relaxation-zone cells (bdyMaskCell = 1, 2, 3, 4, 5)**
- **Two layers of specified-zone cells (bdyMaskCell = 6, 7)**

The integer variable, bdyMaskCell, identifies boundary cell types in the regional mesh file

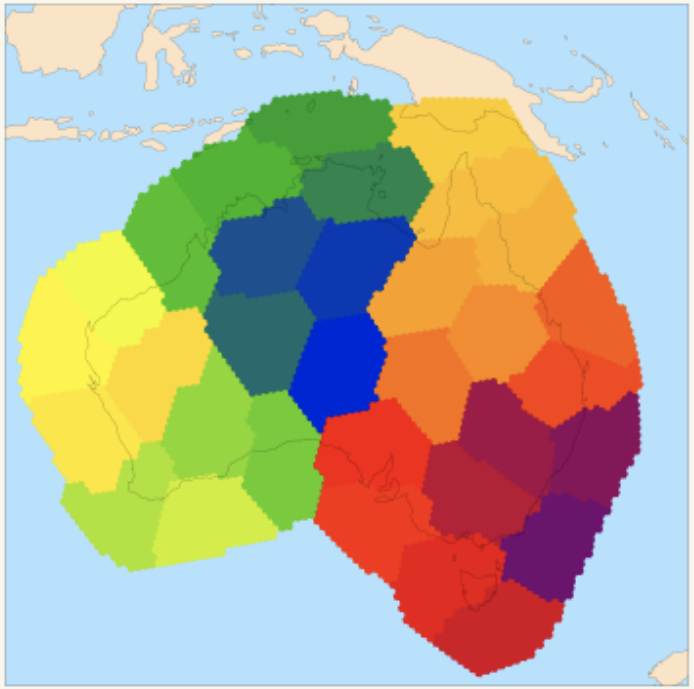
Regional-MPAS: mesh partitioning for parallel run

For newly created limited-area meshes, one must partition the mesh for parallel execution

MPAS-Limited-Area writes not only the netCDF mesh file, but also a *graph.info* file



Above: An illustration of the mesh connectivity information contained in a graph.info file



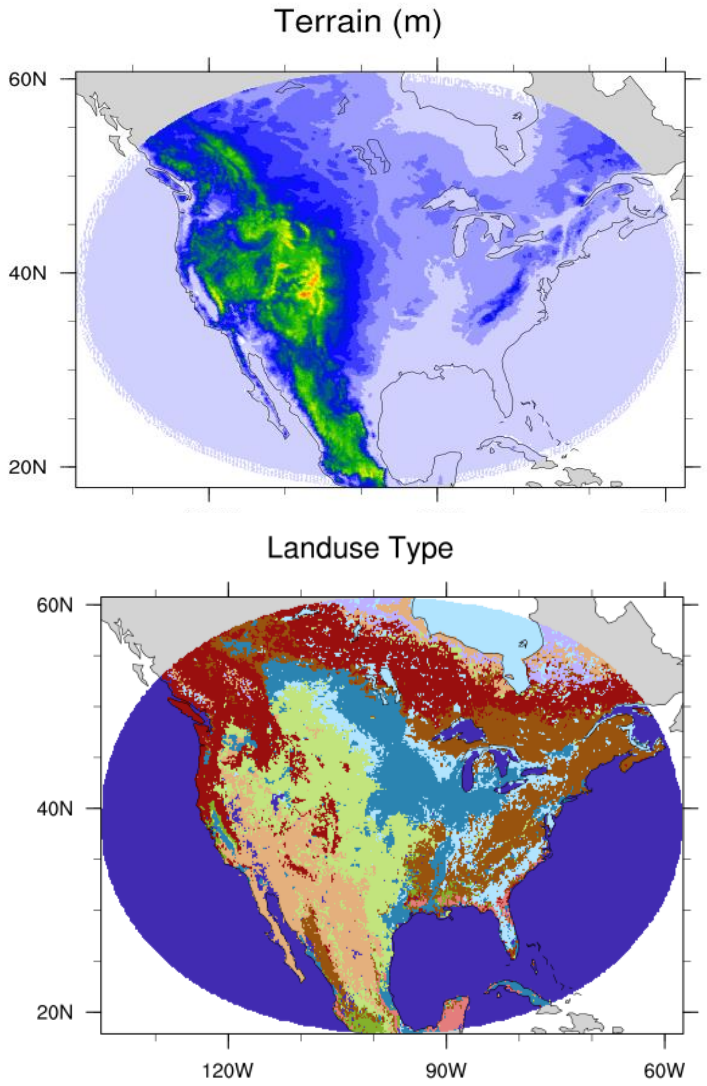
Above: Cells in a regional mesh colored according to their partition

See Section 4.1 in the User's Guide

Regional MPAS: generating static fields and initial condition

- **Static fields : If we rotate the refinement to the region of our interests, we need to generate static data for that region.**
  (See Section 7.2.1 in User's Guide)

- **Initial condition: Generating initial condition for regional MPAS simulation is basically the same as that for global MPAS run.**
  (a) Edit `namelist.init_atmosphere`
  (b) Edit `streams.init_atmosphere`
  (c) Run `init_atmosphere`
  (d) Check tail of `log.init_atmosphere.0000.out`



MPAS: regional domain static fields

Regional MPAS: generating initial condition

Edit namelist.init_atmosphere

```
&vertical_grid
   config_init_case = 7
   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 = true
```

Note: Important to set the above option!
With above option, terrain height in boundary cells are blended with terrain height from the first-guess dataset

Edit `streams.init_atmosphere`

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

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

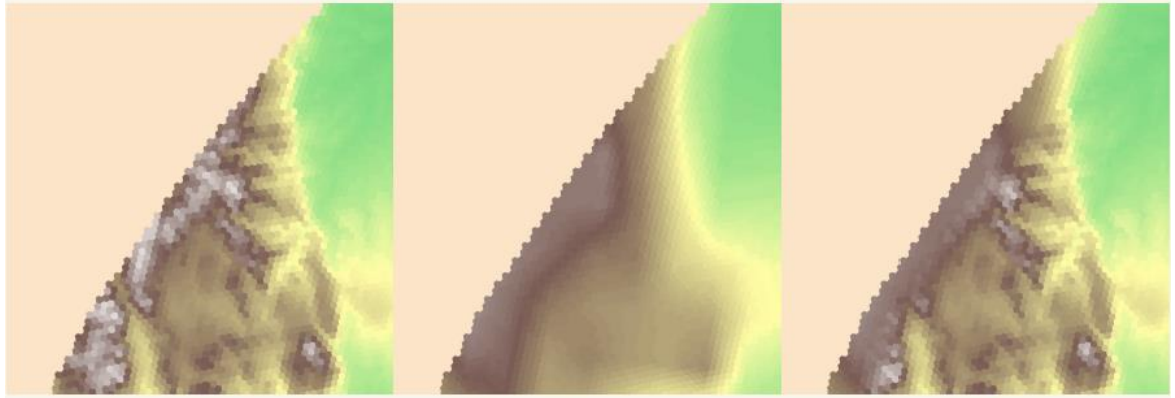
We are providing as input: **CONUS.static.nc**
We are creating as output: **CONUS.init.nc**

Regional MPAS: generating static fields and initial condition

MPAS Model for Prediction Across Scales

Regional ICs: blending boundary terrain

The `config_blend_bdy_terrain` option only affects terrain in the boundary cells (where `bdyMaskCell` > 0)



Terrain field from 3-km static file, interpolated directly from GMTED2010

0.25-deg GFS terrain field interpolated to 3-km mesh

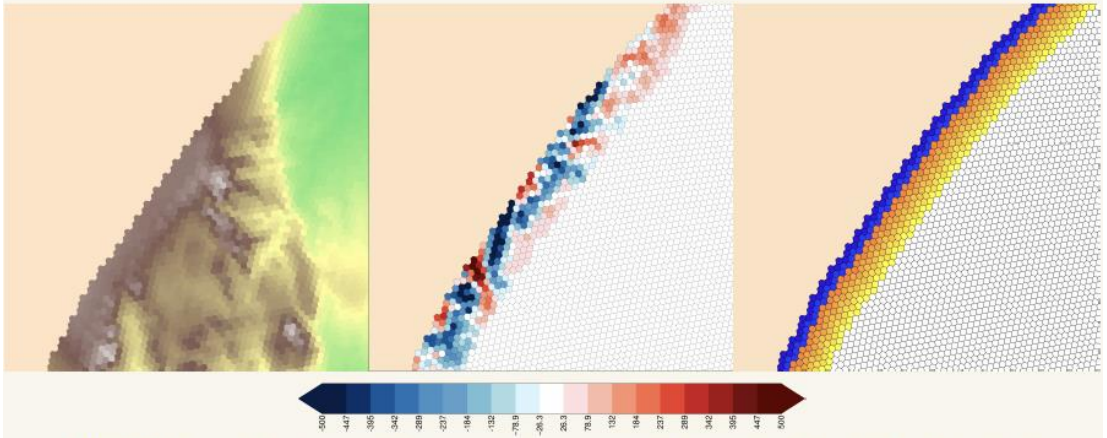
Blended terrain field used in the generation of vertical coordinate surfaces

MPAS topography GFS topography Blended topography

MPAS Model for Prediction Across Scales

Regional ICs: blending boundary terrain

The `config_blend_bdy_terrain` option only affects terrain in the boundary cells (where `bdyMaskCell` > 0)



Blended terrain field

Difference between blended terrain field and original terrain

bdyMaskCell (>0 for yellow-orange and blue-purple cells)

Regional MPAS: generating lateral boundary condition

Edit namelist.init_atmosphere

```
&nhyd_model
   config_init_case = 9
   config_start_time = '2017-02-01_00:00:00'
   config_stop_time  = '2017-02-04_00:00:00'

&data_sources
   config_met_prefix = 'GFS'
   config_sfc_prefix = 'SST'
   config_fg_interval = 10800
   config_use_spechumd = false

&vertical_grid
   config_tc_vertical_grid = true
   config_blend_bdy_terrain = false
```

→ "9" indicates this is a lateral boundary processing case

time to begin and end processing LBC data

→ The prefix of the intermediate data files to be used for LBC

→ Interval between intermediate files (in seconds)

Regional MPAS: generating lateral boundary condition

Edit `streams.init_atmosphere`

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

<immutable_stream name="lbc"
          type="output"
          filename_template="lbc.$Y-$M-$D_$h.nc"
          filename_interval="output_interval"
          packages="lbcs"
          output_interval="3:00:00" />
```

→ **Provide vertical grid information**

→ **The output_interval must be the same as config_fg_interval (=10800) in namelist.init_atmosphere**

We are providing as input: **CONUS.init.nc**

We are creating as output: **lbc.yyyy-mm-dd_hh.nc**

Regional MPAS: variables in initial & lateral boundary conditions

Important variables in initial condition

Horizontal and vertical coordinate information
Mesh structure
Static fields (terrain height, landuse type, landmask, vegetation fraction, etc.)
Soil moisture and temperature, snow cover, snow depth, etc
Atmospheric moisture fields (water vapor, rain water, cloud water, etc.)
Potential temperature, dry air density, relative humidity, horizontal wind, vertical velocity

Lateral boundary condition includes:

Potential temperature
Dry density
Normal components of horizontal winds on edges
Vertical velocity on vertical cell interfaces
Scalars (water vapor, cloud water, rain water, etc.)
Valid time of fields

Regional MPAS: How to Run the Model

Edit "namelist.atmosphere" and "streams.atmosphere"

The most important option for running regional MPAS model (namelist.atmosphere)

```
&limited_area
   config_apply_lbcs = true
/
```

This is the only namelist option that activates regional MPAS simulation

If `config_apply_lbcs` is not set to true for a regional simulation, the model will stop with the following error:

```
ERROR: Boundary cells found in the bdyMaskCell field, but config_apply_lbcs = false.
ERROR: Please ensure that config_apply_lbcs = true for limited-area simulations.
ERROR: Please correct issues with the model input fields and/or namelist.
```

Regional MPAS: How to Run the Model

Need to include stream ‘lbc_in’ in the file “streams.atmosphere”

```
<immutable_stream name="lbc_in"
          type="input"
          filename_template="lbc.$Y-$M-$D_$h.nc"
          filename_interval="input_interval"
          input_interval="3:00:00" />
```

same as **config_fg_interval = 10800**

If the interval specified here is different to that between the LBC files, the model will crash with errors like:

```
ERROR: Could not read from 'lbc_in' stream after the current date to update lateral
boundary tendencies
ERROR: Failed to process LBC data at next time after 2019-08-31_00:00:00
```

Regional MPAS: Summary

Running regional MPAS simulation is slightly more difficult than running a global simulation. The basic steps are as follows:

1. **Create a subset of an existing global MPAS mesh using the MPAS_limited _area tool**
2. **Generating initial conditions**
   - **config_init_case = 7**
   - **config_blend_bdy_terrain = true**
3. **Generating LBC conditions**
   - **config_init_case = 9**
4. **Run the model with the option**
   - **config_apply_lbcs = true**

Regional MPAS: How to Run

We are ready for regional MPAS run !

Any questions?