# GSD HAFS Project Update

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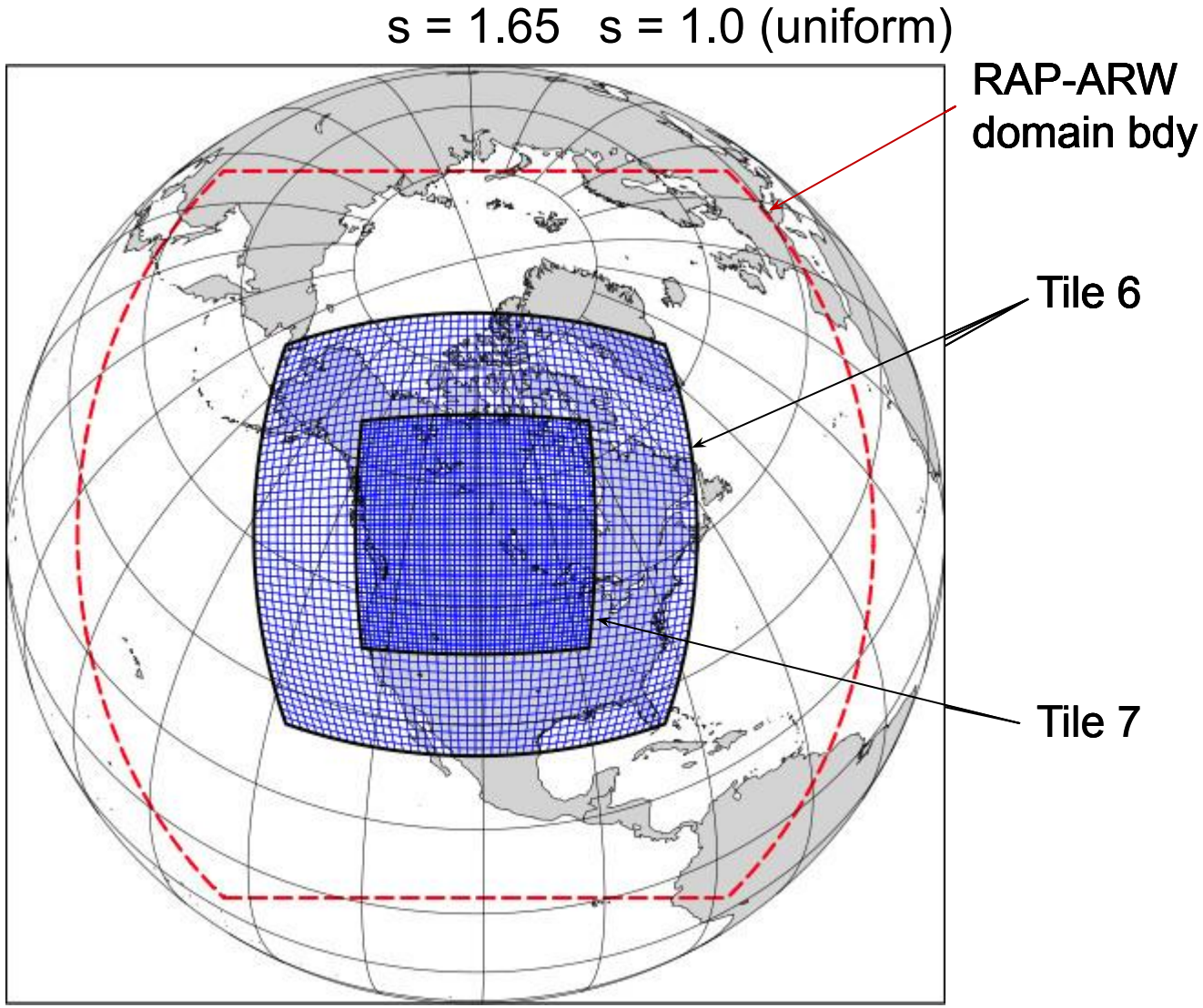
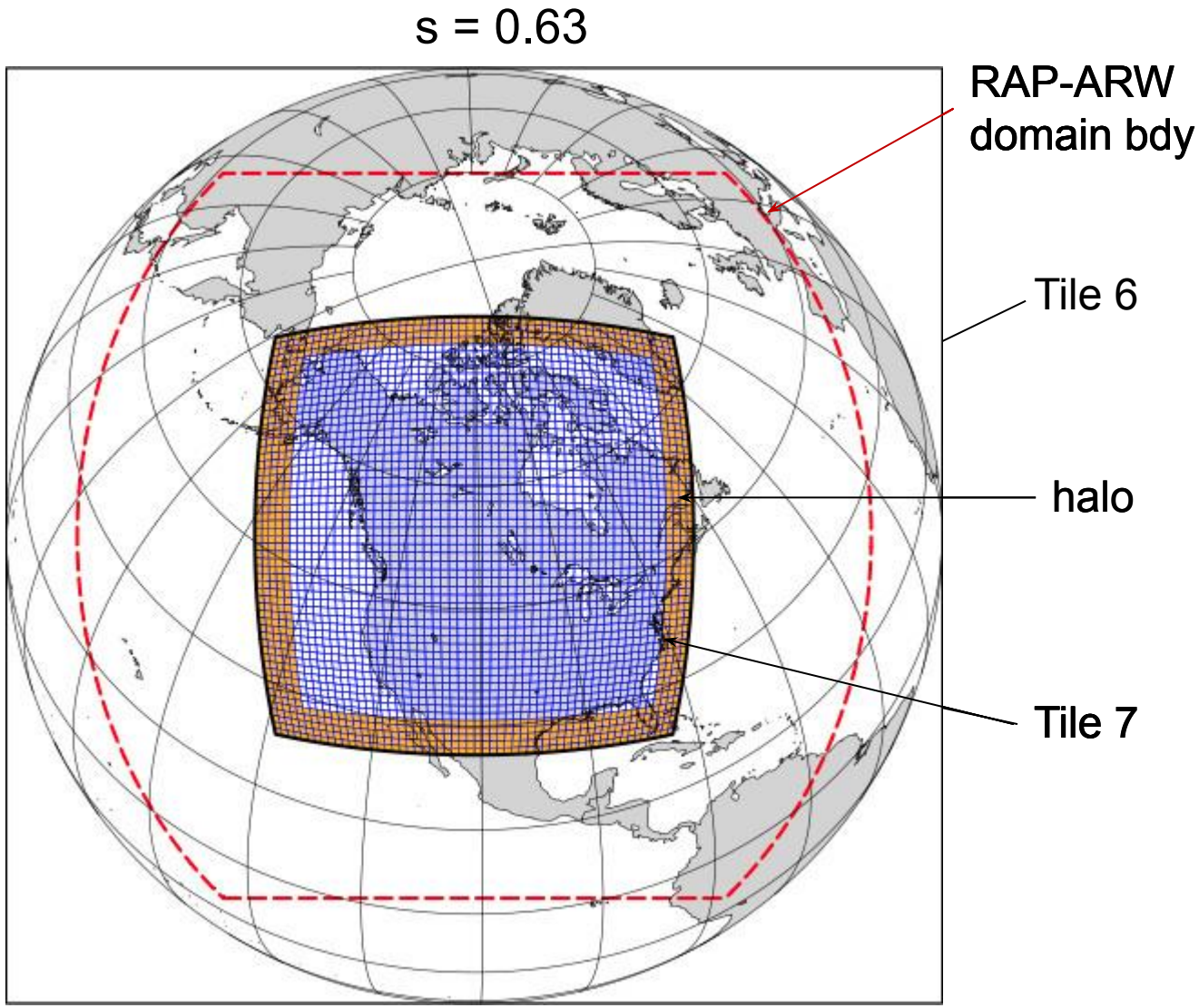
# The Global FV3 Cubed Sphere Grid: Introduction

- Consists of 6 tiles of a cube projected onto a sphere
- Uses a gnomonic projection in which grid lines coincide with great circles
- Has stretching capability (via Schmidt factor, s) to compress (expand) tile 6 to increase (decrease) resolution
  - s < 1 ⇒ tile 6 stretched (coarser grid)
  - s = 1 ⇒ no stretching (tile 6 is “uniform”)
  - s > 1 ⇒ tile 6 compressed (finer grid)
- Nesting capability – can include a nested grid (“tile” 7) within tile 6 that obtains its lateral BCs from tile 6 and passes information back to tile 6 (i.e. 2-way nesting)



# Modifications by EMC to Global FV3 to Obtain SAR Grid

- Use the nesting capability of the global FV3 to generate a standalone regional grid ("tile" 7)
  - Tiles 1-6 serve as the global "parent" grid during grid generation
  - Forecast performed only on tile 7 (as opposed to tiles 1-6 for a global forecast or tiles 1-7 for a global + nest forecast)
- Modify global FV3 code to include a region of cells around tile 7 (the halo) that is used to feed BCs to tile 7
  - BCs interpolated to halo from output of external model (e.g. GFS, RAP)
- Still allow for stretching by shrinking/expansion of tile 7 during grid generation step (via Schmidt factor)
  - This is necessary for larger domains (e.g. RAP) that do not fit within one tile of the uniform global grid [note: crossing of tile boundaries is not (yet?) allowed in global FV3]



# RAP- and HRRR-Equivalent Domains in SAR-FV3: Initial Attempt

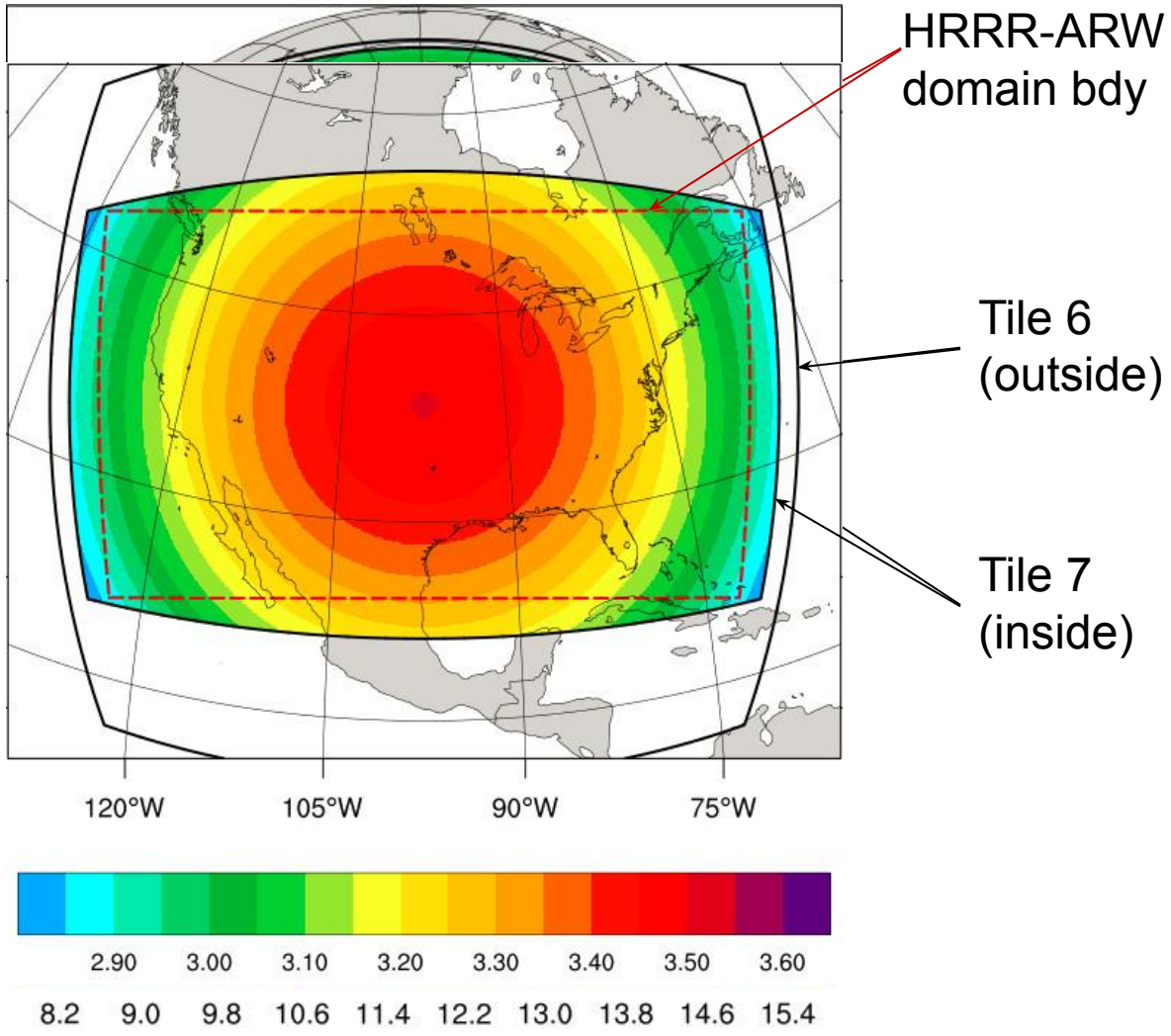
**RAP-equivalent domain:**

- WRF-ARW's RAP domain is much larger than a "uniform" (s = 1) FV3 global tile
  - Need to expand tiles 6 and 7 of FV3 global parent grid to fit tile 7 within WRF-ARW's RAP domain
  - This requires setting Schmidt factor s = 0.63
- This results in a RAP-equivalent domain/grid that has the following cell size stats:
  - min = 7.92 km;  max = 15.28 km (max/min = 1.92)
  - median = 11.18 km;  mean = 11.44 km
- Want cell size as uniform as possible across domain because:
  - Time step determined by smallest cell
  - Physics parameterizations may not be scale-aware (don't want to venture into "gray zone")
- This RAP-equivalent domain not sufficiently uniform!

**HRRR-equivalent domain:**

- Does not suffer as much cell size variation due to its smaller extent, but can still be improved

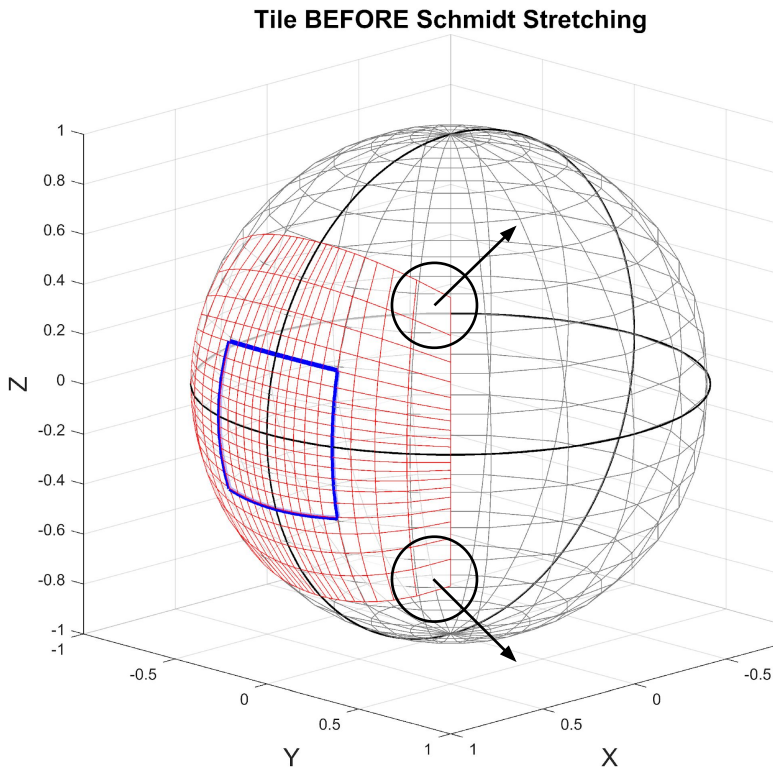
HRRR-equivalent Domain/Grid

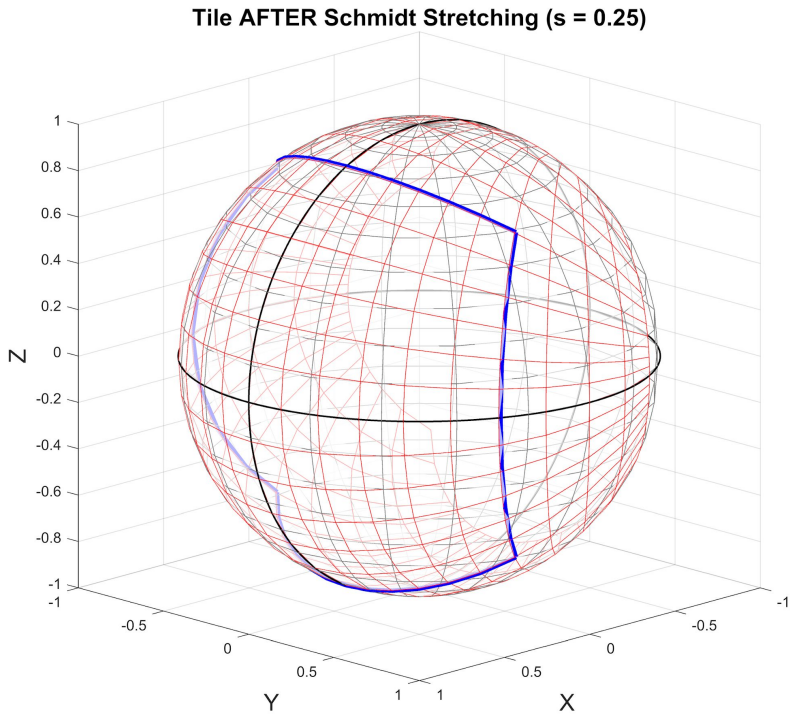


# Modification of the Gnomonic Grid

**Through collaboration with EMC (Jim Purser):**

- Concentrate model coordinates (great circles) near center of tile six to improve uniformity after stretching
- Added two plotting parameters (alpha and kappa) to the generation of the gnomonic grid
- Flares the corners of the grid to reduce grid variability

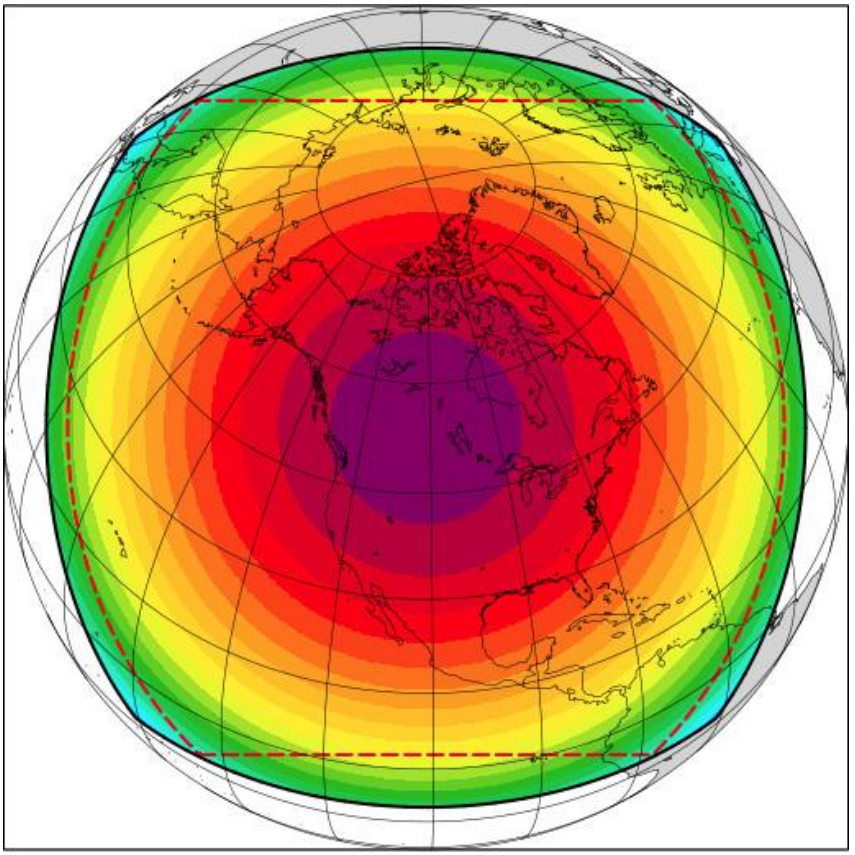


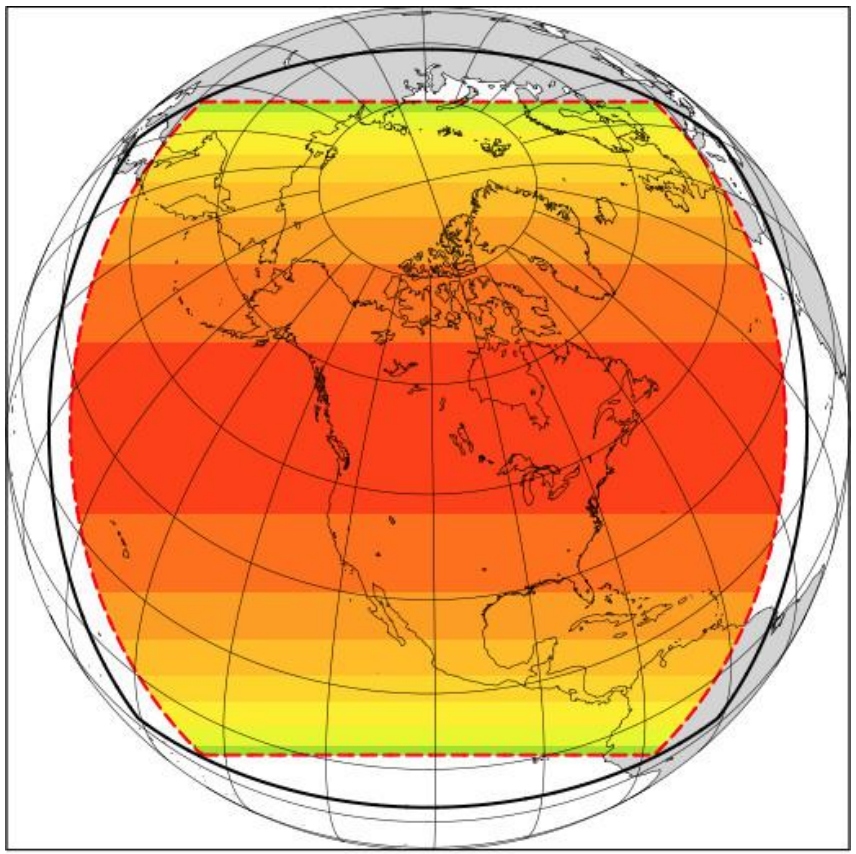

Blue represents the outline of the SAR grid (tile seven) with the sixth tile of the global FV3 in red

# Comparison of RAP/RAP-equivalent Grids

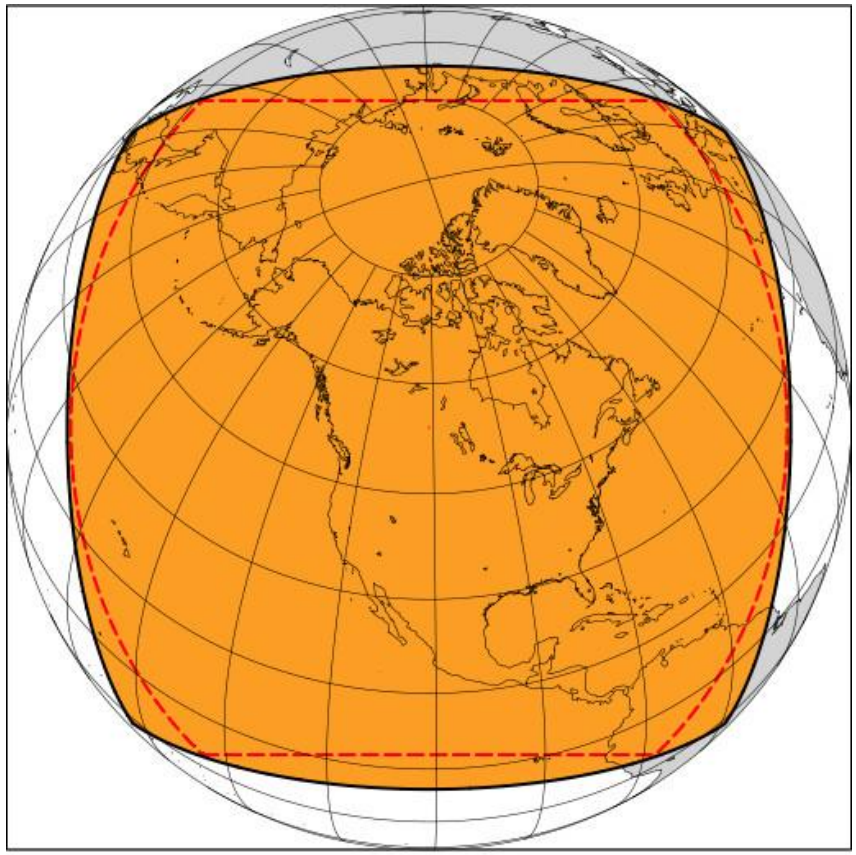
With Global “Parent” Grid

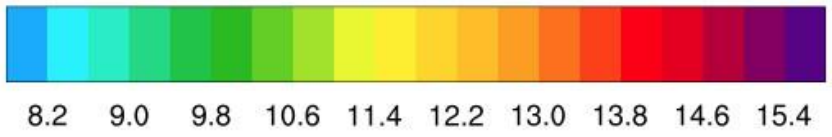


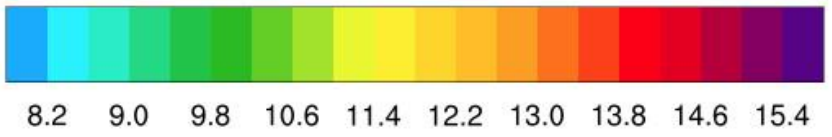
Original RAP-ARW Grid

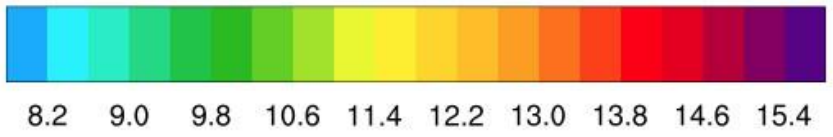


No Global “Parent” Grid
(Best option!)

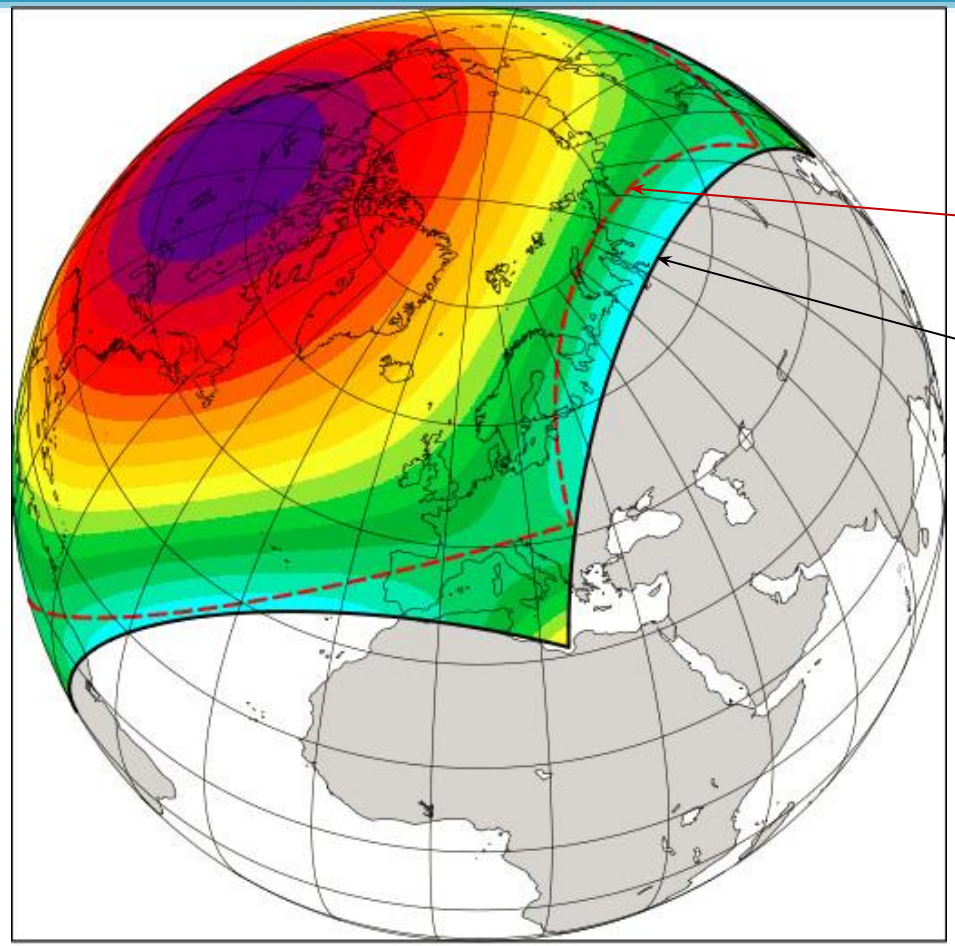


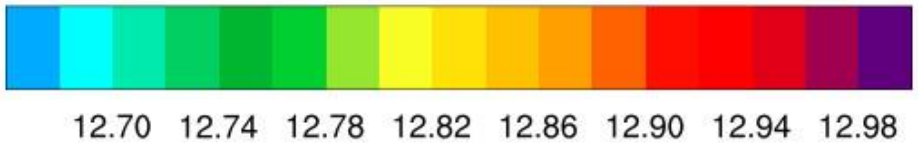


# Flaring of Edges for the RAP-equivalent SAR-FV3 Domain



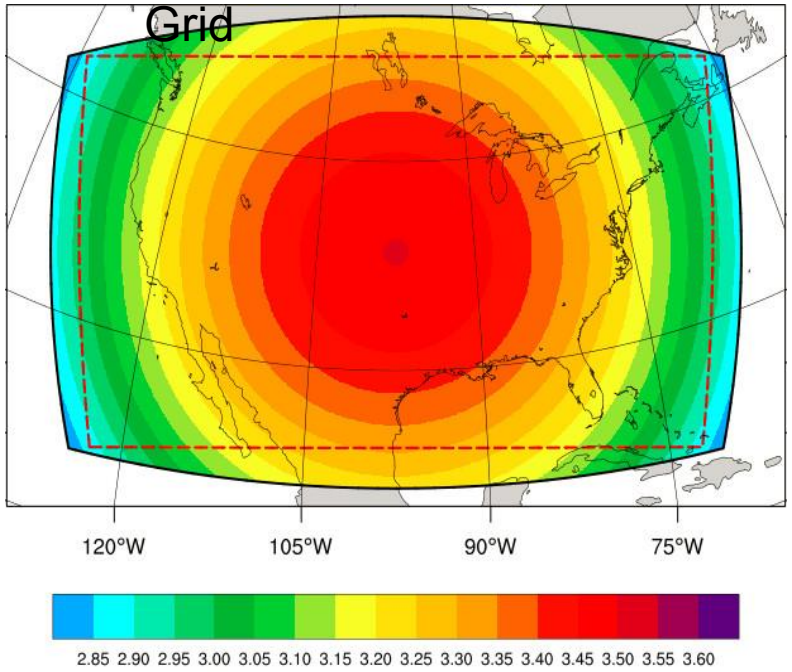




Cell size stats:

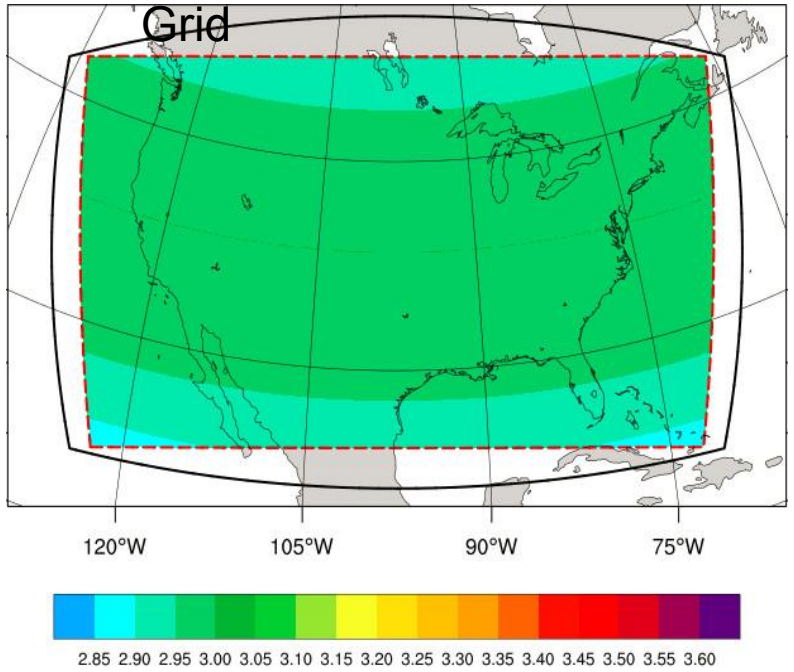
```
Min    = 12.68 km
Max    = 13.0  km
Median = 12.81 km
Mean   = 12.82 km
```

# Comparison of HRRR/HRRR-equivalent Grids

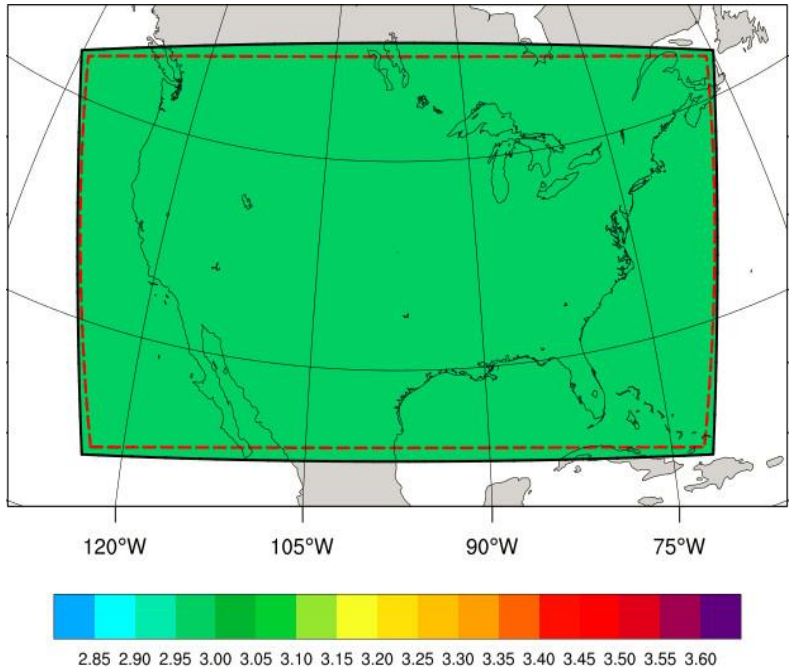
With Global “Parent” Grid



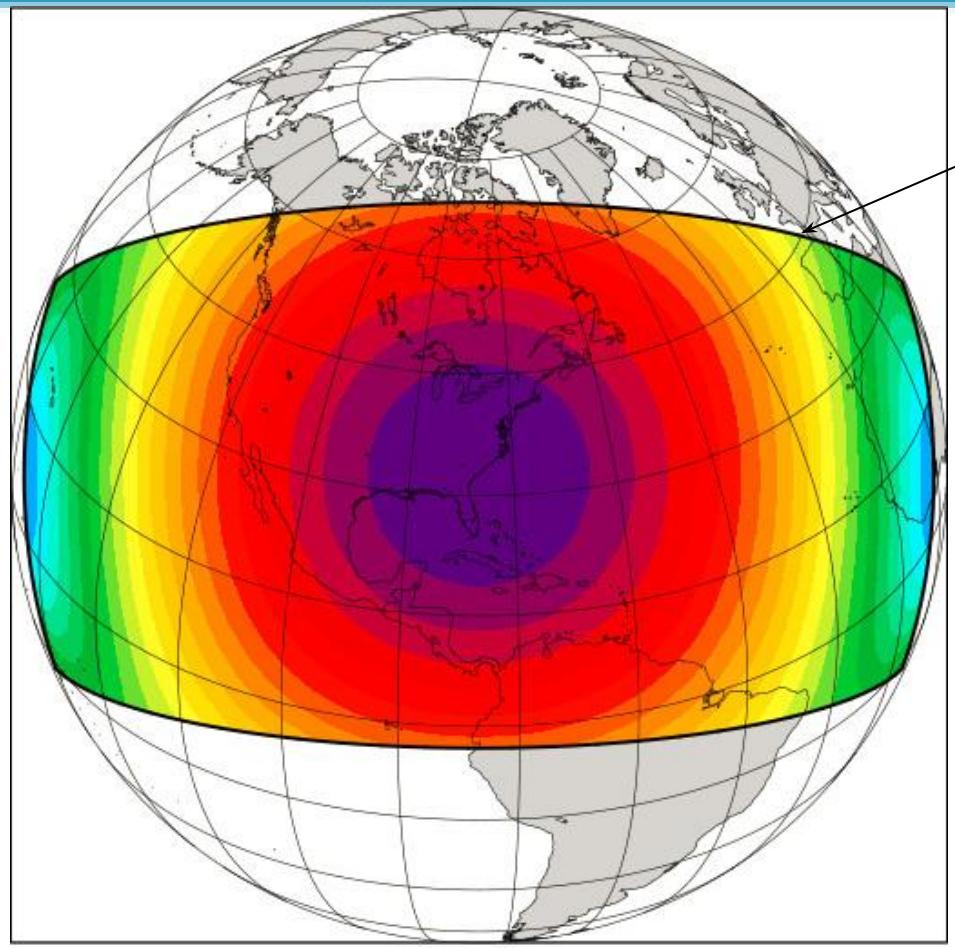

Original HRRR-ARW Grid

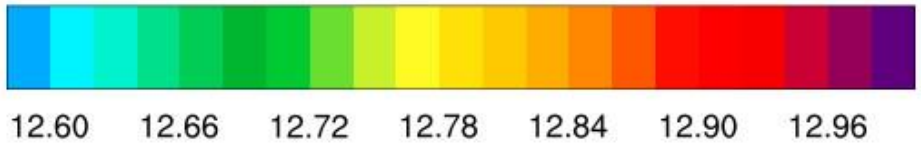



No Global “Parent” Grid (Best option!)



# First Attempt at Double-Basin Hurricane Domain/Grid



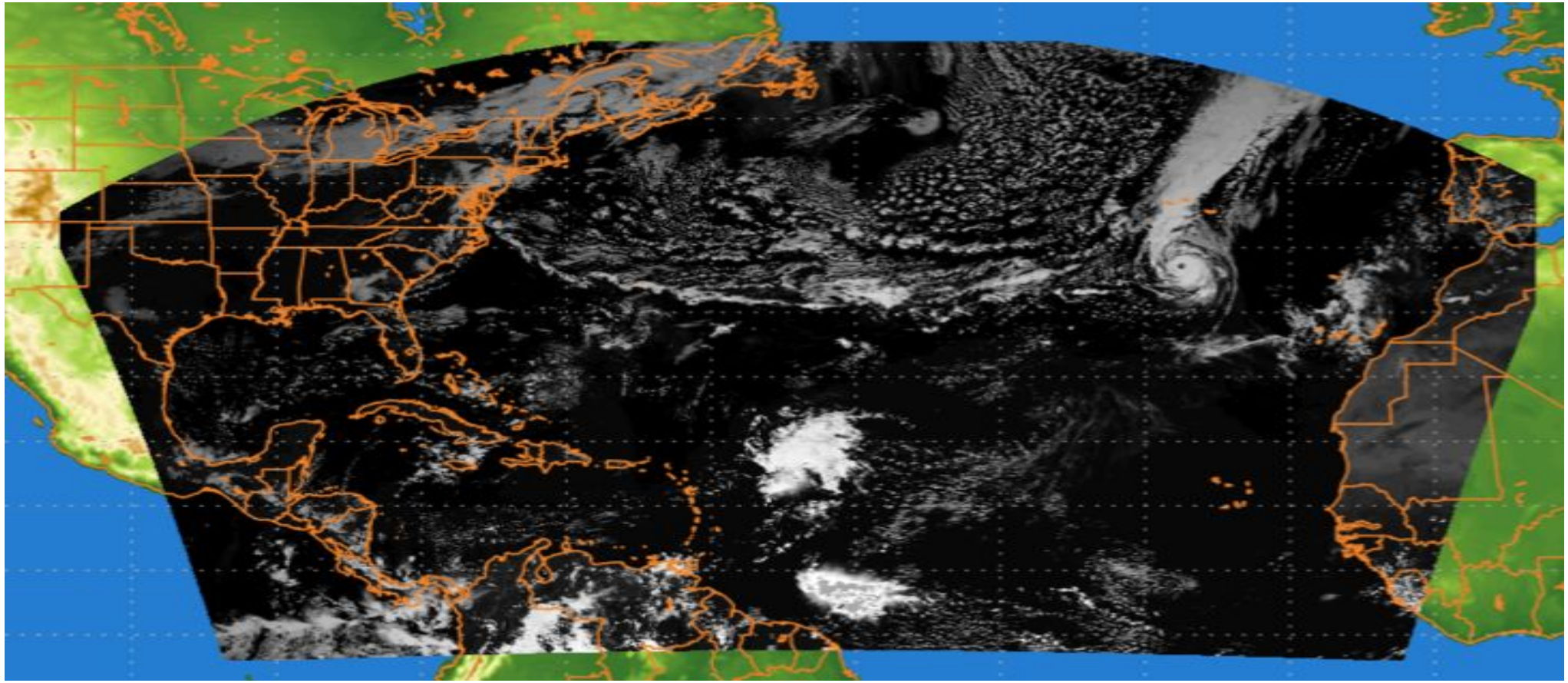




Cell size stats:

```
Min    = 12.58 km
Max    = 13.0  km
Median = 12.84 km
Mean   = 12.82 km
```

# HFIP Summer Demo Experiments:

Nested 3-km FV3 GFS



1. **HAFS v0.A** – A FV3 SAR configuration, analogous to the CAM FV3 SAR configuration, but for TC regions of interest. GFS physics and RAP/HRRR (continental CAM physics)
2. **HAFS v0.B** – A FV3 nest within the FV3 global model (as shown above)

Image courtesy of Andrew Hazelton (NOAA/AOML/HRD).

# Incorporation of the RAP/HRRR Physics Suite

- FV3 as implemented by EMC currently using the GFS physics, which:
  - Has not been developed or tuned for convection-permitting resolutions

  ⇒ Insufficient for the SAR-FV3 CAM applications

- GSD (i.e. RAP/HRRR) physics:
  - Specifically designed for convection-permitting resolutions
  - Over a decade of development & testing

  ⇒ Hence retain and port to the SAR-FV3

- The strategic goals of NGGPS include leveraging US research community expertise for physics development as well, with funds already allocated to that end

| Parameterization | RAP/HRRR Suite |
|---|---|
| Microphysics | AA, radiation-coupled Thompson |
| LSM | RUC (9 level) |
| PBL | SA-MYNN |
| Radiation | RRTMG |
| Cumulus | SA-Grell/Freitas (GF) |

# Implementation of External IC/BCs into the SAR-FV3

- `chgres` – EMC's software package to generate IC/BCs for the SAR-FV3 running the GFS physics suite
- Collaboration started with NSSL and EMC to modify `chgres` to generate SAR IC/BCs from RAP grib2 output
- Generated tables to map from RAP (or other external model) to FV3 variables for multiple physics options. Table format:

```
external_model_var(1)    FV3_model_var(1)    missing_var_method(1)   fill_value(1)
external_model_var(2)    FV3_model_var(2)    missing_var_method(2)   fill_value(2)
external_model_var(3)    FV3_model_var(3)    missing_var_method(3)   fill_value(3)
...
external_model_var(N)    FV3_model_var(N)    missing_var_method(N)   fill_value_var(N)
```

  - `missing_var_method(j)` can be "stop", "skip", or "set_to_fill_value"
  - `fill_value(j)` is the value to use if `missing_var_method(j)` is set to "set_to_fill_value".

- Code is in development with plans to implement by the end of the month

# SAR-FV3 Community Workflow

**Incorporation of all model components to facilitate SAR-FV3 retrospective and real-time simulations:**

- ROCOTO-based XML workflow that calls individual shell scripts for each component of the simulation:
  - Generate the grid (pre-processing utilities)
  - Retrieve archived data and generate IC/BCs
  - Prepare the work directory and stage files
  - Run the SAR-FV3
  - Post-process the results (NetCDF → grib2)
- Being designed to work on multiple supercomputing platforms (so far on NOAA HPC in Boulder (Theia, Jet) and in DC (WCOSS), OU, and NCAR)
- Features user-customizable configure script with options to set date, time, forecast length, output interval, choose pre-defined domains, etc.
- Will eventually be able to use FV3GFS, GFS-GSM, RAP/HRRR, or NAM data for IC/BCs
- Can run with CCPP for either the GFS or GSD physics suites
- Intended to be as flexible as possible for users across both research and academic communities
- Documentation is being developed concurrently through use of Sphinx (NCAR/DTC)

```
.....

<workflow realtime="F" scheduler="&SCHED;" cyclethrottle="20">

<cycledef>00 &HH; &DD; &MM; &YYYY; *</cycledef>

 <log>
  <cyclestr>&LOG_DIR;/FV3_@Y@m@d@H.log</cyclestr>
 </log>

 <task name="make_grid_orog" maxtries="3">

  <command>&USHDIR;/make_grid_orog.sh</command>
  <nodes>&PROC_MAKE_GRID_OROG;</nodes>
  <jobname>make_grid_orog</jobname>
  <join><cyclestr>&LOG_DIR;/make_grid_orog_@Y@m@d@H.log</cyclestr></join>

 </task>

 <task name="get_GFS_files" maxtries="3">

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  <join><cyclestr>&LOG_DIR;/get_GFS_files_@Y@m@d@H.log</cyclestr></join>

  <dependency>
    <taskdep task="make_grid_orog"/>
  </dependency>

 </task>

.....
```