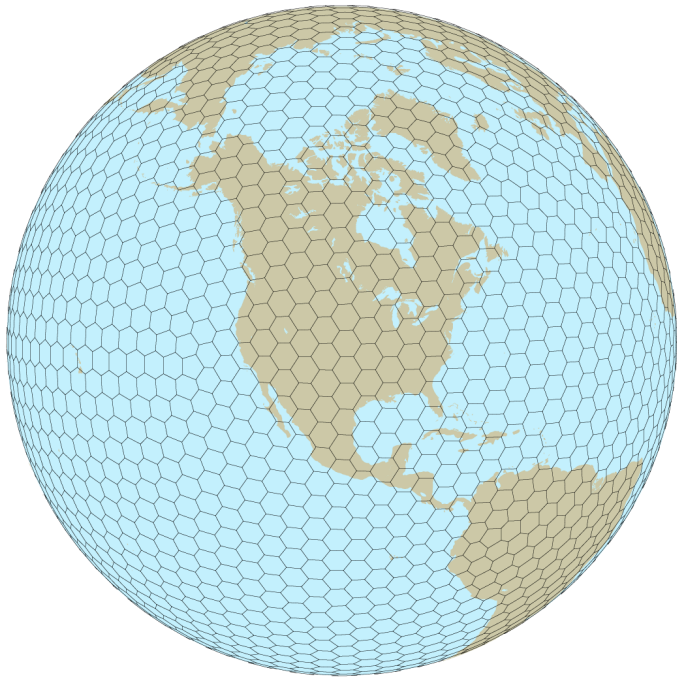
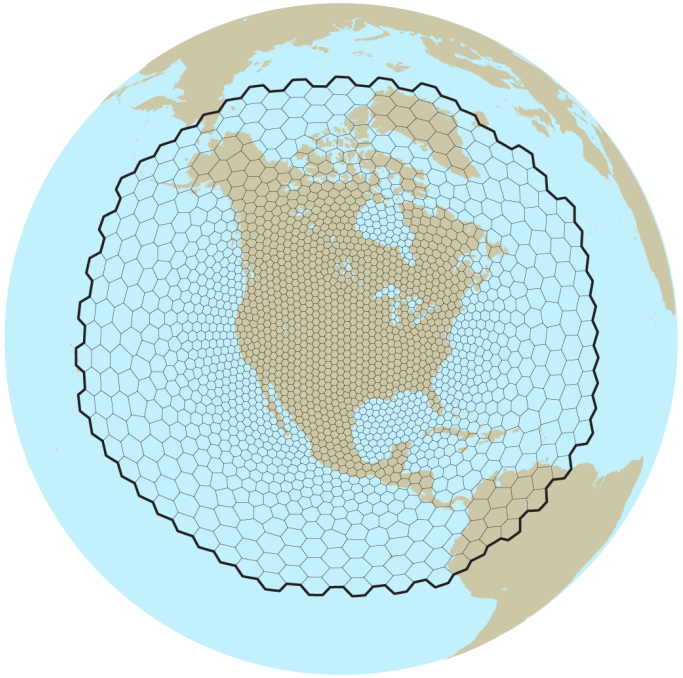
MPAS
Model for Prediction Across Scales

Regional MPAS is (Almost) Here





MPAS-A: *WRF numerics and physics with a height coordinate on a centroidal Voronoi mesh*

MMM-MPAS team: Dave Ahijevych, Michael Duda, Laura Fowler, SoYoung Ha, Jihyeon Jang, Joe Klemp, Sang-Hun Park (YSU), Bill Skamarock, Wei Wang, May Wong, Colin Zarzycki

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MPAS
Model for Prediction Across Scales

Latest MPAS Release – V5.0

MPAS-V5.0 released in January 2017, previous release (MPAS-V4.0), 22 May 2015

MPAS-Atmosphere updates in MPAS-V5.0

- Updates to physics suite *mesoscale_reference*
- New physics suite: *convection_permitting*
- New MPAS-Atmosphere optimizations
  Dynamical core: greater than 2x speedup (on Yellowstone) over V4
  Hybrid parallelism using OpenMP (new) and MPI, fully bit-reproducible

Ongoing development

- Community Earth System Model (CESM)
  MPAS-A is a dynamical core in CAM: NWP/climate testing, early applications.
- Regional MPAS-Atmosphere
  Prototype is being tested. General release (MPAS Version 6) 2018.
- Data Assimilation work and development is ongoing with DART and NCEP/GSI
- We are developing a common physics repository for MPAS and WRF.
- MPAS-A can now drive regional WRF (one-way) in the latest WRF (V3.9) release.
- GPU version of MPAS-A dynamical core is working; development is ongoing.

MPAS
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Latest MPAS Release – V5.0

MPAS-Atmosphere updates in physics for MPAS-V5.0

(1) Updates to physics suite *mesoscale_reference*

(2) New suite: *convection_permitting*

Surface Layer: module_sf_mynn.F as in WRF 3.5.
PBL: Mellor-Yamada-Nakanishi-Niino (MYNN) as in WRF 3.8.
Land Surface Model (NOAH 4-layers): as in WRF 3.6.1.
Gravity Wave Drag: YSU gravity wave drag scheme.
Convection: Grell-Freitas scale aware scheme (modified from WRF 3.6.1)
Microphysics: Thompson scheme (non-aeosol aware): as in WRF 3.8
Radiation: RRTMG sw as in WRF 3.4.1; RRTMG lw as in WRF 3.4.1

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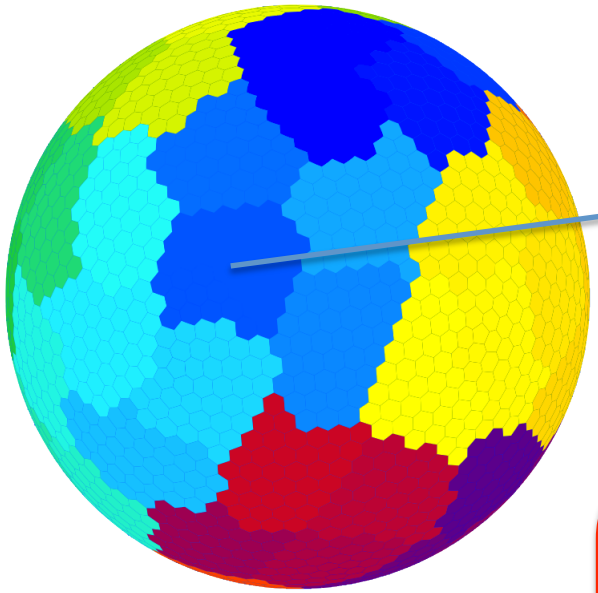
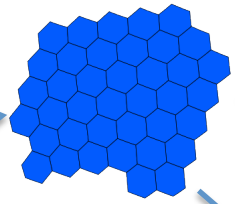
Latest MPAS Release – V5.0

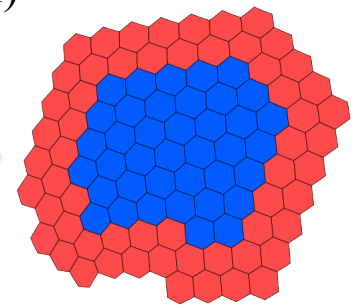
DM parallel decomposition of the MPAS mesh



Block of cells owned by a process

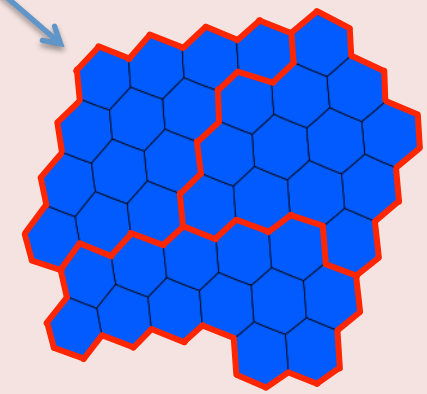


MPAS uses halo (or ghost) cells; Halo values are communicated (currently MPI)



Block plus two layers of halo/ghost cells

Multithreading: Block of cells (shared memory) divided into *nThreads* threads and advanced in parallel (using OpenMP)



nThreads = 3

MPAS
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Next MPAS Release – V5.0

Latest MPAS release (MPAS-V5.0) - 7 January 2017
No changes to MPAS-Ocean or MPAS-Land-Ice (DOE cores)
Major updates in MPAS-Atmosphere and some minor updates in the framework

MPAS optimization results:

MPAS-A solver code section	beta MPAS V4.0 wallclock time (s)	beta-V5.0 wallclock time (s)	V4.0/V5.0 (speedup)
atm_rk_integration_setup	0.49477	0.60908	0.81232
atm_compute_moist_coefficients	0.33890	0.11056	3.06530
atm_compute_dyn_tend	5.91591	2.00918	2.94444
small_step_prep	1.52425	0.70700	2.15594
atm_advance_acoustic_step	7.43139	2.02894	3.66270
atm_recover_large_step_variables	1.97341	1.14142	1.72891
atm_compute_solve_diagnostics	4.06778	0.90181	4.51068
atm_advance_scalars	8.85072	3.17388	2.78861
atm_advance_scalars_mono	6.57595	6.31774	1.04087
time integration	**41.40388**	**20.57849**	**2.01200**

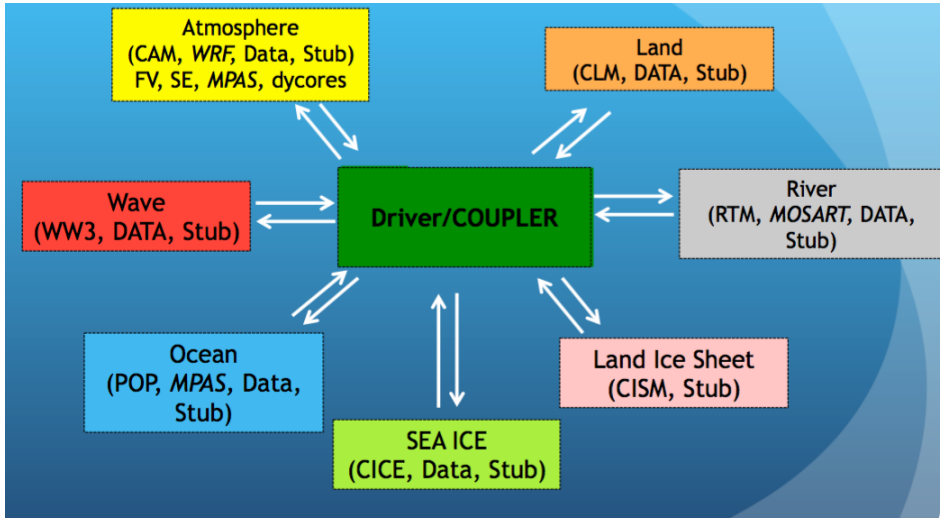
NWSC Yellowstone computer using the Intel 15.0.1 compilers, with 16 MPI tasks per node and no OpenMP threading. 120 km mesh (40,962 cells), 64 levels, Jablonowski and Williamson baroclinic wave test, 11 tracers, 24 h integration.

MPAS
Model for Prediction Across Scales

MPAS Development

Community Earth System Model (CESM)

- MPAS-A is an atmospheric dynamical core in CAM
- NWP and climate testing is underway
- Coupled model simulations are underway (w/ocean)
- Physics evaluation for NWP is major focus of early testing
- NCAR/MMM partnering with NCAR/CGD, DOE/PNNL and the University of Oklahoma in development, testing and applications of MPAS-A in CESM
- Release: possibly in 2018.



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MPAS
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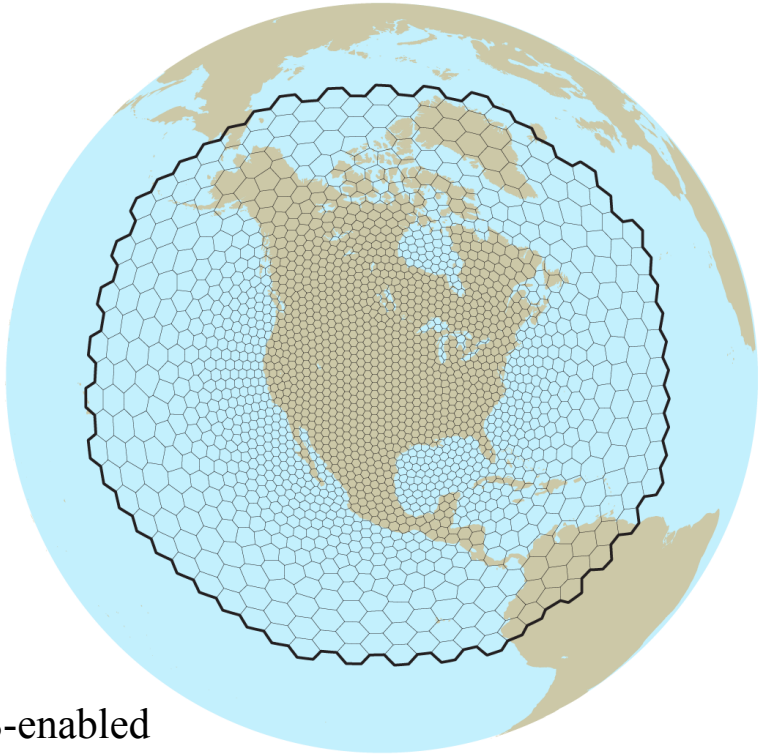
Regional MPAS



Why develop a regional version of MPAS given we have WRF?

- Provide a consistent (equations, mesh) regional solver to complement global MPAS.
- Allow for more efficient (less costly) testing of MPAS at high resolutions.
- Leverage MPAS development for next-generation architectures to regional applications.
- Enable regional atmospheric applications within MPAS-enabled coupled modeling systems (e.g. CESM).
- Employ variable resolution in regional applications to reduce LBC errors.
- External (to NCAR) users have asked for a regional MPAS and are supporting its development (e.g. KISTI).

MPAS
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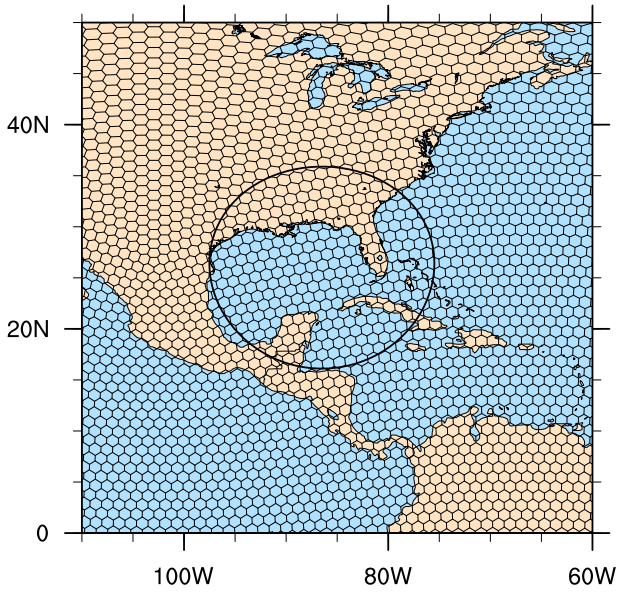
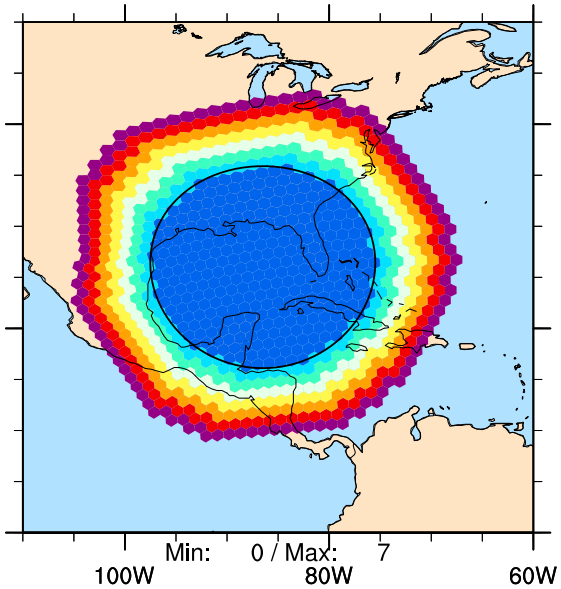
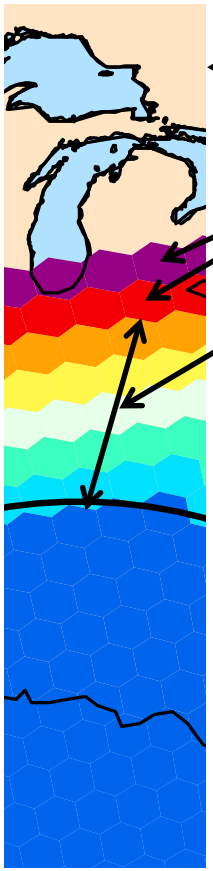
Regional MPAS







outside regional domain

2 cells in the specified region

5 cells in the sponge region

free regional solution

Specified cell values are spatially/ temporally interpolated from driving-model solution or other analysis (as in WRF)

Sponge region handled the same way is in WRF: model integration with weighted horizontal filtering of perturbation variables (perturbation from driving analysis)

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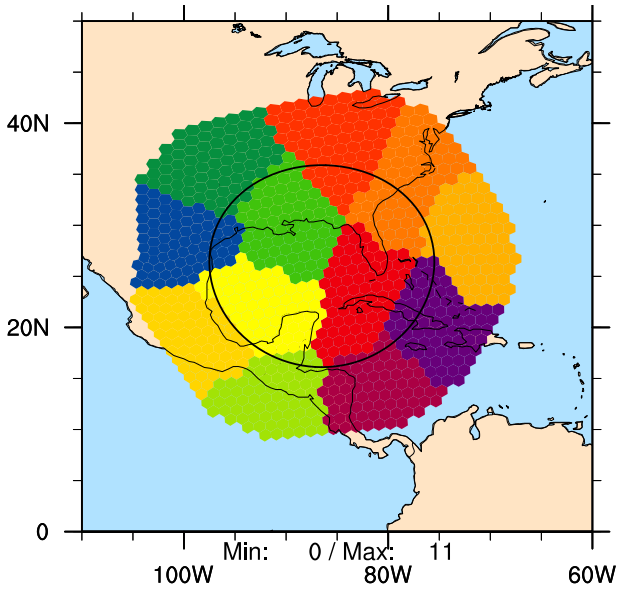
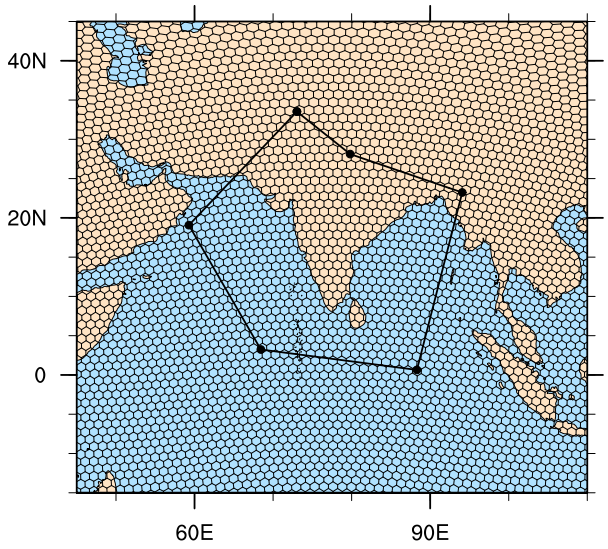
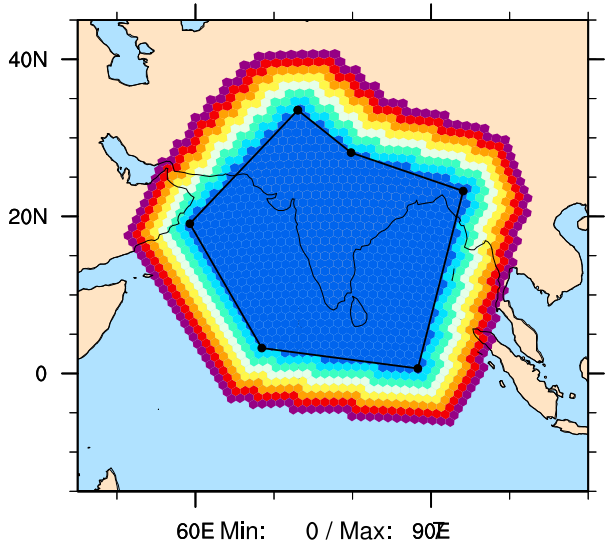
Regional MPAS



Parallelization by horizontal domain decomposition is accomplished the same way as in global MPAS

Existing tool allows regional zones to be specified as circles, ellipses, or polygons





MPAS
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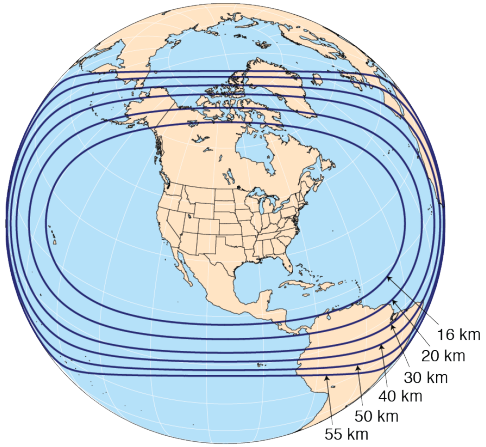
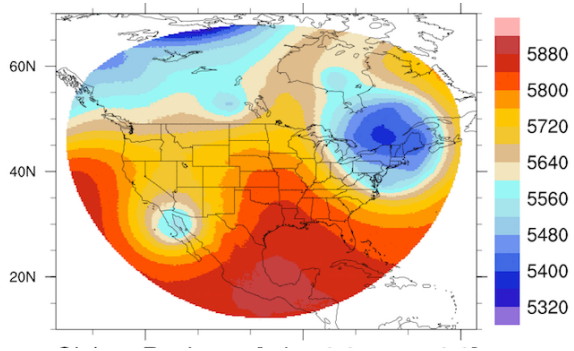
Regional MPAS

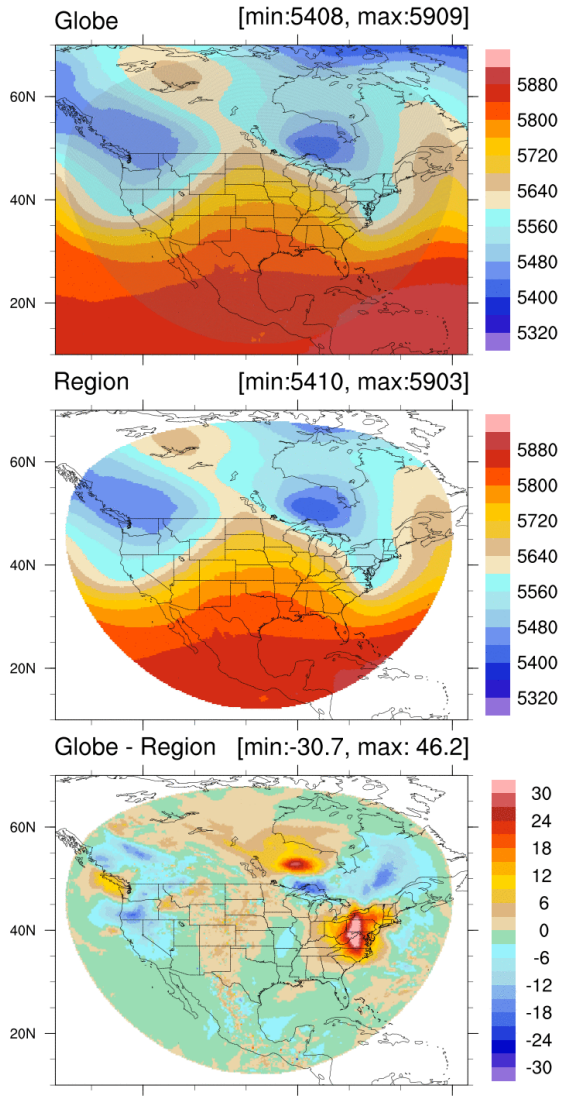
NCAR real-time forecasts
November 2016 - June 2017
Daily 10-day MPAS forecasts
00 UTC GFS analysis initialization



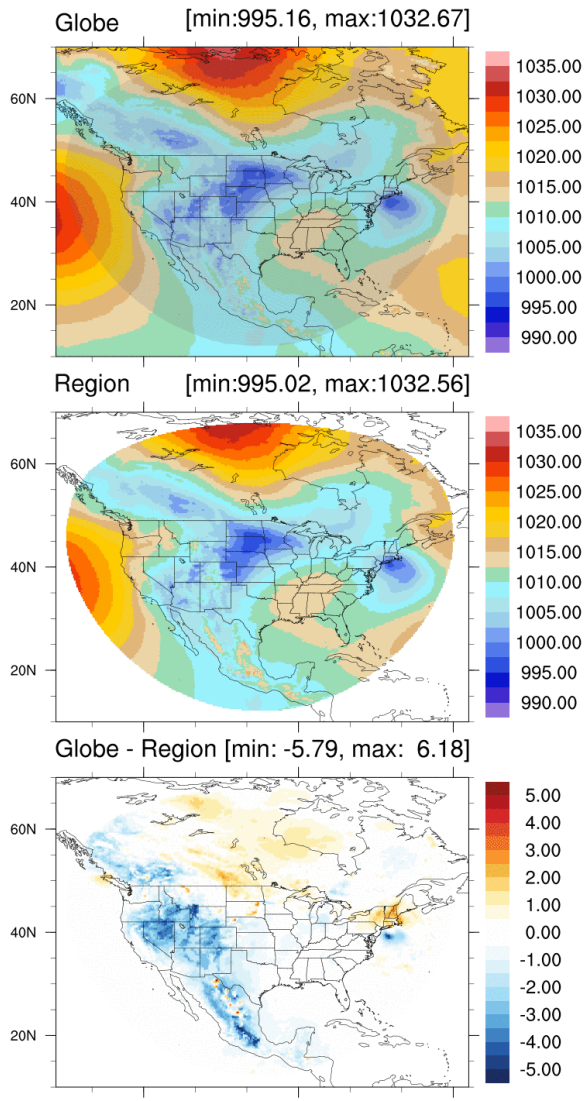
Regional initialization
500 hPa height field (m)
2017-05-09_00



FCST 120H at 2017-05-14_00 in height_500hPa [m]



FCST 120H at 2017-05-14_00 in mslp [hPa]



MPAS
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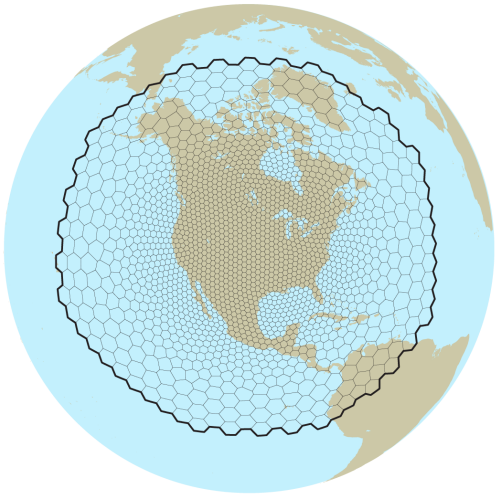
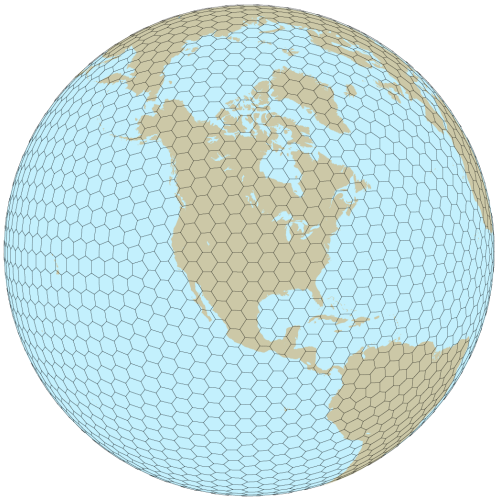
Regional MPAS is (Almost) Here

Further development:

- Enable interpolation of LBC fields from other (nonaligned) MPAS meshes and from other analyses (e.g. ECMWF, GFS, ERA).
- Implement inflow-outflow conditions for scalars that are not externally specified (e.g. condensates).
- Software engineering cleanup.
- Post-processing tools.

Release: Sometime in 2018





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