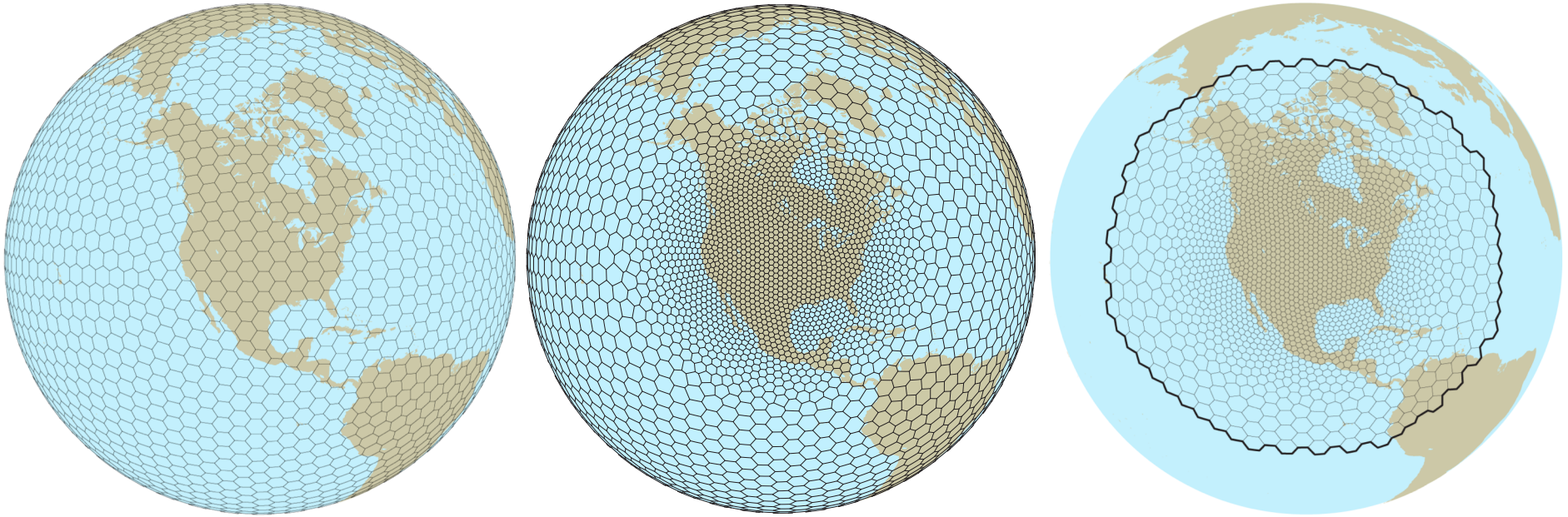
MPAS
Model for Prediction Across Scales

The Model for Prediction Across Scales

Version 7.0 release and future development directions.



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

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

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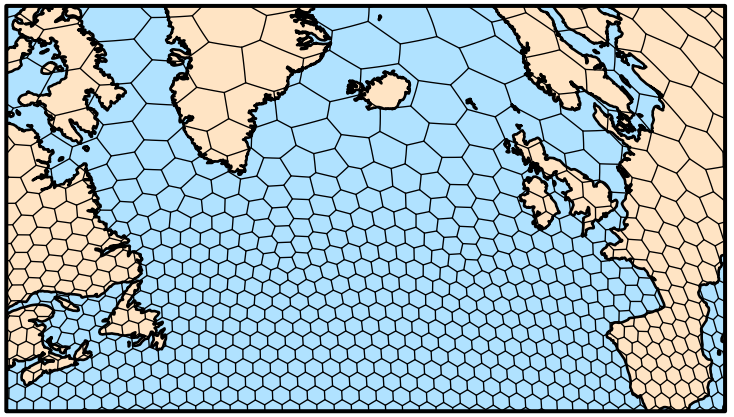
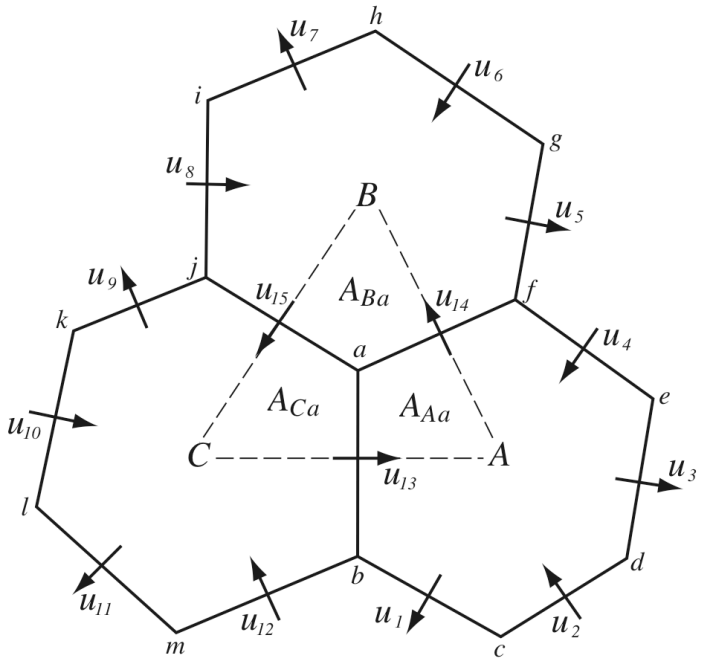
Centroidal Voronoi Meshes

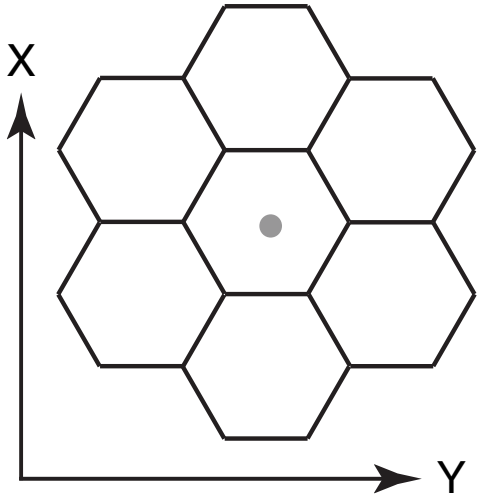
The horizontal mesh is *unstructured*

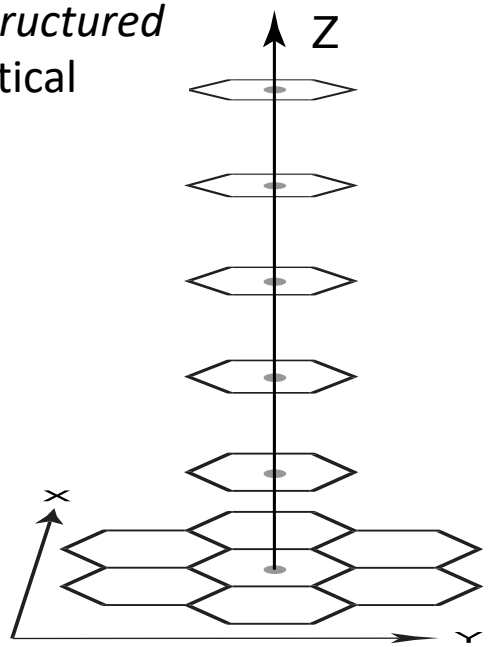


MPAS uses a C-grid staggering



The mesh is *structured* in the vertical





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MPAS V7.0 release

MPAS-Atmosphere Version 7.0 - 7 June 2019

MPAS does not follow a yearly release schedule.

Releases in new functionality increments the integer version number.

Bugfixes increments the integer to the right of the decimal point.

Today:

- Physics updates
- Regional capability
- Ongoing development: MPAS in CESM
- Ongoing development: MPAS and GPUs
- Ongoing development: deep atmosphere

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MPAS V7.0 release

MPAS-Atmosphere Version 7 physics

As in MPAS-A Version 6, we have two physics suites:

mesoscale-reference suite

Parameterization	Scheme
Convection	New Tiedtke
Microphysics	WSM6
Land surface	Noah
Boundary layer	YSU
Surface layer	Monin-Obukhov
Radiation, LW	RRTMG
Radiation, SW	RRTMG
Cloud fraction for radiation	Xu-Randall
Gravity wave drag by orography	YSU

convection-permitting suite

Parameterization	Scheme
Convection	Grell-Freitas
Microphysics	Thompson (non-aerosol aware)
Land surface	Noah
Boundary layer	MYNN
Surface layer	MYNN
Radiation, LW	RRTMG
Radiation, SW	RRTMG
Cloud fraction for radiation	Xu-Randall
Gravity wave drag by orography	YSU

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MPAS-Atmosphere Version 7 physics

From the *MPAS V7 User's Guide*

Table 6.3: Possible options for individual physics parameterizations. Namelist variables should be added to the &physics namelist record.

Parameterization	Namelist variable	Possible options	Details
Convection	config_convection_scheme	`cu_tiedtke`	Tiedtke (WRF 3.8.1)
		`cu_ntiedtke`	New Tiedtke (WRF 4.0.3)
		`cu_grell_freitas`	Modified version of scale-aware Grell-Freitas (WRF 3.6.1)
		`cu_kain_fritsch`	Kain-Fritsch (WRF 3.2.1)
Microphysics	config_microp_scheme	`mp_wsm6`	WSM 6-class (WRF 4.1)
		`mp_thompson`	Thompson non-aerosol aware (WRF 3.8.1)
		`mp_kessler`	Kessler
Land surface	config_lsm_scheme	`noah`	Noah (WRF 4.0.3)
Boundary layer	config_pbl_scheme	`bl_ysu`	YSU (WRF 4.0.3)
		`bl_mynn`	MYNN (WRF 3.6.1)
Surface layer	config_sfclayer_scheme	`sf_monin_obukhov`	Monin-Obukhov (WRF 4.0.3)
		`sf_mynn`	MYNN (WRF 3.6.1)
Radiation, LW	config_radt_lw_scheme	`rrtmg_lw`	RRTMG (WRF 3.8.1)
		`cam_lw`	CAM (WRF 3.3.1)
Radiation, SW	config_radt_sw_scheme	`rrtmg_sw`	RRTMG (WRF 3.8.1)
		`cam_sw`	
Cloud fraction for radiation	config_radt_cld_scheme	`cld_fraction`	Xu and Randall (1996)
		`cld_incidence`	0/1 cloud fraction depending on $q_c + q_i$
Gravity wave drag by orography	config_gwdo_scheme	`bl_ysu_gwdo`	YSU (WRF 4.0.3)

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Regional MPAS-Atmosphere

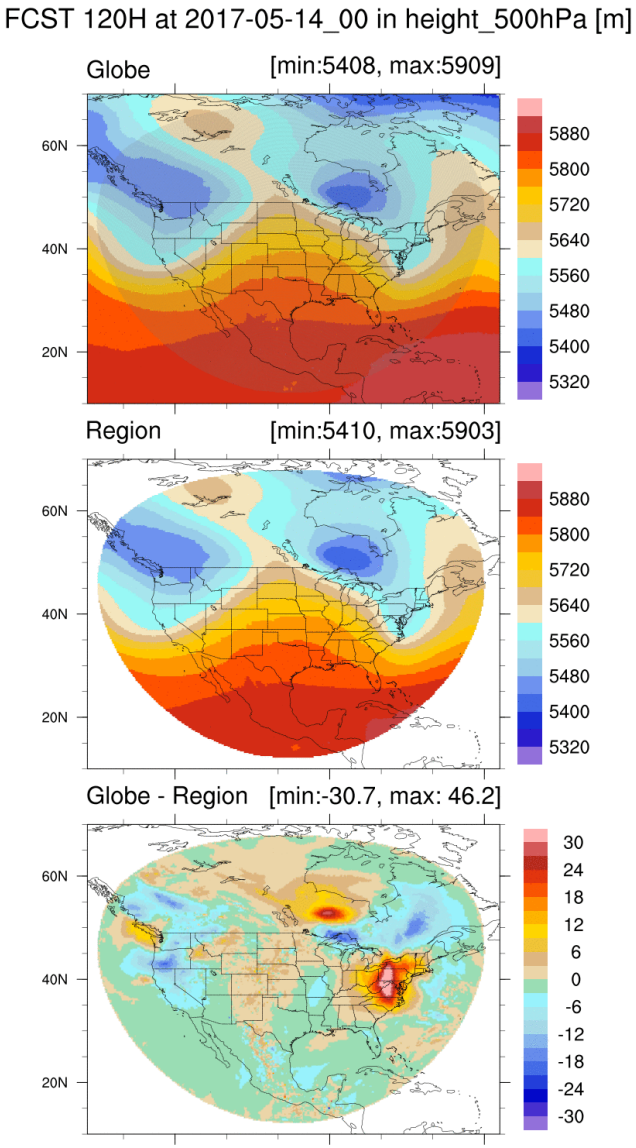
Regional MPAS can be driven by other MPAS global or regional simulations, by GFS, by CFSR, IFS forecasts, etc.

Horizontal meshes are created by cutting out a region from a global mesh.

Same parallelization approach as in global MPAS

Similar lateral boundary formulation as in WRF

See Ming Chen's talk (10.3) Thursday afternoon presenting CONUS forecast comparisons between regional MPAS and WRF



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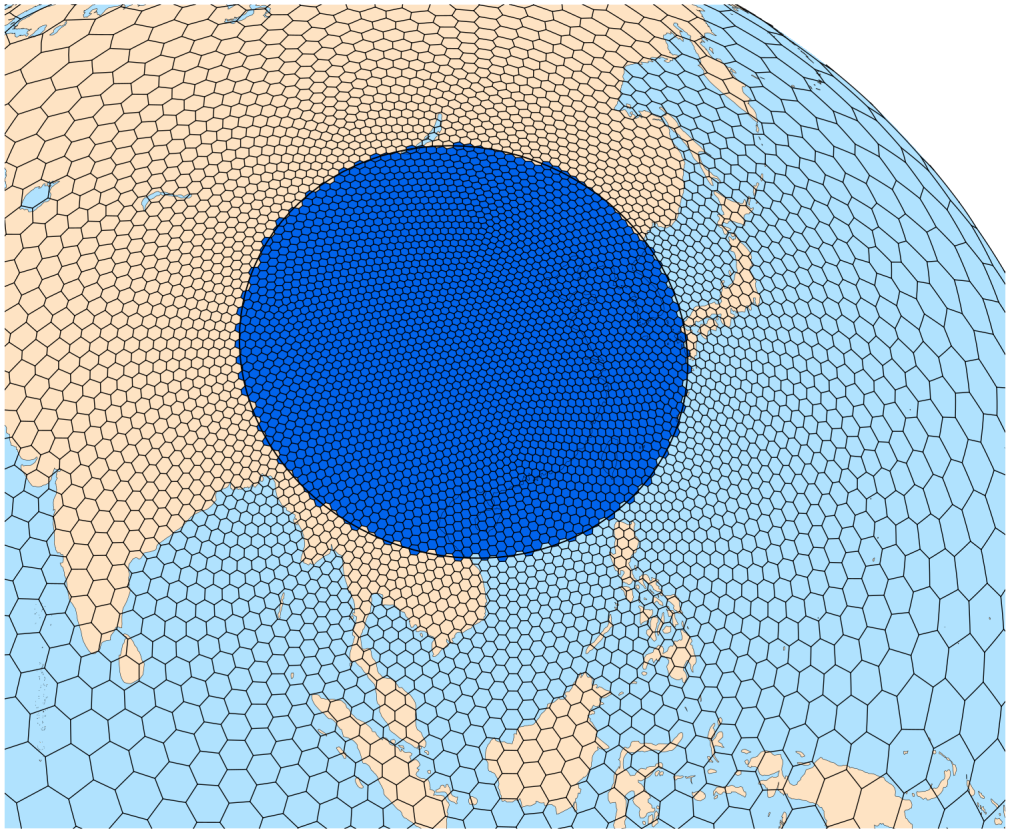
Regional MPAS-Atmosphere meshes

1. Take any existing (global) mesh, rotate the refinement as needed

2. Identify a region of interest

3. Let the regional domain consist of all cells whose generating point (center, roughly) lies within the region



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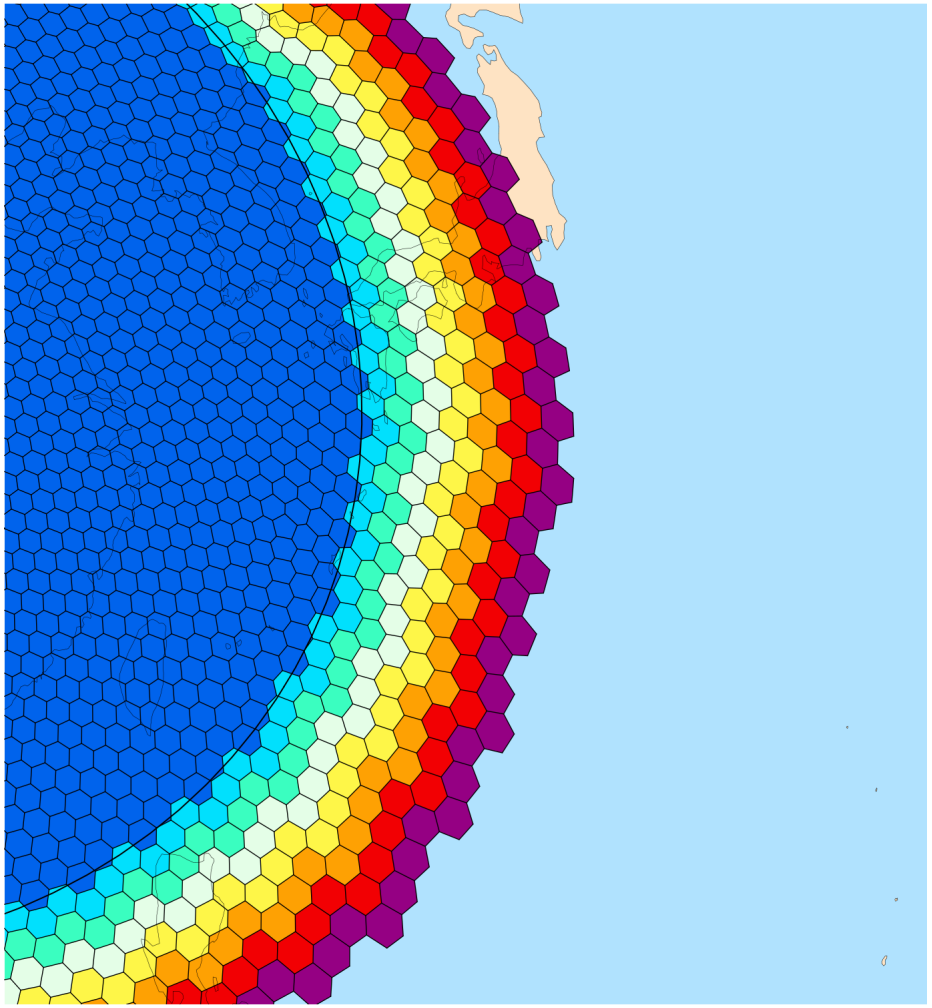
Regional MPAS-Atmosphere meshes

4. Build layers of “relaxation zone” cells (the default is 5)

5. Add two layers of “specified zone” cells

6. Cull any remaining cells and re-index cells/edges/vertices to a contiguous range of indices



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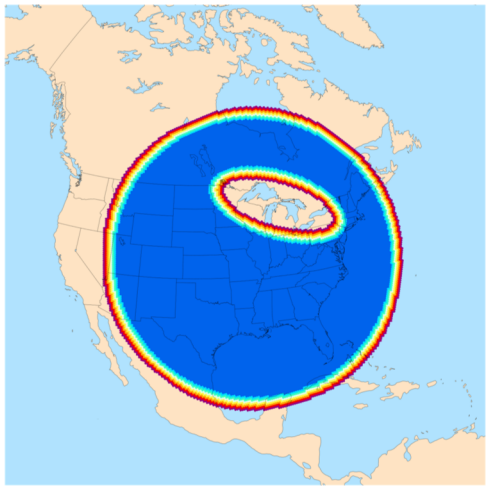
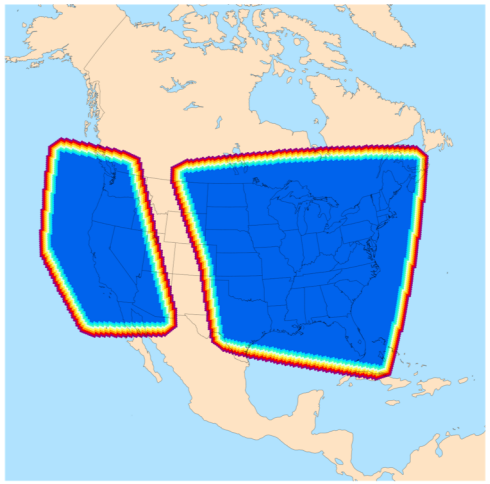
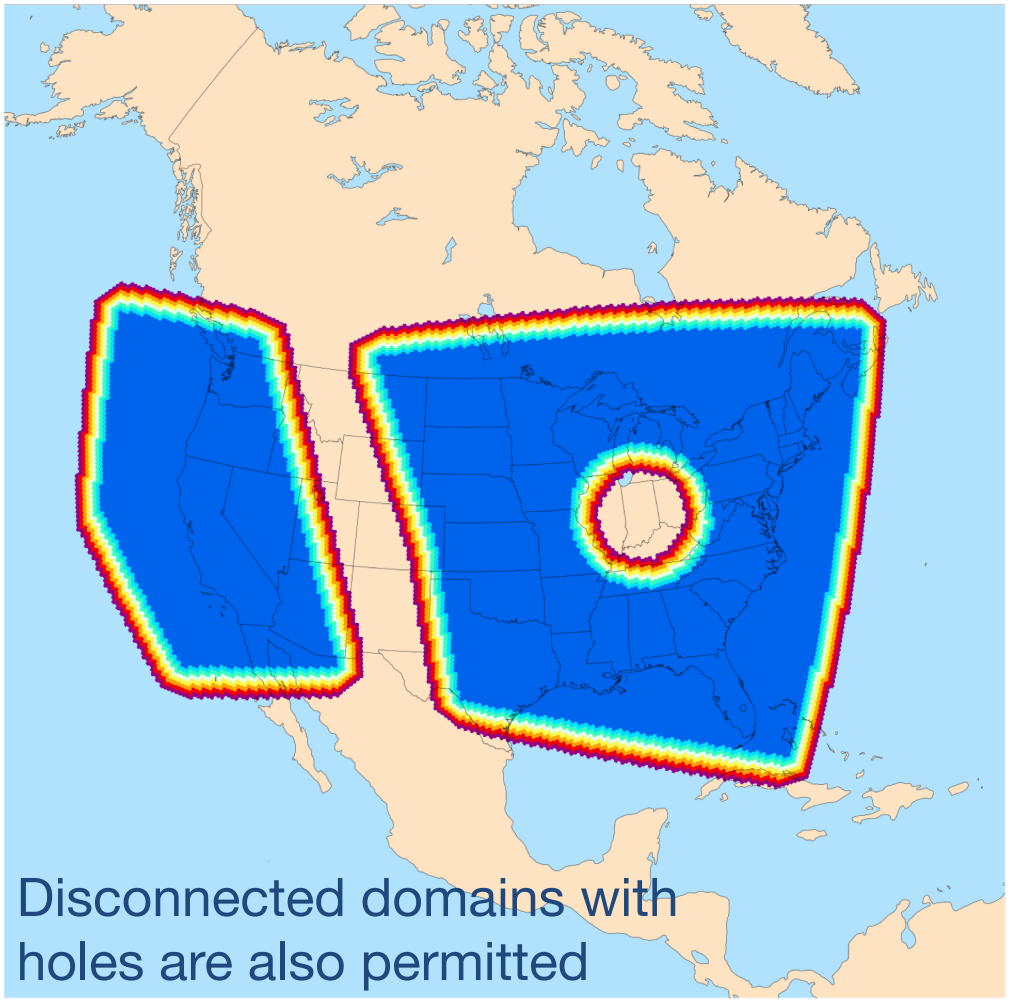
Regional MPAS-Atmosphere meshes







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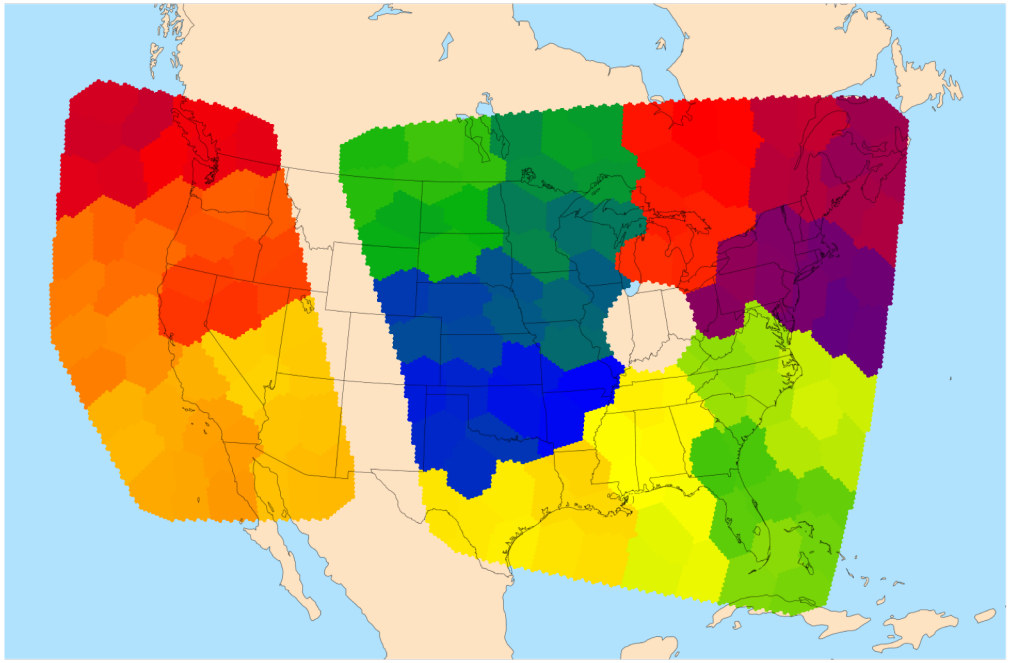
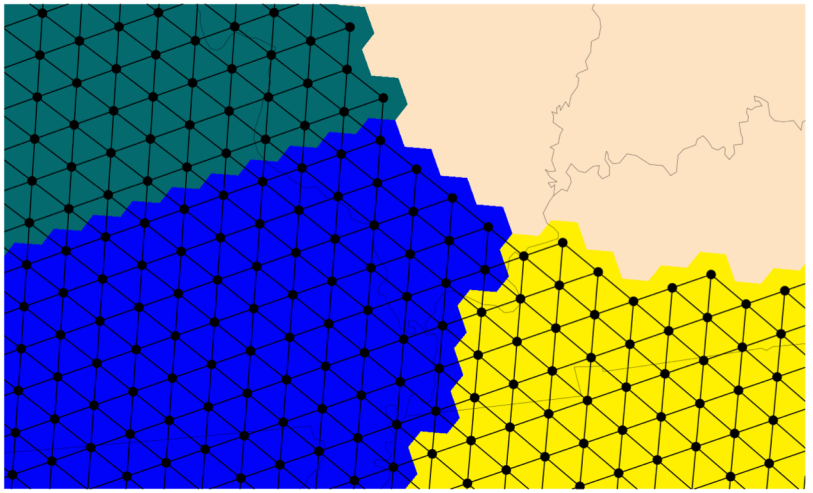
MPAS V7.0 release

Regional MPAS-Atmosphere meshes

Partitioning limited-area meshes works the same as for global meshes



Partitioning of a regional MPAS mesh by Metis into 144 partitions.



The connectivity graph of cells near the south-west of Indiana.

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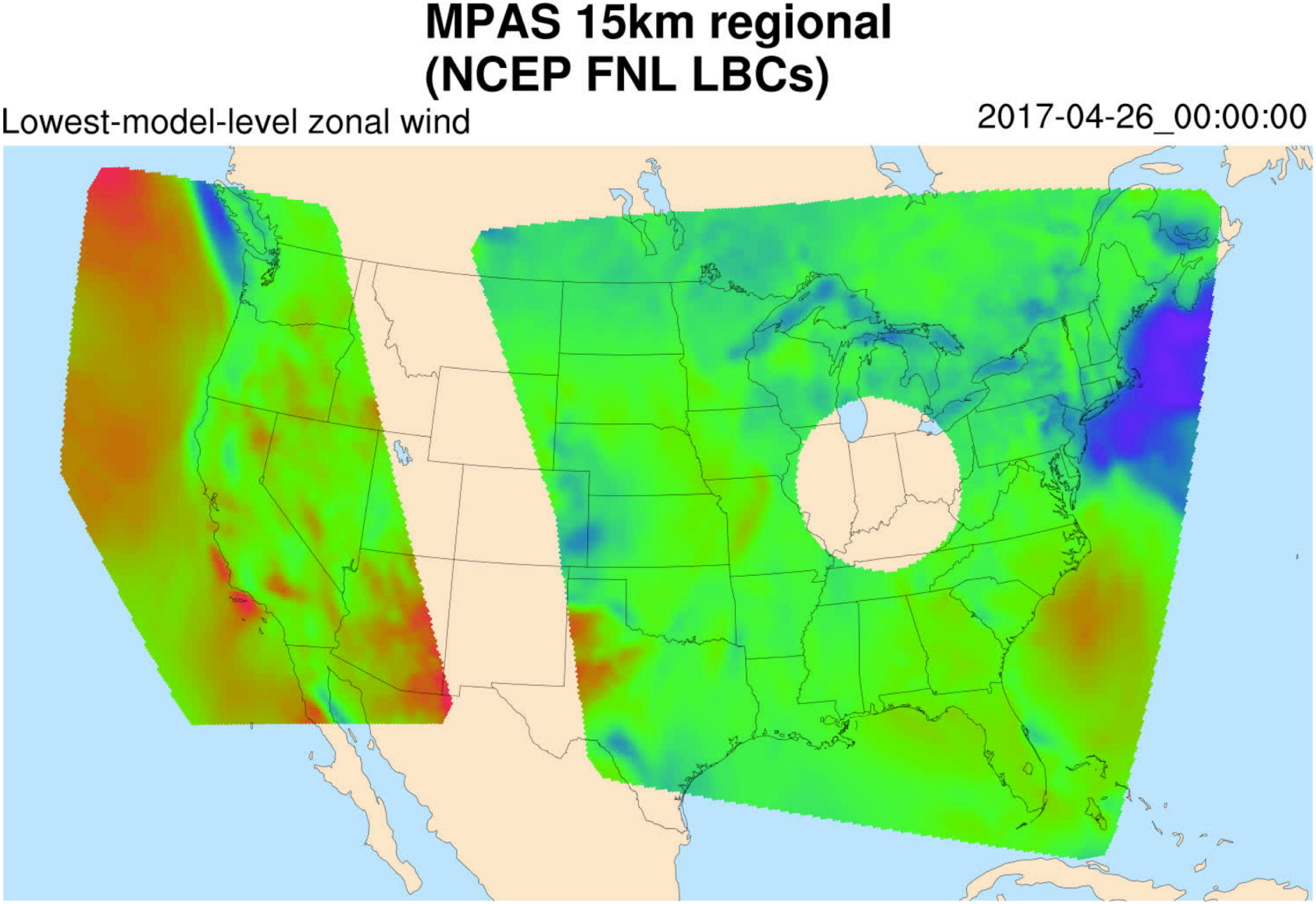
MPAS V7.0 release



MPAS
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Ongoing Development

MPAS-Atmosphere in CESM/CAM

- A clean, supportable implementation of MPAS-A into CESM is being constructed. Builds of MPAS-A in CESM/CAM pull MPAS-A directly from the MPAS development/release github repository.
- The new MPAS-Atmosphere port to CESM is part of the *SIMA* project to unify atmospheric modeling at NCAR (weather, climate and geospace). *See Chris Davis' presentation at the Thursday afternoon wrap-up discussion.*
- MPAS-Atmosphere is adopting the Community Physics Framework (CPF) being developed to access WRF and CESM/CAM physics, and MICM chemistry. *See Dom Heinzeller's talk on the CCPP/CPF (10.6) on Thursday afternoon.*
- Regional MPAS-A capabilities should be available in CESM/CAM.
- We plan to release MPAS/CAM/CESM when it is NWP capable.

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Ongoing Development

GPU/accelerator capabilities in MPAS-Atmosphere

Development of MPAS-A using GPUs through OpenACC directives continues.

Participating organizations: The Weather Company, IBM, NCAR, Univ. Wyoming, NVIDIA

Questions being addressed in this development:

- Can we achieve significant performance enhancement on GPUs using OpenACC?
- Can we maintain and evolve a single-source code (CPU/GPU) in our development and for release and support to the community?

We have made major progress - for further information see:

(3.2) MPAS on GPUs - Supreeth Suresh

(3.4) Challenges and techniques to port MPAS on to GPUs.
Raghuraj Kumar, NVIDIA, S. Suresh, NCAR

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Ongoing Development

Deep atmosphere equations in MPAS

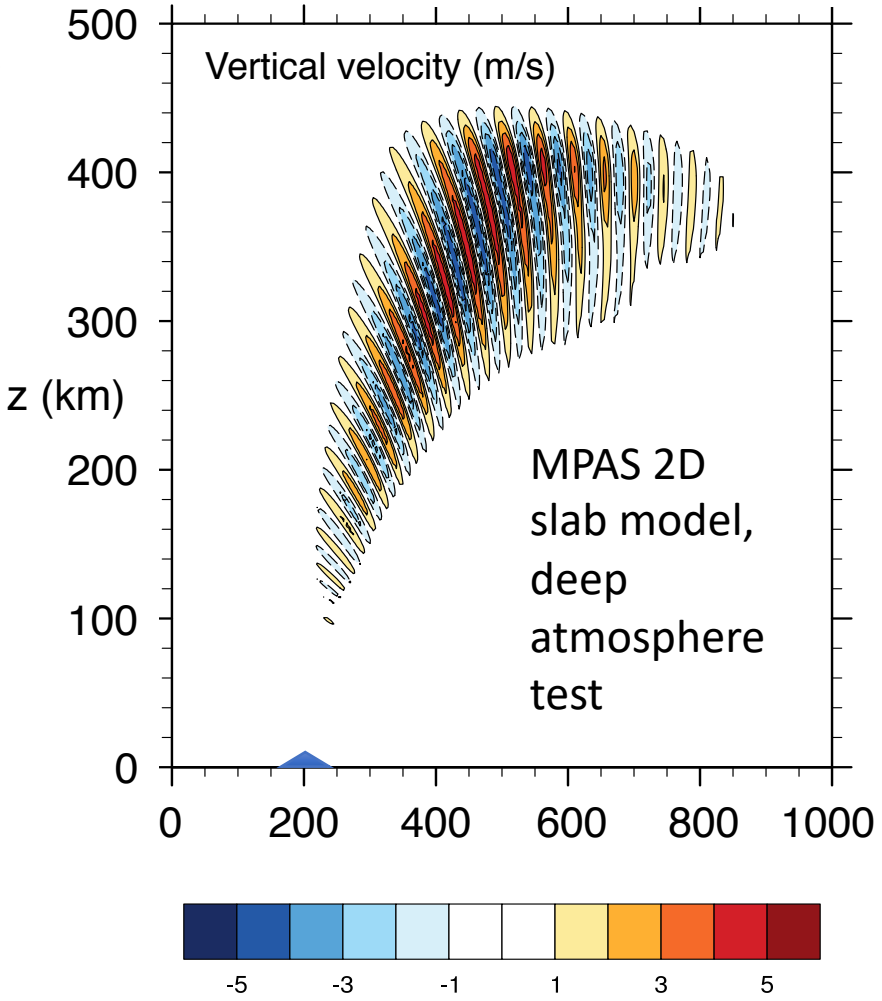
MPAS currently solves fluid-flow equations that use the shallow atmosphere approximation

Deep atmosphere

- Geometric effects: $\Delta x = f(r)$
- Full Coriolis terms
- Variable gravity
- ln(p) formulation for pressure gradients

Geospace

- General state equation
- Solver accommodation for large physical viscosities



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MPAS TUTORIAL

MODEL FOR PREDICTION ACROSS SCALES – ATMOSPHERE (MPAS-A) TUTORIAL

9–11 September, 2019
NCAR Foothills Lab, Boulder, CO

Will cover both global
and regional MPAS-Atmosphere

Registration is now open.
https://www.mmm.ucar.edu/mpas-tutorial