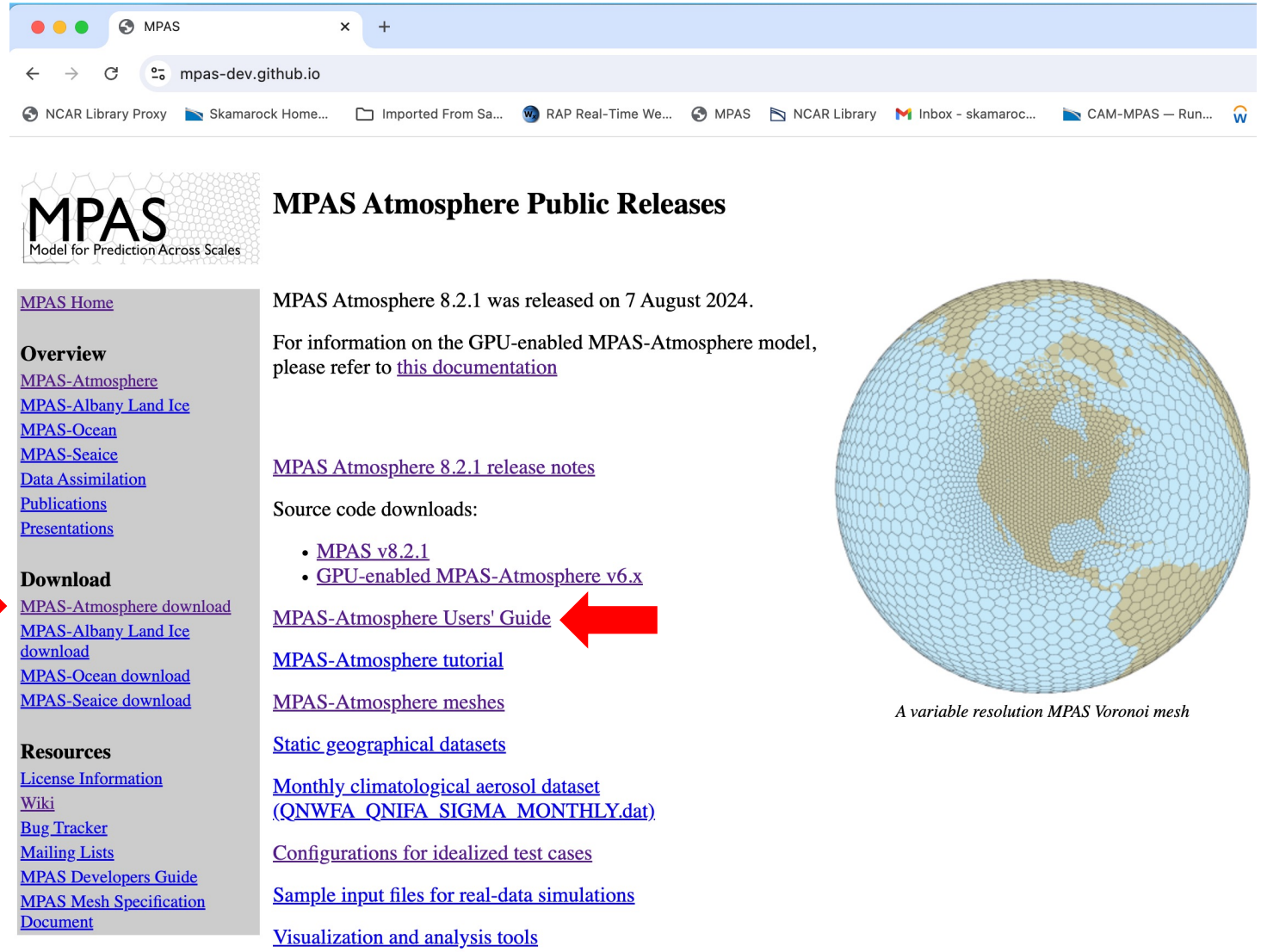
MPAS
Model for Prediction Across Scales

MPAS-Atmosphere Resources

MPAS-Atmosphere Users' Guide: On the MPAS-Atmosphere download page



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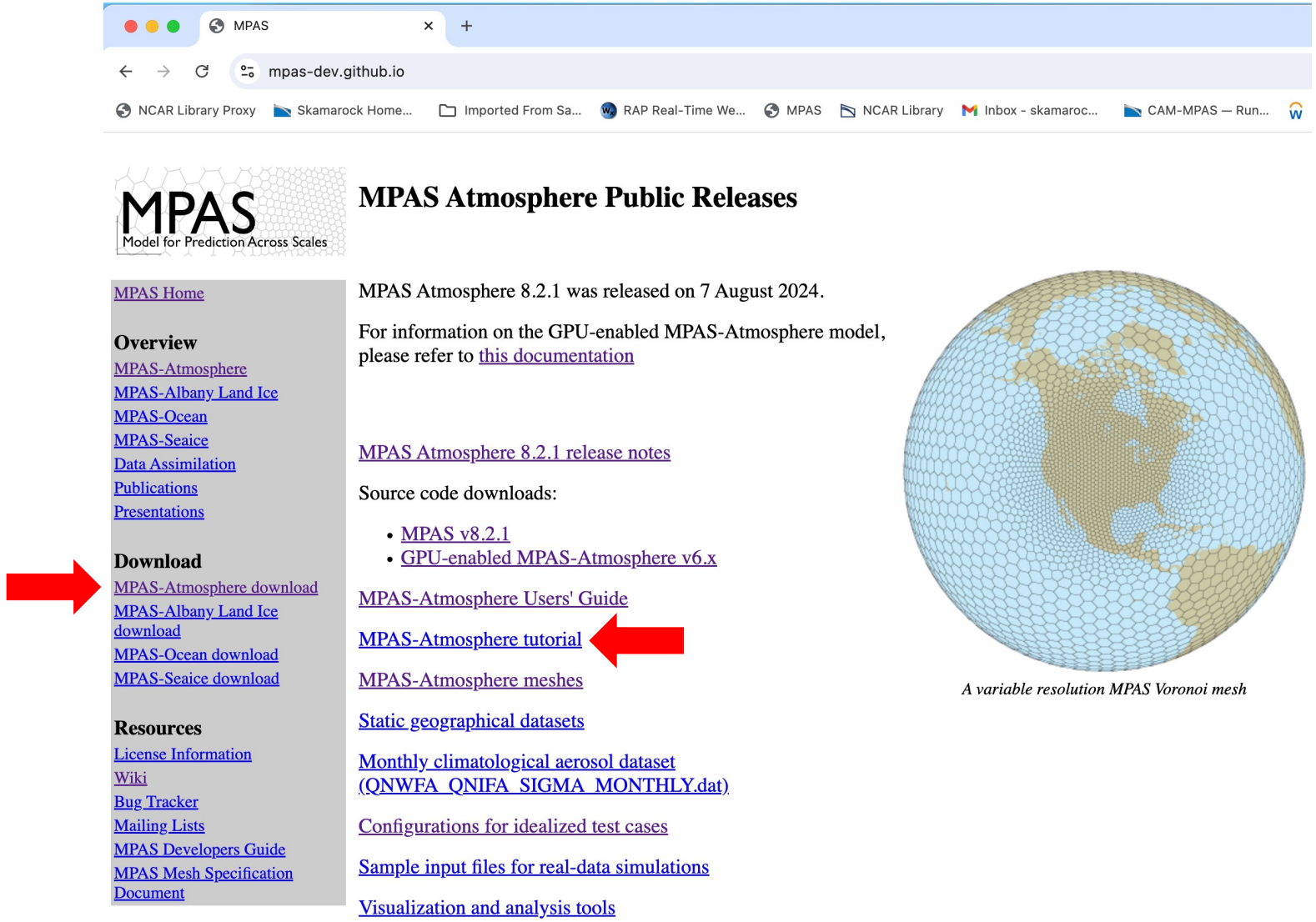
MPAS-Atmosphere Resources

MPAS-Atmosphere tutorial: On the MPAS-Atmosphere download page



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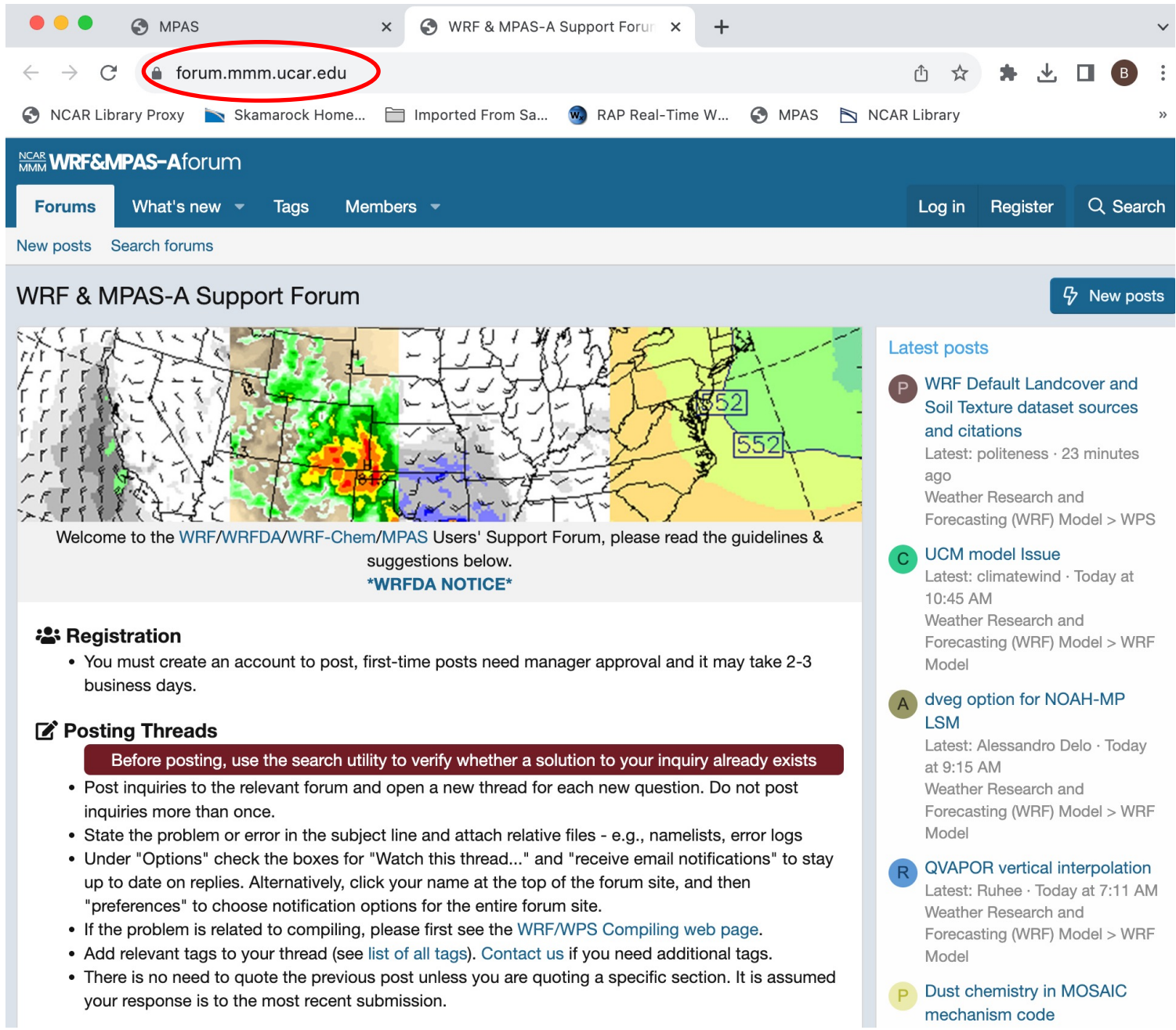
MPAS-Atmosphere Resources

WRF&MPAS-A Support Forum

You need to create an account to post to it.

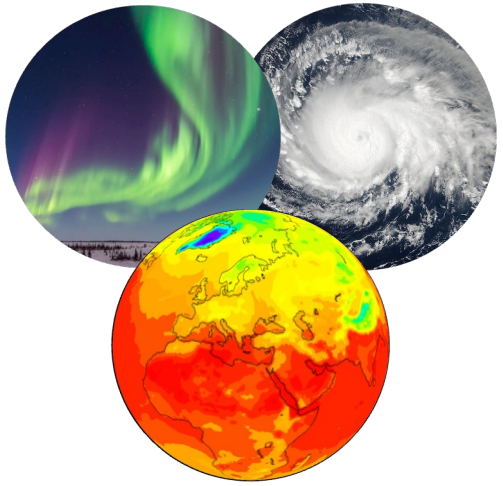
Searchable



The Model for Prediction Across Scales Atmosphere

MPAS-Atmosphere and the future

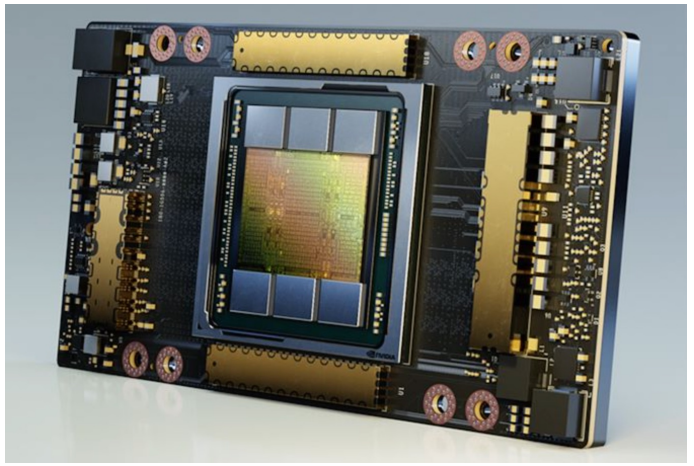
MPAS-A in an Earth System Model



SIMA

EarthWorks

MPAS-A and GPUs



NVIDIA Ampere A100 GPU

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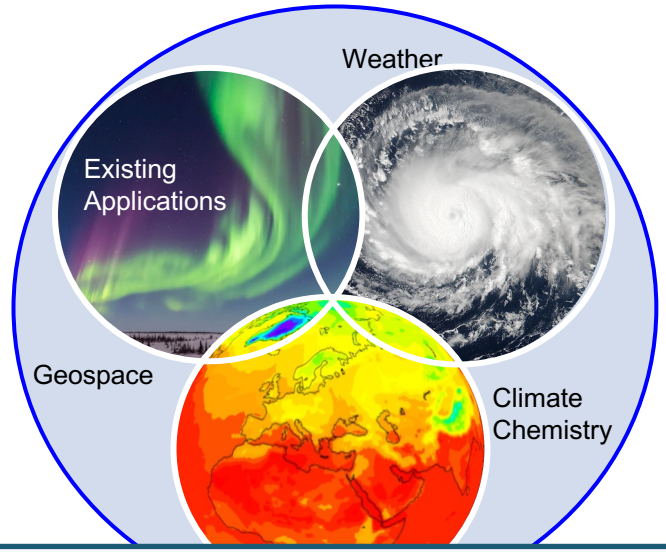
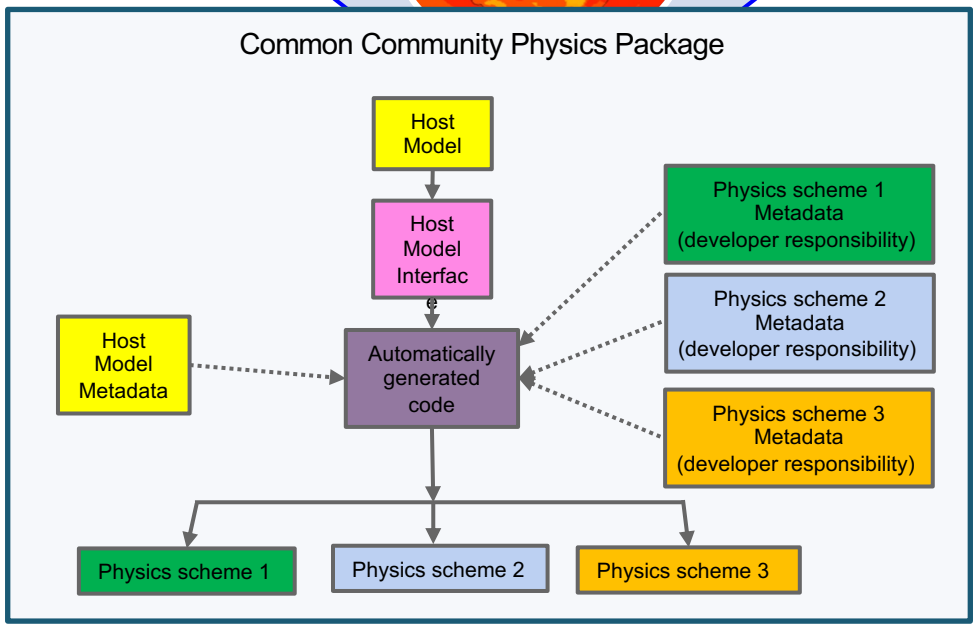
System for Integrated Modeling of the Atmosphere (SIMA)



(1) MPAS-Atmosphere in an Earth System Model (ESM), using CESM components. Other ESM components: ocean, land, land and sea ice, chemistry

(2) WRF/MPAS physics in an ESM using the Common Community Physics Package (CCPP) interface.



Status:

- *MPAS-A in CESM is being tested.*
- *Only CESM/CAM physics will be available in a first release.*
- *CCPP implementation in MPAS and CESM is not yet complete.*
- *Initial release (experimental) TBD.*

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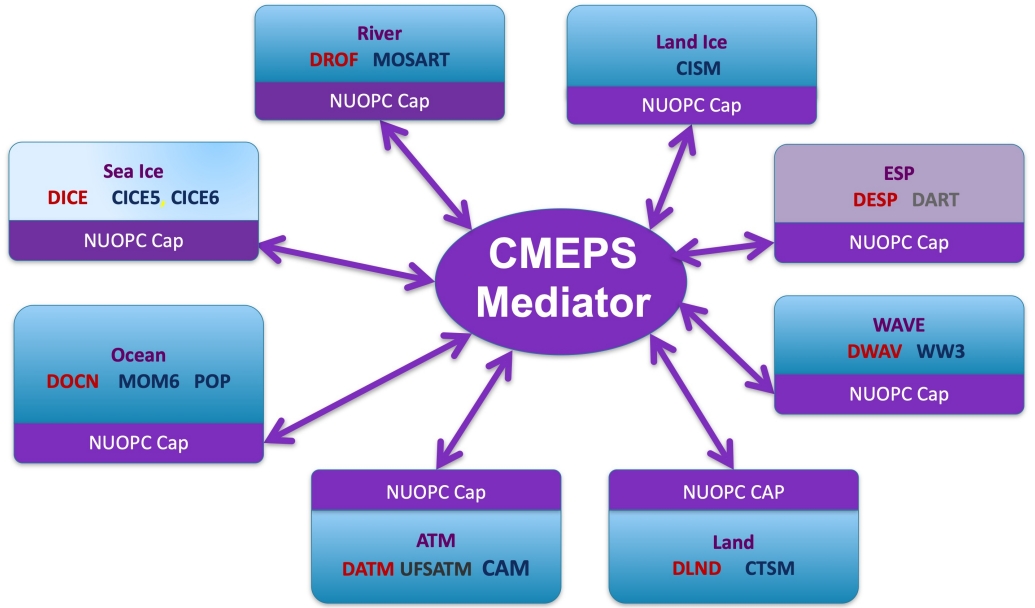
EarthWorks

EarthWorks is a five-year university-based project (CSU), supported by NSF/CISE, to develop a *global convection-permitting coupled model* based on the CESM with GPU capability for all components.

Earthworks consists of:

- The MPAS non-hydrostatic dynamical core, with a resolved stratosphere and CAM-ish physics
- The MPAS ocean model, developed at Los Alamos
- The MPAS sea ice model, based on CICE
- The Community Land Model (CLM)
- The Community Mediator for Earth Prediction Systems (CMEPS)



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EarthWorks

EarthWorks is available now in a first “functional” release:
git clone https://github.com/EarthWorksOrg/EarthWorks.git

Earthworks consists of:

- The MPAS non-hydrostatic dynamical core, with a resolved stratosphere and CAM-ish physics
- The MPAS ocean model, developed at Los Alamos
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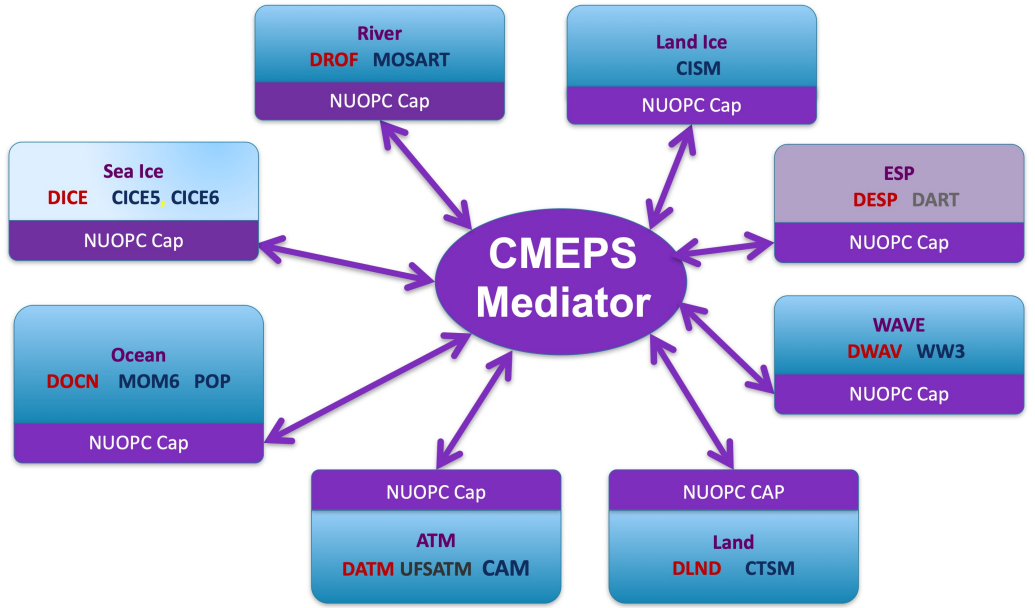

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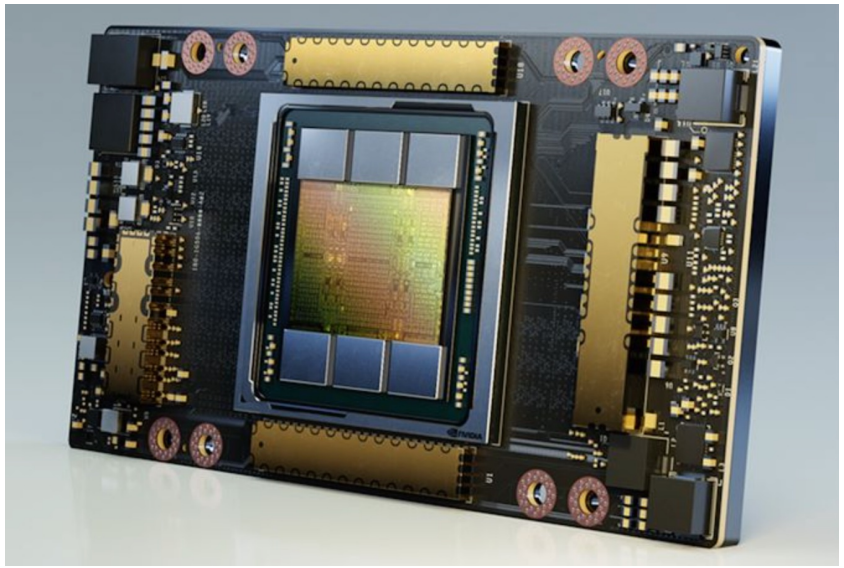
MPAS and GPUs

We released the GPU-enabled MPAS-Atmosphere in October 2020 as a branch from MPAS Version 6.1. We have a Version 7 update but it has not been released.



NVIDIA Ampere A100 GPU

What is in current (2020) release:

- GPU-enabled MPAS dynamical core using OpenACC directives.
- Some GPU-enabled physics (e.g. YSU, WSM6, M-O, scale-aware nTiedtke)
- Asynchronous execution capability on heterogenous architectures - currently radiation (lagged) and NOAH land model on CPUs, all else on GPUs
- Configurations tested and validated on IBM POWER9 architectures and on AMD architectures employing NVIDIA V100 and A100 GPUs.

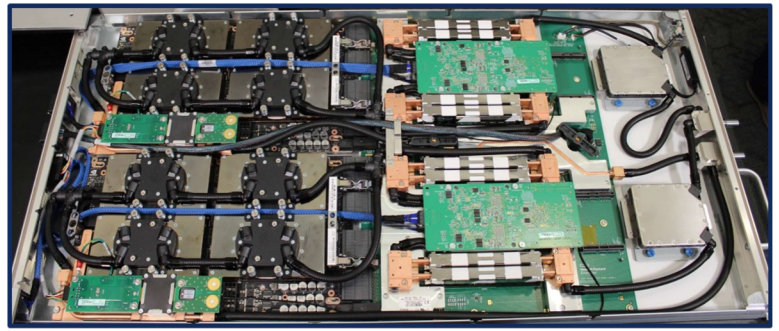
MPAS-Atmosphere Upcoming Releases

MPAS-Atmosphere GPU Implementation

GPU implementation for MPAS-Atmosphere
https://mpas-dev.github.io/atmosphere/OpenACC/index.html

Based on our experience with this release, we are re-implementing this capability

- Initial (partial) GPU capability has been released and in MPAS v8.2.0
- Subsequent MPAS-A releases will incrementally extend GPU capabilities in the dynamical core and physics.
- Demonstrates commitment to MPAS-A as a community model designed for next-generation computing systems
- Builds on lessons learned from past partnerships with IBM, The Weather Company, the University of Wyoming, and NVIDIA.



Above: A Derecho GPU blade with two GPU nodes, each with 1 AMD EPYC Zen3 "Milan" 64-core processor and 4 NVIDIA A100 Ampere GPUs.

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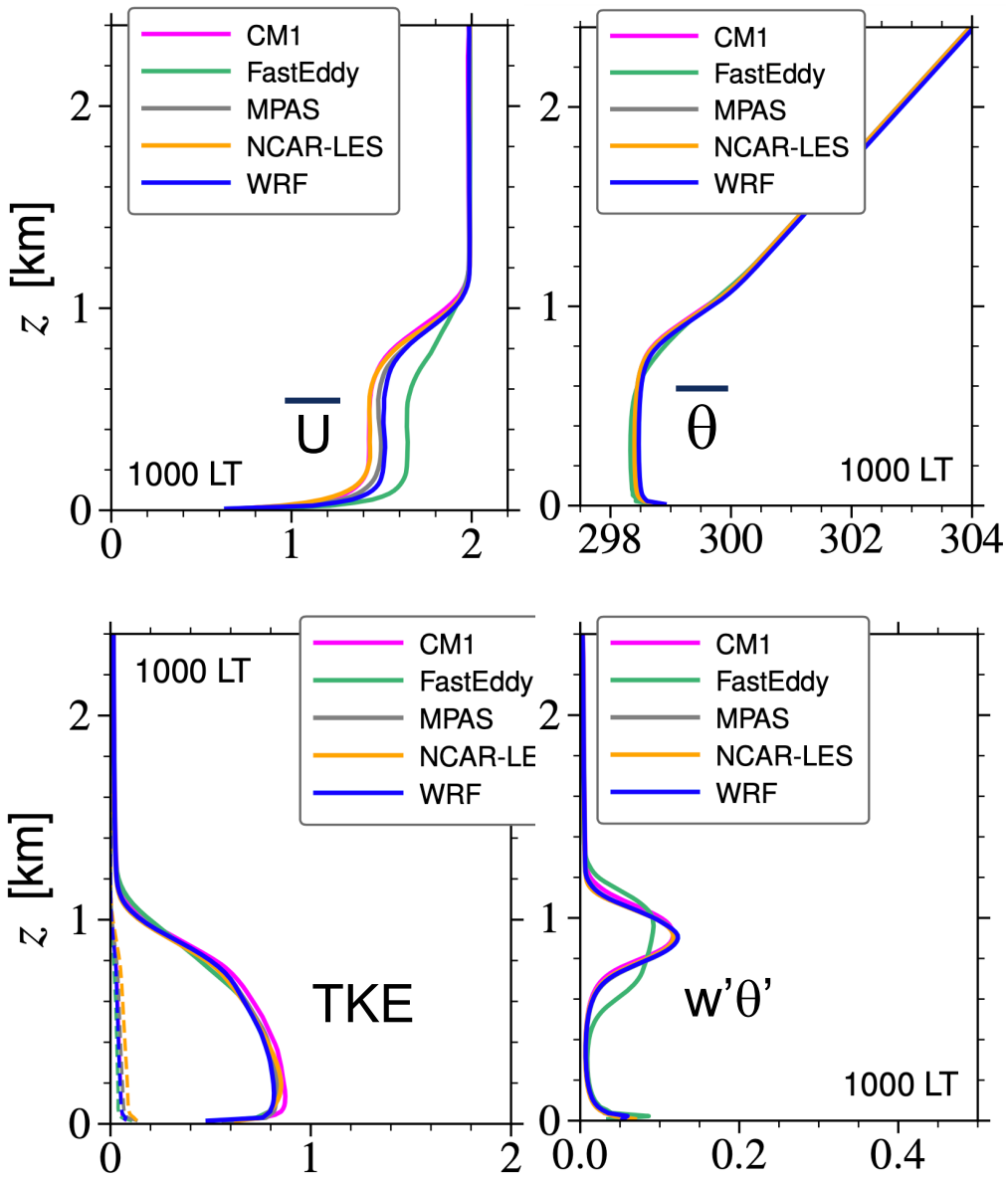
LES capabilities in MPAS

We implemented 2 LES SGS turbulence models in MPAS: 3D Smagorinsky scheme (diagnostic) and a 1.5 order TKE scheme (prognostic).

MPAS LES results look at lot like WRF and CM1 results.

Extensions for terrain need implementing.

Release timetable TBD.



SAS LES test case, NCAR PBL reinvestment project

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Also under development…

- Scalar transport in physics parameterizations (convection, boundary layer) in preparation for chemistry.
- Prognostic ozone
- GOCART implementation
- Unified (MPAS, WRF, CM1) physics
- Mesh generation, global and regional
- MPAS-Atmosphere Technical Note

There are ongoing discussions about a full chemistry implementation

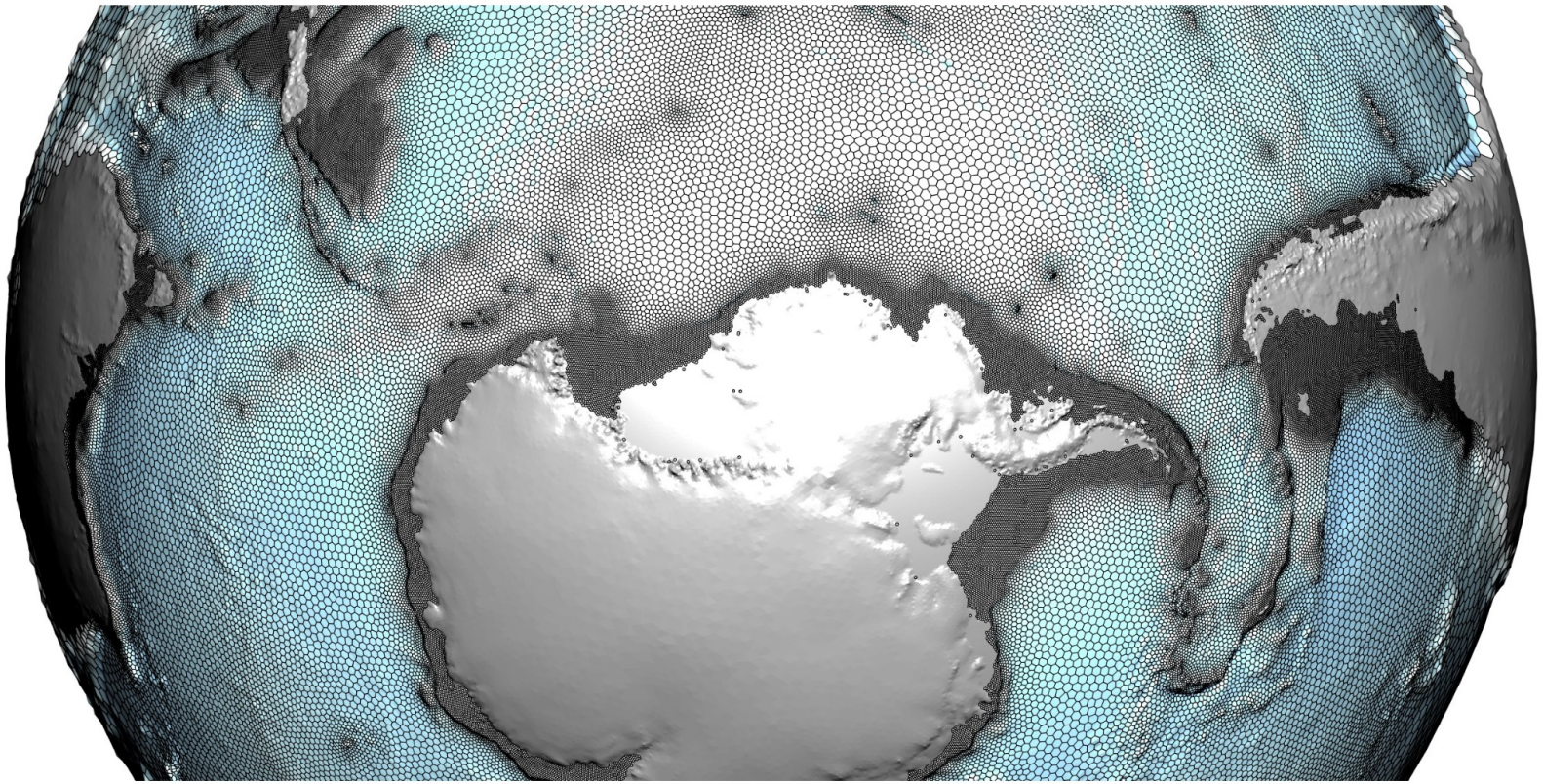
Mesh Generation

JIGSAW(GEO): potentially much faster (10x?) variable-resolution mesh creation.

https://github.com/dengwirda/jigsaw-geo-python

Darren Engwirda

`JIGSAW(GEO): Mesh generation for geoscientific modelling`



MPAS
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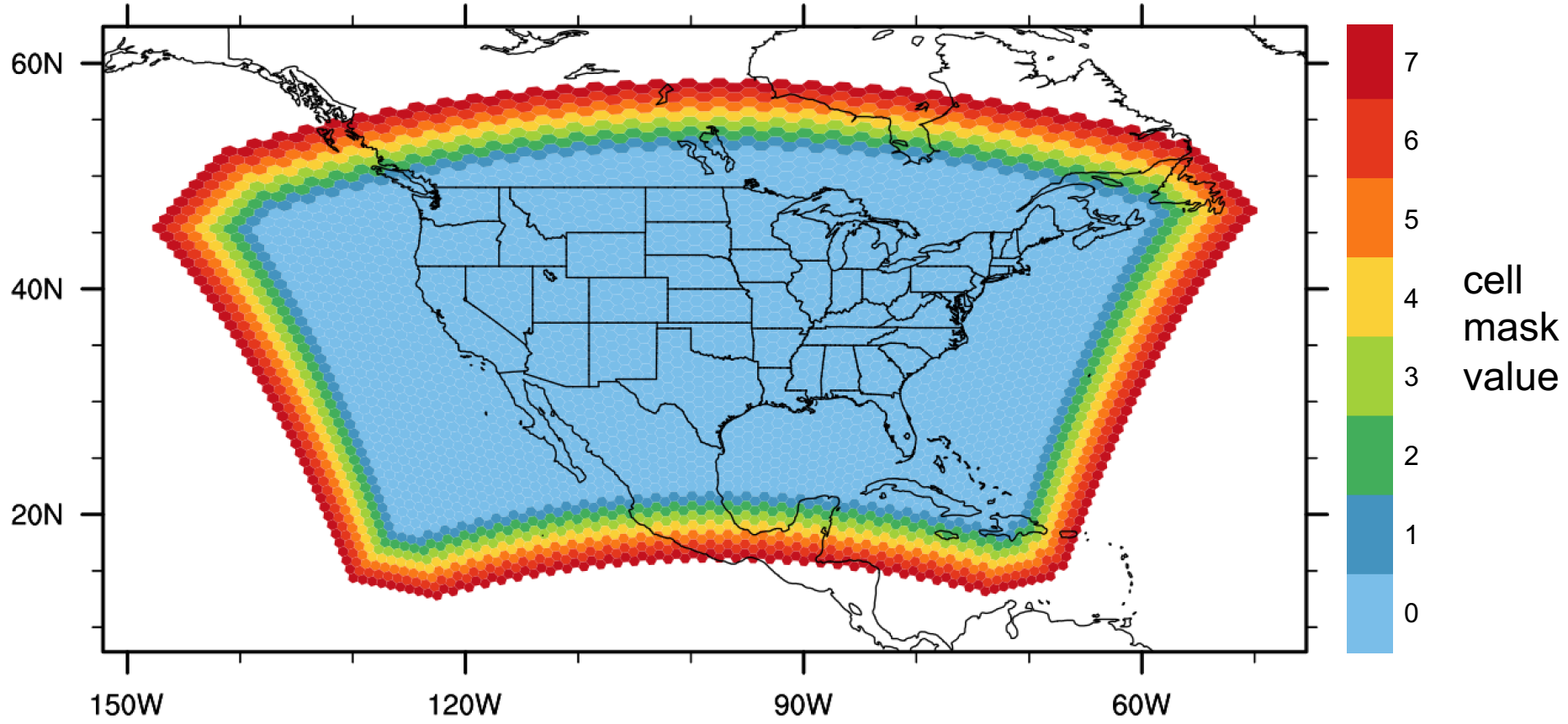
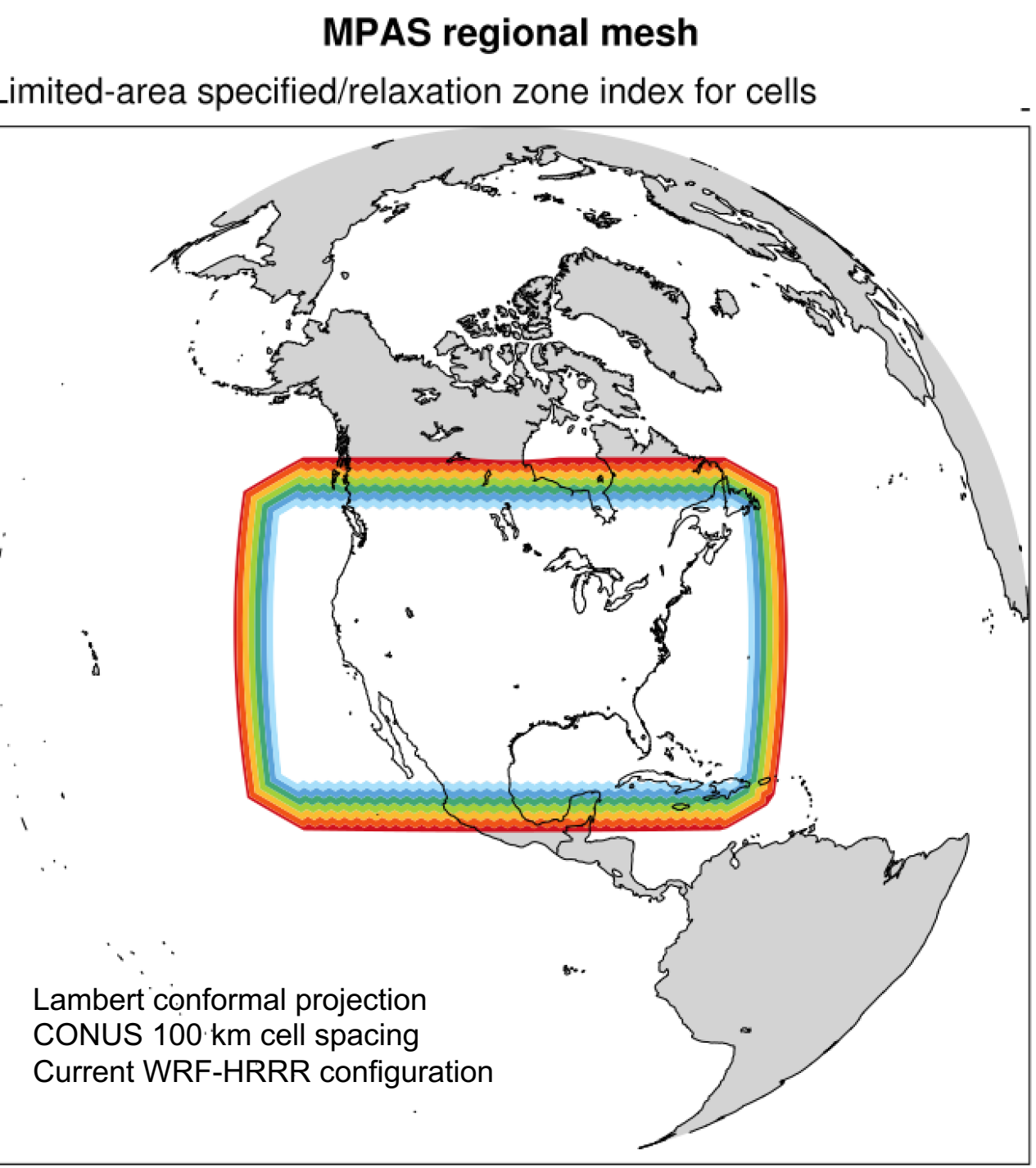
Also under development…

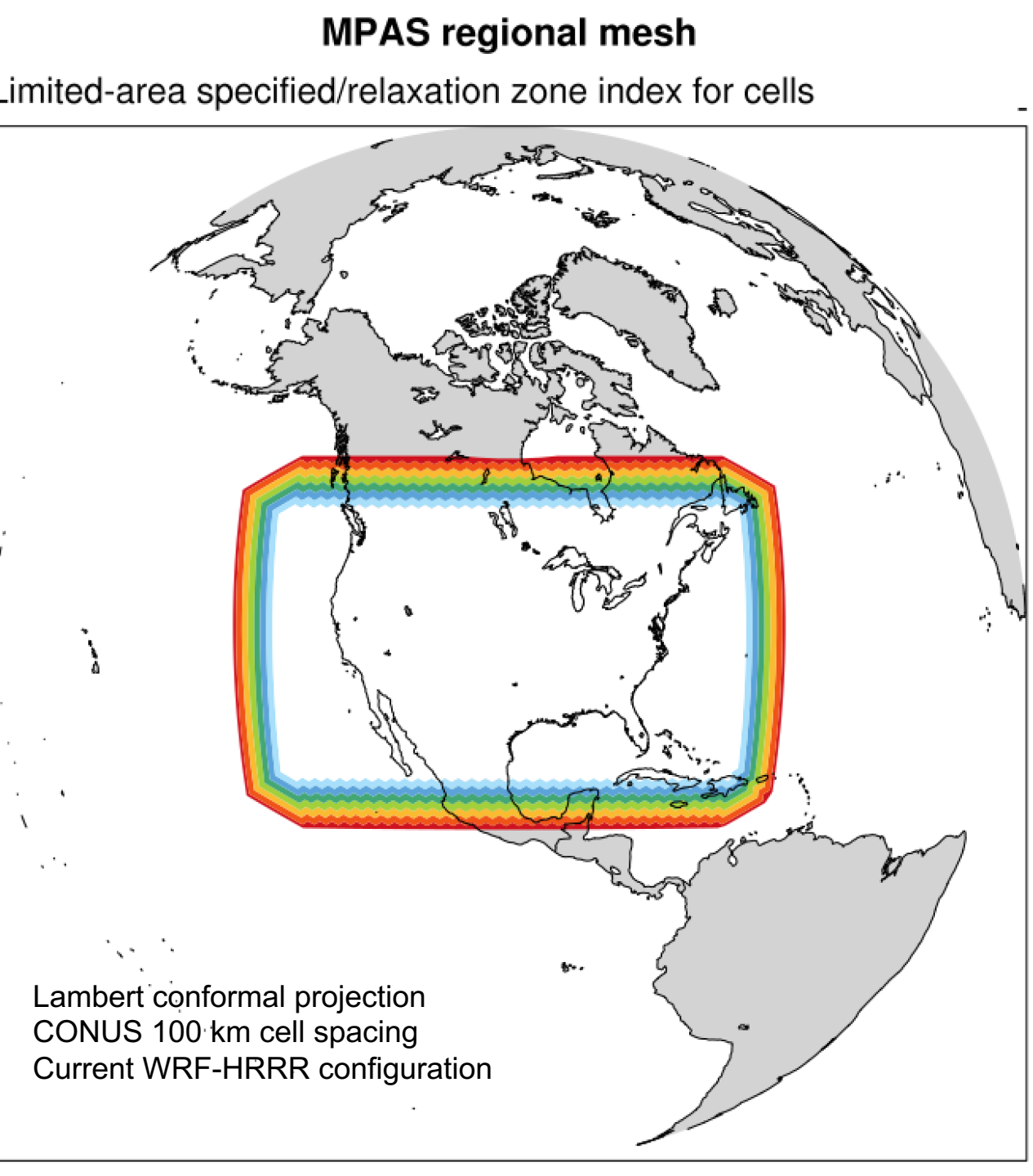
Mesh of perfect hexagons projected to the sphere. Lambert conformal projection

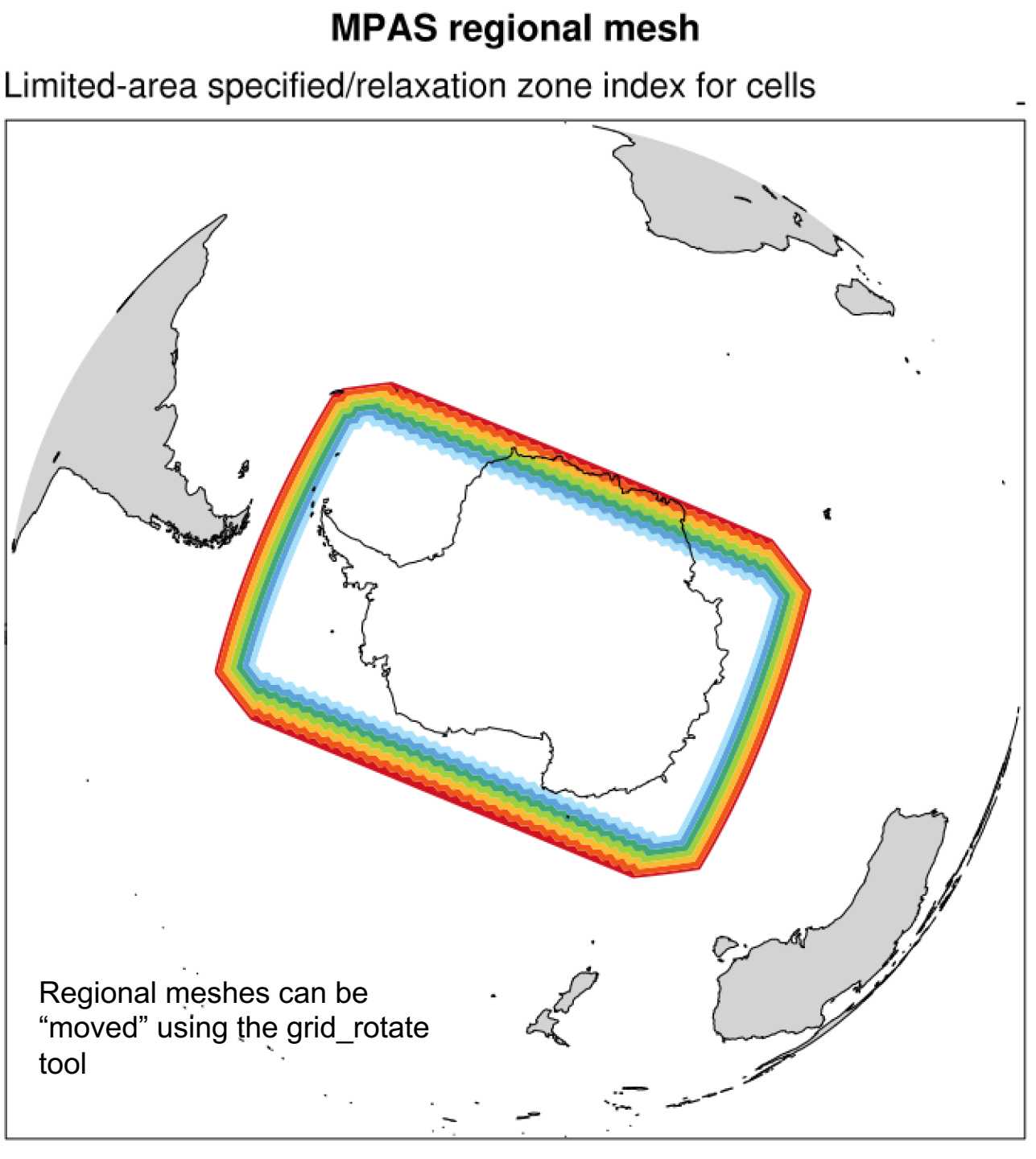


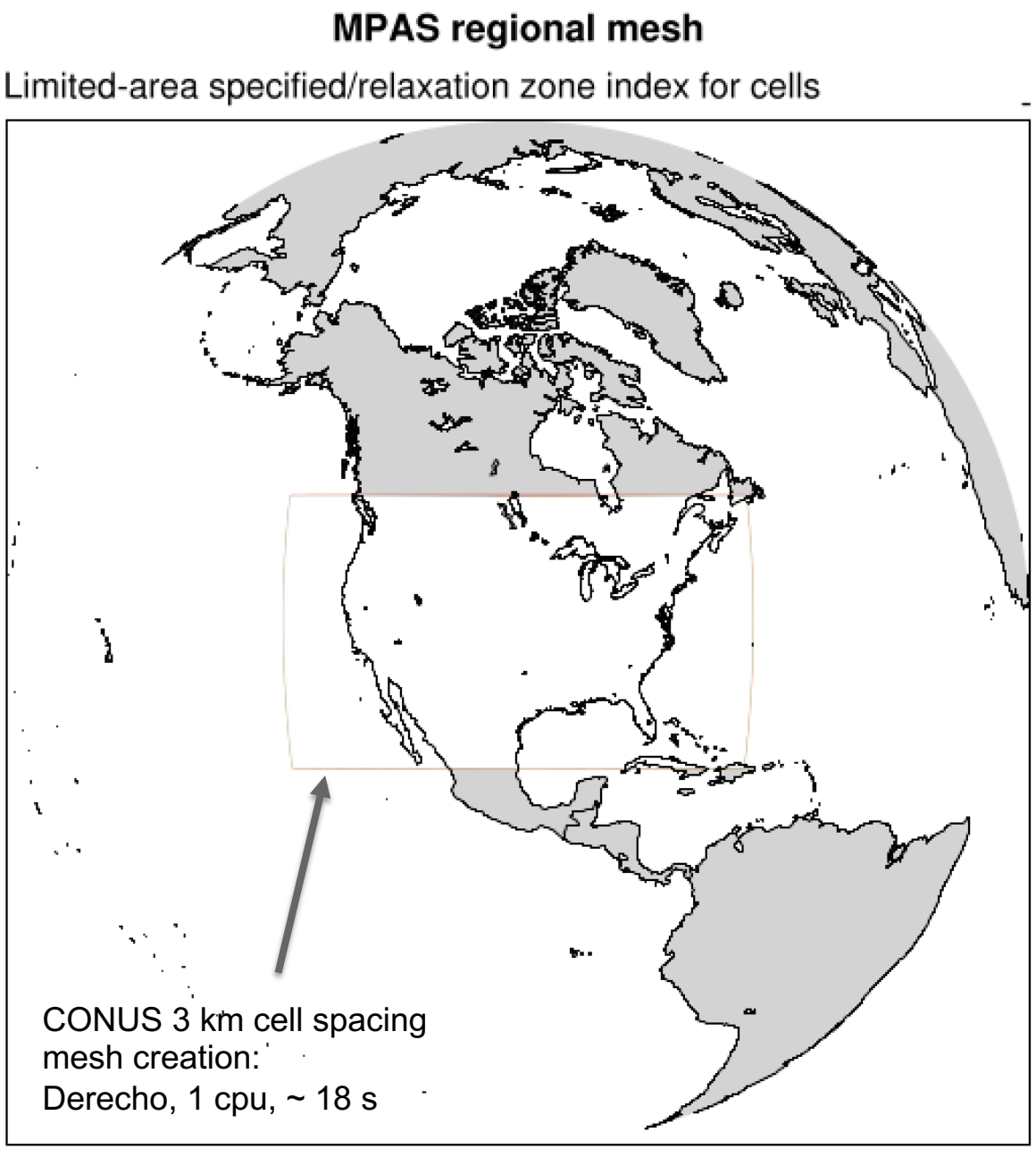


Regional Mesh Generation

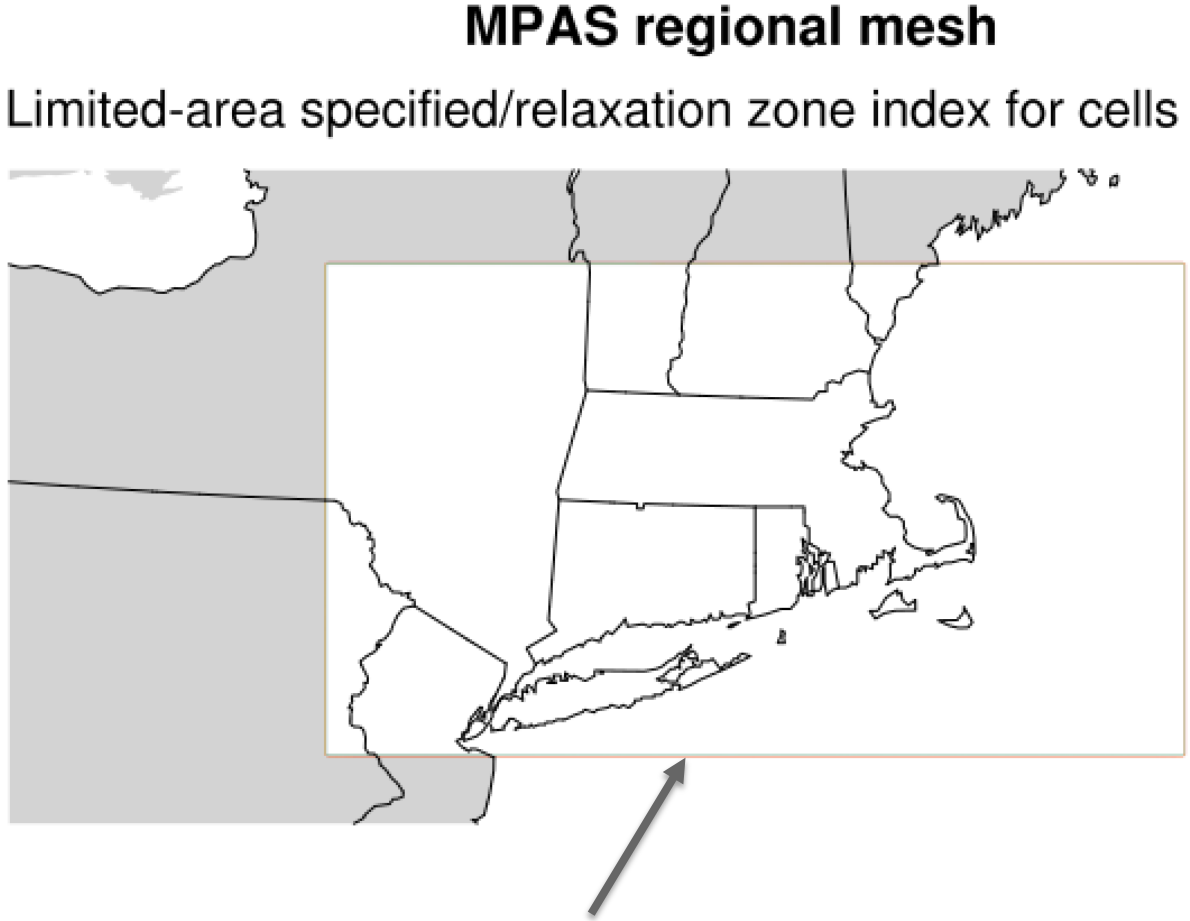
Project perfect hexagons on an (xy) Cartesian plane to the sphere using standard projections


MPAS regional mesh
Limited-area specified/relaxation zone index for cells
Lambert conformal projection
CONUS 100 km cell spacing
Current WRF-HRRR configuration


MPAS regional mesh
Limited-area specified/relaxation zone index for cells
Regional meshes can be
“moved” using the grid_rotate
tool



CONUS 3 km cell spacing
mesh creation:
Derecho, 1 cpu, ~ 18 s



300 meter cell spacing
mesh creation:
Derecho, 1 cpu, ~ 18 s

An example from the draft technical note

Vertical Vorticity

The discrete vertical vorticity is evaluated at the vertices of the MPAS CVT mesh. Referring to figure 2.1, the vertical vorticity at vertex a is computed using the circulation theorum applied to the MPAS dual triangular mesh. The relative vertical vorticity at vertex a is computed as

$$\zeta_a = \frac{u_{13} \left|\overrightarrow{CA}\right| t_{13,a} + u_{14} \left|\overrightarrow{AB}\right| t_{14,a} + u_{15} \left|\overrightarrow{BC}\right| t_{15,a}}{A_a}, \tag{4.27}$$

where A_a is the area of the triangle centered at vertex a. The indicator function $t_{e,v}$ corrects for the direction of a positive velocity from the first cell center to the second in the circulation calculation. In the example (4.27), the indicator functions are all equal to 1. In contrast, the indicator functions would be equal to -1 for these same velocities contributing to the circulation about vertices b, f and j. Also note that these computations are performed on MPAS horizontal surfaces. Finally, the absolute vorticity at the vertices $\eta_a = \zeta_a + 2\Omega \sin(\phi)$, where Ω is the angular velocity of the earth's rotation and ϕ is the latitude.

MPAS code: *The vertical vorticity is computed in subroutine atm_compute_solve_diagnostics found in MPAS-Model/src/core_atmosphere/dynamics/mpas_atm_time_integration.F. The relative vertical vorticity at a vertex ζ_v is stored in the array* vorticity(level,vertex). *The indicator function $t_{e,v}$ is stored in the array* edgesOnVertex_sign(edge,vertex).
The absolute vorticity at the vertices η_v is stored in the array pv_vertex(level,vertex). *The name goes back to MPAS-A's initial implementation of a shallow water model.*

MPAS
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Coming Events

WRF-MPAS workshop: 3-6 June 2025 (in person)

We've begun work on an MPAS NCAR Technical Note. Draft – early 2025?

We have two tutorials each year, NH spring (virtual) and NH fall (in person):

- April 2025.
- Fall 2025

Feature and bug releases occur whenever components are ready.