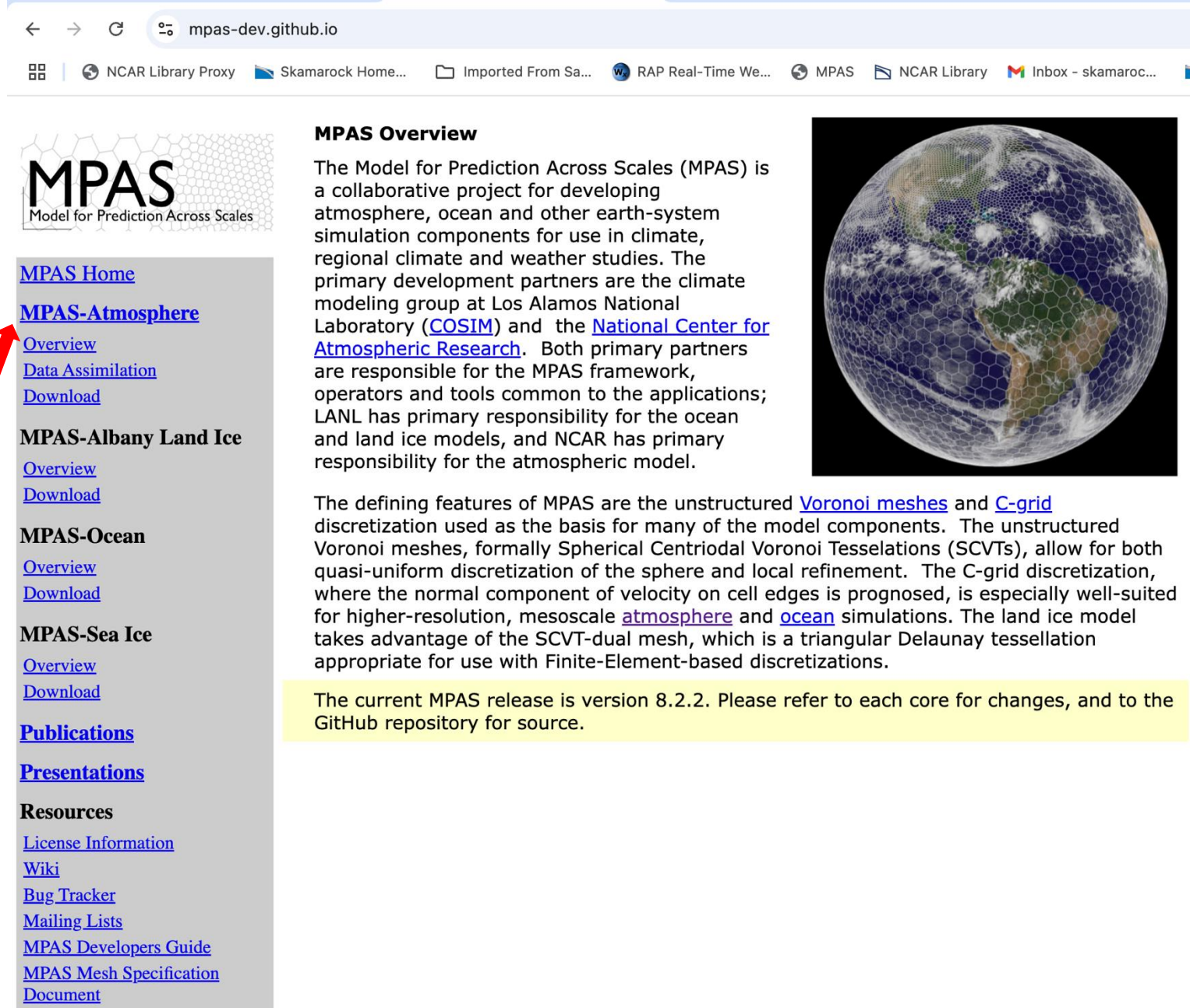


## The Github MPAS web page

## MPAS-Atmosphere



The screenshot shows the MPAS-Atmosphere Github repository page. The browser address bar displays 'mpas-dev.github.io'. The page features a sidebar with navigation links: 'MPAS Home', 'MPAS-Atmosphere' (highlighted with a red arrow), 'Overview', 'Data Assimilation', 'Download', 'MPAS-Albany Land Ice', 'Overview', 'Download', 'MPAS-Ocean', 'Overview', 'Download', 'MPAS-Sea Ice', 'Overview', 'Download', 'Publications', 'Presentations', 'Resources', 'License Information', 'Wiki', 'Bug Tracker', 'Mailing Lists', 'MPAS Developers Guide', 'MPAS Mesh Specification', and 'Document'. The main content area includes an 'MPAS Overview' section with a description of the project, its partners (Los Alamos National Laboratory and the National Center for Atmospheric Research), and its defining features (unstructured Voronoi meshes and C-grid discretization). A yellow box at the bottom states: 'The current MPAS release is version 8.2.2. Please refer to each core for changes, and to the GitHub repository for source.' An image of the Earth with a mesh overlay is also present.

**MPAS Overview**

The Model for Prediction Across Scales (MPAS) is a collaborative project for developing atmosphere, ocean and other earth-system simulation components for use in climate, regional climate and weather studies. The primary development partners are the climate modeling group at Los Alamos National Laboratory ([COSIM](#)) and the [National Center for Atmospheric Research](#). Both primary partners are responsible for the MPAS framework, operators and tools common to the applications; LANL has primary responsibility for the ocean and land ice models, and NCAR has primary responsibility for the atmospheric model.

The defining features of MPAS are the unstructured [Voronoi meshes](#) and [C-grid](#) discretization used as the basis for many of the model components. The unstructured Voronoi meshes, formally Spherical Centriodal Voronoi Tessellations (SCVTs), allow for both quasi-uniform discretization of the sphere and local refinement. The C-grid discretization, where the normal component of velocity on cell edges is prognosed, is especially well-suited for higher-resolution, mesoscale [atmosphere](#) and [ocean](#) simulations. The land ice model takes advantage of the SCVT-dual mesh, which is a triangular Delaunay tessellation appropriate for use with Finite-Element-based discretizations.

The current MPAS release is version 8.2.2. Please refer to each core for changes, and to the GitHub repository for source.



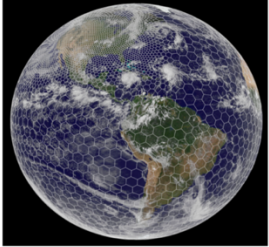


## MPAS-Atmosphere Tutorial (currently the 2024 virtual tutorial)

← → ↻ <https://www2.mmm.ucar.edu/projects/mpas/site/> [Google Lens](#) [📄](#) [🔖](#) [⬇️](#)

[📁](#) [NCAR Library Proxy](#) [Skamarock Home...](#) [Imported From Sa...](#) [RAP Real-Time We...](#) [MPAS](#) [NCAR Library](#) [Inbox - skamaroc...](#) [CAM-MPAS — Run...](#) [Home - Workday](#) [Home](#)

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### MPAS Atmosphere

Model for Prediction Across Scales - Atmosphere

Documentation +

Access Code +

GPU-enabled MPAS-A +

Visualization

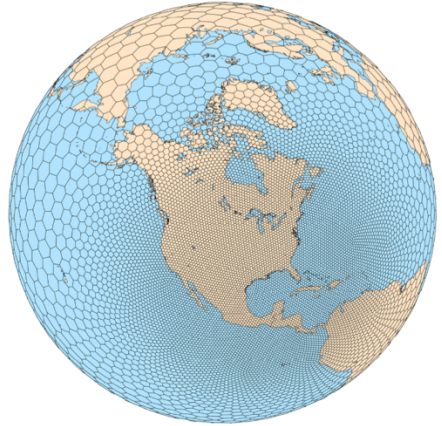
News & Events +

Publications

[Home](#) / [Model for Prediction Across Scales - Atmosphere](#) [↩️ View source](#) [GitHub](#)

## Model for Prediction Across Scales - Atmosphere

The atmospheric component of MPAS uses an unstructured centroidal Voronoi mesh (grid, or tessellation) and C-grid staggering of the state variables as the basis for the horizontal discretization in the fluid-flow solver. The unstructured variable resolution meshes can be generated having smoothly-varying mesh transitions (see figure (a) below), which ameliorates many issues associated with the traditional mesh refinement strategy of one-way and two-way grid nesting where the transitions are abrupt. The flexibility of the MPAS meshes allows for applications in high-resolution numerical weather prediction (NWP) and regional climate, in addition to global uniform-resolution NWP and climate applications.



### Documentation & Resources

- [Overview of MPAS-A](#)
- [MPAS-A User Guide](#)
- [MPAS-A Code Contributor Guide](#)
- [MPAS Mesh Specification](#)
- [MPAS-A Tutorial Practice Guide](#)
- [MPAS Data Assimilation](#)

### Access Code

Information and links to MPAS-A source code, static geographical datasets, meshes, and input files for real-data and idealized test cases



# MPAS-Atmosphere Resources

## WRF & MPAS-A Support Forum

You need to create an account to post to it.

Searchable

MPAS

Model for Prediction Across Scales

WRF & MPAS-A Support Forum

Forums What's new Tags Members Log in Register Search

New posts Search forums

WRF & MPAS-A Support Forum

Welcome to the [WRF/WRFDA/WRF-Chem/MPAS](#) Users' Support Forum, please read the guidelines & suggestions below.  
**\*WRFDA NOTICE\***

**Registration**

- You must create an account to post, first-time posts need manager approval and it may take 2-3 business days.

**Posting Threads**

Before posting, use the search utility to verify whether a solution to your inquiry already exists

- Post inquiries to the relevant forum and open a new thread for each new question. Do not post inquiries more than once.
- State the problem or error in the subject line and attach relative files - e.g., namelists, error logs
- Under "Options" check the boxes for "Watch this thread..." and "receive email notifications" to stay up to date on replies. Alternatively, click your name at the top of the forum site, and then "preferences" to choose notification options for the entire forum site.
- If the problem is related to compiling, please first see the [WRF/WPS Compiling web page](#).
- Add relevant tags to your thread (see [list of all tags](#)). [Contact us](#) if you need additional tags.
- There is no need to quote the previous post unless you are quoting a specific section. It is assumed your response is to the most recent submission.

**Latest posts**

- P** [WRF Default Landcover and Soil Texture dataset sources and citations](#)  
Latest: politeness · 23 minutes ago  
Weather Research and Forecasting (WRF) Model > WPS
- C** [UCM model Issue](#)  
Latest: climatwind · Today at 10:45 AM  
Weather Research and Forecasting (WRF) Model > WRF Model
- A** [dveg option for NOAH-MP LSM](#)  
Latest: Alessandro Delo · Today at 9:15 AM  
Weather Research and Forecasting (WRF) Model > WRF Model
- R** [QVAPOR vertical interpolation](#)  
Latest: Ruhee · Today at 7:11 AM  
Weather Research and Forecasting (WRF) Model > WRF Model
- P** [Dust chemistry in MOSAIC mechanism code](#)



MPAS virtual tutorial, 7-9 April 2025

## Under Development

- Large Eddy Simulation (LES) capability.
- Mesh generation, global and regional
- MPAS-Atmosphere Technical Note.
- Unified (MPAS, WRF, CM1) physics.
- NOAA physics used in the UFS and the WoFS.
- GOCART implementation
- Scalar transport in physics parameterizations (convection, boundary layer) for GOCART and chemistry.
- Earth System Model capabilities.
- GPU capability.

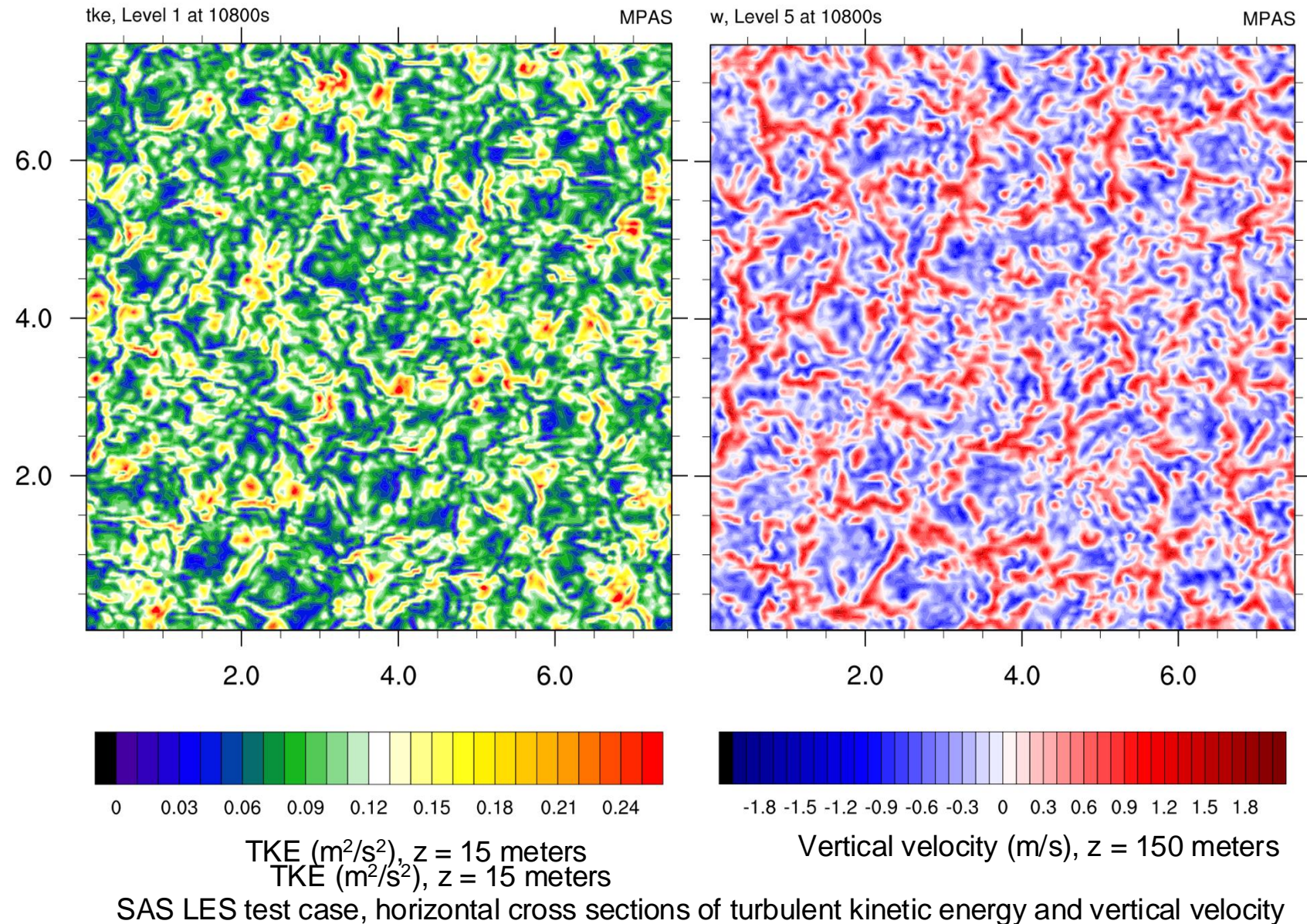
## LES capabilities in MPAS

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 a lot like WRF and CM1 results.

Extensions for terrain need implementing.

Release expected in 2025.



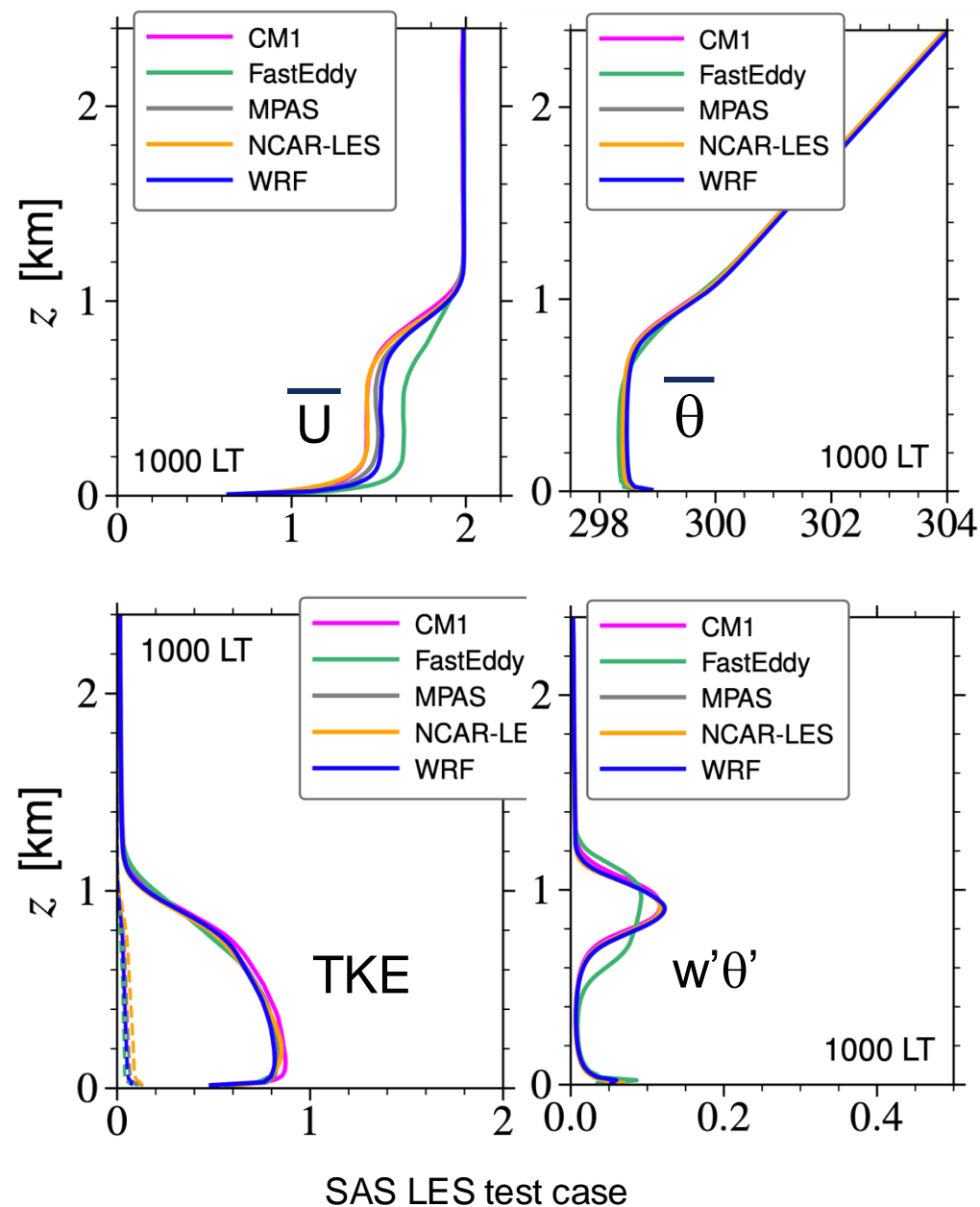
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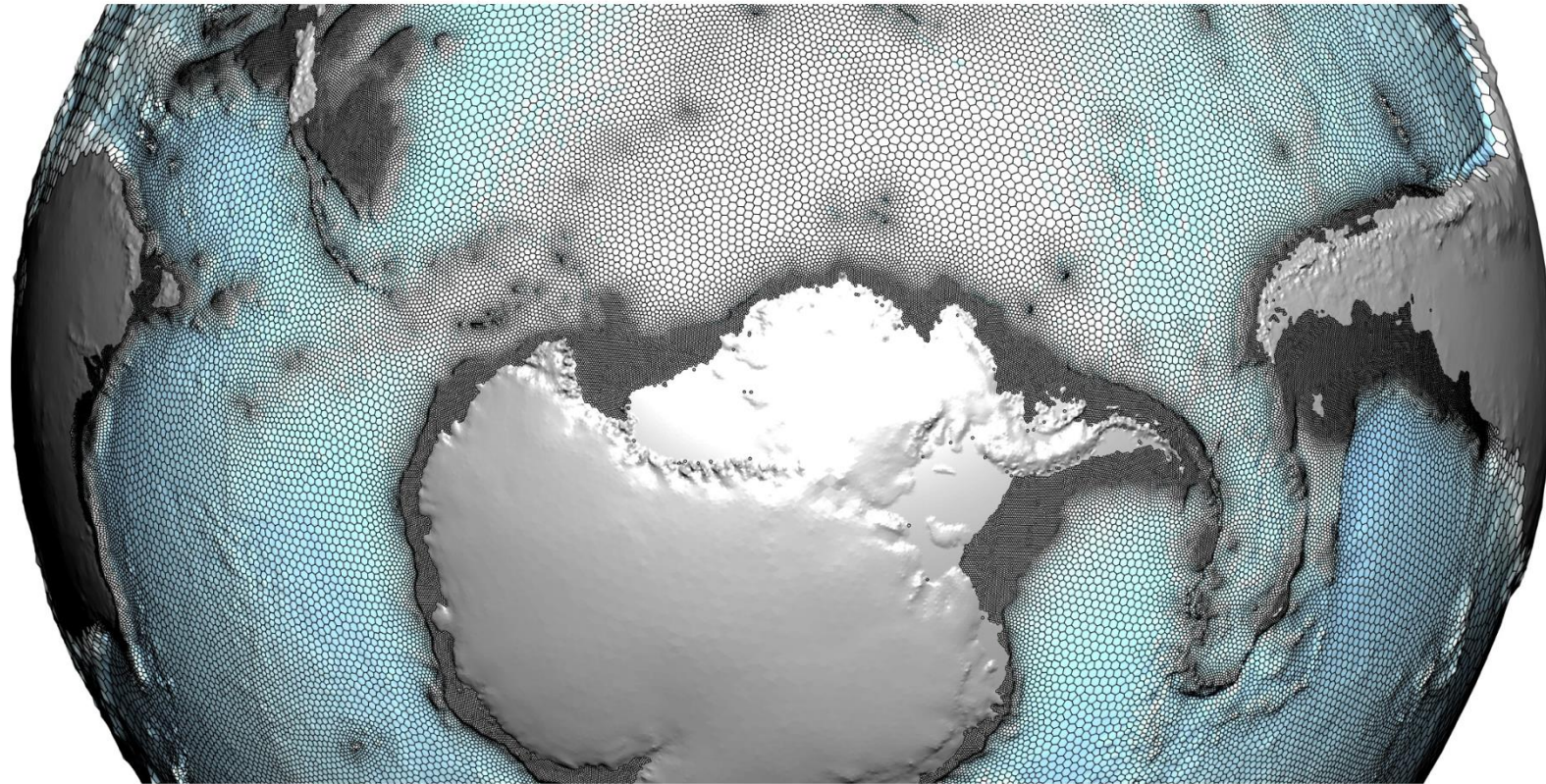
# Mesh Generation

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**

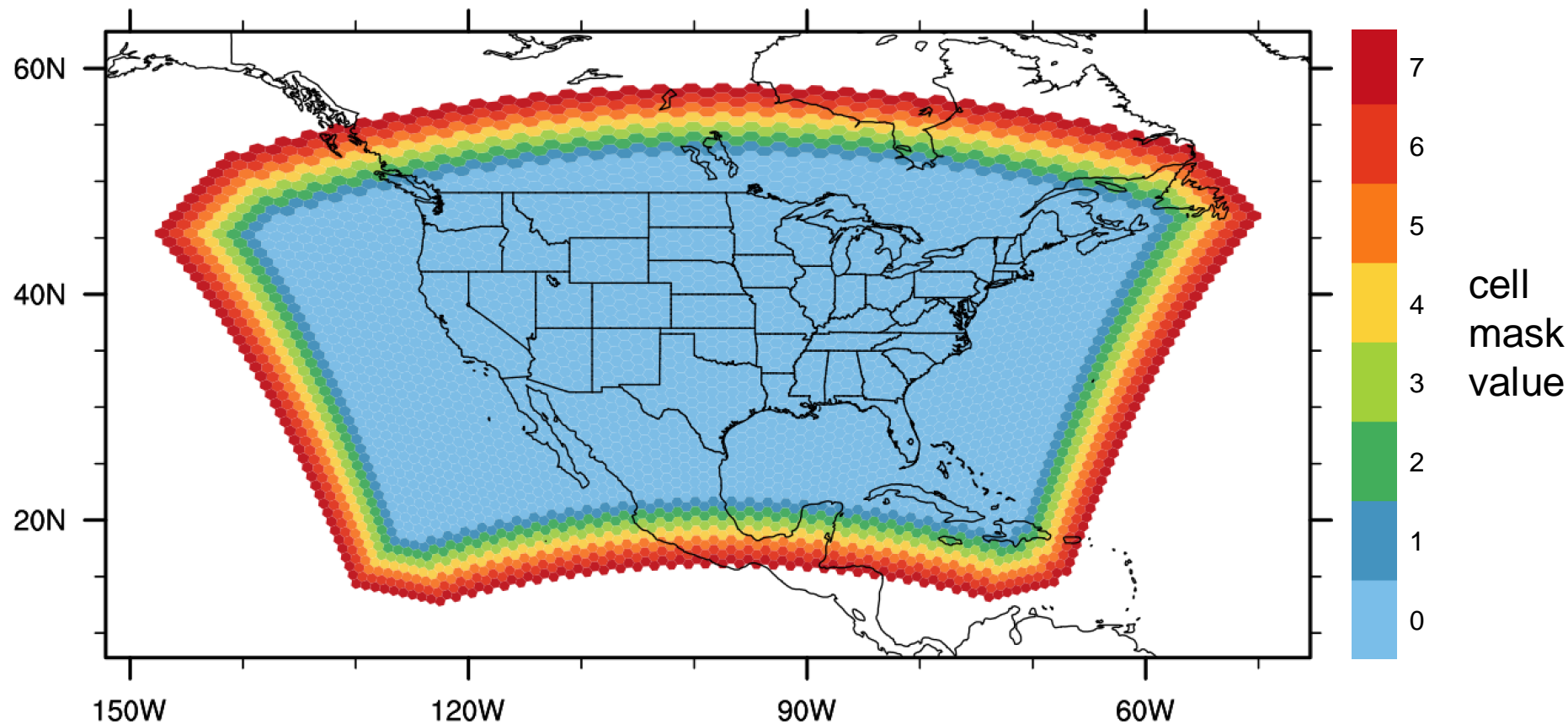


## Available on Github

<https://github.com/MPAS-Dev/MPAS-Tools.git>

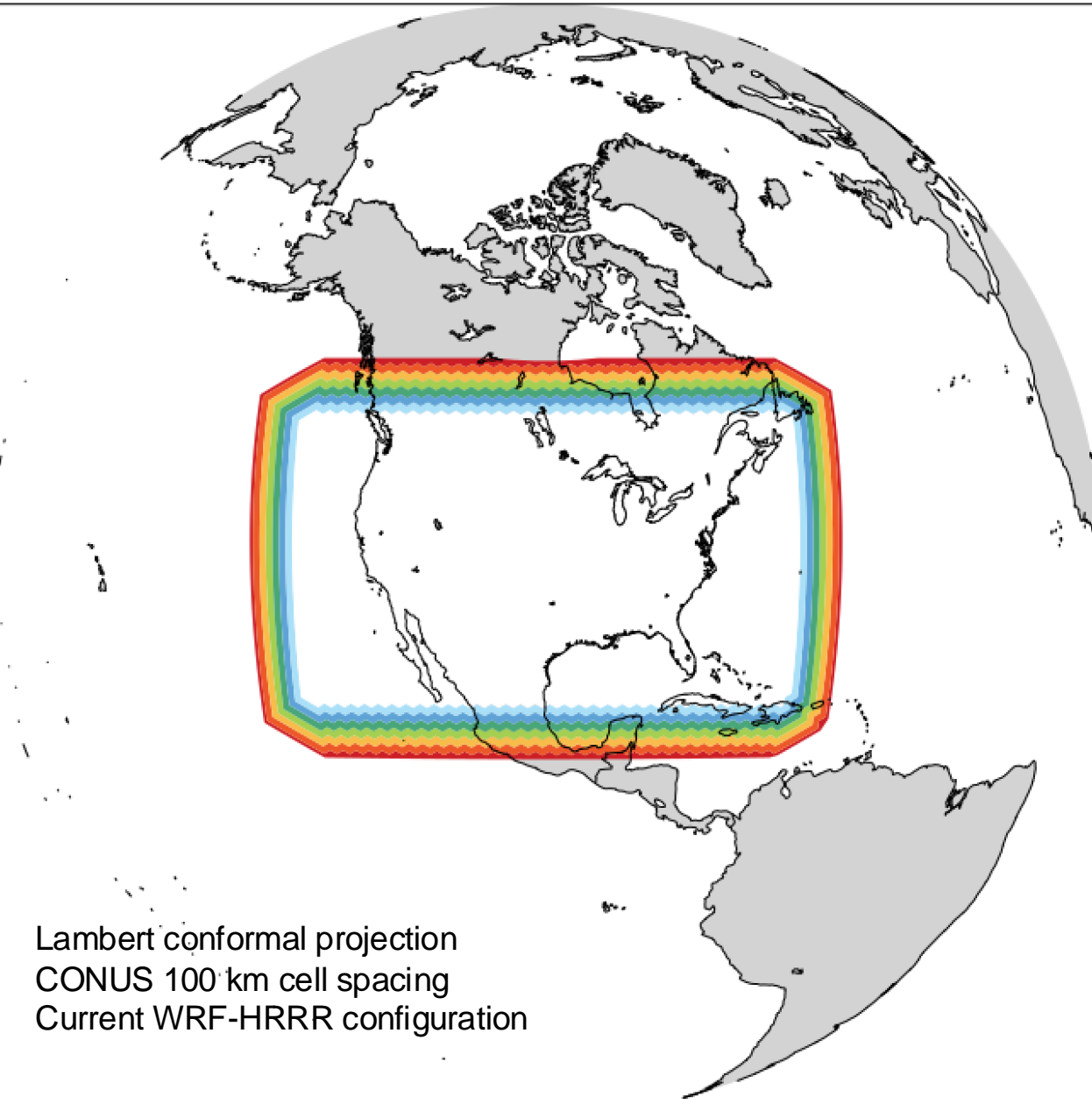
MPAS-Tools/mesh\_tools/hex\_projection

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



## MPAS regional mesh

Limited-area specified/relaxation zone index for cells



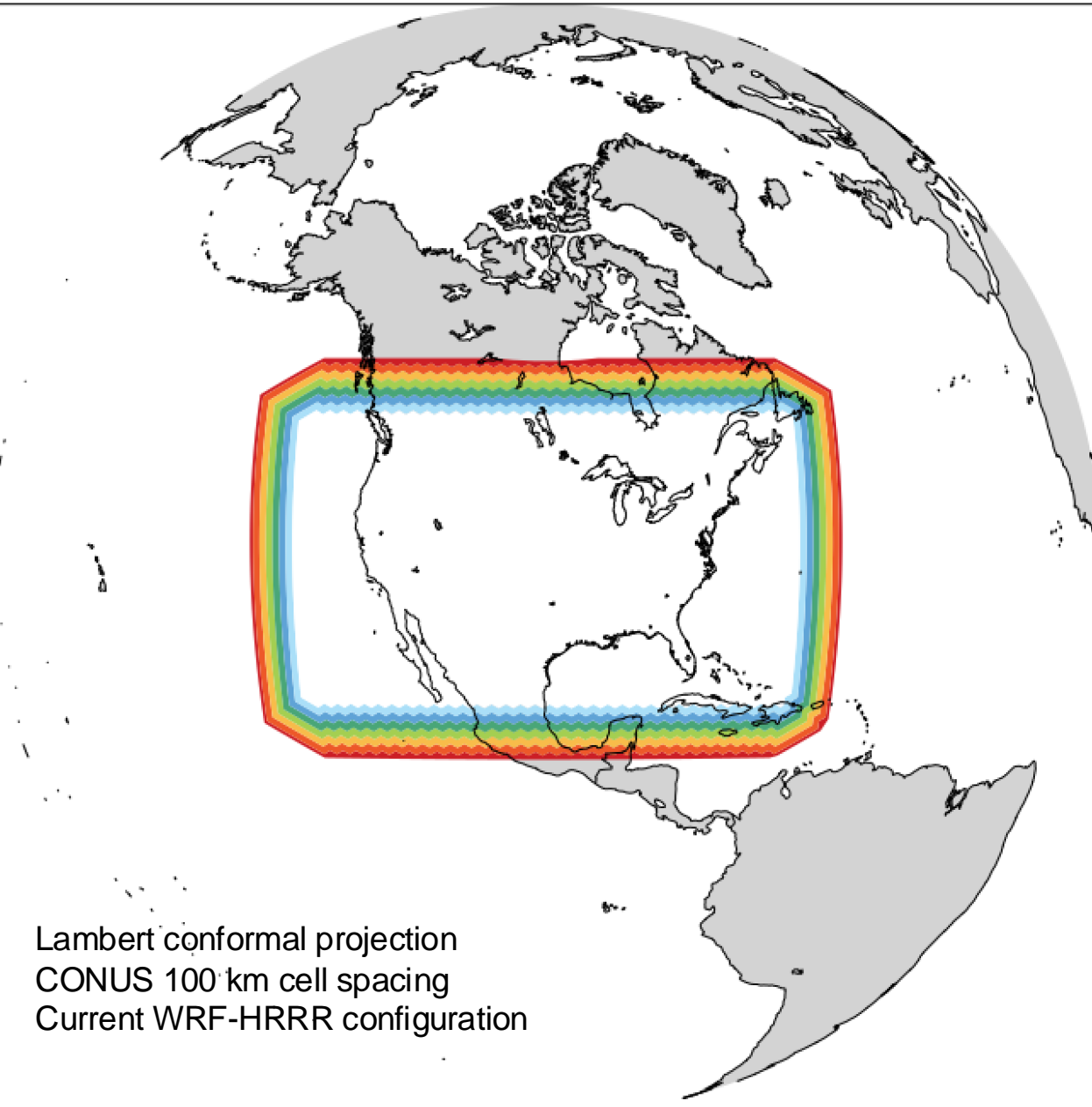
## Regional Mesh Generation

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



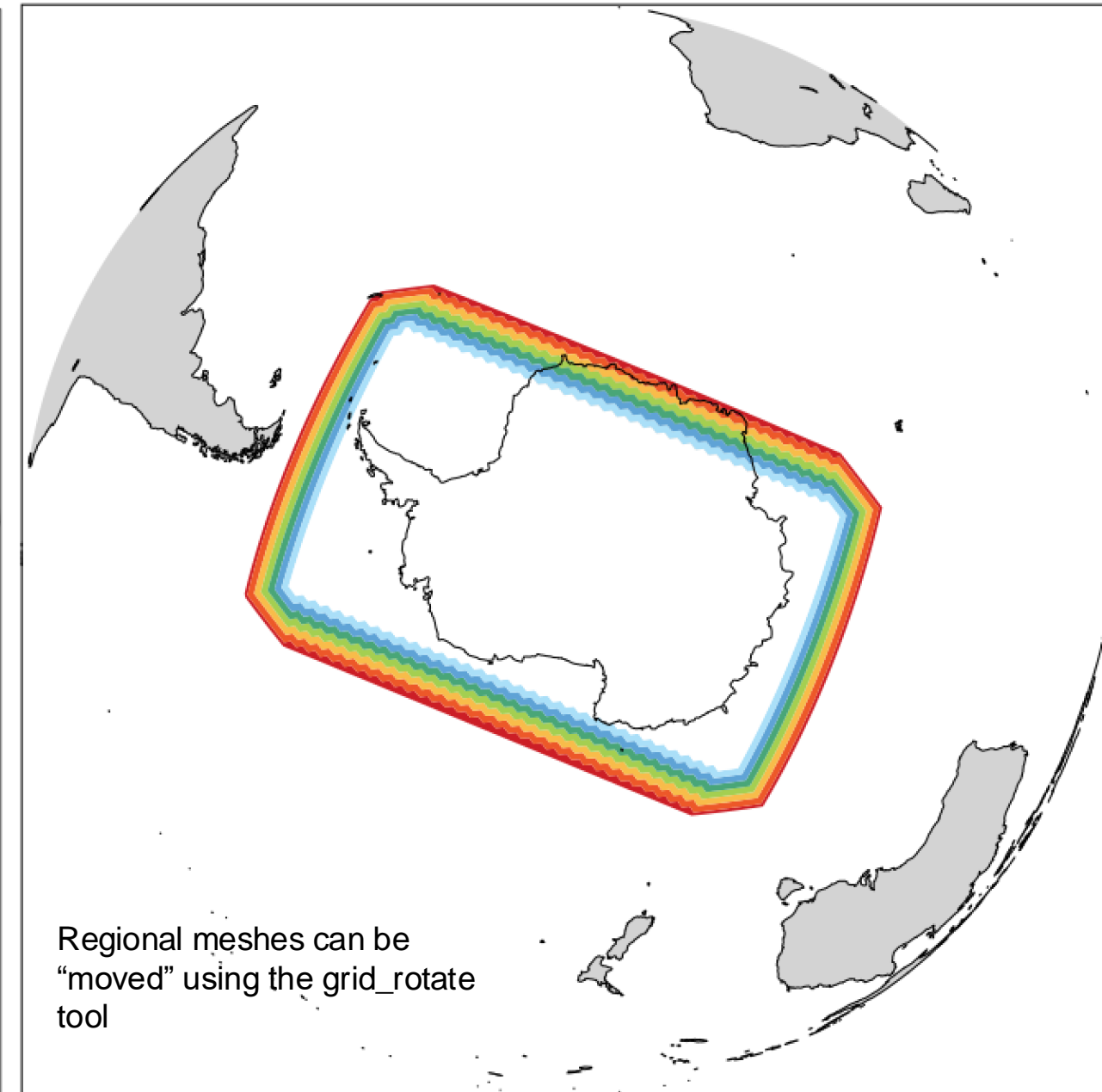
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Limited-area specified/relaxation zone index for cells



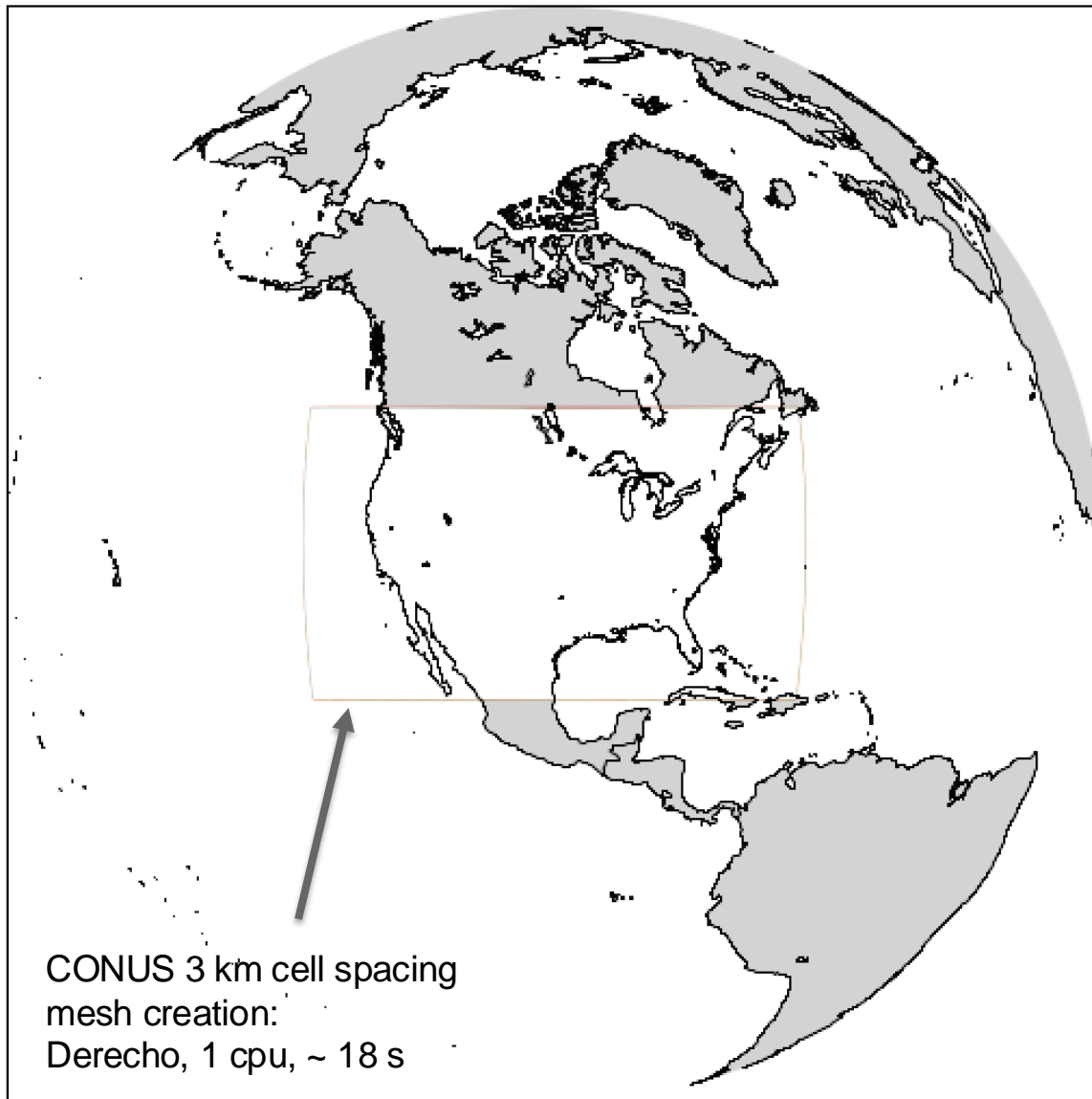
## MPAS regional mesh

Limited-area specified/relaxation zone index for cells



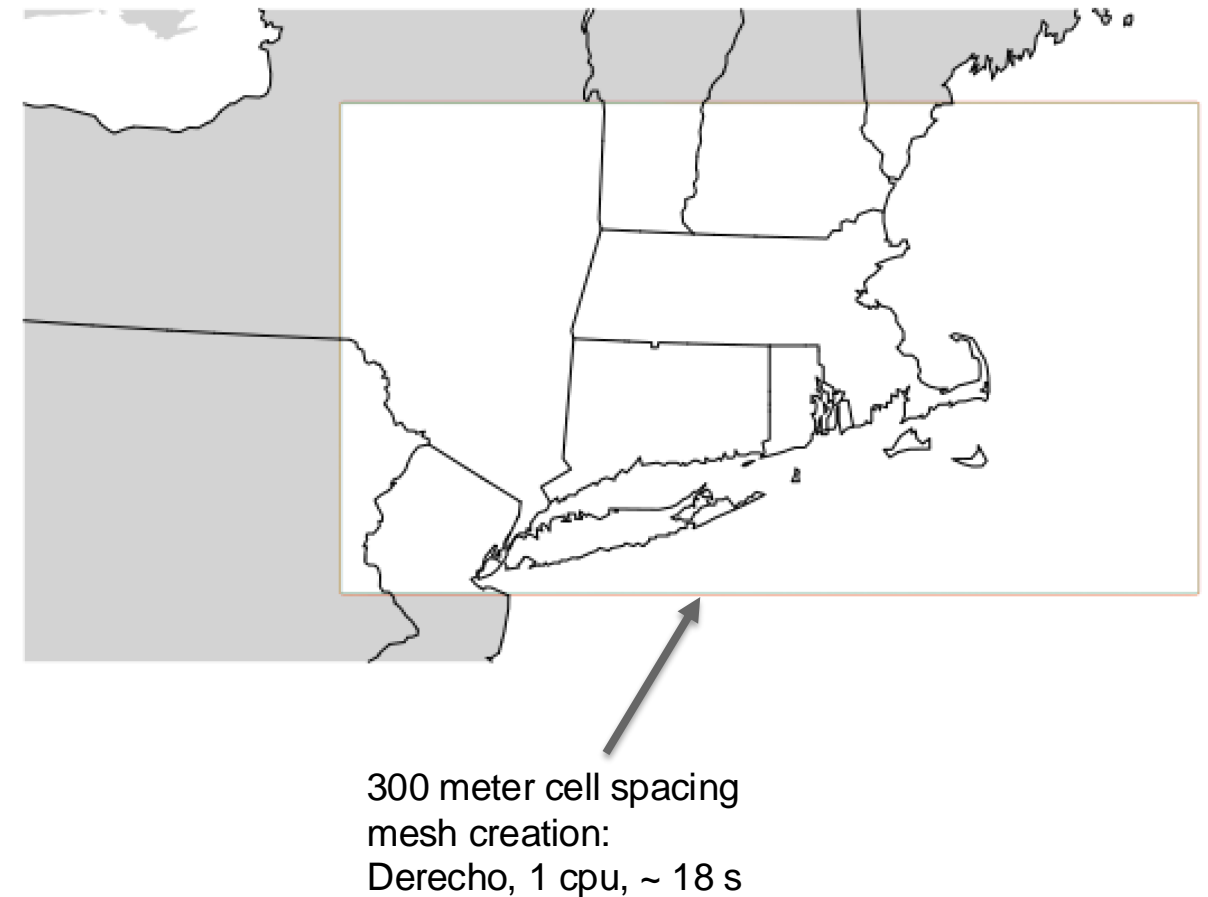
## MPAS regional mesh

Limited-area specified/relaxation zone index for cells



## MPAS regional mesh

Limited-area specified/relaxation zone index for cells



# 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 theorem applied to the MPAS dual triangular mesh. The relative vertical vorticity at vertex  $a$  is computed as

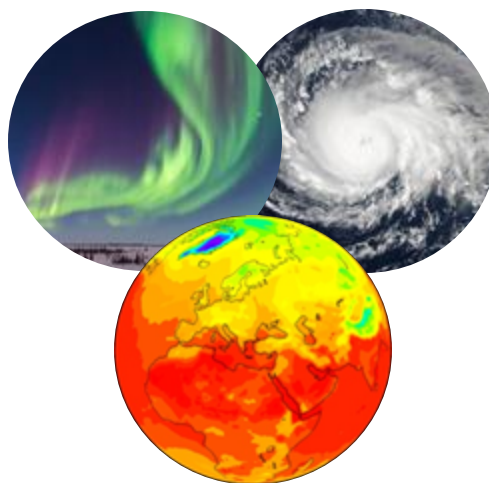
$$\zeta_a = \frac{u_{13} |\overrightarrow{CA}| t_{13,a} + u_{14} |\overrightarrow{AB}| t_{14,a} + u_{15} |\overrightarrow{BC}| t_{15,a}}{A_a}, \quad (4.27)$$

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  $\Omega$  is the angular velocity of the earth's rotation and  $\phi$  is the latitude.

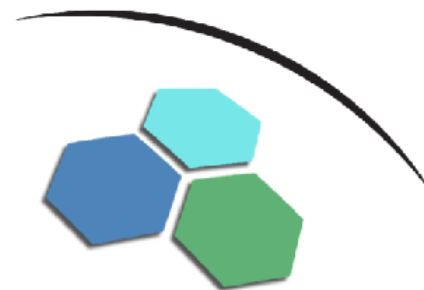
**MPAS code:** *The vertical vorticity is computed in subroutine `atm_compute_solve_diagnostics` found in `MPAS-Model/src/core_atmosphere/dynamics/mpas_atm_time_integration.F`. The relative vertical vorticity at a vertex  $\zeta_v$  is stored in the array `vorticity(level,vertex)`. The indicator function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

# The Model for Prediction Across Scales Atmosphere

## MPAS-A in Earth Systems Models



SIMA



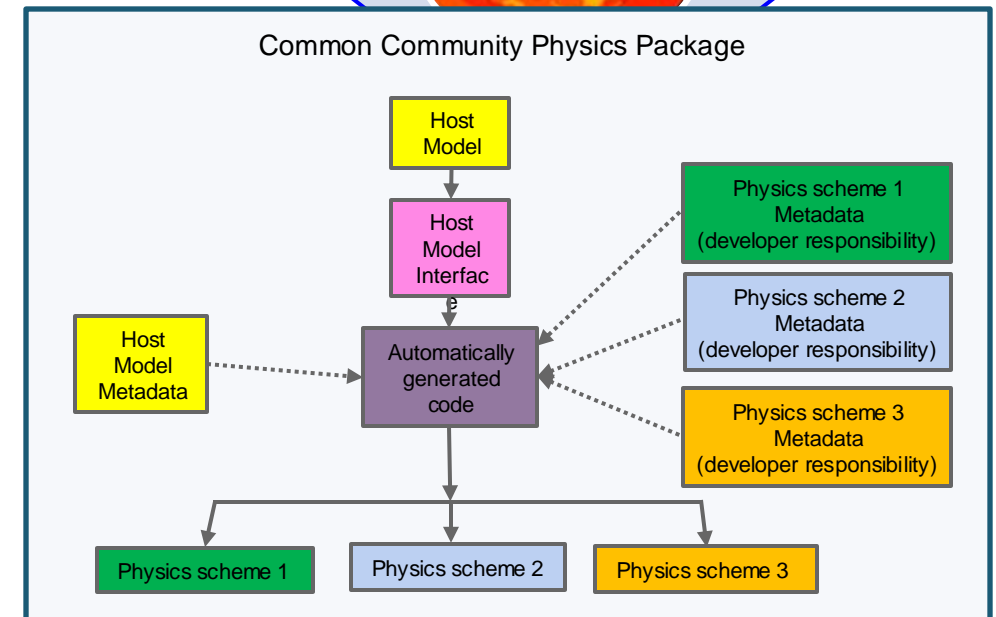
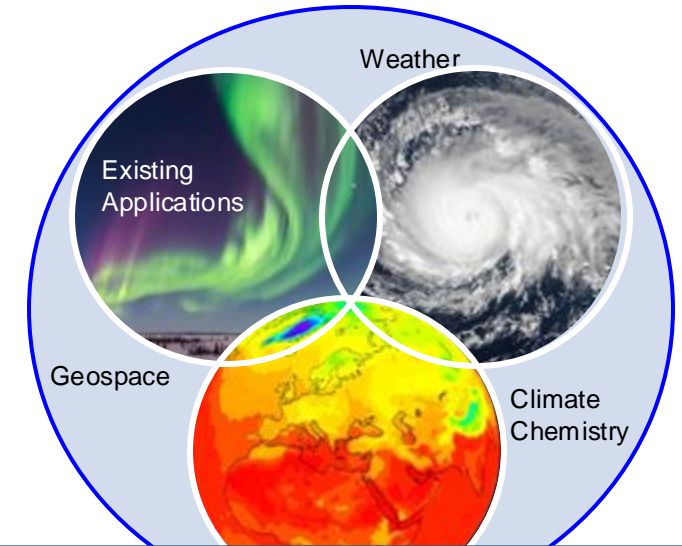
EarthWorks

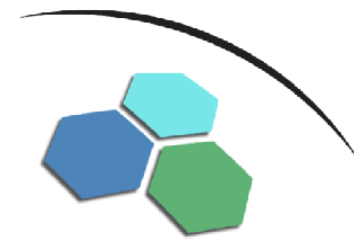
## System for Integrated Modeling of the Atmosphere (SIMA)

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

### Status:

- *MPAS-A in CESM is being tested.*
- *Only CESM/CAM physics will be available in a first release with MPAS-Atmosphere.*
- *Initial release (experimental) TBD.*

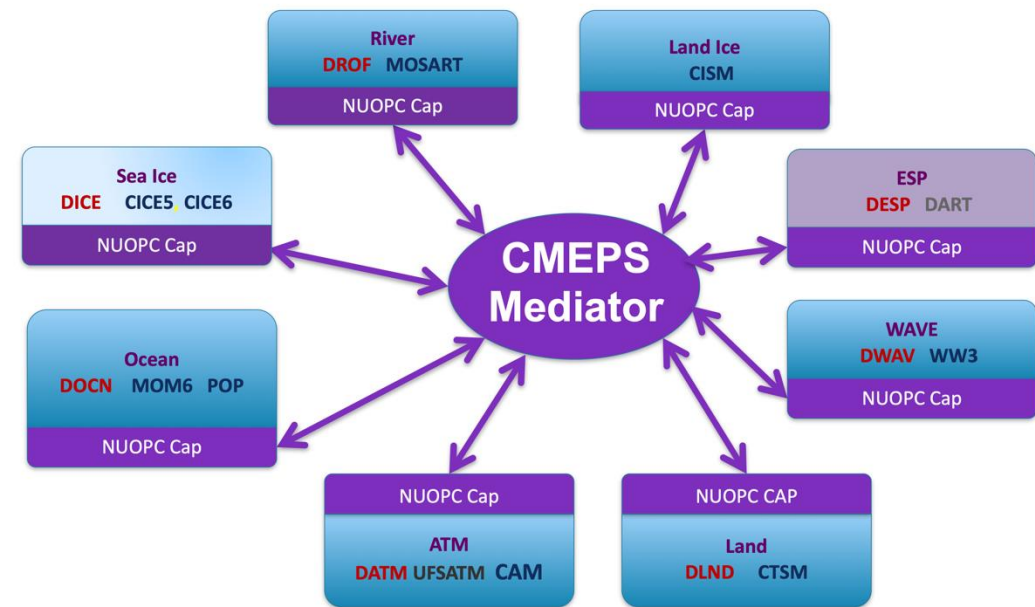


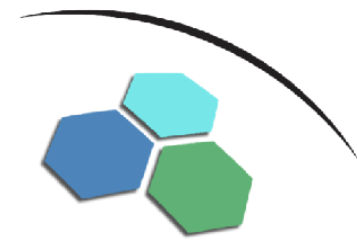


EarthWorks is a five-year university-based project (CSU), supported by NSF/CISE, to develop a *global convection-permitting coupled model* based on the CESM with GPU capability for all components.

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)

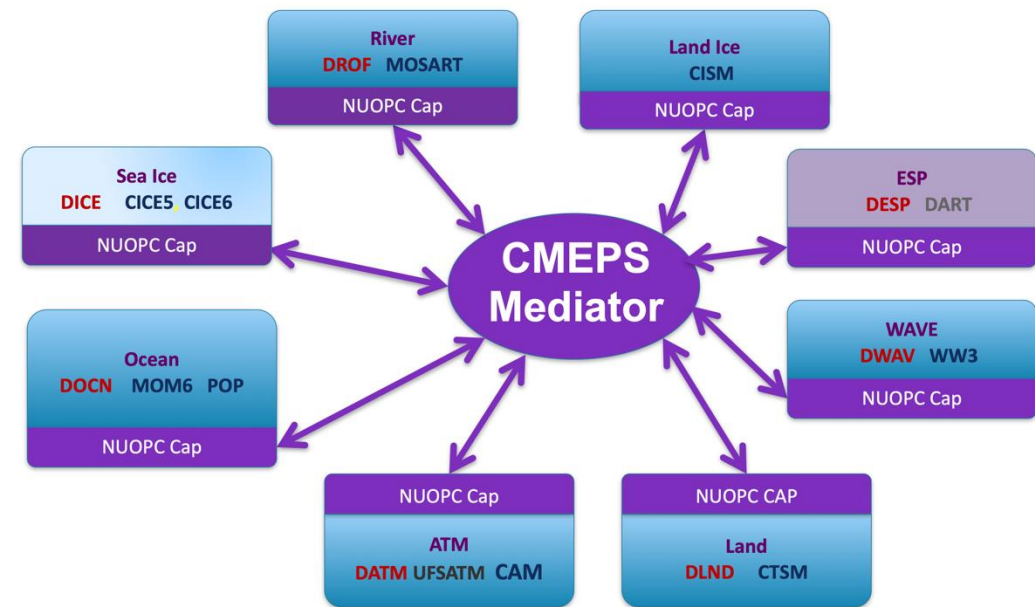




EarthWorks is available now in a first “functional” release:  
[git clone https://github.com/EarthWorksOrg/EarthWorks.git](https://github.com/EarthWorksOrg/EarthWorks.git)

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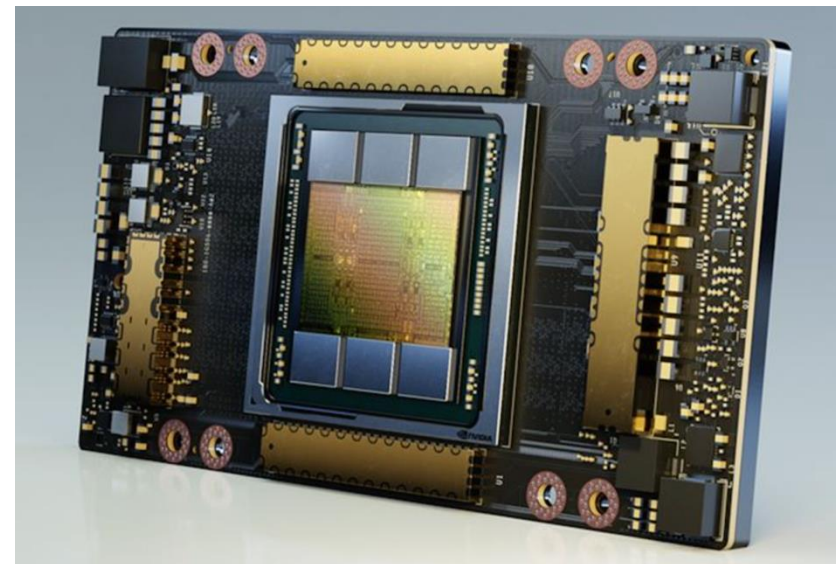


## MPAS and GPUs

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.

GPU implementation for MPAS-Atmosphere

<https://mpas-dev.github.io/atmosphere/OpenACC/index.html>



NVIDIA Ampere A100 GPU

What is in current GPU 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

Based on our experience with the existing separate release, we are re-implementing this capability in the main MPAS release.

- Initial (partial) GPU capability has been released and in MPAS v8.2.0 (transport in the dynamics).
- 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.*

# Coming Events

MPAS-WRF workshop: 3-6 June 2025 (in person (Boulder CO), plus virtual option)  
<https://www.mmm.ucar.edu/events/workshops/wrf-mpas>

We've begun work on an MPAS NCAR Technical Note. Draft release before the MPAS-WRF workshop?

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

- April 2025 (this one).
- Fall 2025 (in person, dates TBD)

Feature and bug releases occur whenever components are ready.