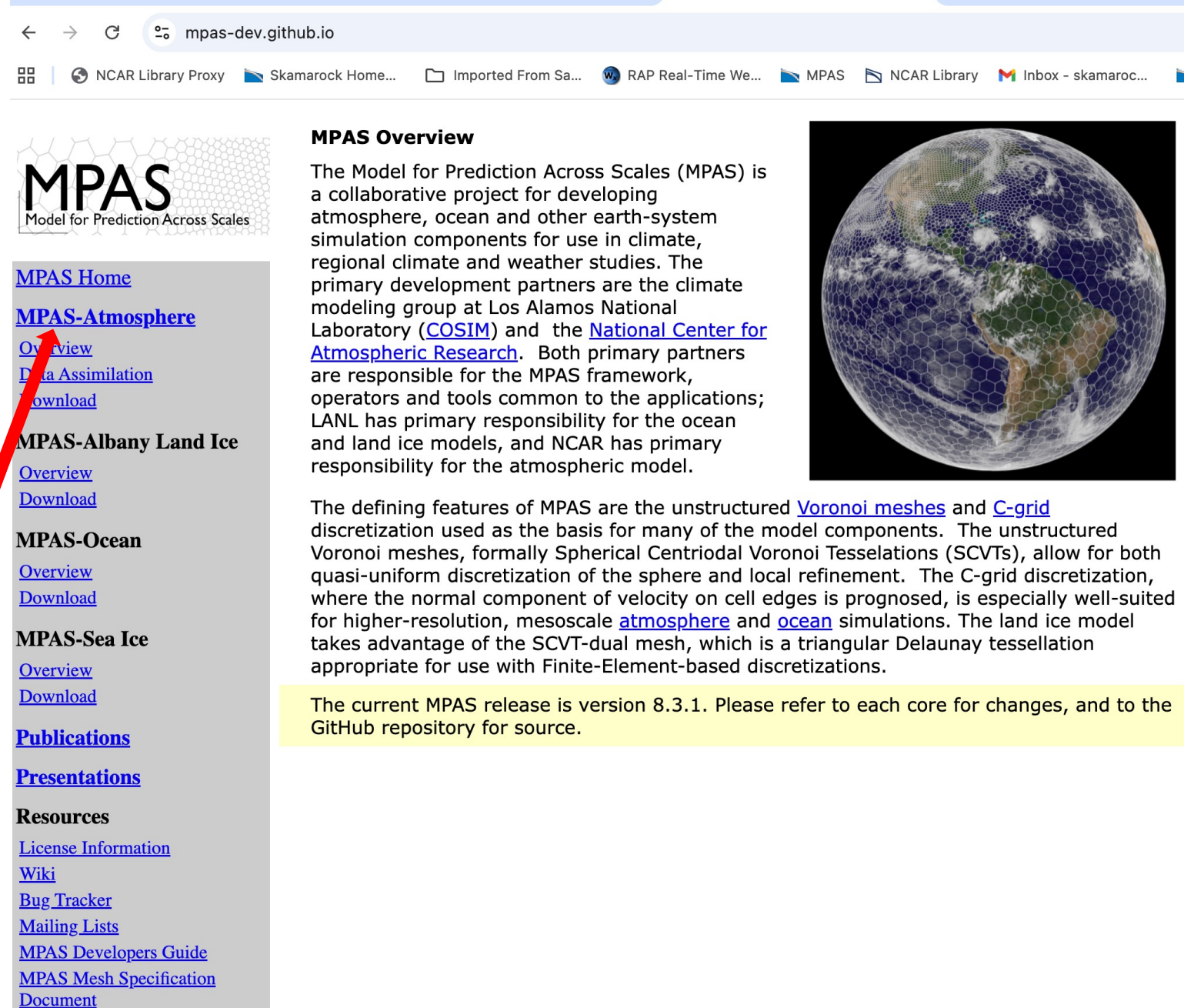


The Github MPAS web page

MPAS-Atmosphere

*All MPAS-A links will take
you to the new web pages*



The screenshot shows the MPAS-Atmosphere GitHub 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), 'MPAS-Albany Land Ice', 'MPAS-Ocean', 'MPAS-Sea Ice', 'Publications', 'Presentations', and 'Resources'. The main content area includes an 'MPAS Overview' section, a globe image with a mesh overlay, and a text block about the current release (version 8.3.1).

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 8.3.1. Please refer to each core for changes, and to the GitHub repository for source.



The new
MPAS-Atmosphere
web page

MPAS-Atmosphere
Users Guide

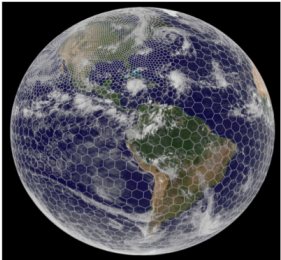
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News & Events

Contact

Support Forum

Site Map





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Downloads

GPU-enabled MPAS-A

Visualization

News & Events

Publications

Search this project

Home / Model for Prediction Across Scales - Atmosphere

View source

GitHub

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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 Technical Description

MPAS Mesh Specification

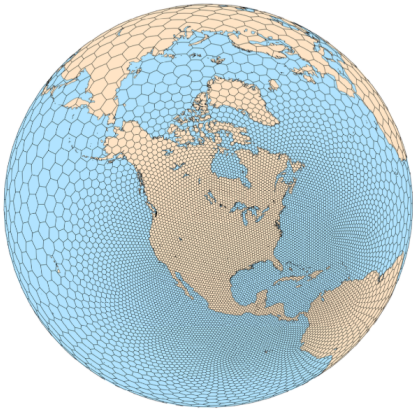
MPAS-A Tutorial Practice Guide

MPAS Data Assimilation

MPAS-JEDI Tutorial Practice Guide

Access Code, Data, & Meshes

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





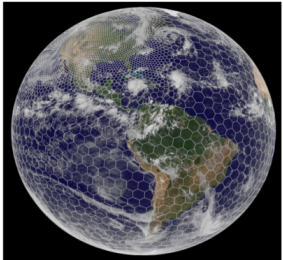
—

MPAS Tutorial, 12-14 January 2026

www2.mmm.ucar.edu/projects/mpas/site/index.html

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News & Events

Publications

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Model for Prediction Across Scales - Atmosphere

The atmospheric component of MPAS uses an unstructured Voronoi mesh (grid, or tessellation) and C-grid variables as the basis for the horizontal discretization. The unstructured variable resolution mesh allows for having smoothly-varying mesh transitions (see Figure 1) which ameliorates many issues associated with the traditional strategy of one-way and two-way grid nesting which is abrupt. The flexibility of the MPAS meshes allows for high resolution numerical weather prediction (NWP) in addition to global uniform-resolution NWP and climate simulations.

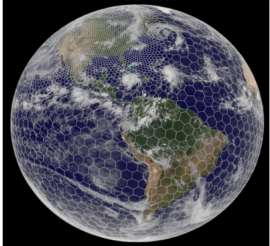
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- MPAS-A Technical Description
- MPAS Mesh Specification
- MPAS-A Tutorial Practice Guide
- MPAS Data Assimilation
- MPAS-JEDI Tutorial Practice Guide

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MPAS Atmosphere

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- Overview of MPAS-A
- Users' Guide +
- MPAS-A Technical Description
- MPAS Tutorial Practice Guide
- Mesh Specification
- MPAS Data Assimilation
- MPAS-JEDI Tutorial Practice Guide

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News & Events

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MPAS Documentation and Resources

Click the links below to access documentation resources for MPAS-A.

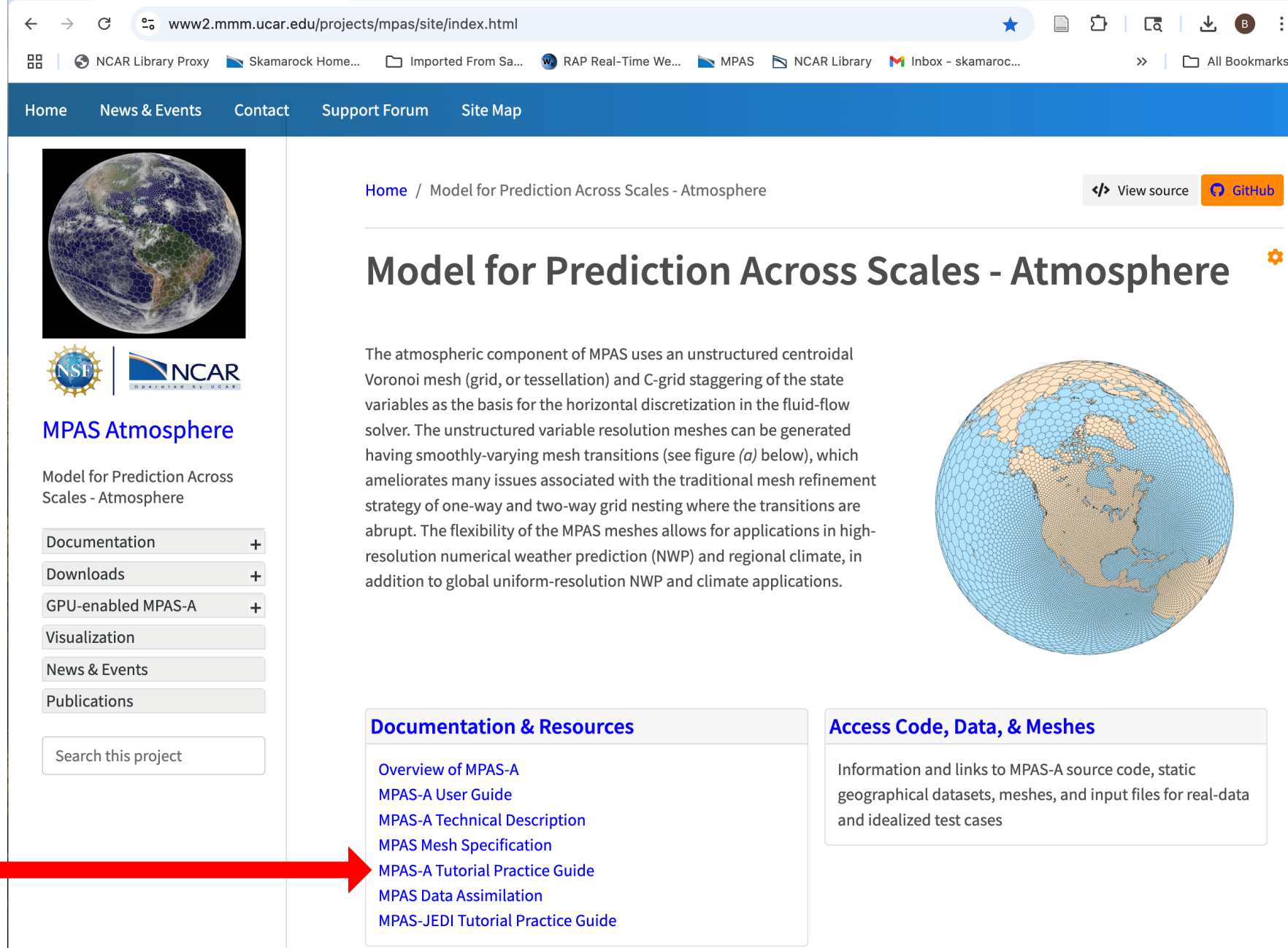
- Overview of MPAS-A
- MPAS-A Users' Guide (pdf)
- MPAS-A Technical Description
- MPAS Mesh Specification
- MPAS-A Tutorial Practice Guide
- MPAS Data Assimilation
- MPAS-JEDI Tutorial Practice Guide

pdf version of the User's guide
(updated with each new feature release)

MPAS

Model for Prediction Across Scales

MPAS-Atmosphere Tutorial (currently the spring 2025 virtual tutorial)



The screenshot shows the MPAS website interface. The top navigation bar includes links for Home, News & Events, Contact, Support Forum, and Site Map. The main content area is titled "Model for Prediction Across Scales - Atmosphere". It features a large image of Earth with a mesh overlay, a sidebar with navigation links (Documentation, Downloads, GPU-enabled MPAS-A, Visualization, News & Events, Publications), and a main text area describing the atmospheric component of MPAS. A red arrow points from the text "currently the spring 2025 virtual tutorial" to the "MPAS-A Tutorial Practice Guide" link in the "Documentation & Resources" section.

Home / Model for Prediction Across Scales - Atmosphere

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

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- [MPAS-A User Guide](#)
- [MPAS-A Technical Description](#)
- [MPAS Mesh Specification](#)
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Information and links to MPAS-A source code, static geographical datasets, meshes, and input files for real-data and idealized test cases

MPAS

Model for Prediction Across Scales

MPAS-Atmosphere Technical Note *2025 draft*

www2.mmm.ucar.edu/projects/mpas/site/index.html

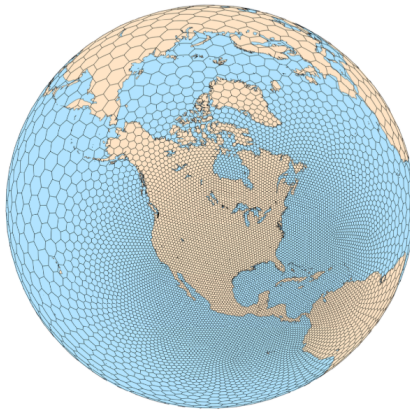
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Technical Note Example

5.1.2 4th-Order Horizontal Filter

The continuous form for the fourth-order horizontal filter is given by the RHS term for the update equation for a scalar ϕ :

$$\frac{\partial(\tilde{\rho}_d \phi)}{\partial t} = \dots - \nabla \cdot (\tilde{\rho}_d \nu_4 \nabla (\nabla_\zeta \cdot \nabla_\zeta \phi)), \quad (5.4)$$

where the hyperviscosity ν_4 has units $m^4 s^{-1}$. Defining a discrete turbulent flux divergence operator $T_2(\phi)$ as

$$\nabla_\zeta \cdot \nabla_\zeta \phi \rightarrow \frac{1}{A_i} \sum_{e_i} L_{e_i} (\mathbf{n}_{e_i} \cdot \nabla \phi) = T_2(\phi), \quad (5.5)$$

Continuous and discrete operators

we can write the discrete 4th-order filter term as

$$\nabla \cdot (\tilde{\rho}_d \nu_4 \nabla (\nabla_\zeta \cdot \nabla_\zeta \phi)) \rightarrow \frac{1}{A_i} \sum_{e_i} L_{e_i} \tilde{\rho}_d \nu_4 (\mathbf{n}_{e_i} \cdot \nabla T_2(\phi)). \quad (5.6)$$

The hyperviscosity ν_4 is constant in the current MPAS implementation, thus there is no averaging operator applied to it. As in the second-order filter, the density at the cell edges is an average of the densities from the cell centers of the two cells sharing the edge for vertically unstaggered variables (θ). The density will also be averaged in z when the filter is applied to w .

Locations in the code where specific computations take place, along with implementation notes

MPAS code: The second-order and fourth-order horizontal filtering for θ and w are computed in *subroutine atm_compute_dyn_tend* in *MPAS-Model/src/core_atmosphere/dynamics/mpas_atm_time_integration.F*. The computations occur only once in each dynamics timestep, during the first RK3 substep. When the 4th-order filter is applied, the turbulent flux divergences from the 2nd-order filter application (5.5) are saved and used in the second application of the turbulent flux divergence operator (5.6) needed to complete the 4th-order operator.



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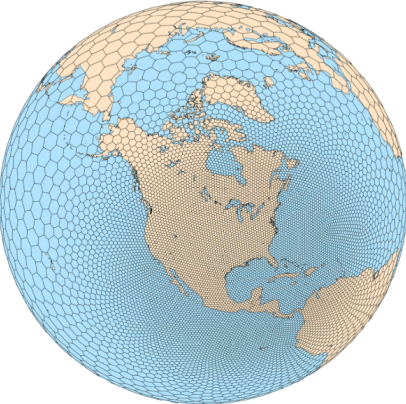
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- [MPAS-A Technical Description](#)
- [MPAS Mesh Specification](#)
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MPAS-Atmosphere
support forum



MPAS-Atmosphere Resources

WRF & MPAS-A Support Forum

You need to create an account to post to it.

Searchable

Under Development

- Large Eddy Simulation (LES) capability.
- Mesh generation, global and regional
- NOAA physics used in the UFS and the WoFS.
- Chemistry: CheMPAS
- Scalar transport in physics parameterizations (convection, boundary layer) for GOCART and chemistry.
- Earth System Model capabilities.
- GPU capability.

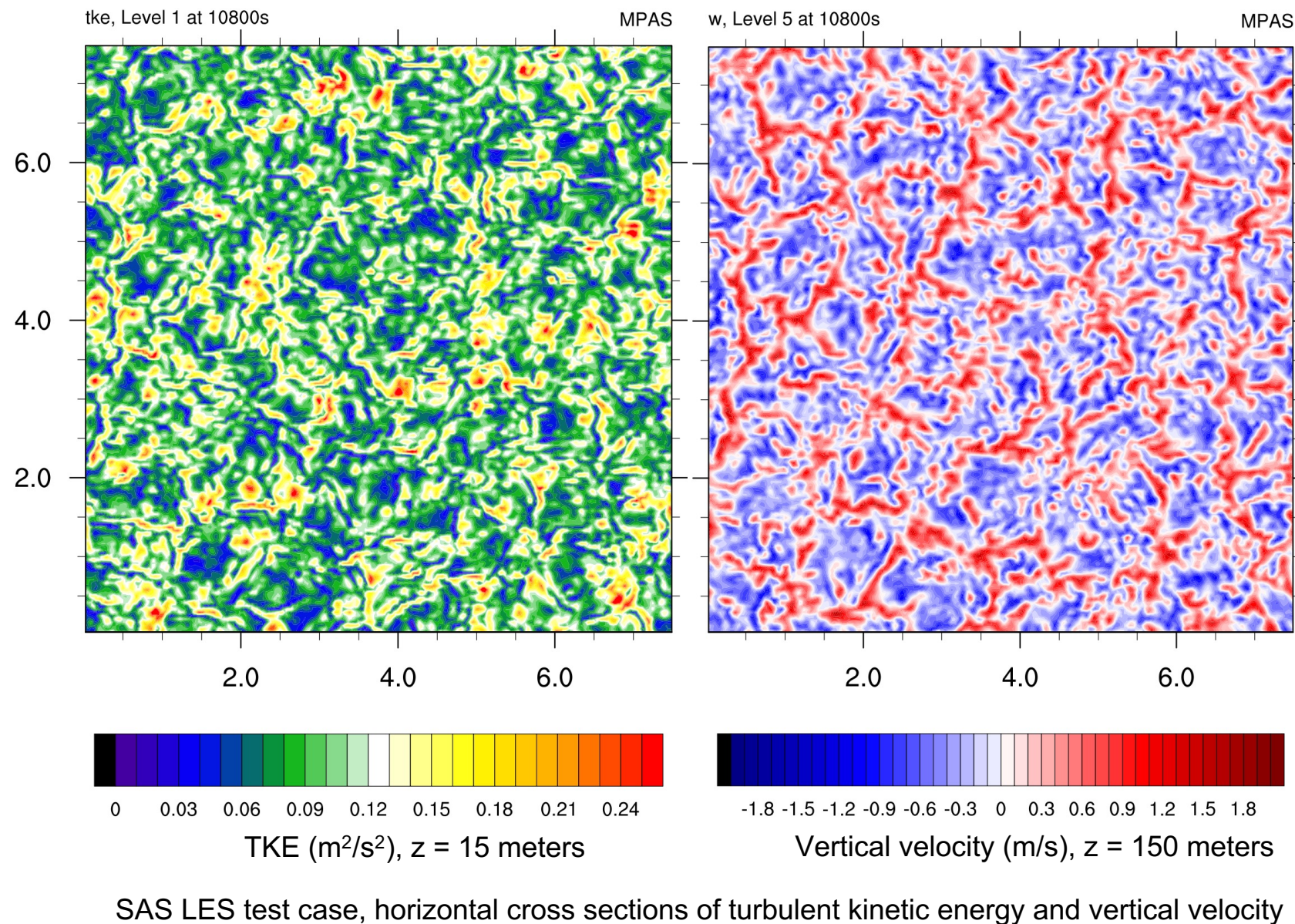
LES capabilities in MPAS

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 2026.



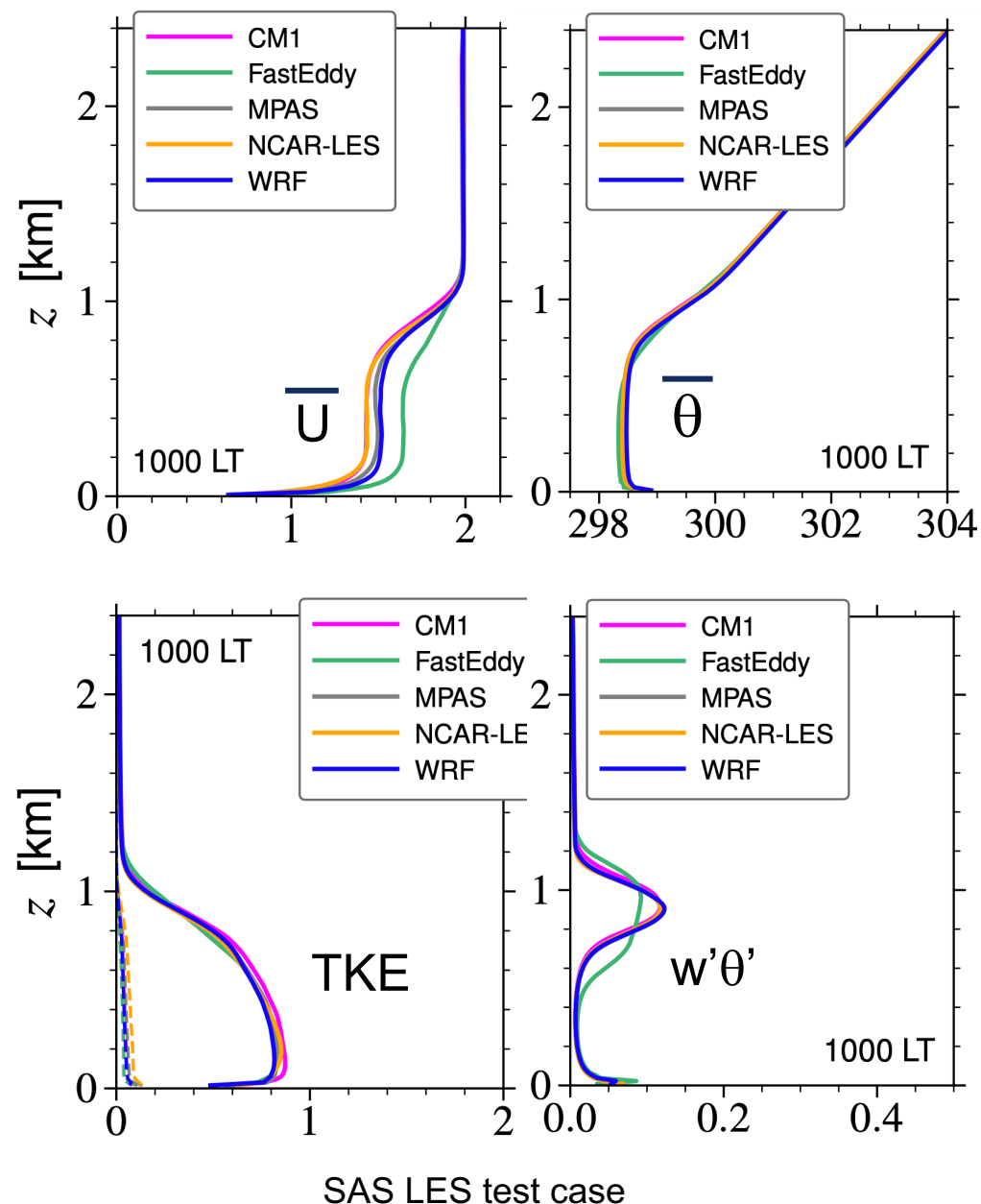
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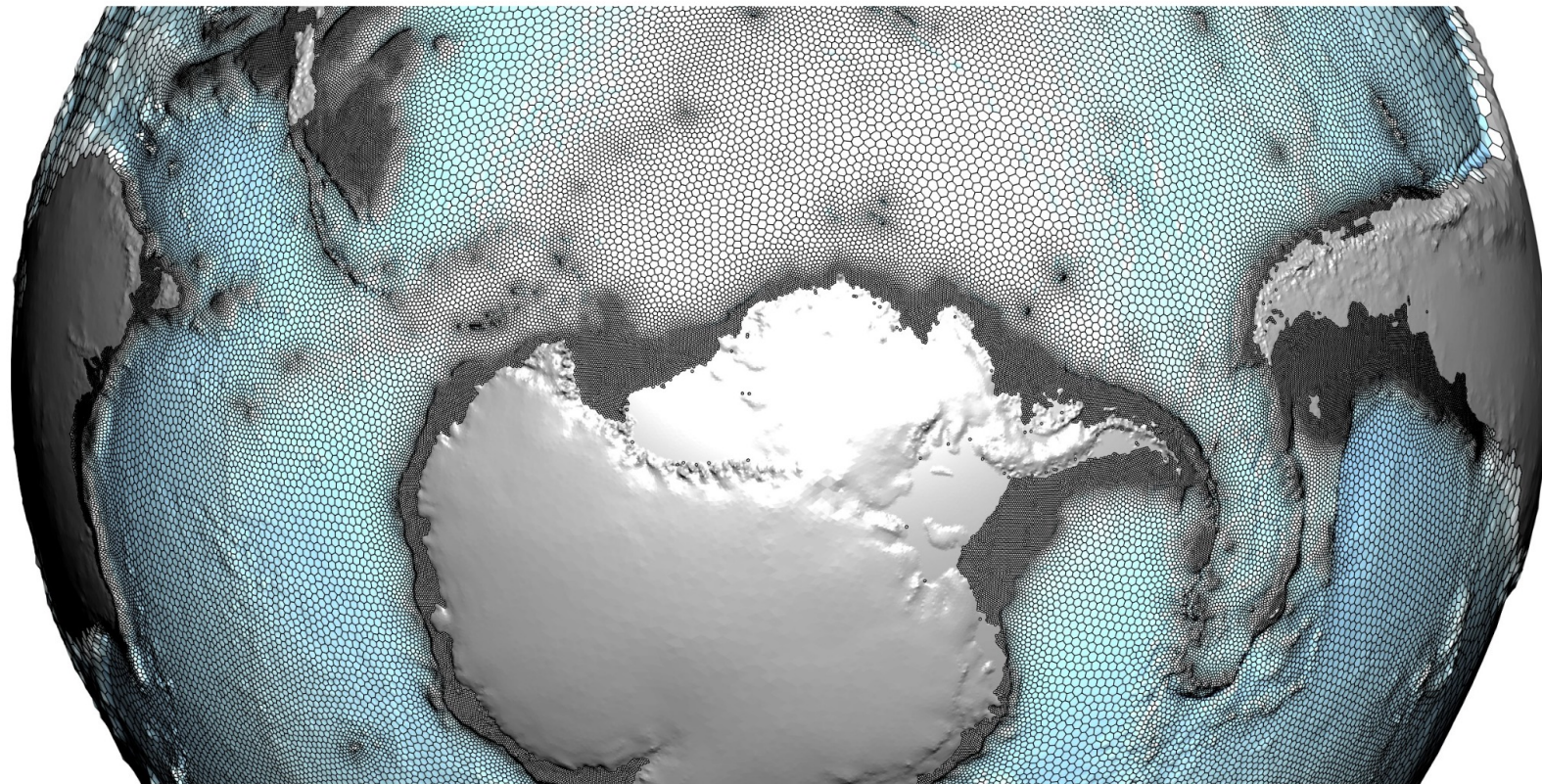
Mesh Generation

JIGSAW(GEO): Mesh generation for geoscientific modelling

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

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

Darren Engwirda



NOAA Physics in MPAS

- (1) The MPAS dynamical core will be used in the Rapid Refresh Forecast System (RRFS) Version 2
- (2) The MPAS-Atmosphere model will be used in the next version of the Warn-on Forecast System (WoFS)
- (3) NOAA is examining global configurations using the MPAS dynamical core.

NOAA is contributing their physics to the community release of MPAS that are used in their MPAS-based pre-operational prototypes.

RRFS: MYNN PBL*, TEMPO microphysics*, IGW gravity-wave drag (in MPAS V8.3.1), Noah-MP land model
*release by the June 2026 MPAS-WRF Workshop

WoFS: multiple PBL schemes, NSSL-2M microphysics (release expected at the end of this month).

Global Forecast System (GFS, part of the UFS) physics (ozone, etc)

*These physics will be pulled from the authoritative NOAA repositories in the MPAS build.
NOAA physics developers will now also be MPAS developers.*



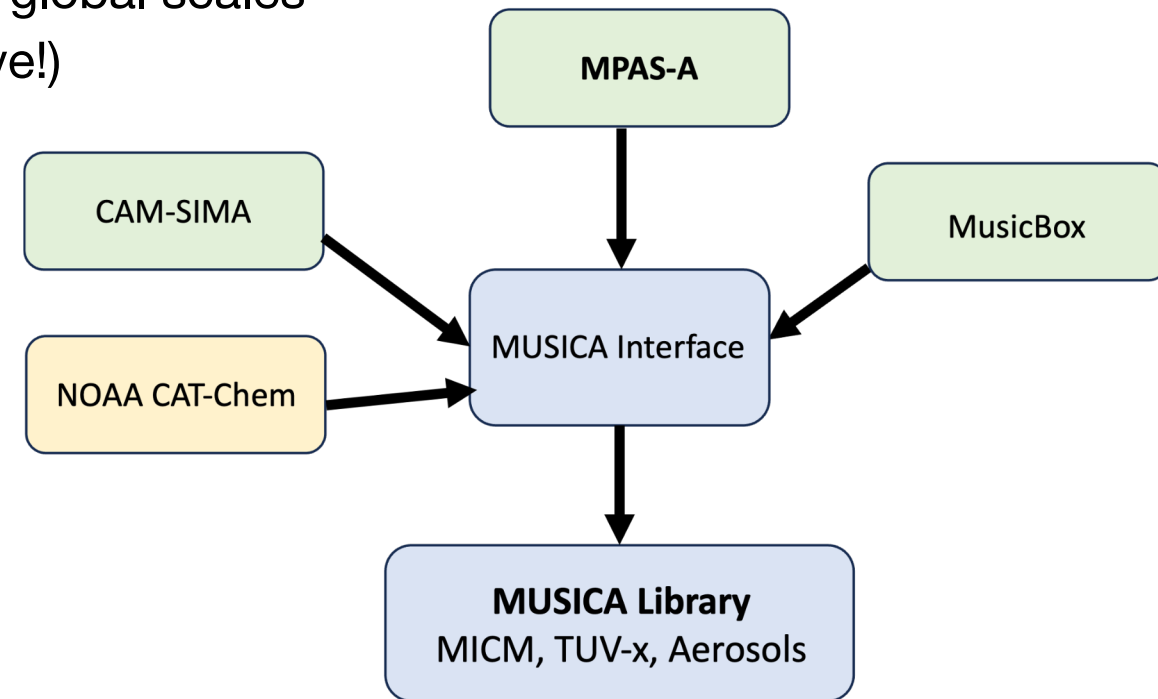
Ongoing Developments: CheMPAS

- Integrating Chemistry into MPAS-A
 - A successor to WRF-Chem
 - Flexible and state-of-the-art modeling
 - Community co-development
 - New frontier science covering micro, meso and global scales
 - Provide a GPU capability (chemistry is expensive!)
 - Compatible with JEDI data assimilation

Integrate the **MUSICA** library in MPAS-A

MUSICA

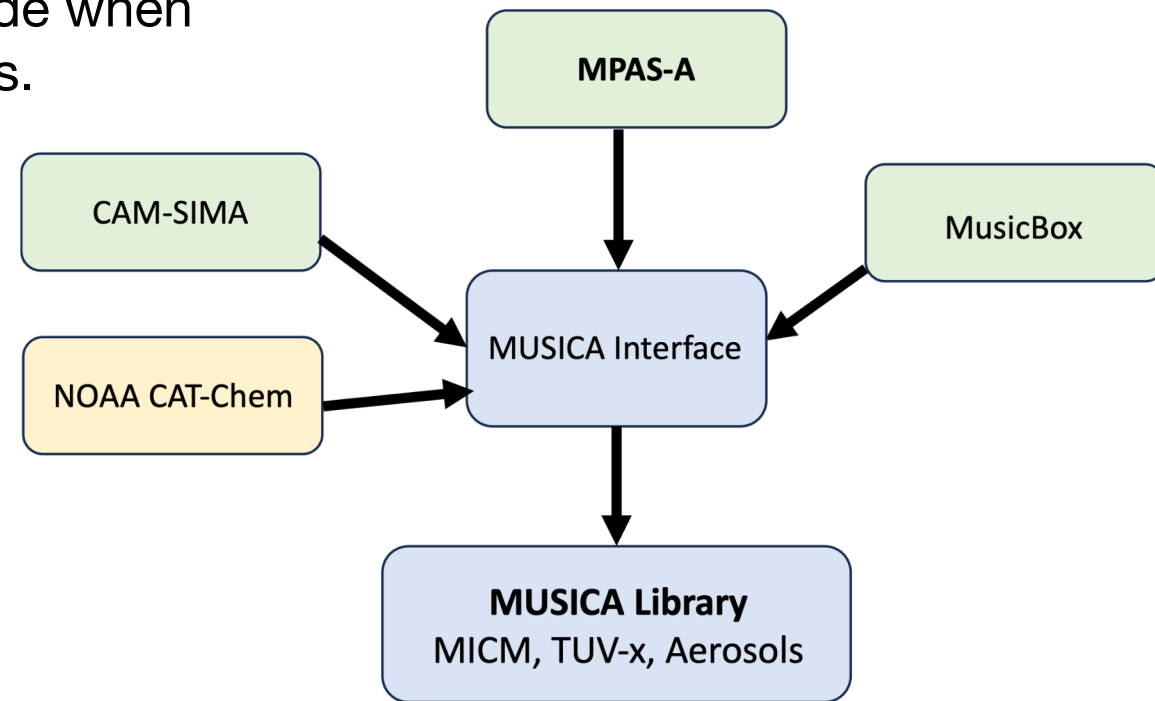
Multiscale Infrastructure for
Chemistry and Aerosols



Ongoing Developments: CheMPAS

- MUSICA is a model-independent infrastructure for chemistry in atmospheric models
- Facilitates use of a variety of chemistry schemes
- MUSICA allow users to build chemical mechanisms at run-time, eliminating the need to work with source code when adding or modifying chemical species or reactions.
- Currently being developed for CESM
- Initial stage for UFS and MPAS-A

There is no timeline for a first version release.



GOCART-2G in MPAS

Goddard Chemistry Aerosol Radiation and Transport – Second Generation (GOCART-2G) model

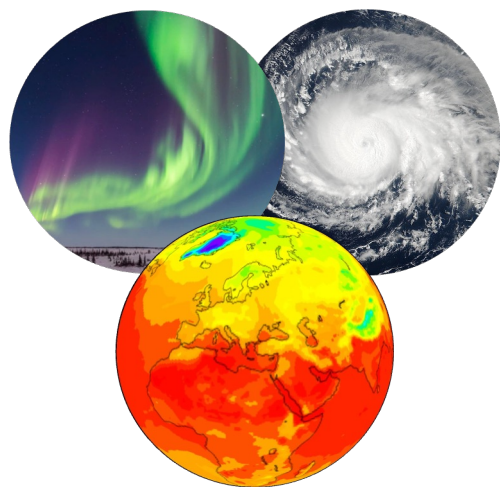
A simplified chemistry and aerosol component that predicts the major aerosol species including dust, organic and black carbon, sea salt, and sulfate aerosols.

Release expected before the June 2026 MPAS-WRF Workshop.



The Model for Prediction Across Scales Atmosphere

MPAS-A in Earth Systems Models



SIMA



EarthWorks

These projects, begun in 2018 and 2020, use NCAR's Community Earth System Model and its infrastructure.

Over the last few years it has become clear that the infrastructure is not well suited for high-resolution atmospheric modeling.

We are examining a number of alternatives:

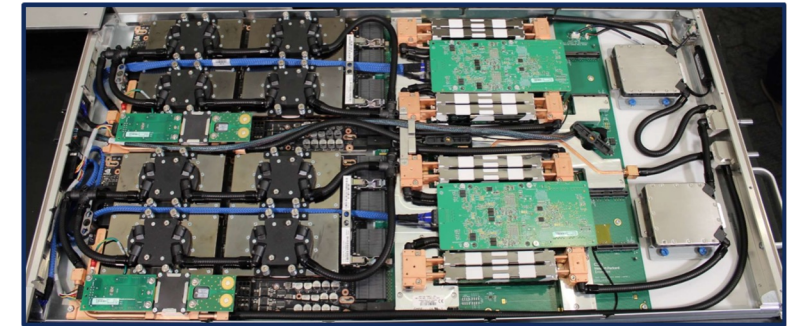
- Re-engineering the infrastructure
- Using NOAA's Unified Forecast system and its components.

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 - MPAS v8.3.0 (the dynamics).
- LES release, plus dynamics optimizations, later this month?
- Subsequent MPAS-A releases will incrementally extend GPU capabilities in the physics, additions to the dynamics (e.g. LES), and optimizations.
- 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.

Upcoming Events

MPAS-WRF workshop: June 2026 (in person (Boulder CO, USA), plus virtual option)
<https://www.mmm.ucar.edu/events/workshops/wrf-mpas> (22-26 June 2026)

We have two NSF NCAR-based tutorials each year, winter (virtual) and summer (in person):

- Summer 2026 (likely in person, dates TBD)
- Feature and bug releases occur whenever components are ready.