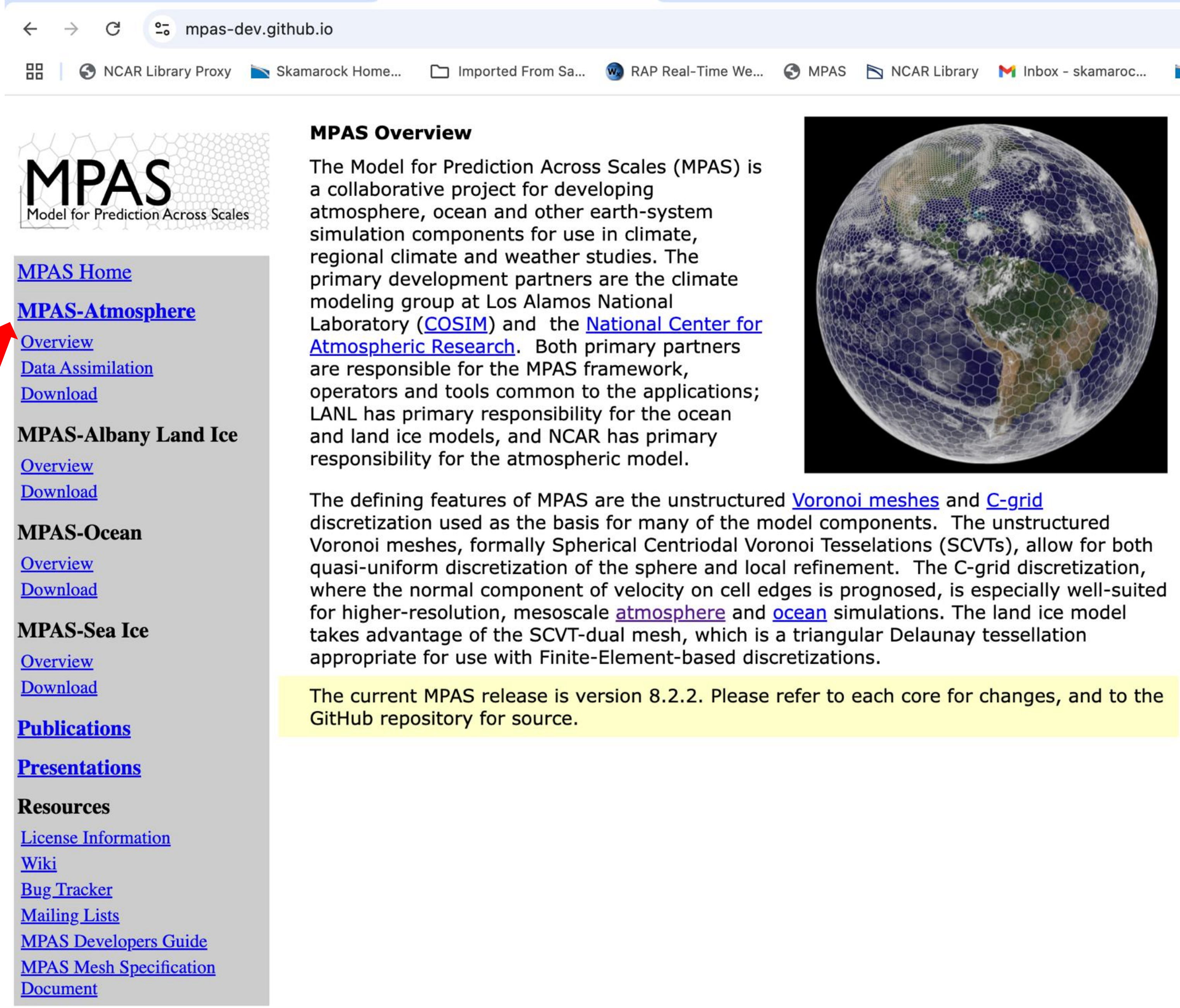
MPAS
Model for Prediction Across Scales

The Github MPAS web page

MPAS-Atmosphere

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


mpas-dev.github.io

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MPAS
Model for Prediction Across Scales

MPAS Home

MPAS-Atmosphere

Overview
Data Assimilation
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MPAS-Albany Land Ice

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MPAS-Ocean

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MPAS-Sea Ice

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Publications

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Resources

License Information
Wiki
Bug Tracker
Mailing Lists
MPAS Developers Guide
MPAS Mesh Specification Document

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 Tesselations (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
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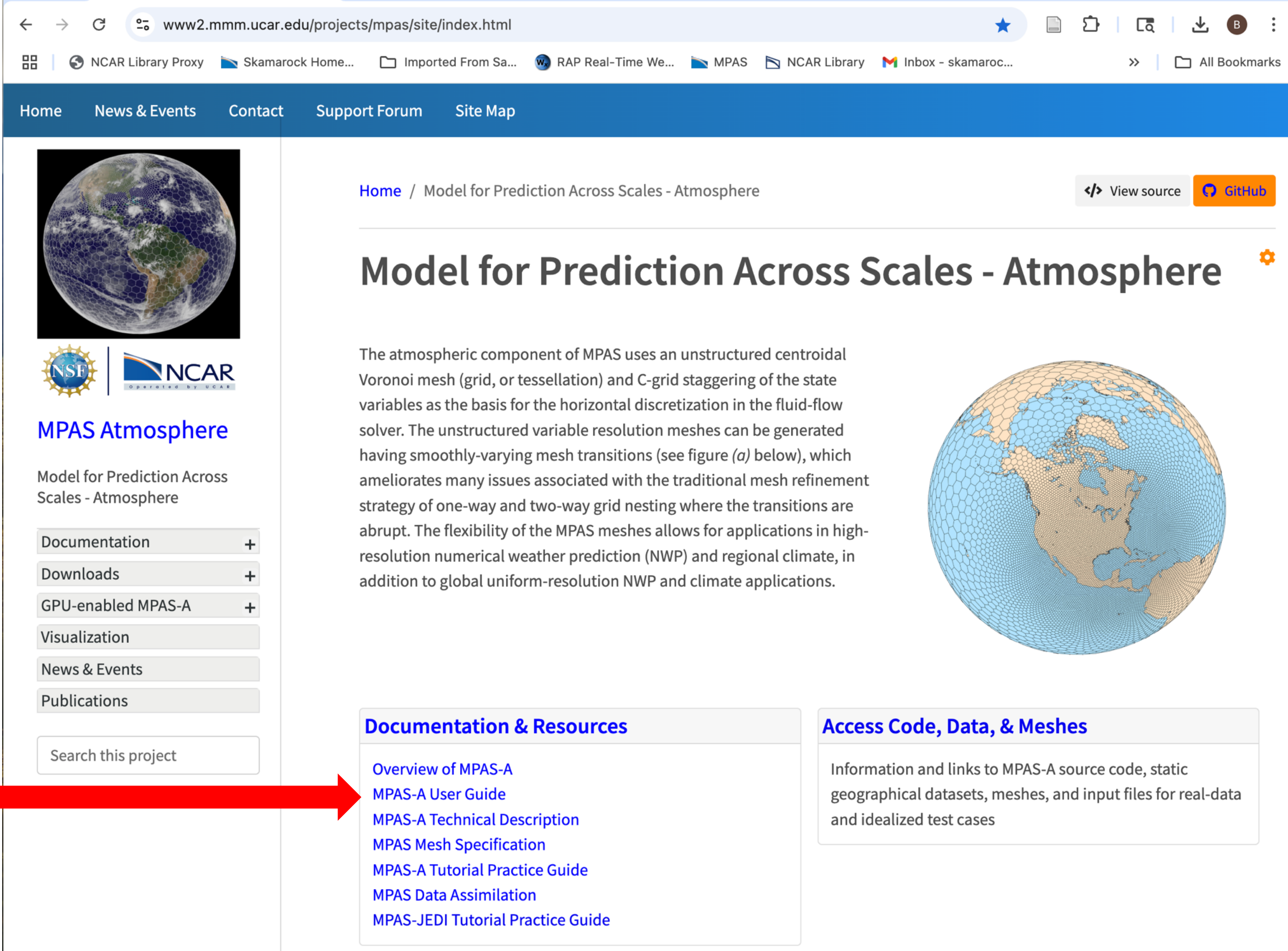
The new MPAS-Atmosphere web page

MPAS-Atmosphere Users Guide



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

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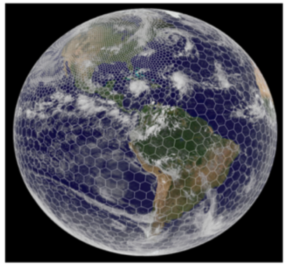

MPAS Atmosphere

Model for Prediction Across Scales - Atmosphere

- Documentation +
- Downloads +
- GPU-enabled MPAS-A +
- Visualization
- News & Events
- Publications

Search this project

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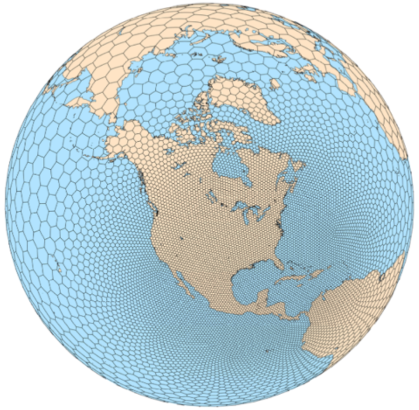
View source | GitHub

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 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-Atmosphere Tutorial
(currently the spring 2025 virtual tutorial)

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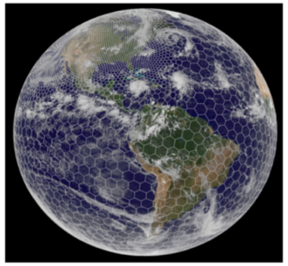

MPAS Atmosphere

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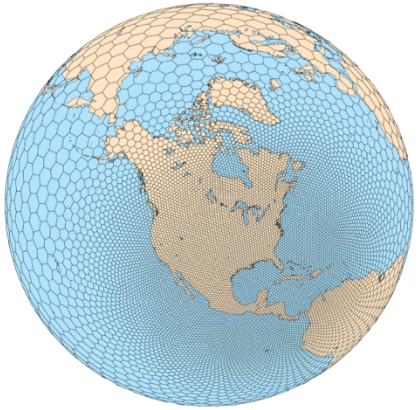

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MPAS-Atmosphere Technical Note

2025 draft

Technical Note Example

Continuous and discrete operators

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

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:

$$\frac{\partial(\tilde{\rho}_d \phi)}{\partial t} = \cdots - \nabla \cdot \left(\tilde{\rho}_d \nu_4 \nabla(\nabla_\zeta \cdot \nabla_\zeta \phi)\right), \tag{5.4}$$

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

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

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

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

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.

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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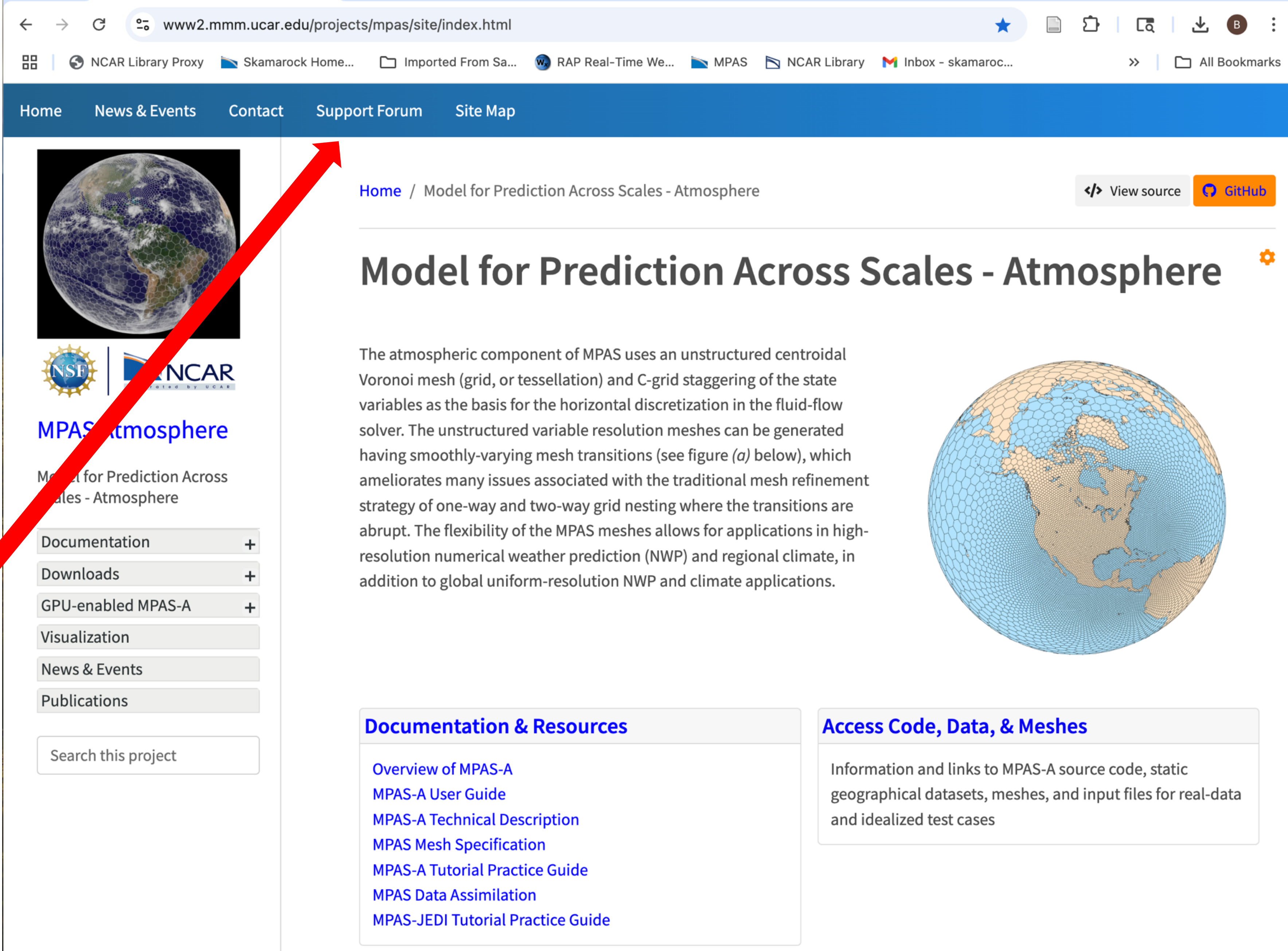
MPAS
Model for Prediction Across Scales



MPAS-Atmosphere support forum

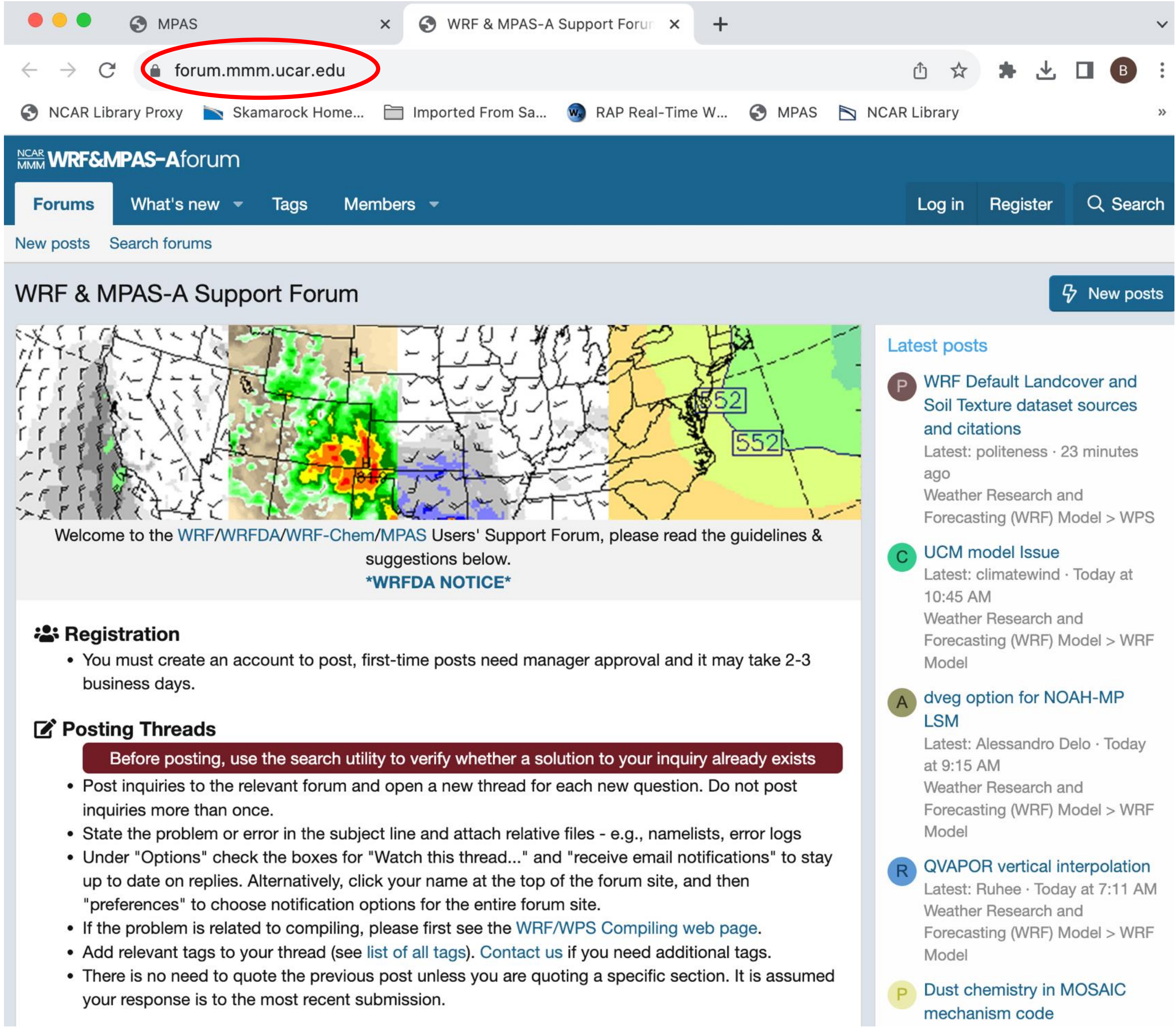
MPAS
Model for Prediction Across Scales

MPAS-Atmosphere Resources

WRF & MPAS-A Support Forum

You need to create an account to post to it.

Searchable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WRF & MPAS-A Support Forum

New posts

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

WRF Default Landcover and Soil Texture dataset sources and citations
Latest: politeness · 23 minutes ago
Weather Research and Forecasting (WRF) Model > WPS

UCM model Issue
Latest: climatewind · Today at 10:45 AM
Weather Research and Forecasting (WRF) Model > WRF Model

dveg option for NOAH-MP LSM
Latest: Alessandro Delo · Today at 9:15 AM
Weather Research and Forecasting (WRF) Model > WRF Model

QVAPOR vertical interpolation
Latest: Ruhee · Today at 7:11 AM
Weather Research and Forecasting (WRF) Model > WRF Model

Dust chemistry in MOSAIC mechanism code

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.

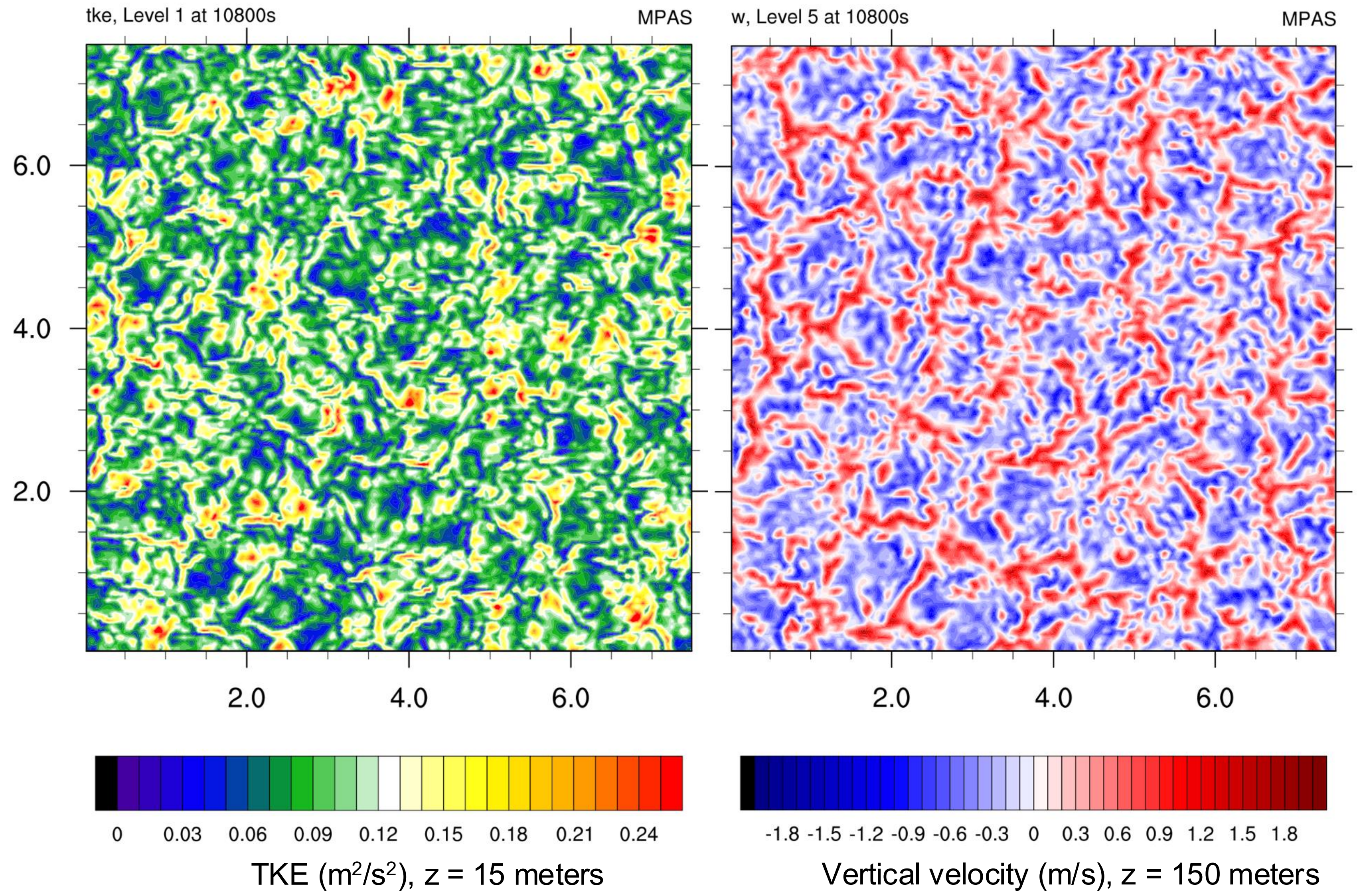
LES capabilities in MPAS

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 at lot like WRF and CM1 results.

Extensions for terrain need implementing.

Release expected in 2025.



SAS LES test case, horizontal cross sections of turbulent kinetic energy and vertical velocity

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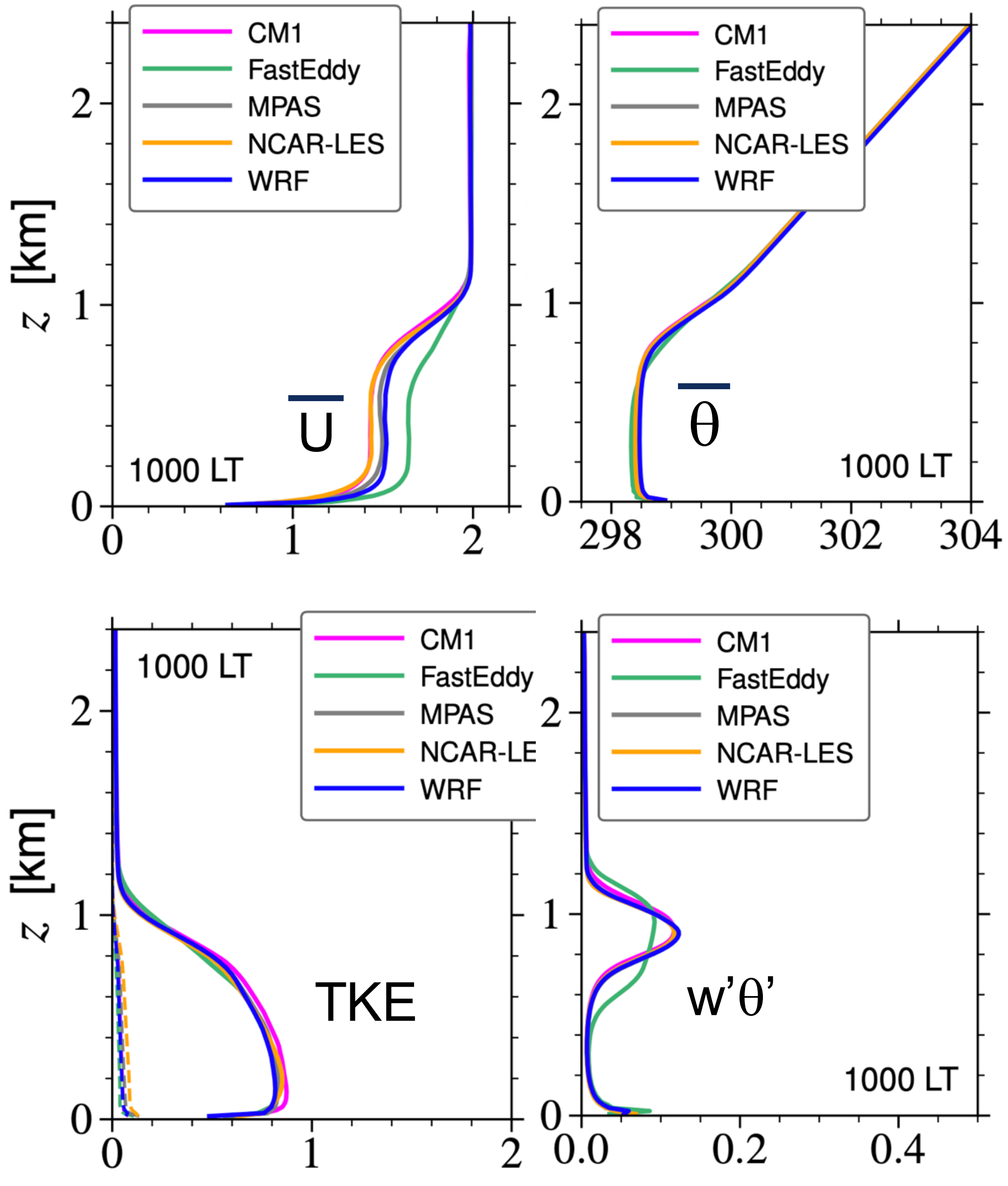


SAS LES test case

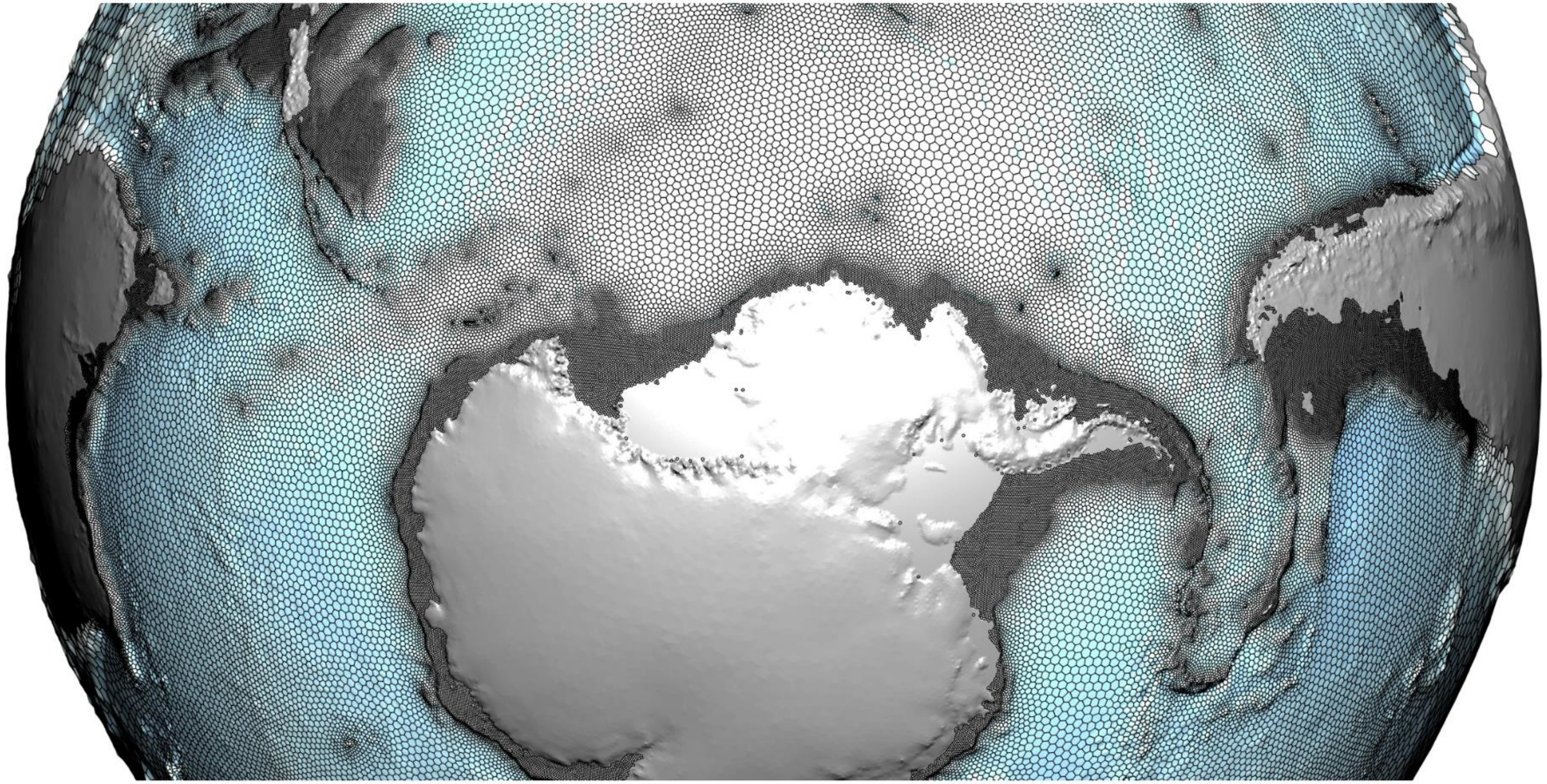
Mesh Generation

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`



NOAA Physics in MPAS

(1) The MPAS dynamical core will 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, Noah-MP land model

WoFS: multiple PBL schemes, NSSL-2M microphysics

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

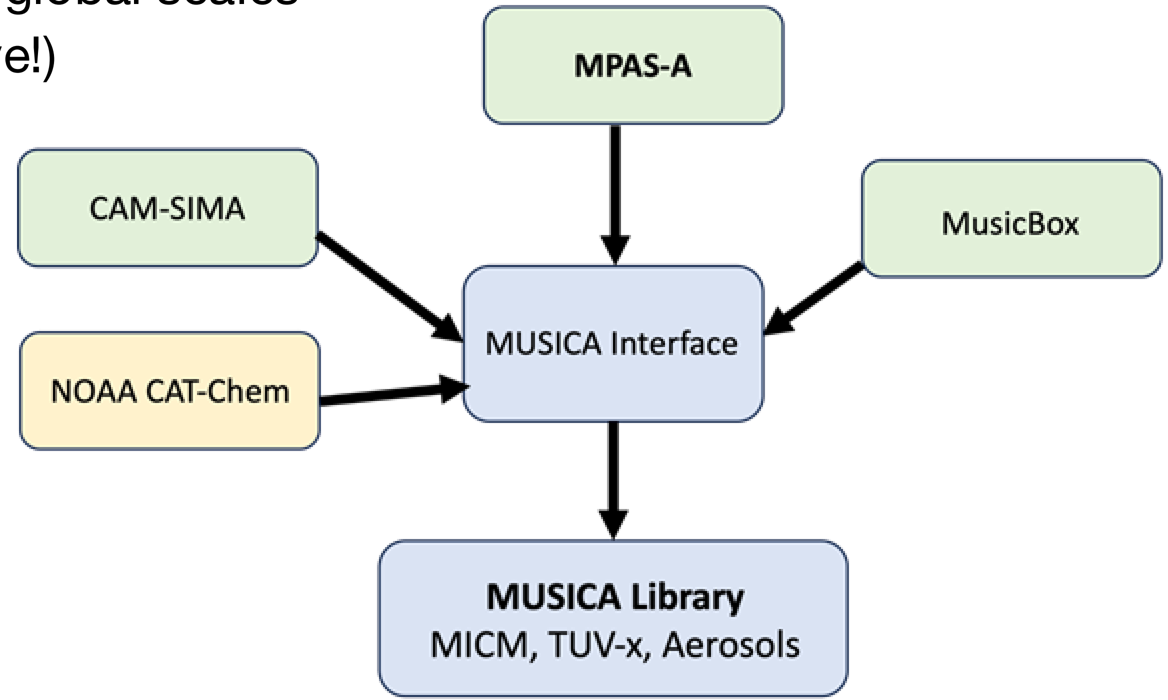
These physics will be pulled from the authoritative NOAA repositories in the MPAS build.
NOAA physics developers will now also be MPAS developers.

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

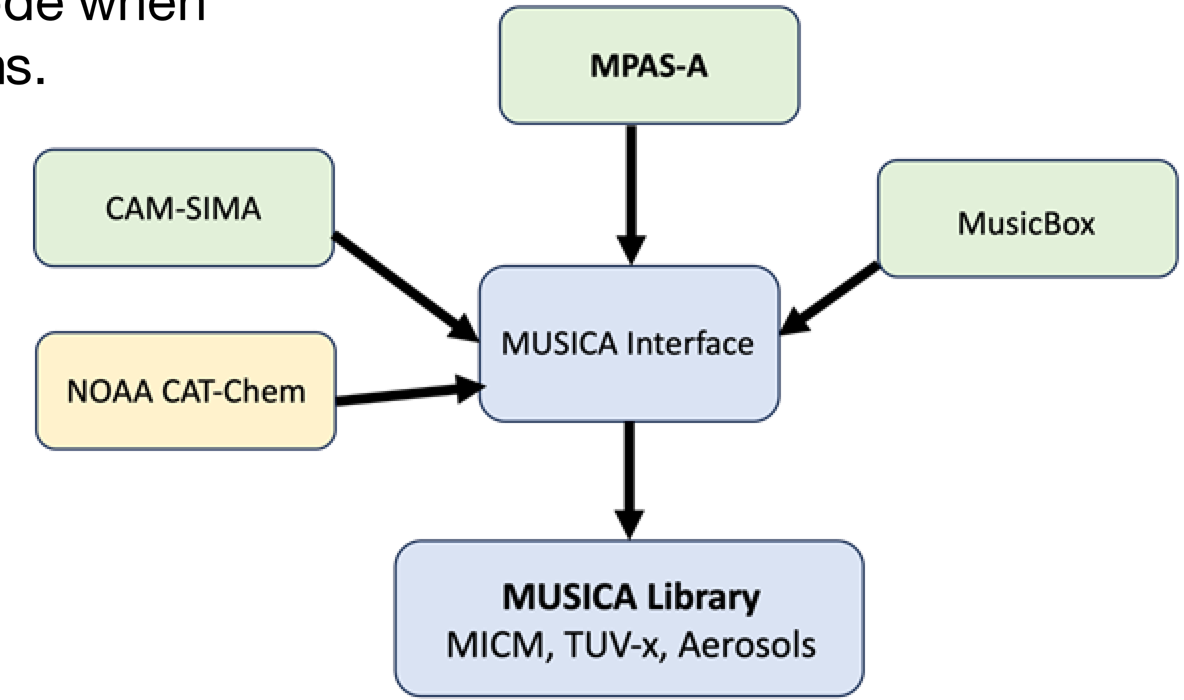
MUSICA
Multiscale Infrastructure for Chemistry and Aerosols



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

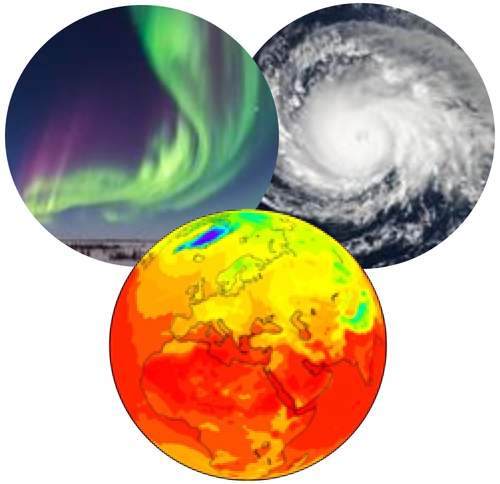
A simplified chemistry and aerosol component that predicts the major aerosol species including dust, organic and black carbon, sea salt, and sulfate aerosols.

Release expected before the end of this calendar year.

MPAS
Model for Prediction Across Scales

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).
- 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.

Coming Events

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

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

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