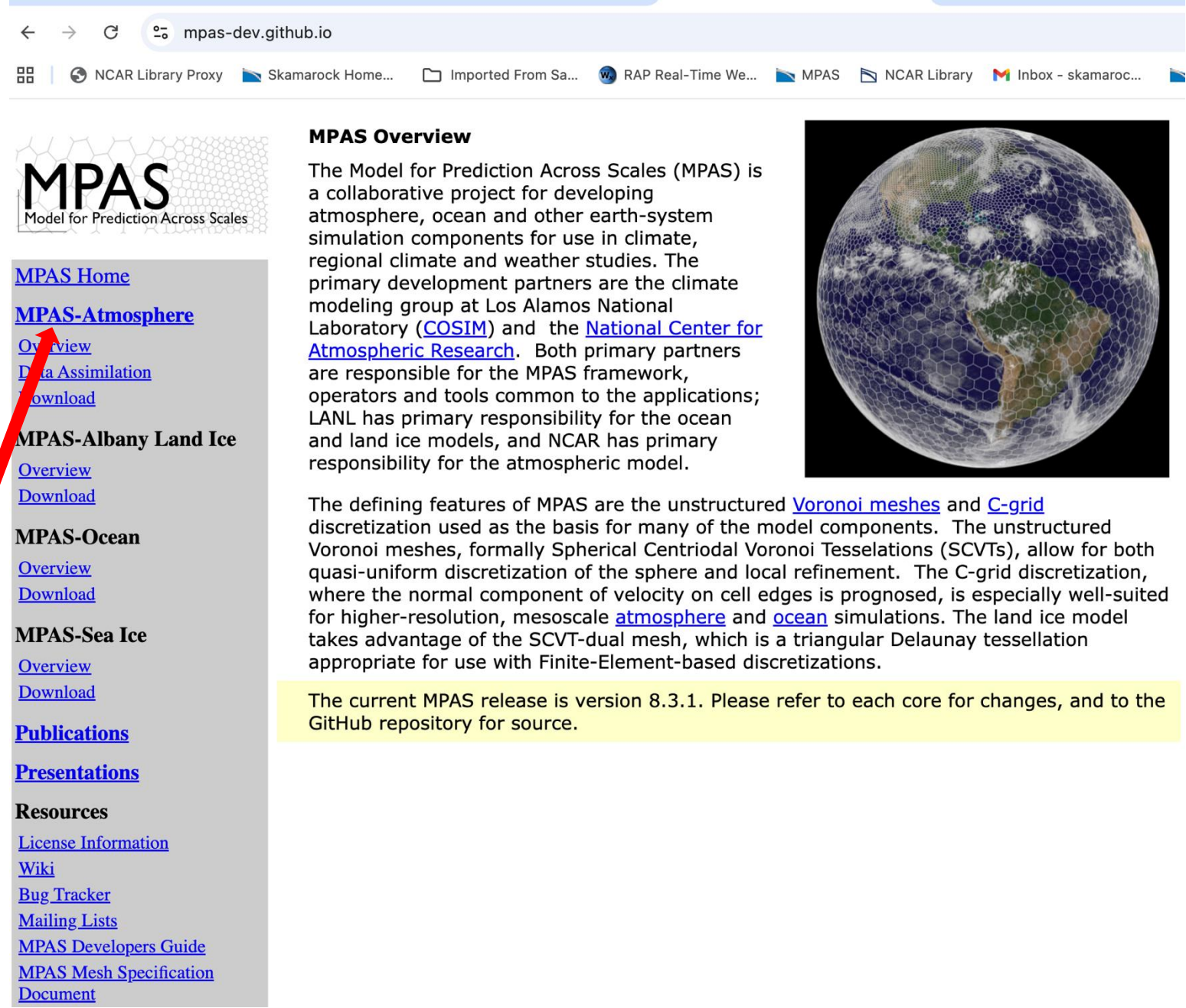
MPAS
Model for Prediction Across Scales

The Github MPAS web page

MPAS-Atmosphere

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



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The official MPAS-Atmosphere web page

MPAS-Atmosphere Users Guide

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

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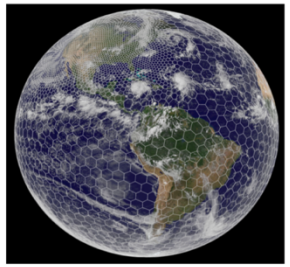

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- Documentation +
- Downloads +
- GPU-enabled MPAS-A +
- Visualization
- News & Events
- Publications

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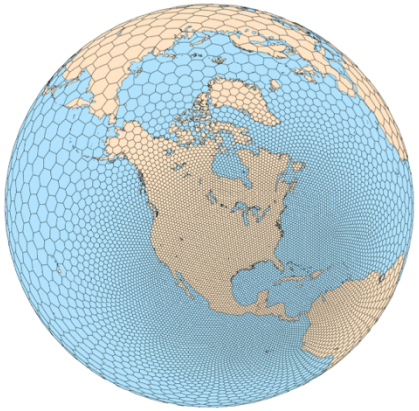
The atmospheric component of MPAS uses an unstructured centroidal Voronoi mesh (grid, or tessellation) and C-grid staggering of the state variables as the basis for the horizontal discretization in the fluid-flow solver. The unstructured variable resolution meshes can be generated having smoothly-varying 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.



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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

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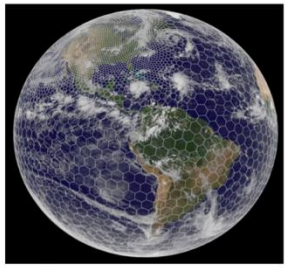

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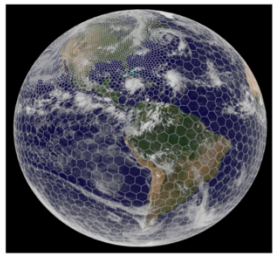

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MPAS Documentation and Resources

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

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

MPAS
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MPAS-Atmosphere Tutorial (currently the winter 2026 virtual tutorial)

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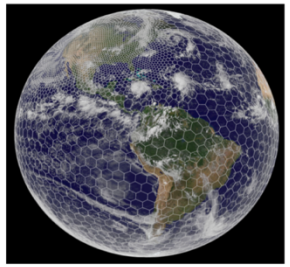

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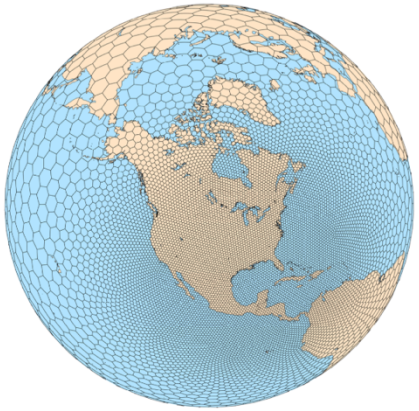

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MPAS-Atmosphere Technical Note

2025 draft

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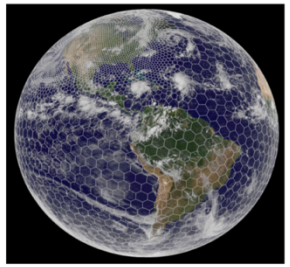

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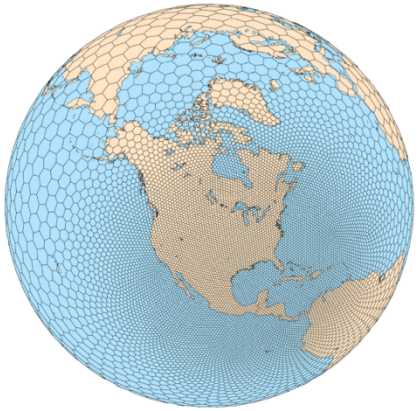

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Technical Note Example

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:

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

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

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

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

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

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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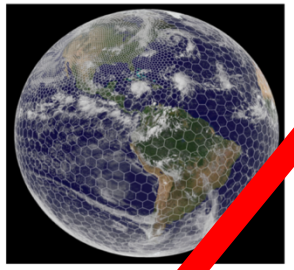

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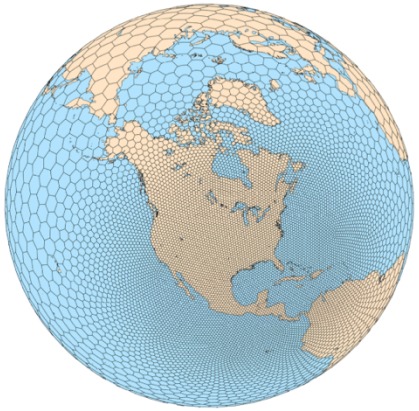

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WRF & MPAS-A Support Forum

You need to create an account to post to it.

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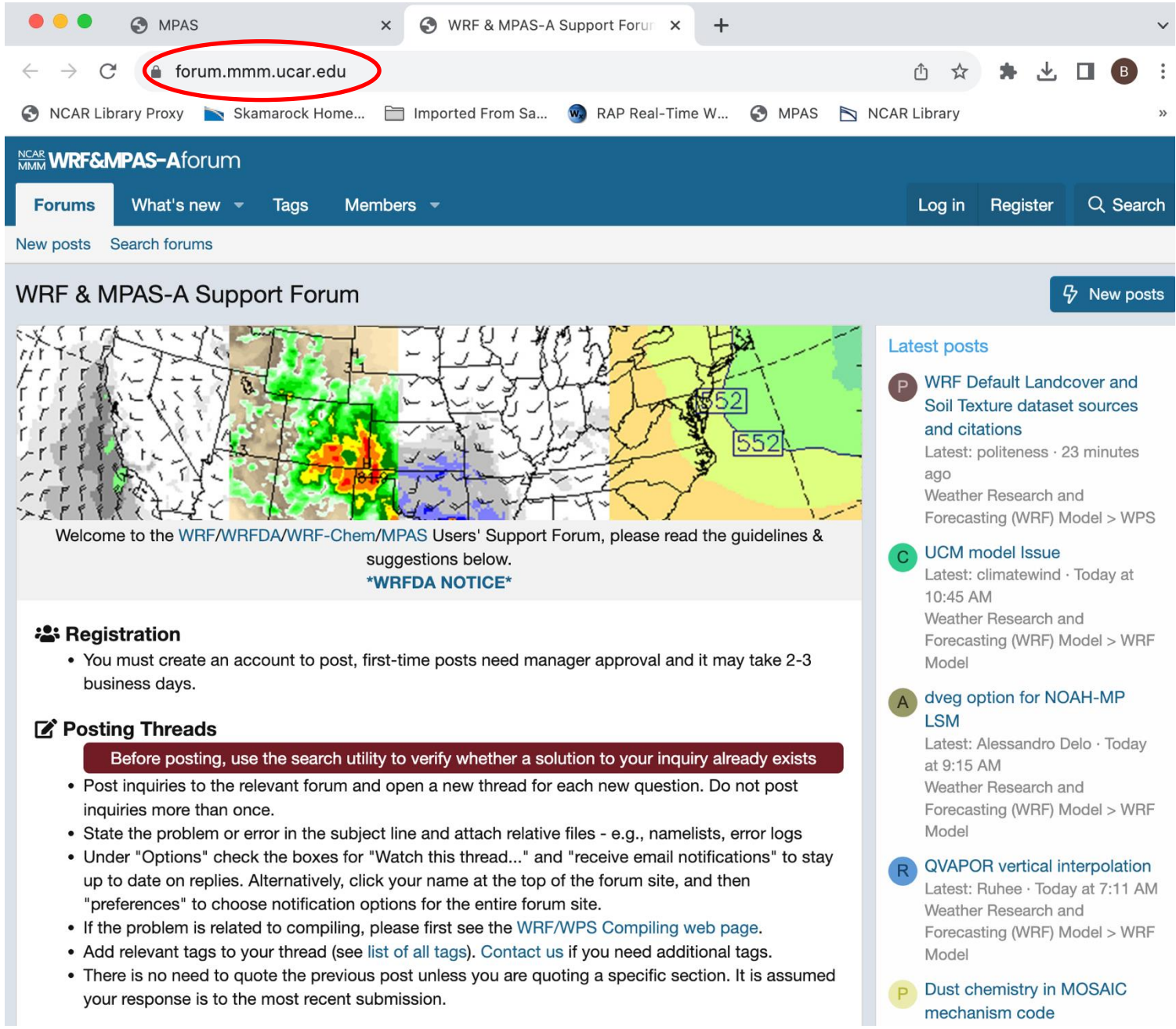

MPAS
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Under Development

- NOAA physics used in the UFS and the WoFS.
- Physics from the community.
- Chemistry: CheMPAS
- Scalar transport in physics parameterizations (convection, boundary layer) for GOCART and chemistry.
- Urban modeling capability.
- Earth System Model capabilities.
- GPU capability.

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 planning to use the MPAS dynamical core in their global forecast system.

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

WoFS: multiple PBL schemes, NSSL-2M microphysics.

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 are now also MPAS developers.

MYNN PBL, TEMPO microphysics, NSSL-2M microphysics will be available in the next release – Fall 2026

MPAS
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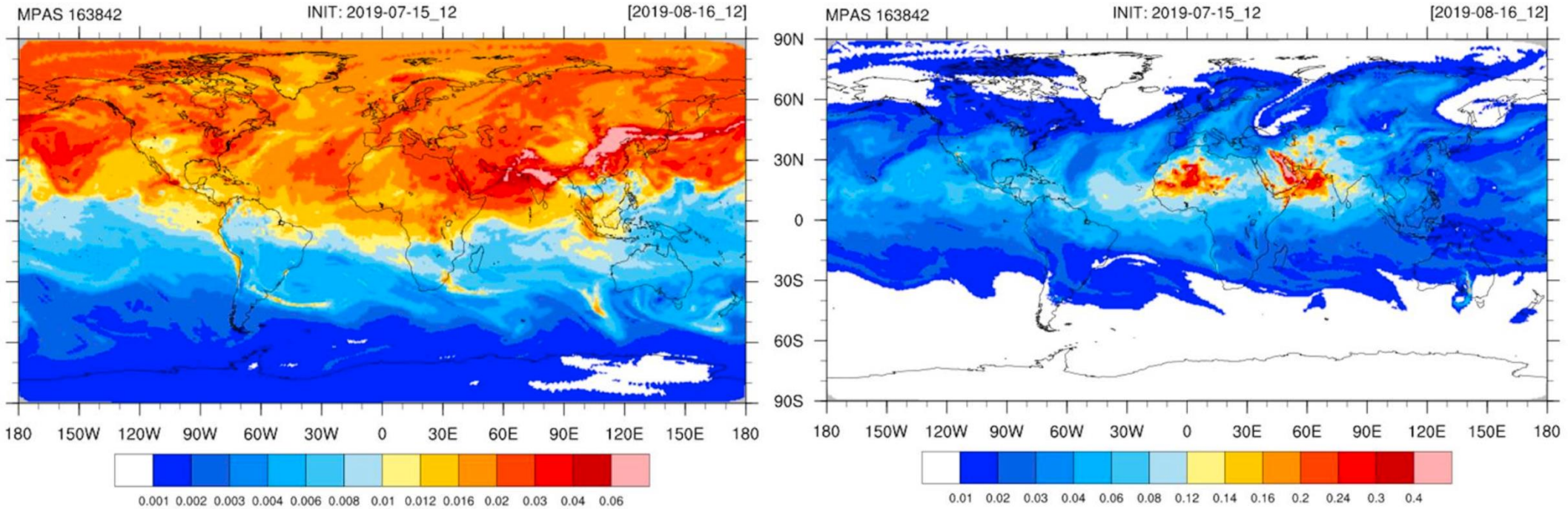
GOCART-2G in MPAS

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.

1 month MPAS-A 60 km global forecast, column mass (gm^{-2})



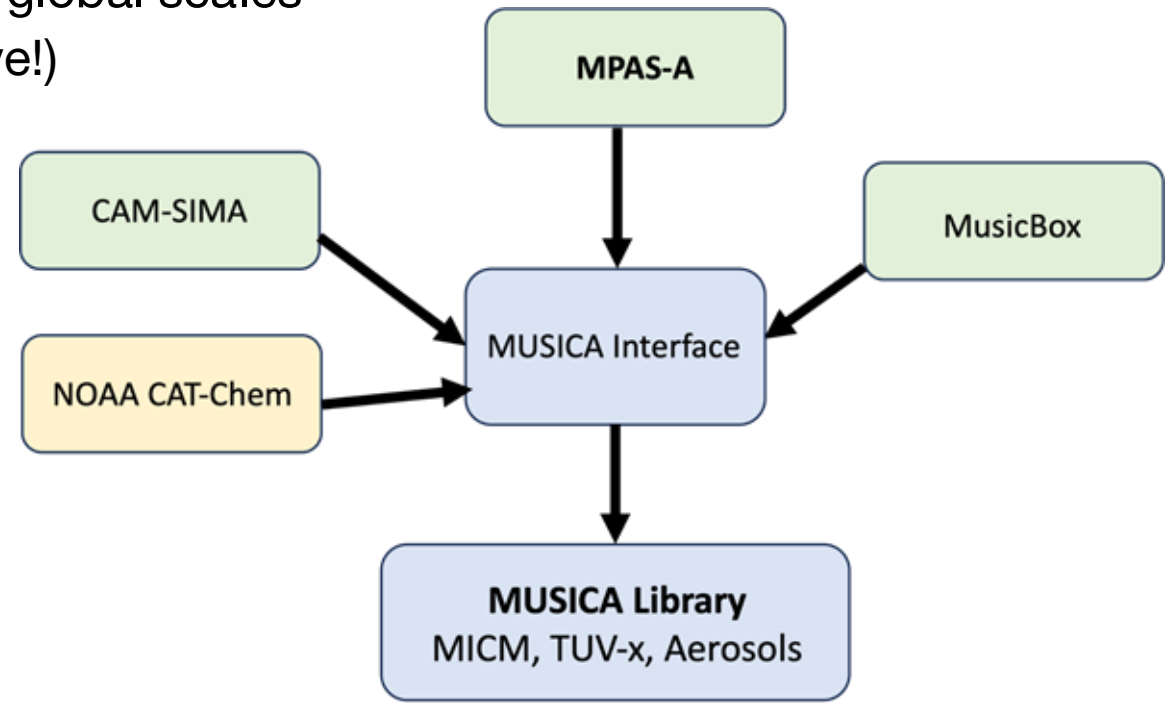
We are targeting a release before the end of this calendar year (ACOM, MMM, RAL)

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

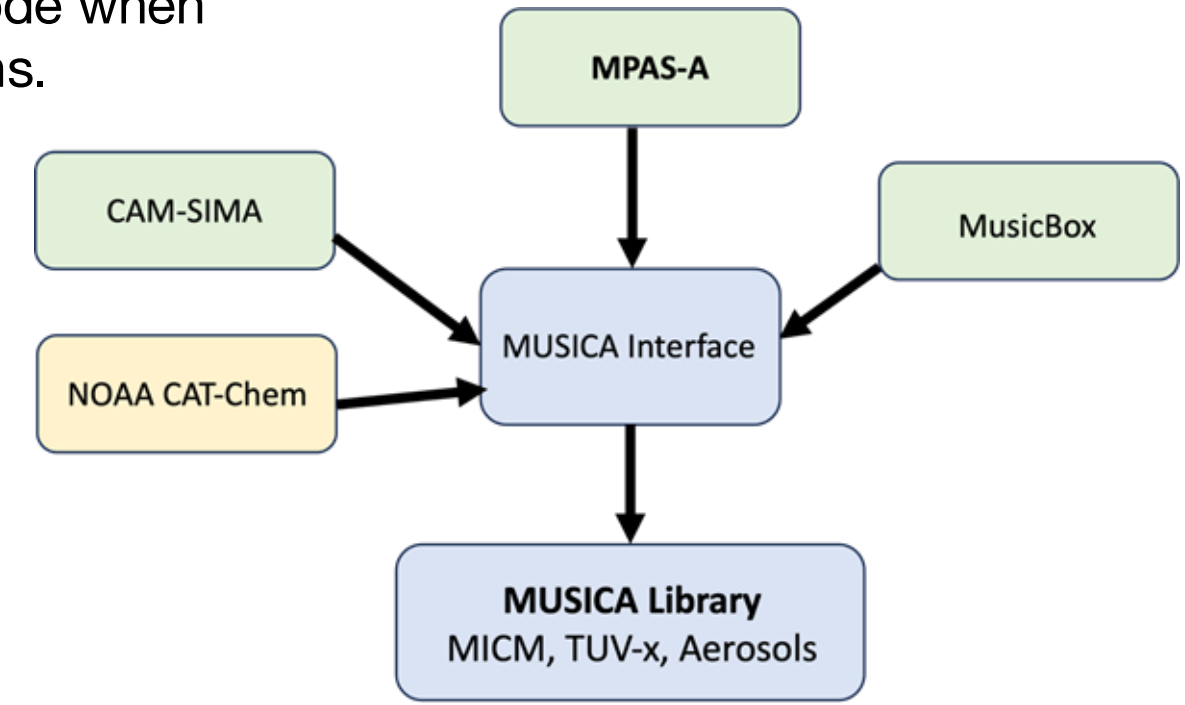
MUSICA
Multiscale Infrastructure for Chemistry and Aerosols



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.



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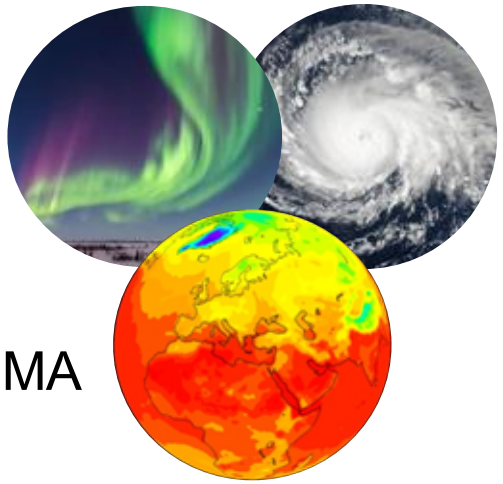
MPAS-A Earth Systems Modeling



SIMA

EarthWorks

Based on NCAR's Community Earth System Model
SIMA (CESM using MOM6 and MPAS-A)
EarthWorks (CESM, using MPAS-A and MPAS-O)

Scaling problems limit applications.
Uncertain support.

NOAA
Unified Forecast System

Based on CESM infrastructure
UFS using MOM6 and MPAS-A

Awaiting port of MPAS-A into the UFS.
Scaling issues? Support?

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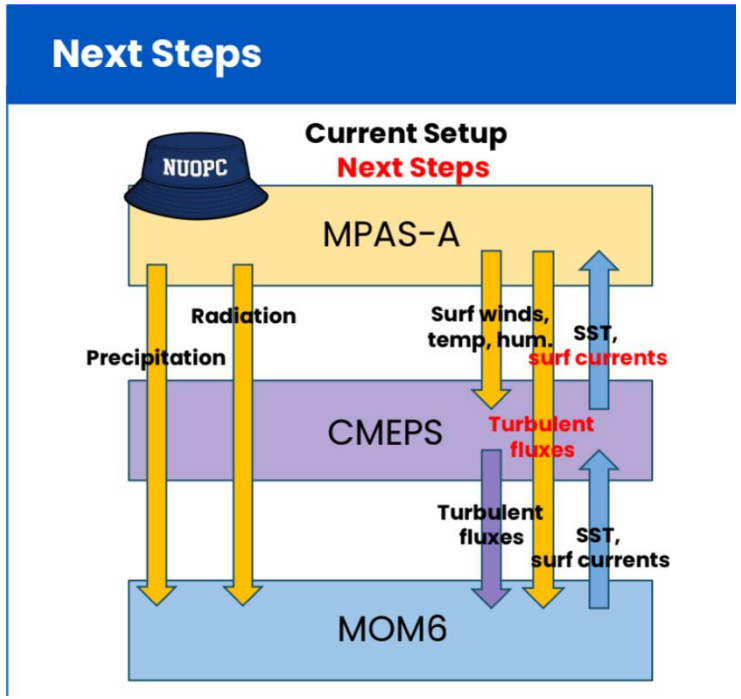
MPAS-A Earth Systems Modeling

https://www.mmm.ucar.edu/events/133496/agenda

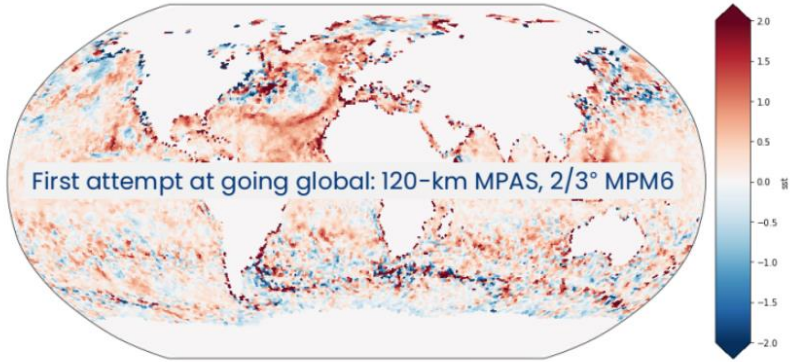
A High-Resolution Regional Coupled MPAS-A–MOM6 Prototype for Air-Sea Interaction Research and Prediction
Amrhein et al, 2026, MPAS-WRF Workshop



Coupling
- Communicating turbulent fluxes from MPAS-A to MOM6 and surface currents to MPAS-A
- Coupling to WaveWatch 3 and CICE (CROCODILE)

Profiling
- Quantify effects of mixed resolution; different load balancing; I/O choices; memory footprints
- How does this coupling scale to global km-scale?

Global km-scale (3.75-km MPAS, 1/36° MOM6)



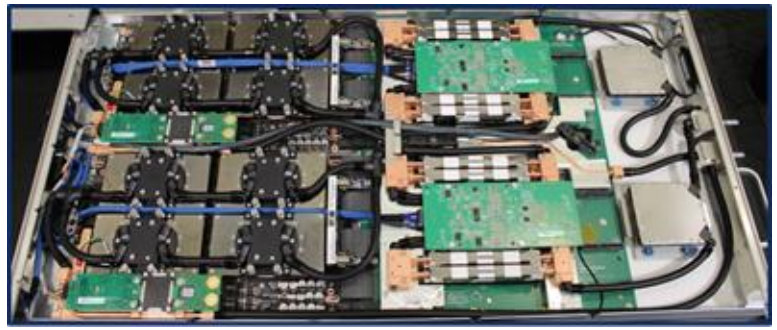
Further testing and development is underway

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 v8.4.0 (the dynamics and LES).
- Subsequent MPAS-A releases will incrementally extend GPU capabilities in the physics and optimizations to the dynamics.



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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Upcoming Events

MPAS-WRF workshop: June 2027 (in person (Boulder CO, USA), plus virtual option) https://www.mmm.ucar.edu/events/workshops/. Dates TBD.

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

- Winter 2027 (virtual, dates TBD, January or early February)
- Feature and bug releases occur whenever components are ready.