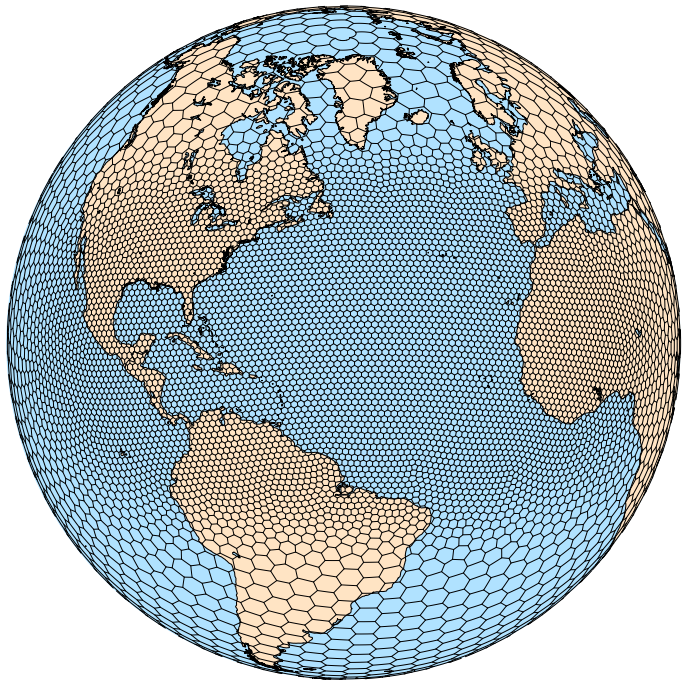
MPAS
Model for Prediction Across Scales

MPAS Updates

Bill Skamarock NCAR/MMM
and a host of other people



GPU enabled MPAS
MPAS Tutorial

Coming soon:
Updates to MPAS and MPAS physics
Updates to the GPU release

Further out:
CCPP and shared WRF-MPAS physics
Deep-atmosphere equations
Geospace capability
MPAS in SIMA/CESM, EarthWorks – tomorrow's talk

MPAS
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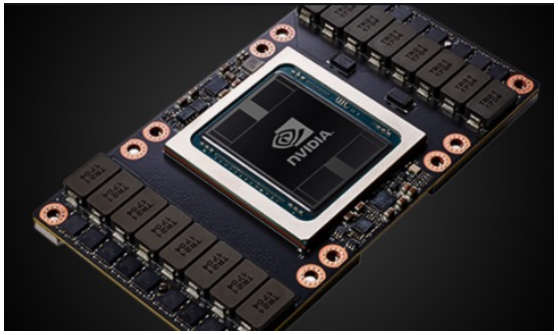
MPAS and GPUs

Project goals:

- Achieve performance portability across heterogeneous CPU/GPU architectures
- Use all the hardware (CPU and GPU) available
- Single source (CPU, CPU-GPU capability) using OpenACC.



NVIDIA Tesla V100 GPU

Status:

- GPU-CPU version of MPAS is now running operationally at IBM/TWC on IBM Power-9 architectures – IBM/TWC GRAF system
- Radiation and land-surface model (NOAH) on CPUs, all else (dynamics, other physics) on GPUs. NOAH LSM is being ported to GPUs.
- GPU-CPU version runs faster and uses less energy than a CPU-only configuration. We've met this important goal.

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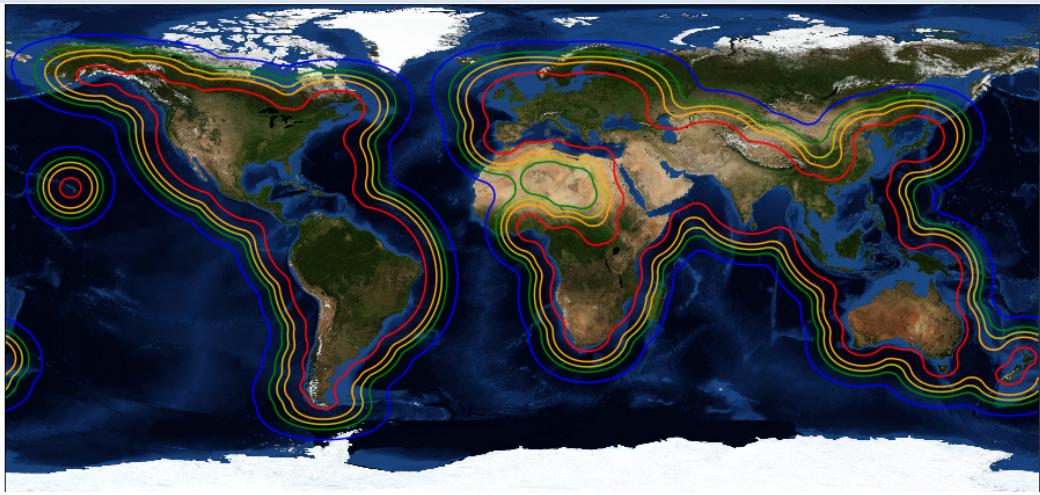
MPAS and GPUs

We released the GPU-enabled MPAS-Atmosphere in October 2020 as a branch from MPAS Version 6.1. We are working on an update to MPAS Version 7.



What is in this release:

- GPU-enabled MPAS dynamical core using OpenACC directives.
- Some GPU-enabled physics (e.g. YSU, WSM6, 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

Our ability to support this release is limited. Users should be be *very friendly* and *very talented* (software engineering expertise is critical for success).

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MPAS Tutorials

We conducted a virtual MPAS tutorial on 12-14 April 2021

https://www.mmm.ucar.edu/mpas-tutorial-agenda

This tutorial covered all aspects of MPAS except for the GPU version, including both global and regional MPAS.

- Recorded talks
- Slides from recorded talk and live tutorial talks

The MPAS webpage tutorial link points to the September 2019 tutorial, both cover MPAS version 7 (the 2019 tutorial was in-person; no recorded talks).

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Coming Soon to MPAS

We anticipate a new release (MPAS Version 8) later this year

Physics:

- Scale-aware version of the nTiedtke convection scheme (following an approach similar to that used in the scale-aware Kain-Fritsch scheme) (Wei Wang lead developer).
- New version of the MYNN PBL scheme – pulled from the DTC-CCPP repository which tracks Joe Olsen's (NOAA) development. Laura Fowler has worked with Joe Olsen to generalize the CCPP interface. The new version includes the EDMF component.
- Not-so-major updates to other physics.

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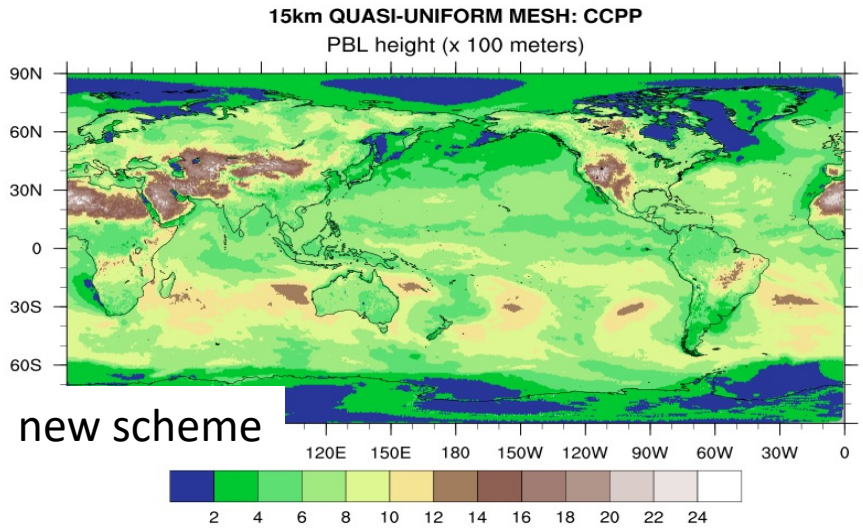
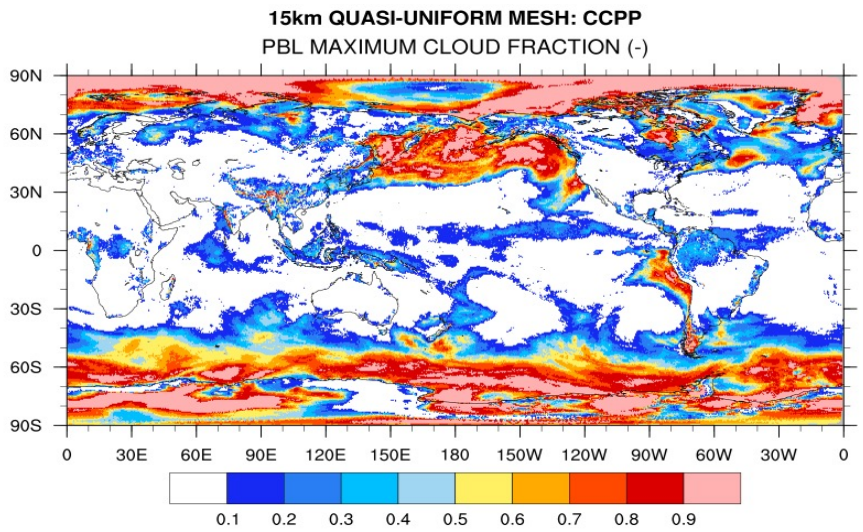
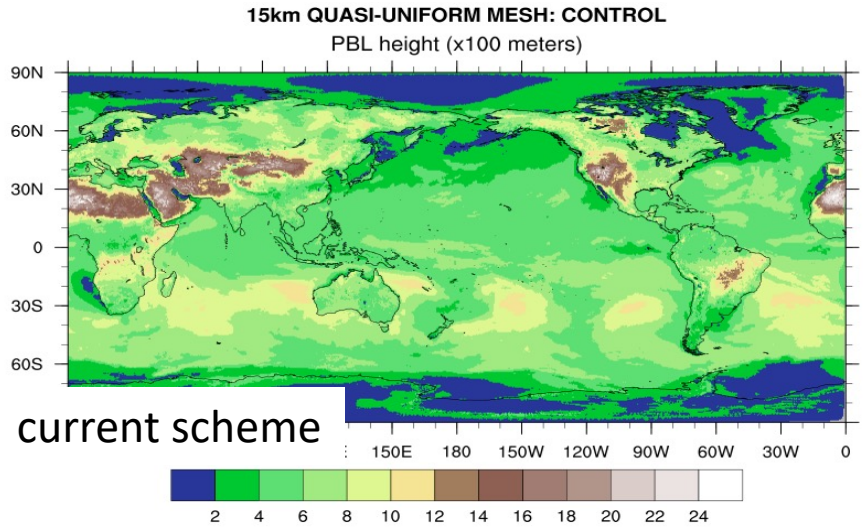
MYNN PBL scheme

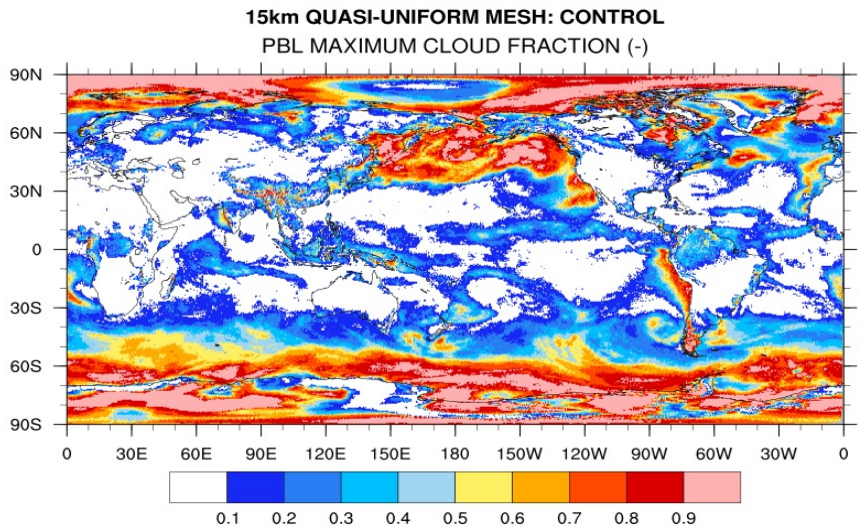


new scheme





current scheme



(3-day averages over days 0.5-3.5 of three forecasts)

Courtesy of Laura Fowler

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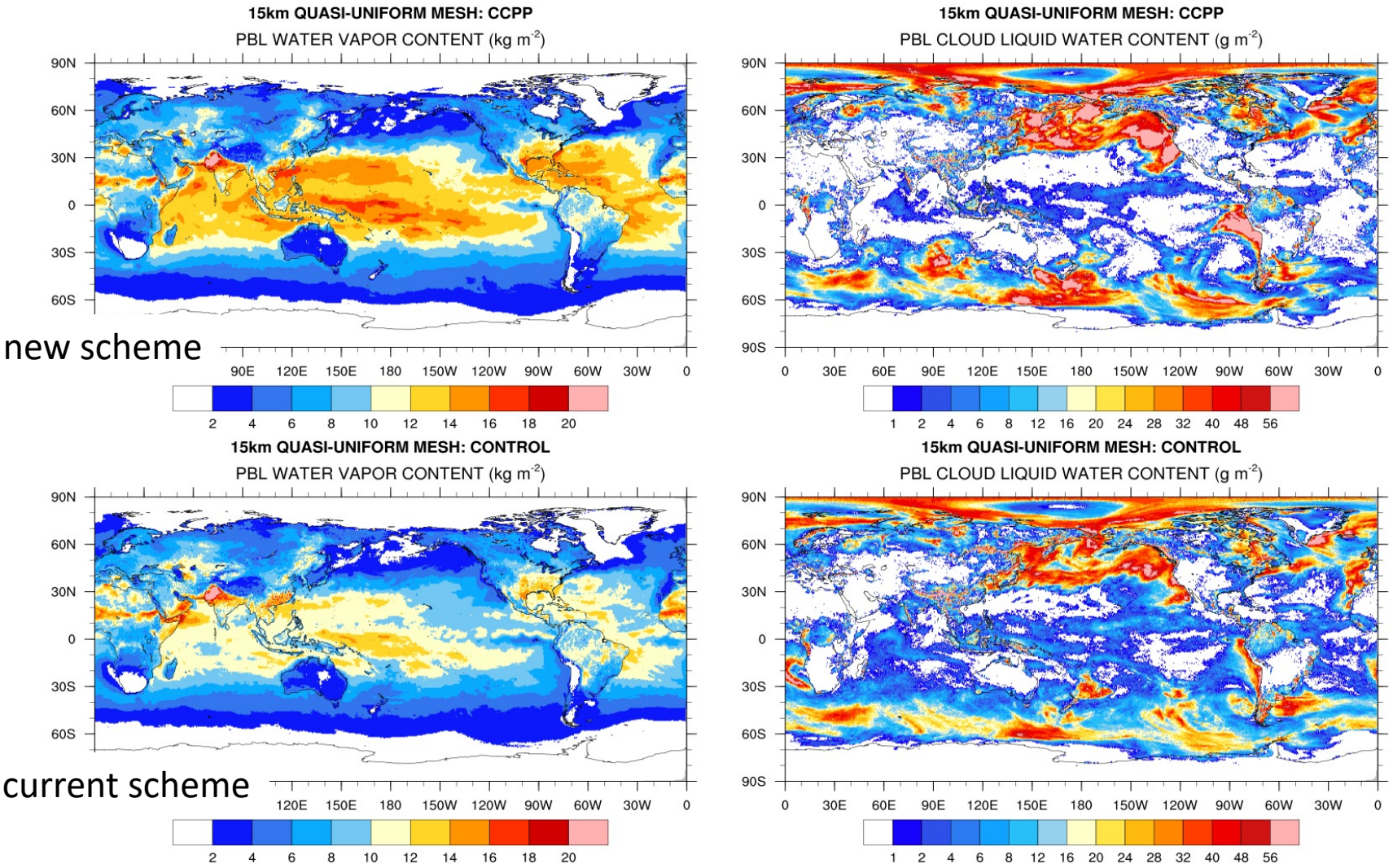
MYNN PBL scheme



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Courtesy of Laura Fowler

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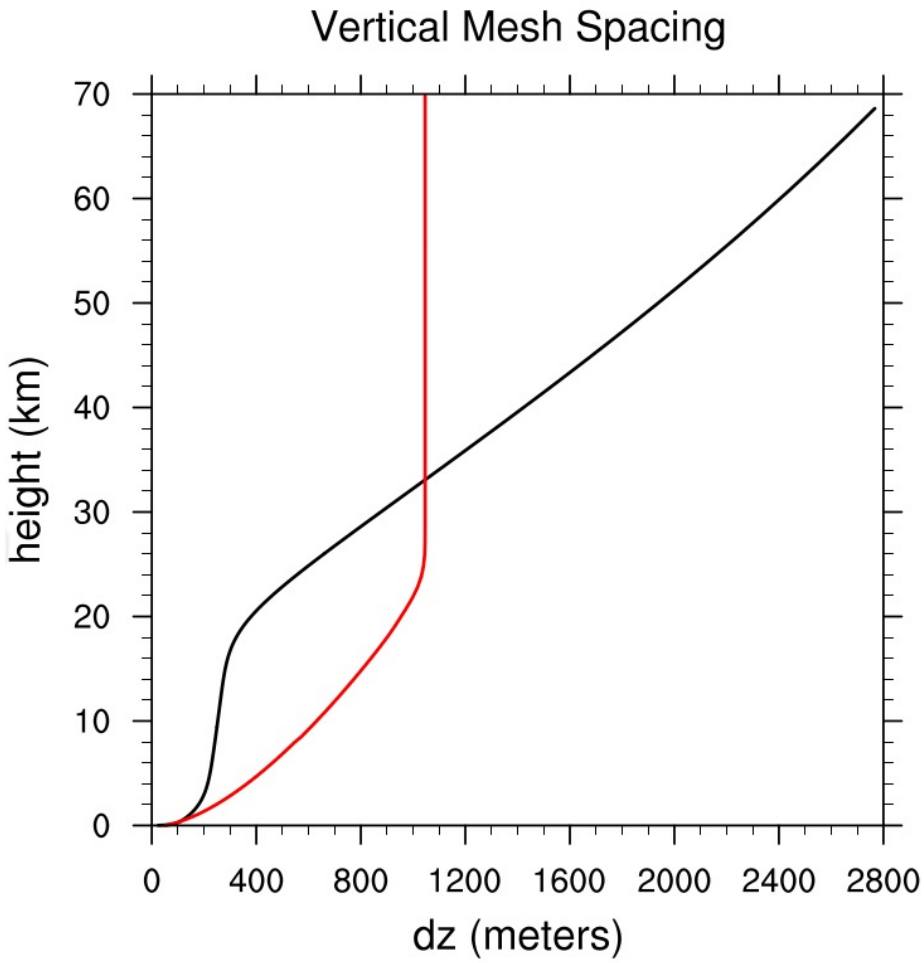
MPAS-Atmosphere configurations with (1) higher model tops and (2) higher tropospheric resolution:

- Satellite data assimilation
- Stratospheric dynamics



Example candidate vertical meshes

Current default, extended to 70 km with constant Δz above ~25 km (95 levels)

High-resolution troposphere ($\Delta z < 300$ m), similar to IFS. 127 levels

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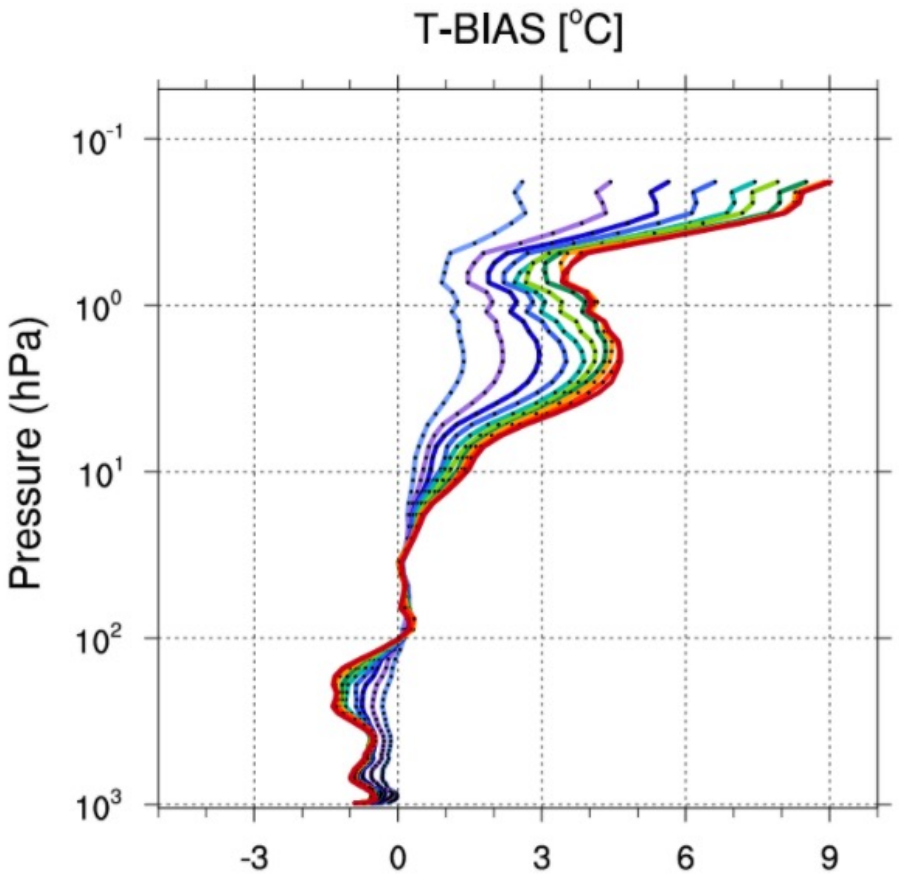
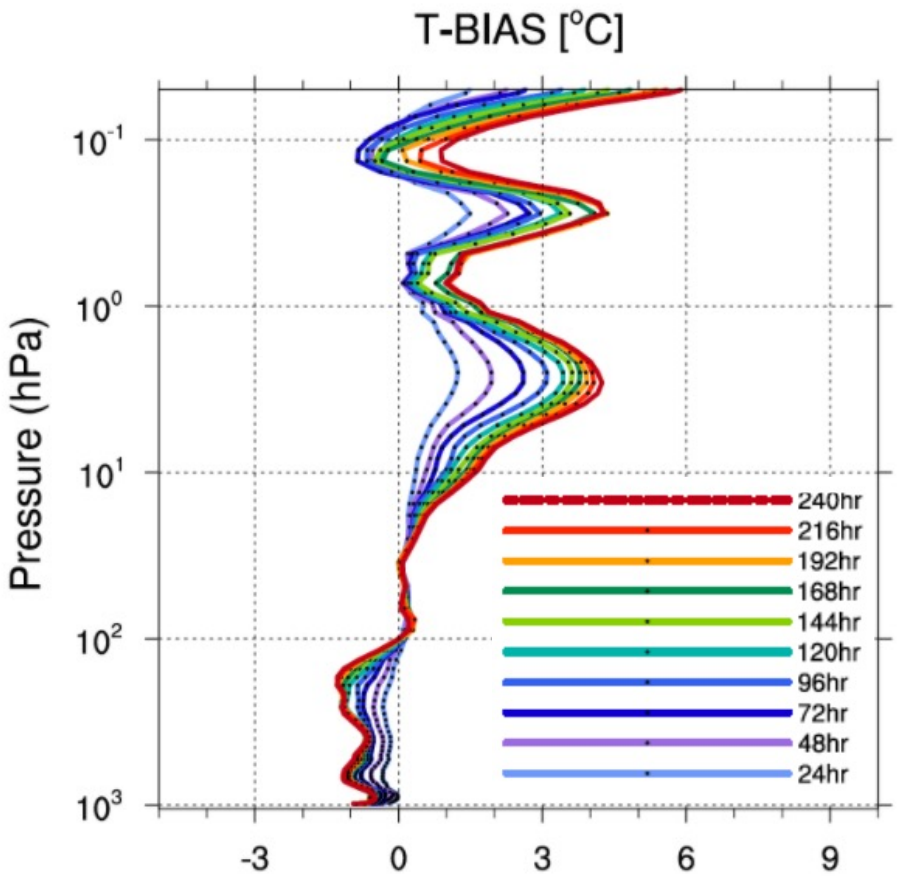
Coming Soon to MPAS

10 day MPAS forecast, 120 km mesh, 15 April 2018 ERA-I initialization

approx. 60 km model top



approx. 70 km model top



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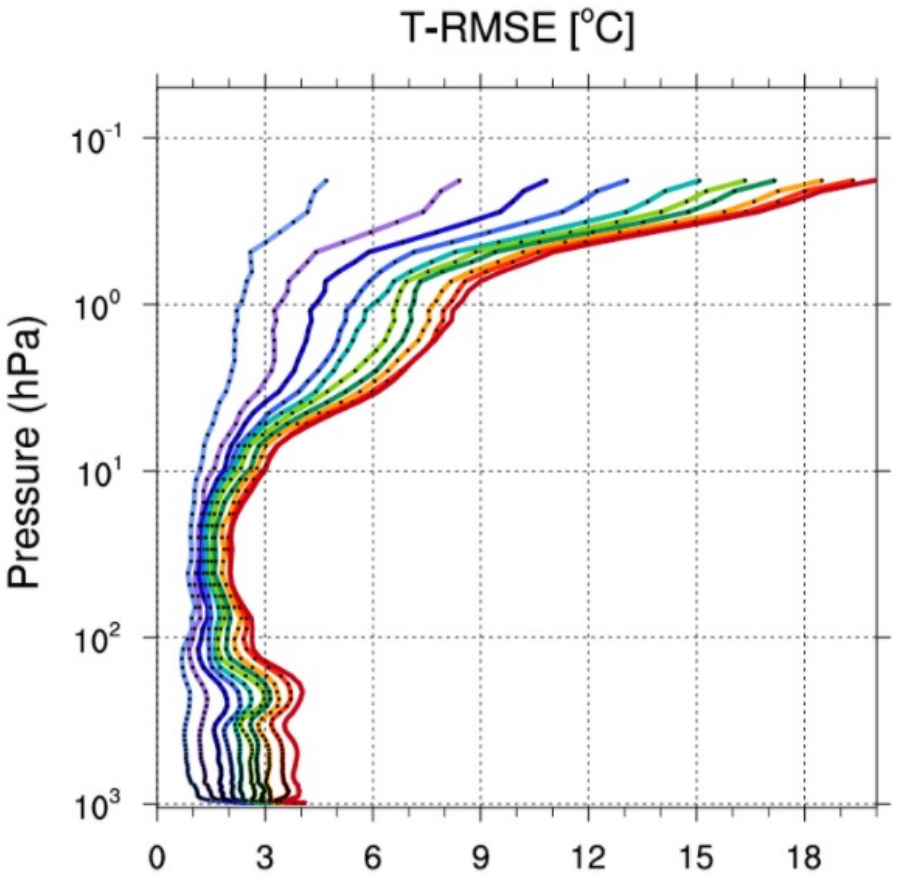

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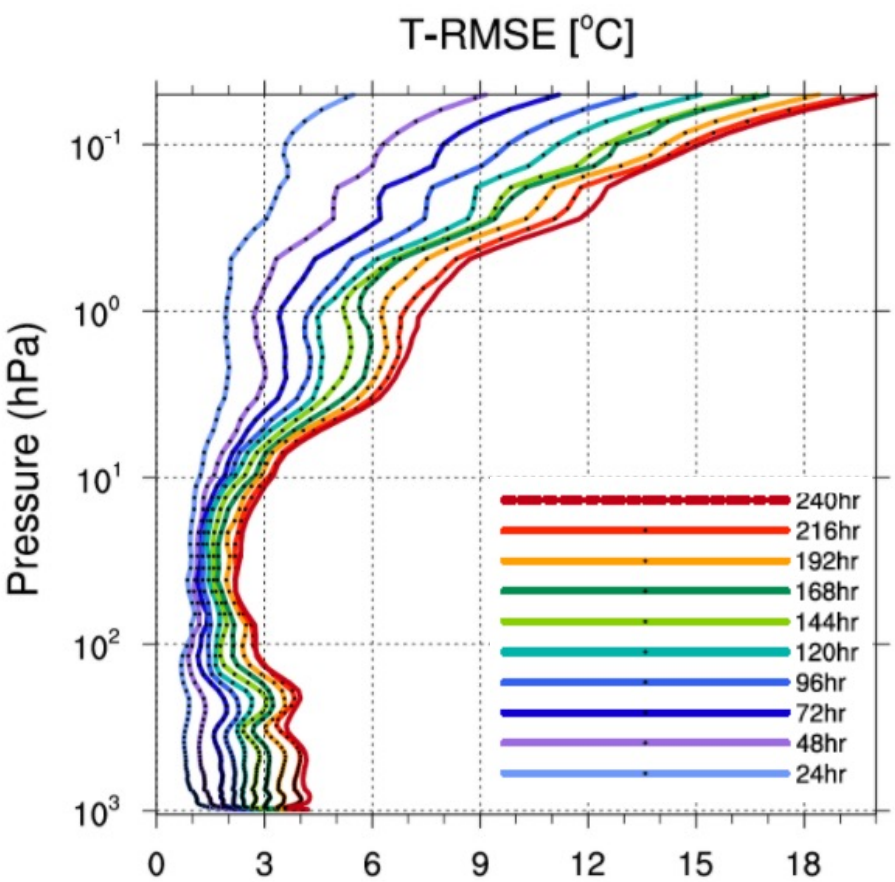

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Coming Soon to MPAS

Update of GPU release to Version 7 (however, this update will not enable regional-MPAS GPU capability).

Update MPAS dynamical core to GPU version (i.e single-source for dynamics). We are not planning to move to single-source for physics; extensive code refactoring was used to enable efficient GPU utilization.

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Somewhat further out…

CCPP in MPAS:

We have MPAS-CCPP prototypes, but we are waiting for the CCPP implementation in CESM/CAM before finalizing the MPAS implementation.

Shared WRF-MPAS physics repository:

We have single-source implementations of the WRF physics that works in MPAS, and that conform to CCPP standards. We are currently maintain these in two separate repositories and have not yet released them.

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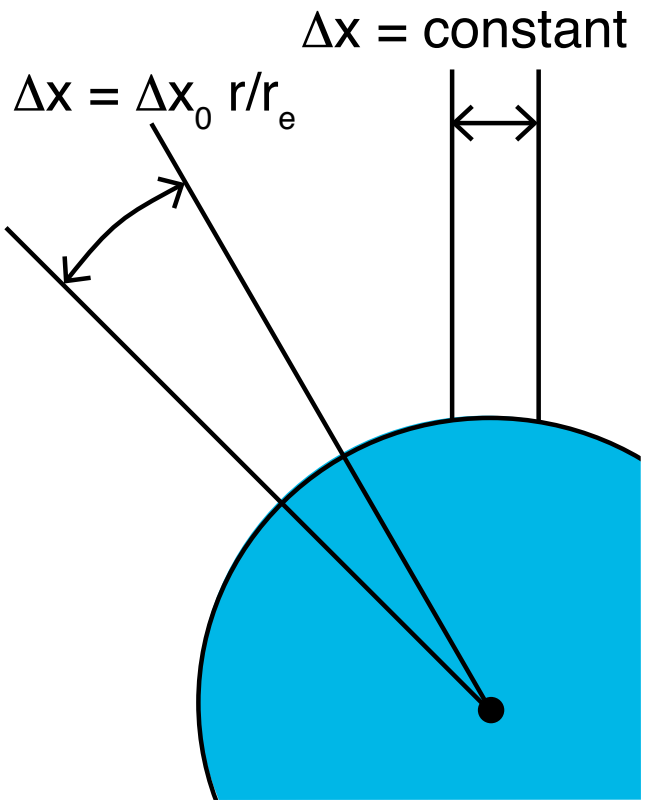
Somewhat further out…



Deep-atmosphere MPAS:

We have a developmental version of MPAS that removes the shallow-atmosphere approximation currently in MPAS. A paper is now out describing its implementation. We do not have a scheduled release date.

W. C. Skamarock, Hing Ong and J. B. Klemp, 2021: A Fully Compressible Nonhydrostatic Deep-Atmosphere-Equations Solver for MPAS. Monthly Weather Review, 149 (2): 571-583, doi:10.1175/MWR-D-20-0286.1

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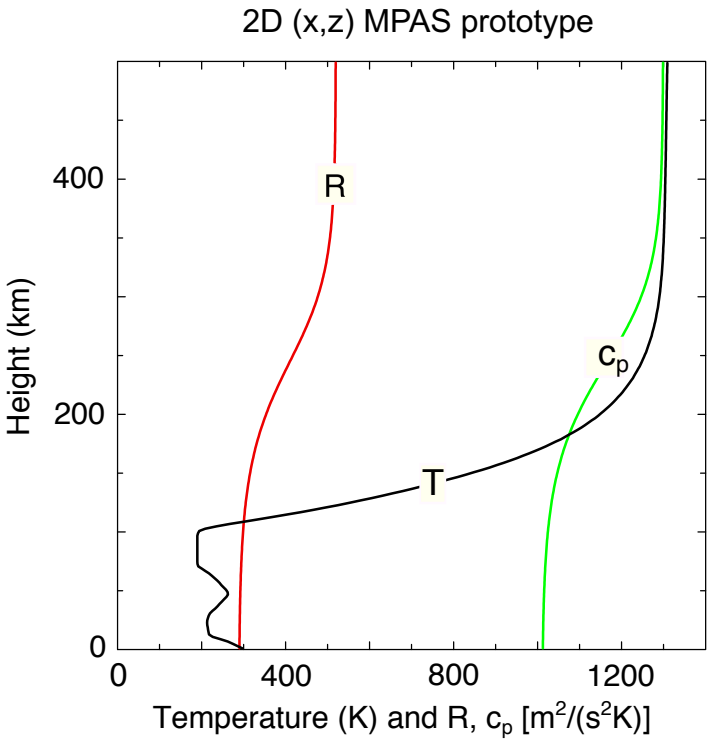
Somewhat further out…

Development and release of a geospace – capable solver (2D prototype design and testing are largely complete).

- Variable (prognostic) constituents (O, O_2, N_2)
- Numerics for large physical viscosities
- Geospace physics

We are doing this development in collaboration with NCAR/HAO, and the implementation will be within CESM as part of SIMA.

See tomorrow's talk by Joe Klemp for details.



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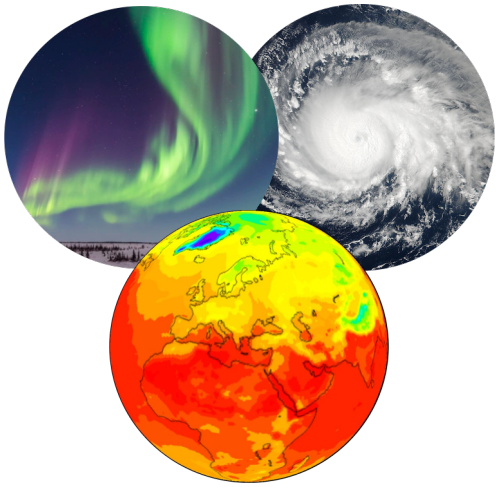
Somewhat further out…

MPAS-Atmosphere in an Earth Systems Model

SIMA – System for Integrated Modeling of the Atmosphere

We have almost completed the implementation of MPAS-Atmosphere in the Community Earth System Model (CESM).



EarthWorks (lead PI: Dave Randall CSU)

EarthWorks

- A high resolution CESM configuration.
- A single ~4 km global grid for the atmosphere, ocean, and land.
- Exascale technology - GPUs
- Based on modified CESM components: CTSM (land), CMEPS coupler
- GPU-enabled MPAS-Atmosphere from the Unified ‘SIMA’ system - Climate and weather applications.

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MPAS Updates

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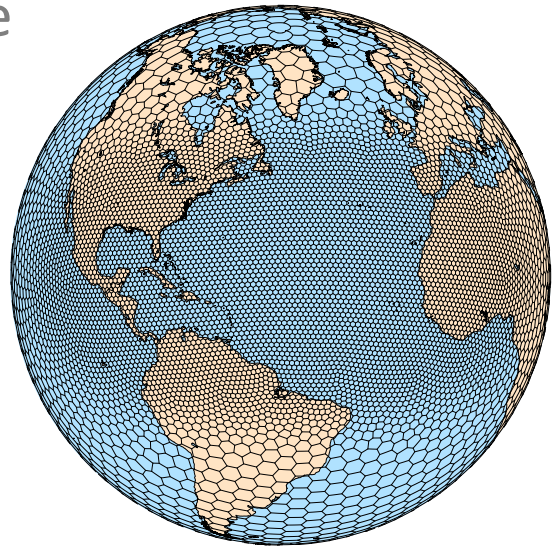

GPU enabled MPAS: *released in Oct 2020*
MPAS Tutorial: *April 2021 tutorial available online*

Coming soon: *Goal - by the end of CY 2021*
Updates to MPAS and MPAS physics
Updates to the GPU release

Further out: *Rate limited by resources, external dependencies*
CCPP and shared WRF-MPAS physics
Deep-atmosphere equations
Geospace capability
MPAS in SIMA/CESM, EarthWorks – tomorrow's talk