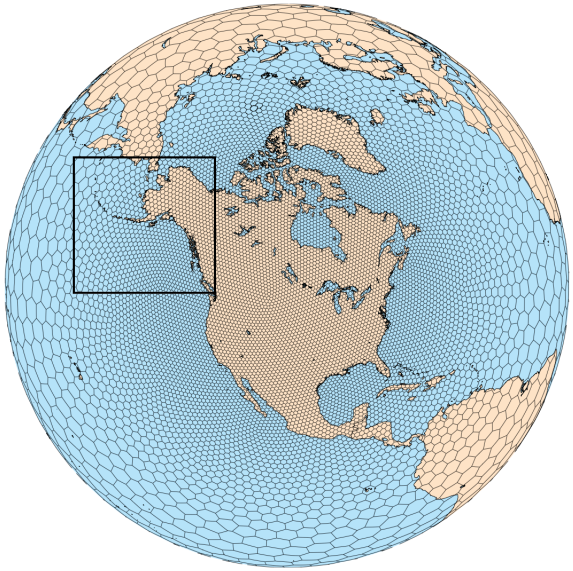
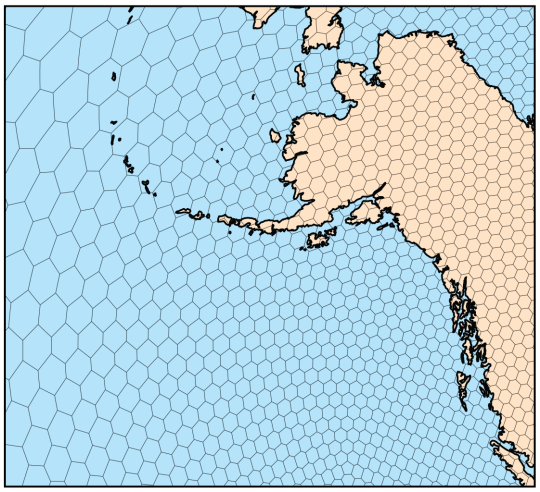
# MPAS: The Model for Prediction Across Scales





MPAS
Model for Prediction Across Scales

*Nonhydrostatic atmosphere and hydrostatic ocean models based on unstructured centroidal Voronoi (hexagonal) meshes using C-grid staggering and selective grid refinement.*

Jointly developed, primarily by NCAR and LANL/DOE

MPAS infrastructure - NCAR, LANL, others.
MPAS - Atmosphere (NCAR)
MPAS - Ocean (LANL)
MPAS - Ice, etc. (LANL and others)

Atmospheric model development team:
M. Duda, L. Fowler, J. Klemp, S.-H. Park, W. Skamarock

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NESL

Beyond WRF: MPAS
A Global Nonhydrostatic Atmospheric Model

2010

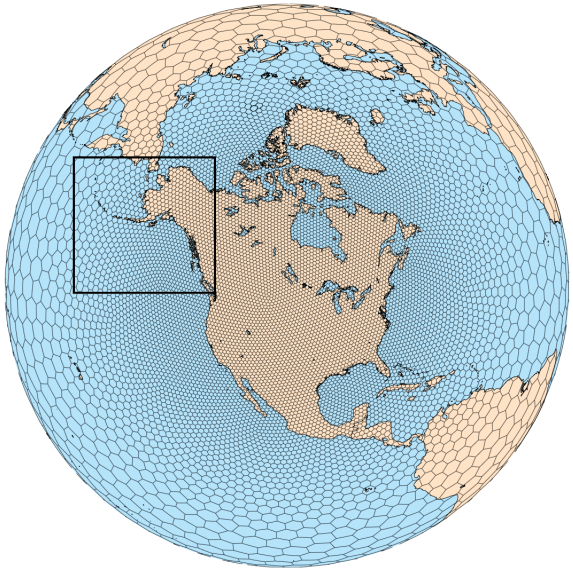
Beyond WRF: Nonhydrostatic Global Modeling with MPAS

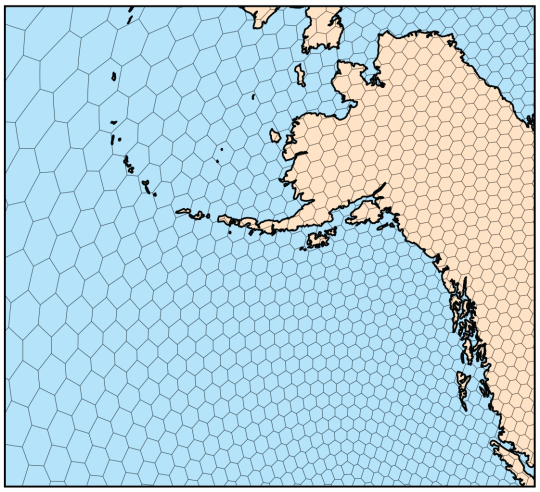
2011

Global Variable-Resolution Tests Results from MPAS using WRF-NRCM Physics

2012

# MPAS: The Model for Prediction Across Scales





MPAS
Model for Prediction Across Scales

*Nonhydrostatic atmosphere and hydrostatic ocean models based on unstructured centroidal Voronoi (hexagonal) meshes using C-grid staggering and selective grid refinement.*

MPAS Version 1.0
Released 14 June 2013
Available at
http://mpas-dev.github.io/

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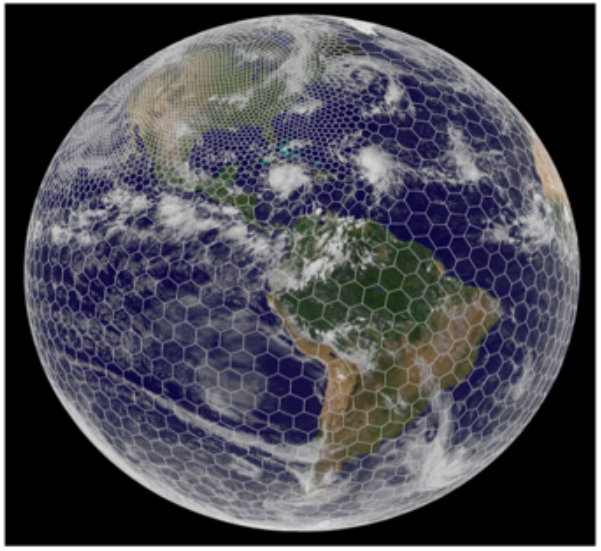
## MPAS Overview



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 model, 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 of the model components. The unstructured Voronoi meshes, formally Spherical Centriodal Voronoi Tesselations (SVCTs), 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.

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# MPAS Atmosphere 1.0 Release

MPAS Home

**Overview**

MPAS-Atmosphere
MPAS-Ocean
DART-MPAS-Atmosphere
Publications
Presentations

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MPAS-Ocean download

**Resources**

License Information
Wiki
Bug Tracker
Mailing Lists
MPAS Developers Guide

MPAS Atmosphere 1.0 was released on 14 June 2013.

*Any questions related to building and running MPAS-Atmosphere should be directed to the MPAS-Atmosphere Help forum. Posting to the forum requires a free google account. Alternatively, questions may be sent from any e-mail address to* "mpas-atmosphere-help **AT** googlegroups.com". *Please note that in either case, questions and their answers will appear on the online forum.*

MPAS Atmosphere 1.0 release notes

MPAS source code download

MPAS Atmosphere Users Guide

MPAS Atmosphere meshes

Configurations for idealized test cases

Visualization and analysis tools

*A variable resolution MPAS Voronoi mesh*

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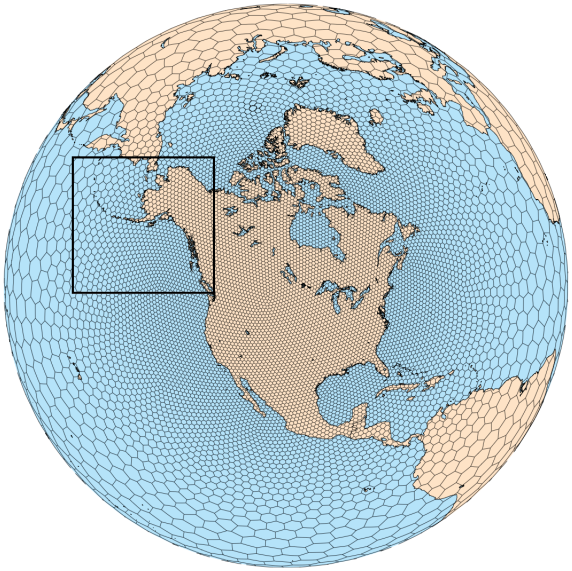
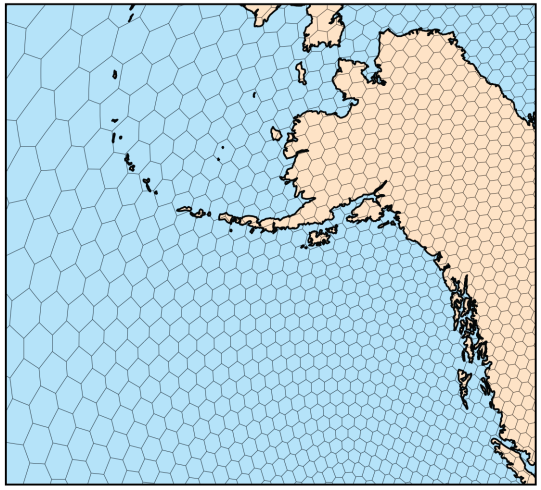
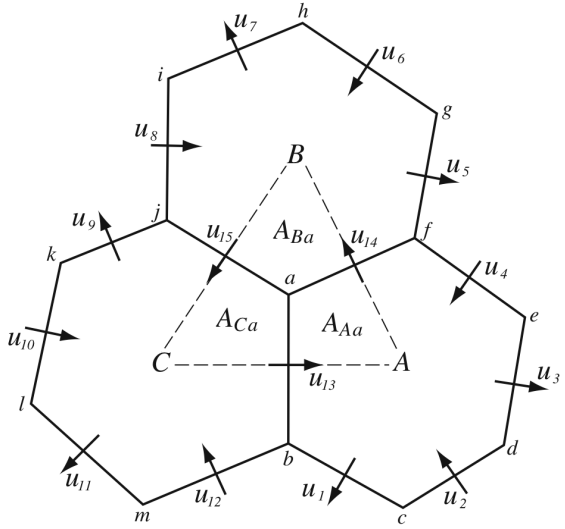
# MPAS-Atmosphere





## Applications

- NWP, Regional Climate and Climate




## Equations

- Fully compressible nonhydrostatic equations (*explicit* simulation of clouds)

## Solver Technology

- Most of the techniques for integrating the nonhydrostatic equations come from WRF.
- C-grid centroidal Voronoi mesh.
- ARW physics (Nested Regional Climate model configuration).

*MPAS is designed to complement ARW, not to replace ARW.*

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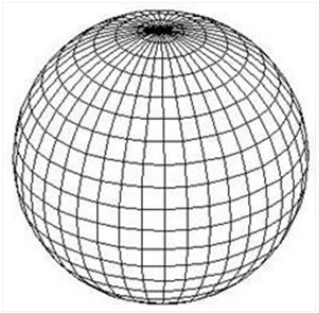
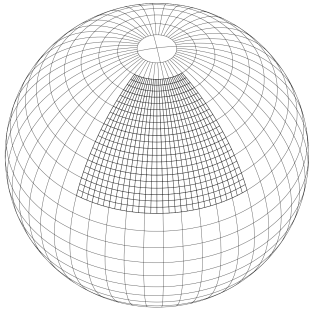
# *Significant differences between WRF and MPAS*

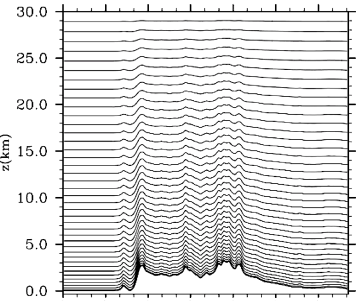


## WRF Characteristics

- Lat-Lon global grid
  - Anisotropic grid cells
  - Polar filtering required



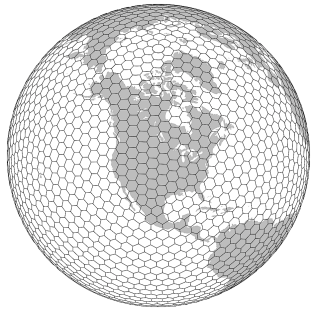
- Grid refinement through domain nesting
  - Flow distortions at nest boundaries



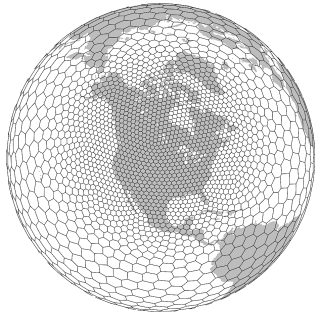

- Pressure-based terrain-following sigma vertical coordinate

## MPAS Characteristics

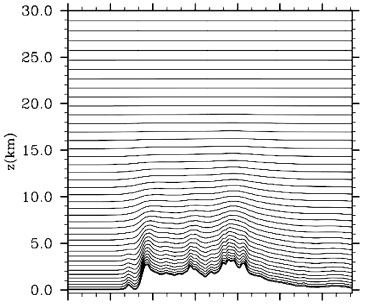
- Unstructured Voronoi (hexagonal) grid
  - Good scaling on massively parallel computers



- Smooth grid refinement on a conformal mesh
  - Increased accuracy and flexibility in varying resolution



- Height-based hybrid smoothed terrain-following vertical coordinate
  - Improved numerical accuracy



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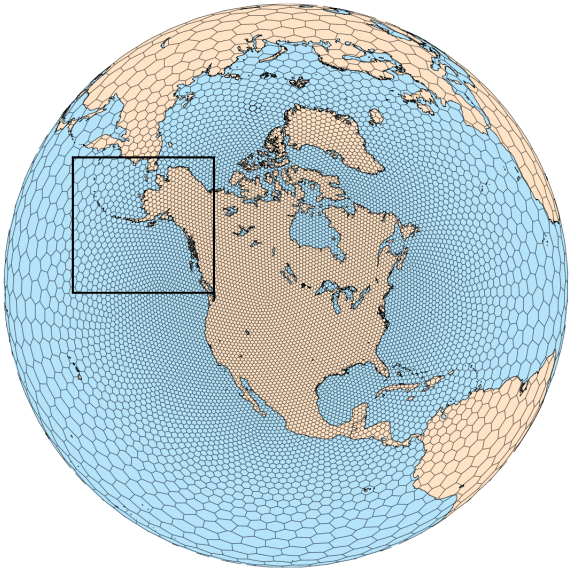
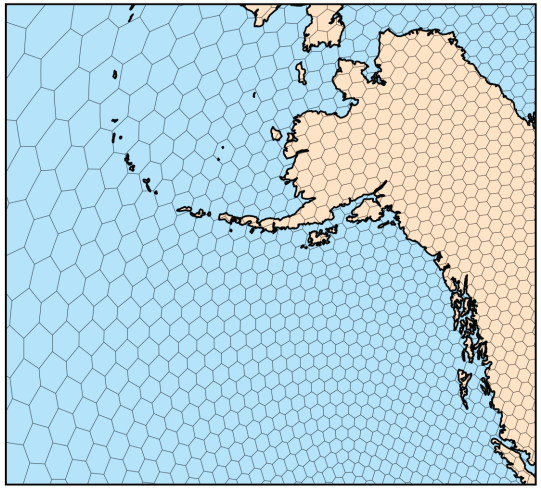
# MPAS-Atmosphere





## MPAS-Atmosphere Version 1.0

Nonhydrostatic atmospheric model
WRF-NRCM physics plus a few options:

- Surface Layer: (Monin Obukhov): module_sf_sfclay.F as in WRF 3.5.
- PBL: YSU as in WRF 3.4.1.
- Land Surface Model (NOAH 4-layers): as in WRF 3.3.1.
- Gravity Wave Drag: as in WRF 3.5.
- Convection: Kain-Fritsch: WRF 3.5; Tiedtke: as in WRFV3.3.1.
- Microphysics: WSM6: as in WRF 3.5
- Radiation: RRTMG sw as in WRF 3.4.1; RRTMG lw as in WRF 3.4.1; CAM radiation as in WRF 3.3.1, with some additions from WRF 3.5.

## Under development (not in Version 1.0)

- Data assimilation (Ensemble DA, Var DA)
- GFS physics
- CAM/CESM port (with coupling to CLM, POP/MPAS-O, ICE, etc.)

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# MPAS-A: Ongoing Testing at NCAR

*NCAR Advanced Scientific Discovery project (Yellowstone)*

Global, uniform resolution.

simulations using average cell-center spacings:

60, 30, 15 and 7.5 with and without convective param, and 3 km.

Cells in a horizontal plane: 163,842 (60 km), 655,362 (30 km),

2,621,442 (15 km), 10,485,762 (7.5 km) and 65,536,002 (3 km).

41 vertical levels, WRF-NRCM physics, prescribed SSTs.

Hindcast periods: 23 October – 2 November 2010, 27 August – 6 September 2010,
15 January – 4 February 2009 (MJO event)

*MPAS comparisons with WRF-NRCM*

Global uniform-resolution and global variable-resolution meshes

*MPAS-Dart:* Ongoing, uniform and variable-resolution meshes

*MPAS TC forecasting:* This fall, uniform and variable-resolution meshes

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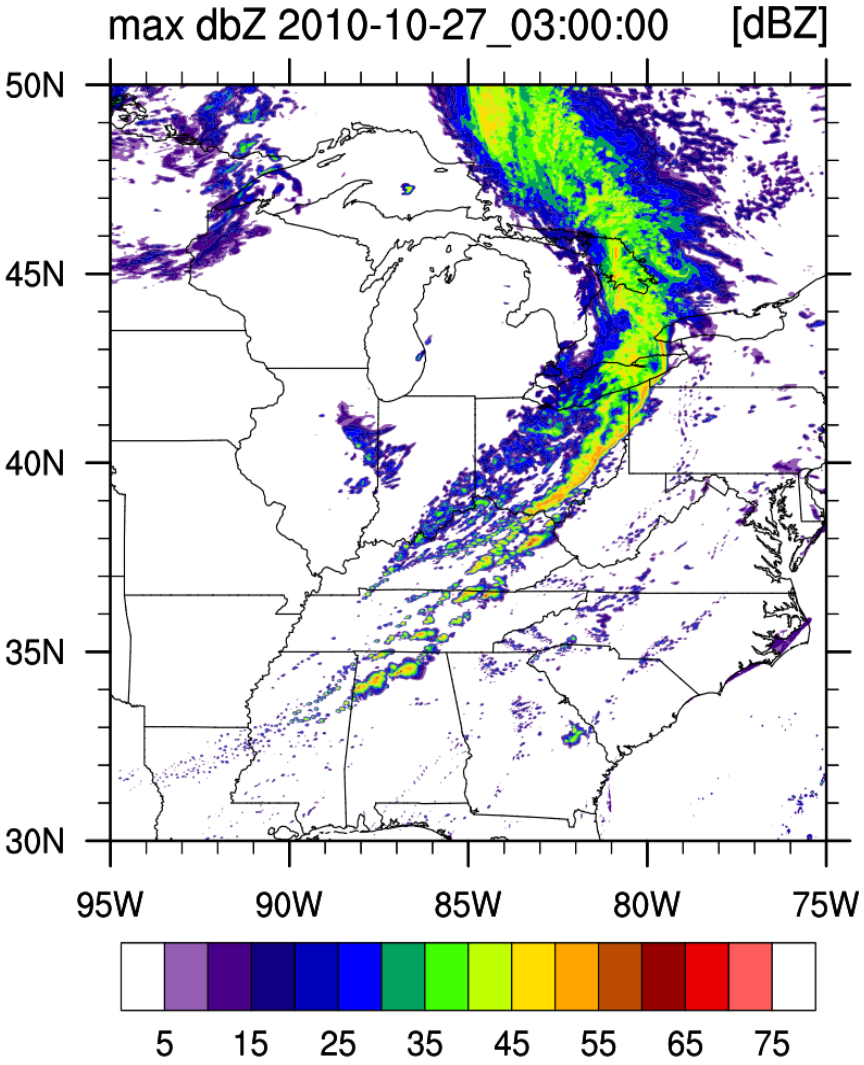
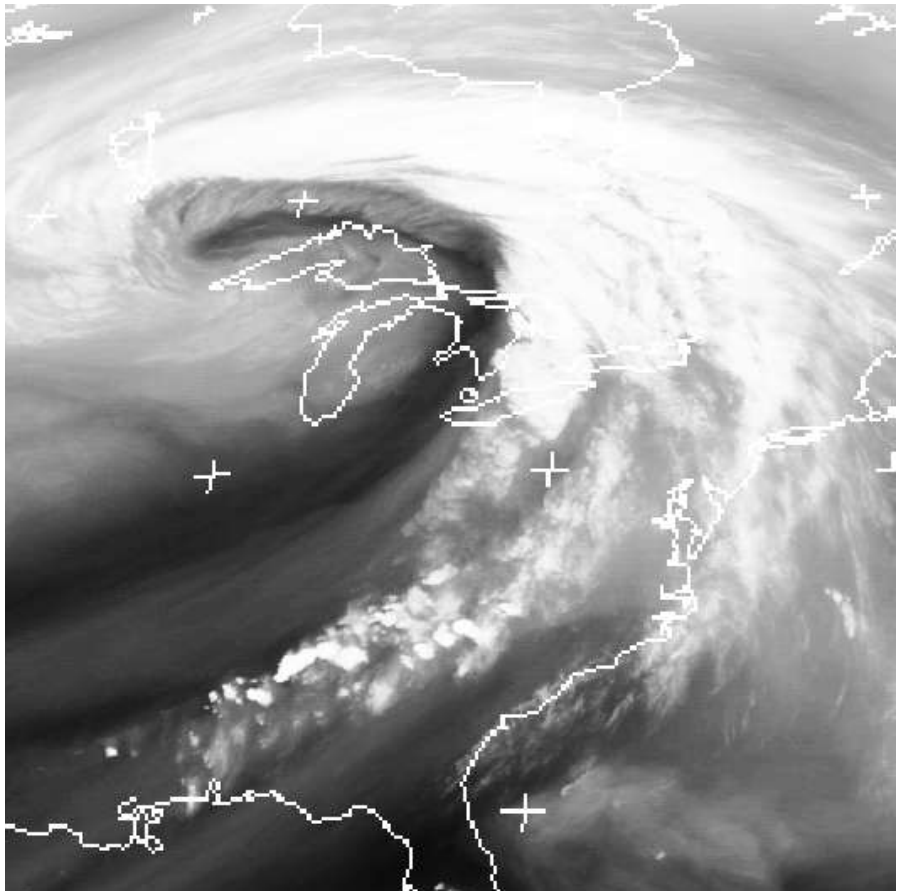
# 3 km global MPAS-A simulation
# 2010-10-23 init




GOES East, 2010-10-27 0 UTC
IR - vapor channel



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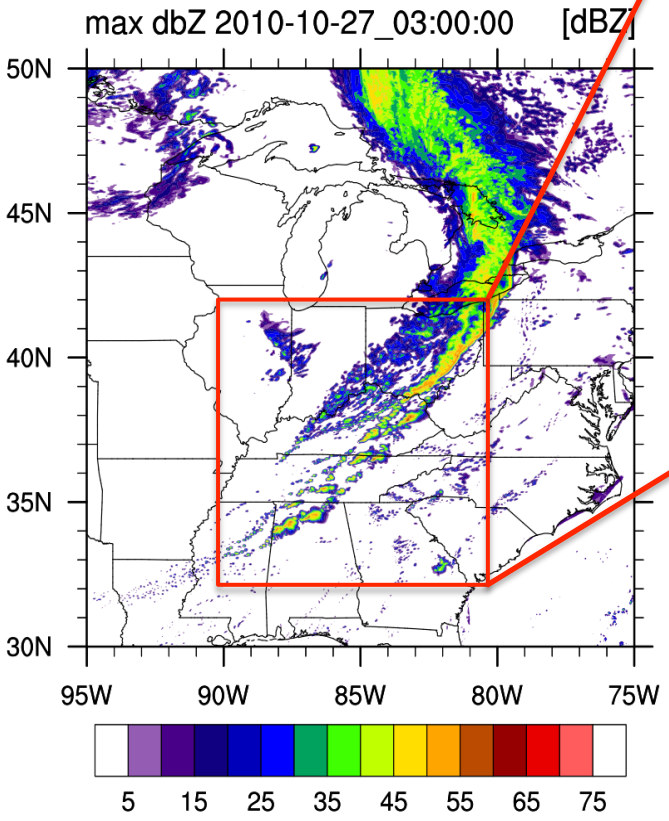
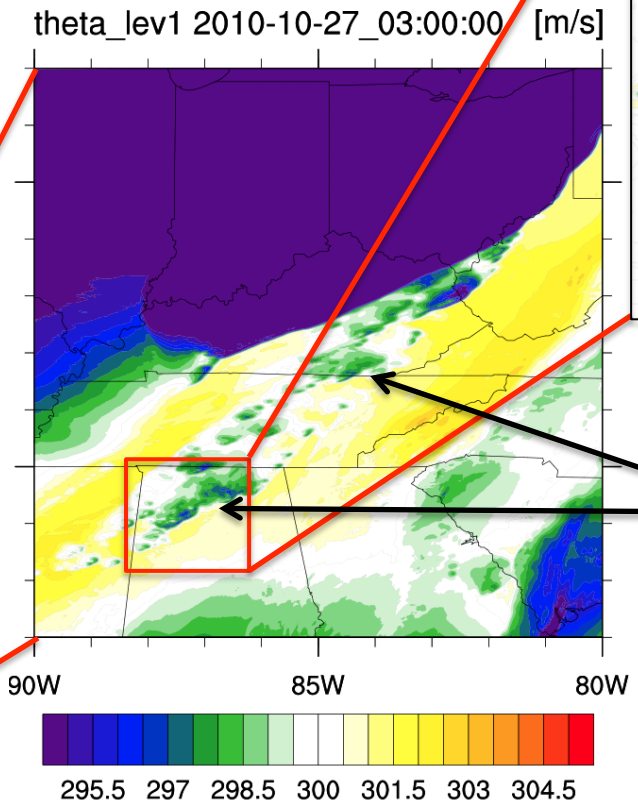
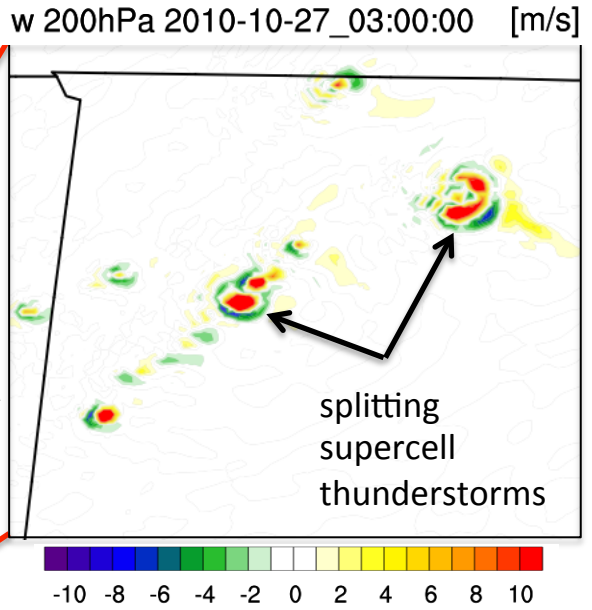
# 3 km global MPAS-A simulation 2010-10-23 init




Cold-pools from isolated storms ahead of the cold front

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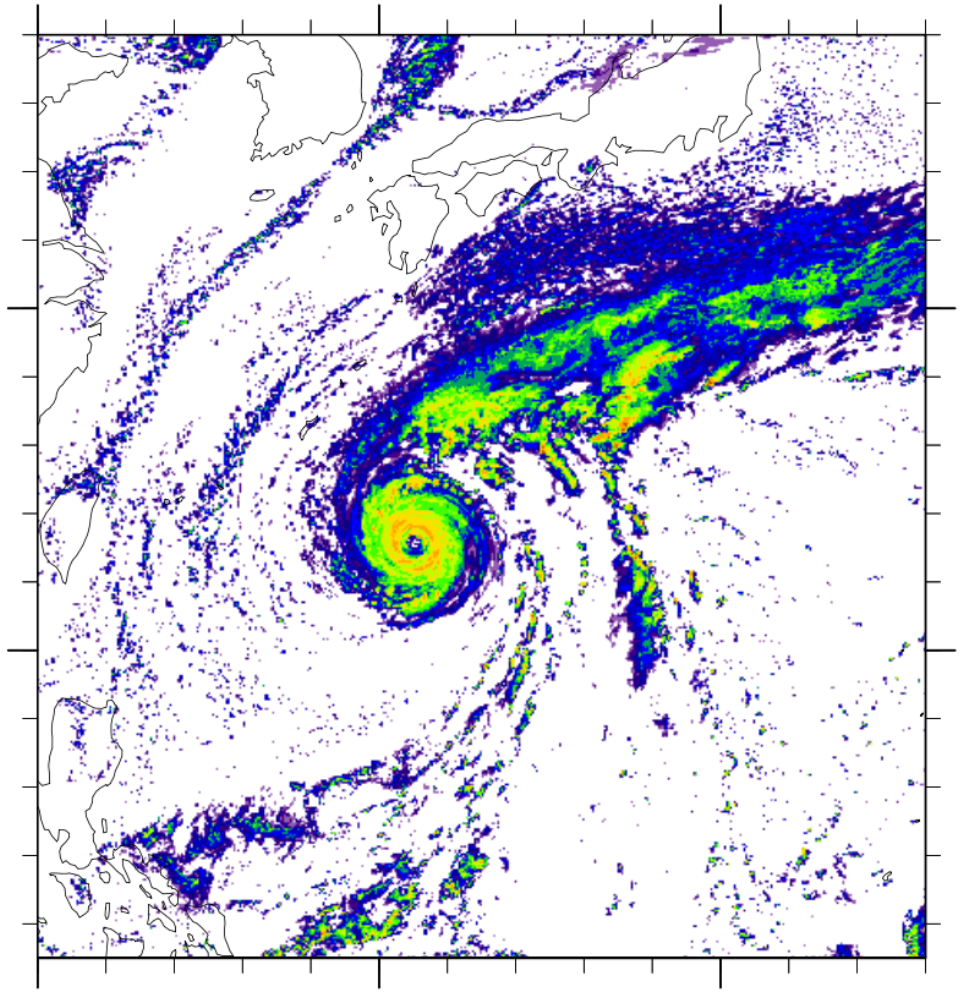
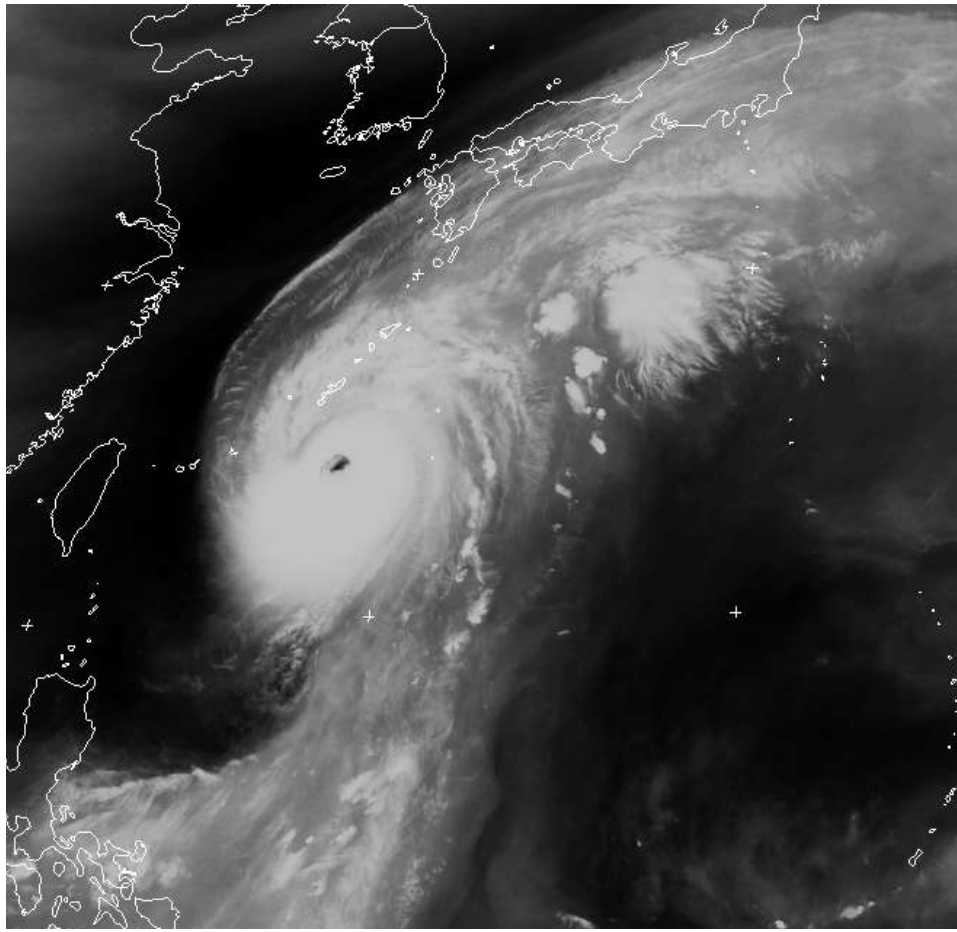
# 3 km global MPAS-A simulation
# 2010-10-23 init

## Typhoon Chaba

max dBZ 2010-10-28_00:00:00 [dBZ]



MTSAT 2010-10-28 0 UTC, IR - vapor



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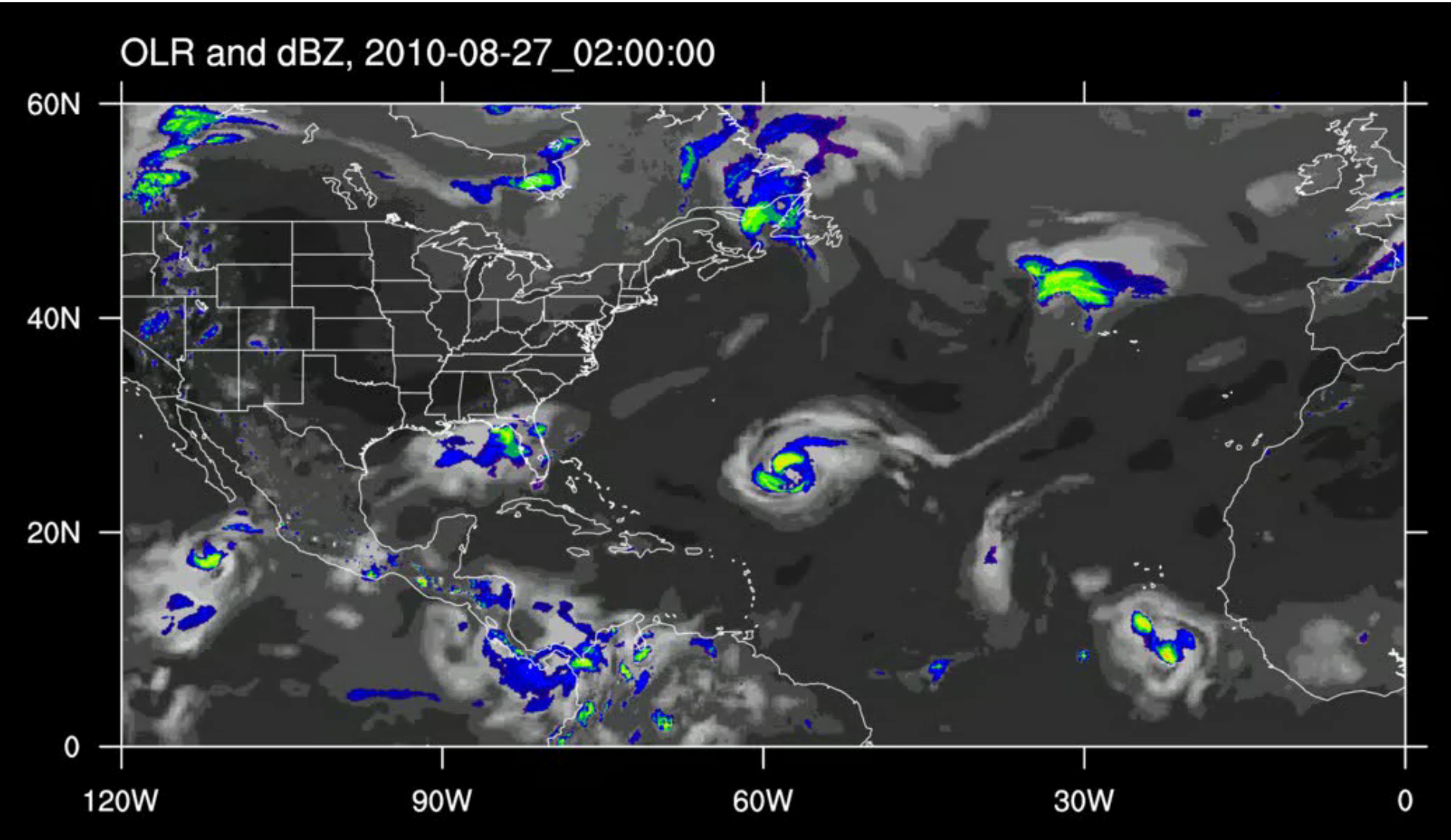
# MPAS 3km global simulations
# 27 Aug – 2 Sept 2010



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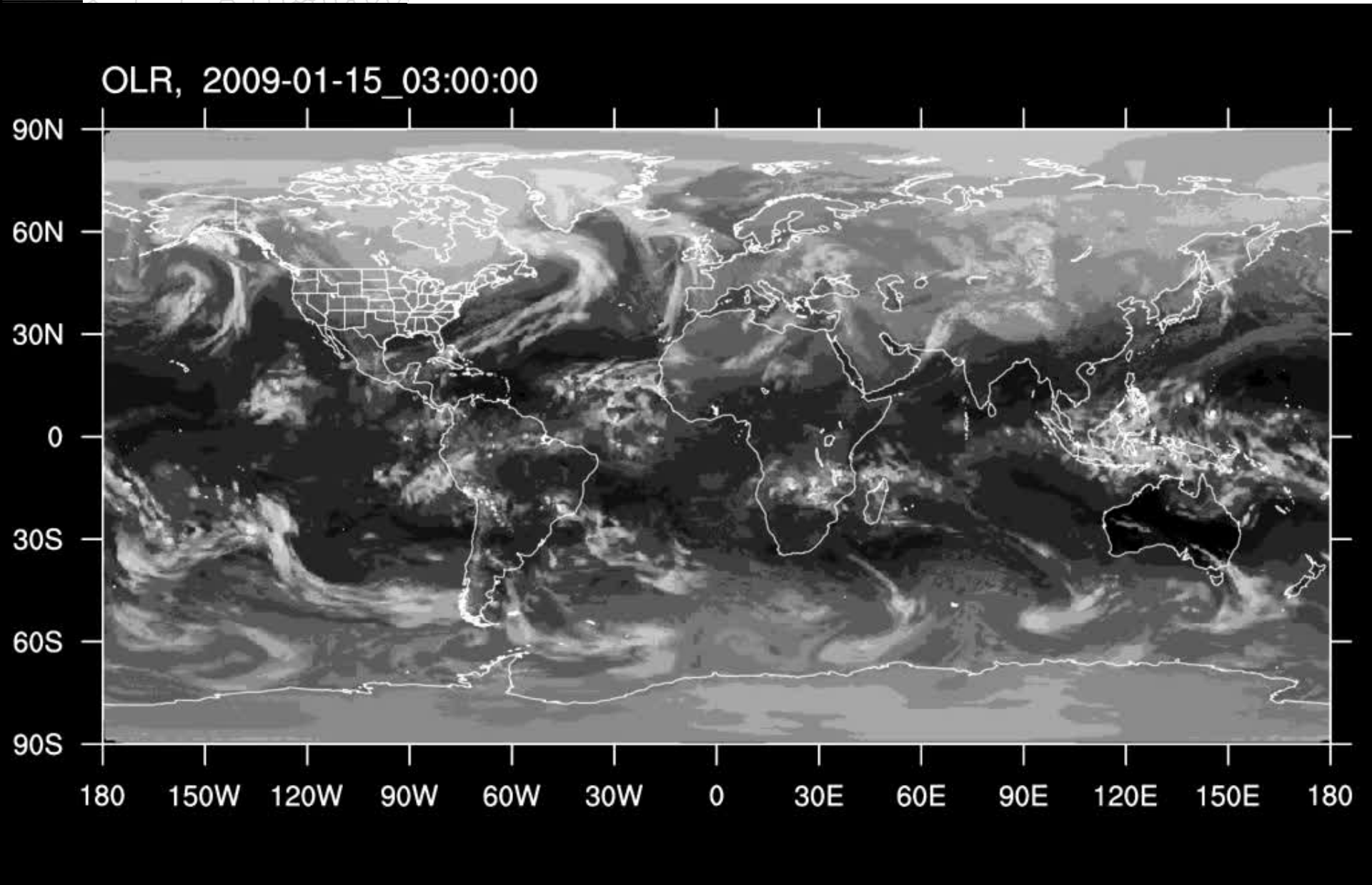
# MPAS 3 km global simulations
# 15 Jan – 4 Feb 2009



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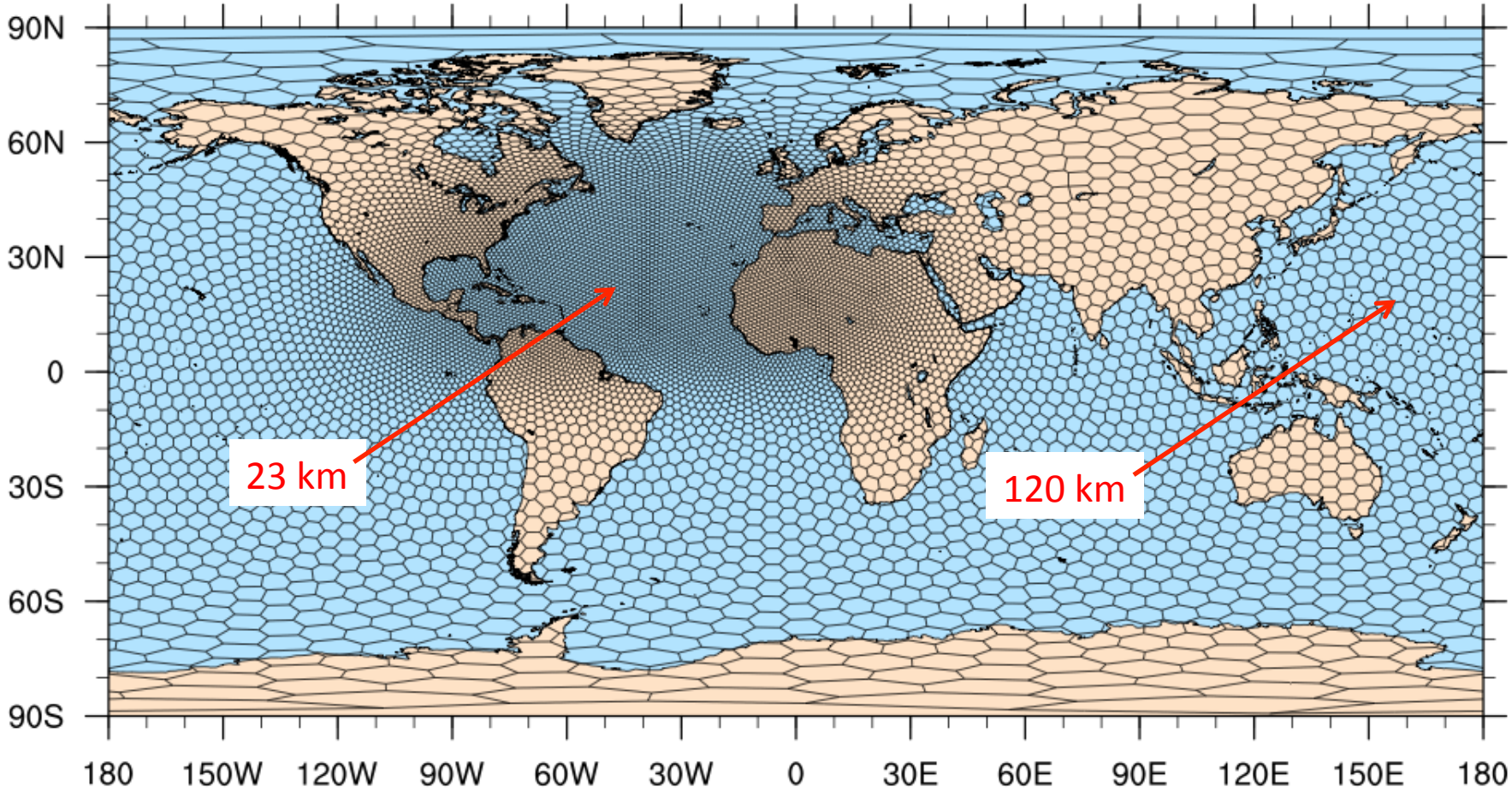
# MPAS variable-resolution global simulations 1 May 2005– 1 Jan 2006



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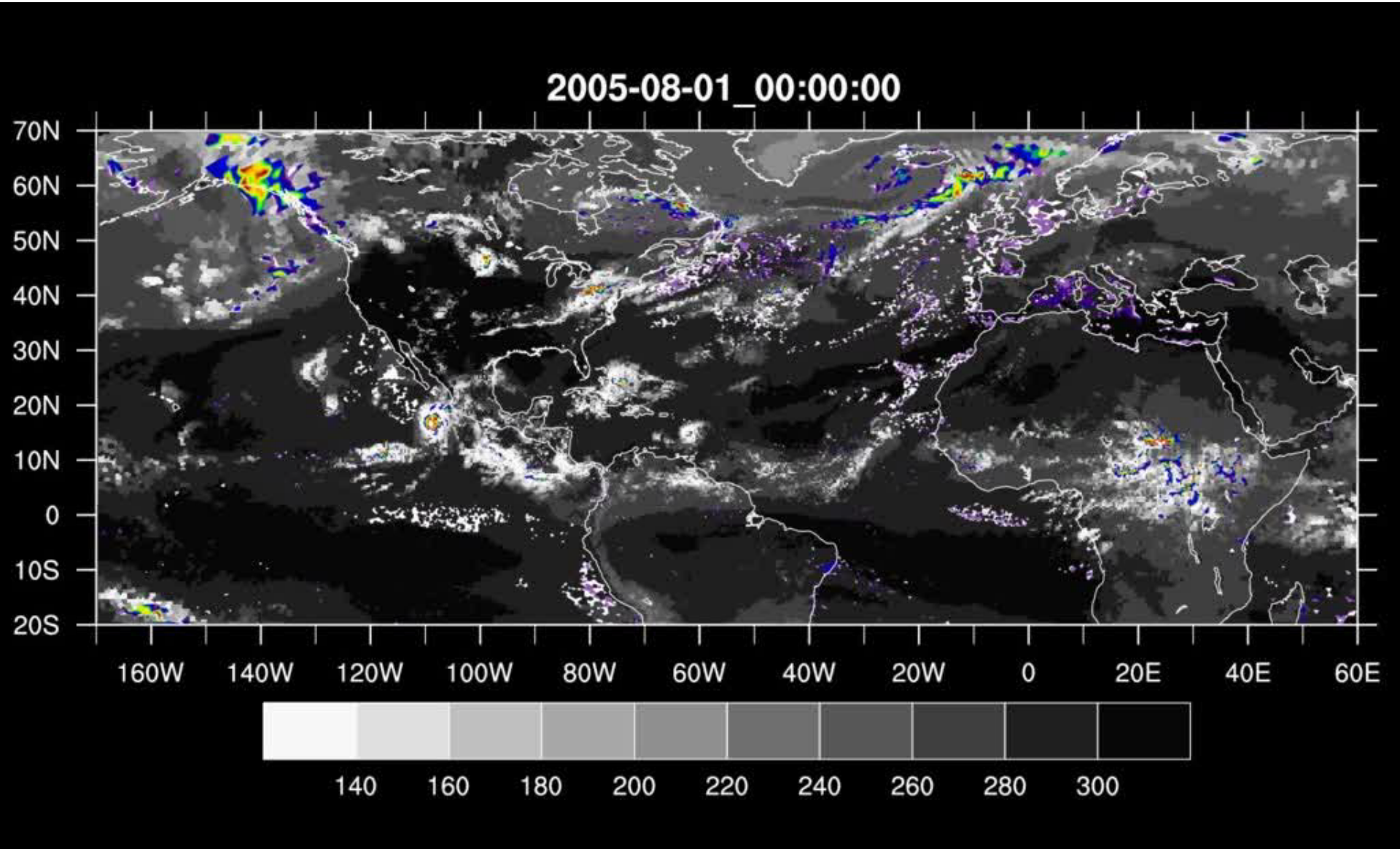
# MPAS 120-23 km global simulations
# 1 Aug – 30 Sept 2005



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# Summary

- Release of MPAS Version 1.0 (MPAS-O and MPAS-A) is now available.
- MPAS-Ocean and MPAS-Atmosphere (nonhydrostatic) are being tested using full-physics NWP and climate tests.
- Variable-resolution results of the MPAS solvers are promising.
- Initial MPI implementations of MPAS-O/A are showing efficiencies and scalings comparable to other models. Much optimization work remains.
- MPAS-A: Our use of variable-resolution meshes is leading us to consider scale-awareness issues in our physics.

*MPAS has been developed for global applications on uniform and variable-meshes. There is no plan to replace WRF with MPAS – they are complementary models.*

*Further information and to access MPAS Version 1.0:*
MPAS: http://mpas-dev.github.io/

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