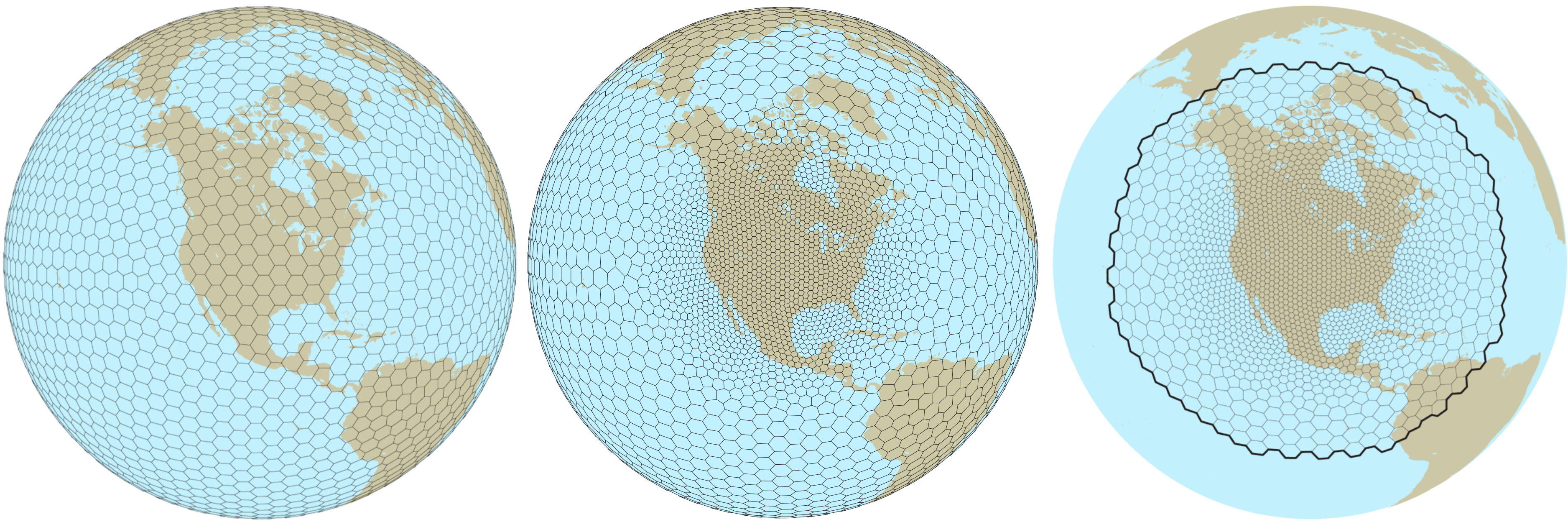
MPAS
Model for Prediction Across Scales

The Model for Prediction Across Scales Version 6.0 release and future development directions.



MPAS-A: *WRF numerics and physics with a height coordinate on a centroidal Voronoi mesh*

MMM-MPAS team: Dave Ahijevych, Michael Duda, Laura Fowler, SoYoung Ha, Jihyeon Jang, Joe Klemp, Sang-Hun Park (YSU), Bill Skamarock, Wei Wang, May Wong, Colin Zarzycki

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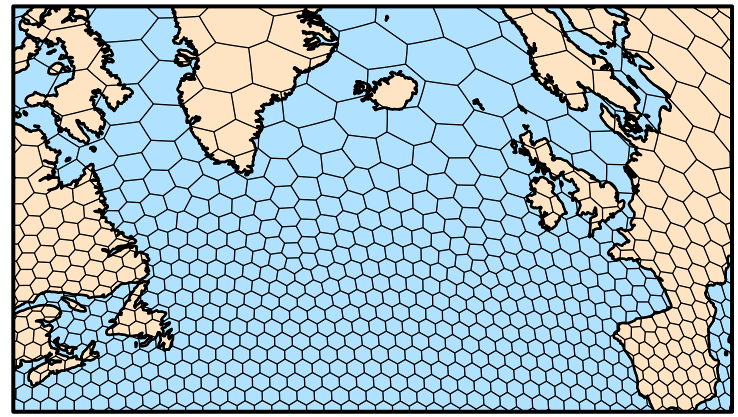
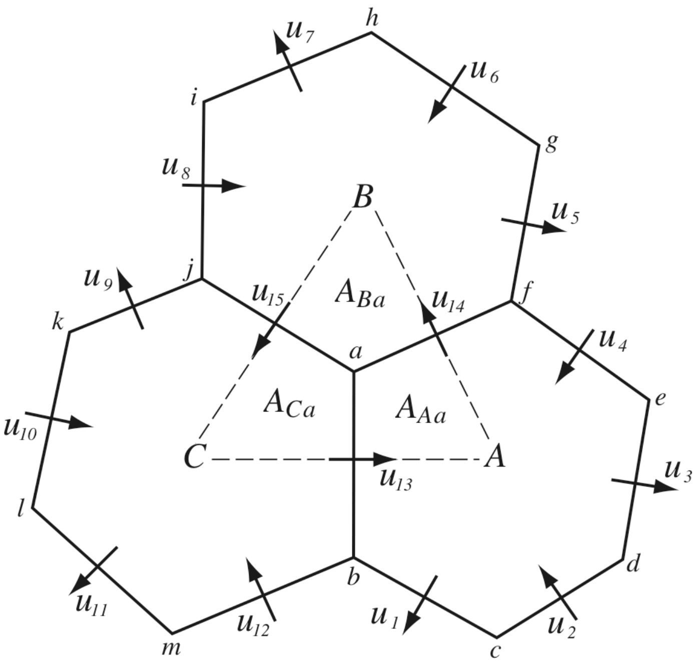
Centroidal Voronoi Meshes

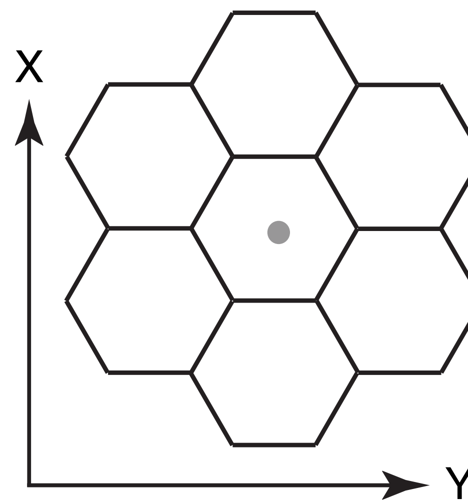
The horizontal mesh is *unstructured*

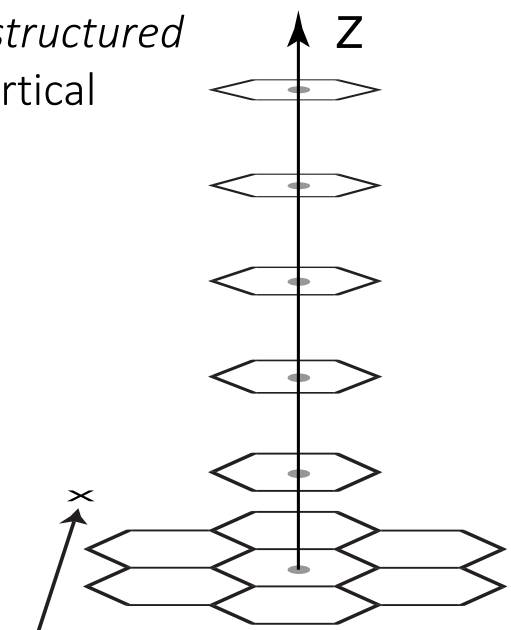


MPAS uses a C-grid staggering



The mesh is *structured*
in the vertical





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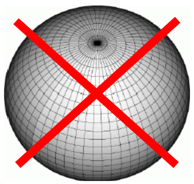
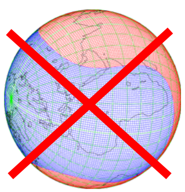
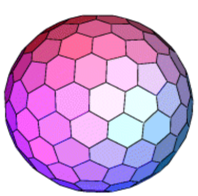
MPAS Development







2005	Global lat-lon (WRF) problematic.
2006	Triangles - problems with divergence.
2007	Yin-Yang: local conservation past 1st-order accuracy? Cubed-sphere: Corner point problems? Hex grid: C-grid problem solved for perfect hex mesh.
2008	C-grid problem solved for general Voronoi mesh.
2009	Unstructured-mesh MPAS SW eqns. solver. MPAS hydrostatic eqns. solver.
2010	MPAS nonhydrostatic eqns. solver. Hydrostatic MPAS in CAM/CESM.
2011	WRF-NRCM physics in MPAS.
2012	DART data assimilation.
2013	3km global mesh tests on Yellowstone. MPAS V1.0 release (atmosphere, ocean) MPAS-Atmosphere real-time TC forecast testing.
2014	Scale-aware physics testing begins.
2015	15-3 km convective forecast HWT experiments begin Release of *mesoscale reference* physics suite
2017	MPAS V5.0 release, Scale-aware *convection_permitting* physics suite released.
2018	MPAS V6.0 release, open source githib repository

MPAS V6.0 release

MPAS-Atmosphere Version 5.0: 7 January 2017
MPAS-Atmosphere v5.1: 12 May 2017
MPAS-Atmosphere v5.2: 1 August 2017
MPAS-Atmosphere v5.3: 22 March 2018

MPAS-Atmosphere Version 6.0: 17 April 2018

In contrast to WRF, MPAS does not follow a yearly release schedule.
Releases in new functionality increments the integer version number.
Bugfixes increments the integer to the right of the decimal point.

MPAS V6: New sea-ice core, major upgrades to the ocean and land-ice models (DOE E3SM release). Only minor increments to the atmospheric model.

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MPAS V6.0 release

MPAS-Atmosphere V6 physics

mesoscale-reference suite

Parameterization	Scheme
Convection	New Tiedtke
Microphysics	WSM6
Land surface	Noah
Boundary layer	YSU
Surface layer	Monin-Obukhov
Radiation, LW	RRTMG
Radiation, SW	RRTMG
Cloud fraction for radiation	Xu-Randall
Gravity wave drag by orography	YSU

convection-permitting suite

Parameterization	Scheme
Convection	Grell-Freitas
Microphysics	Thompson (non-aerosol aware)
Land surface	Noah
Boundary layer	MYNN
Surface layer	MYNN
Radiation, LW	RRTMG
Radiation, SW	RRTMG
Cloud fraction for radiation	Xu-Randall
Gravity wave drag by orography	YSU

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MPAS V6.0 release

MPAS-Atmosphere V6 physics

Table 6.3: Possible options for individual physics parameterizations. Namelist variables should be added to the &physics namelist record.

Parameterization	Namelist variable	Possible options	Details
Convection	config_convection_scheme	cu_tiedtke	Tiedtke
		cu_ntiedtke	New Tiedtke (WRF 3.8.1)
		cu_grell_freitas	Modified version of scale-aware Grell-Freitas (WRF 3.6.1)
		cu_kain_fritsch	Kain-Fritsch (WRF 3.2.1)
Microphysics	config_microp_scheme	mp_wsm6	WSM 6-class (WRF 3.8.1)
		mp_thompson	Thompson non-aerosol aware (WRF 3.8.1)
		mp_kessler	Kessler
Land surface	config_lsm_scheme	noah	Noah (WRF 3.3.1)
Boundary layer	config_pbl_scheme	bl_ysu	YSU (WRF 3.8.1)
		bl_mynn	MYNN (WRF 3.6.1)
Surface layer	config_sfclayer_scheme	sf_monin_obukhov	Monin-Obukhov (WRF 3.8.1)
		sf_mynn	MYNN (WRF 3.6.1)
Radiation, LW	config_radt_lw_scheme	rrtmg_lw	RRTMG (WRF 3.8.1)
		cam_lw	CAM (WRF 3.3.1)
Radiation, SW	config_radt_sw_scheme	rrtmg_sw	RRTMG (WRF 3.8.1)
		cam_sw	
Cloud fraction for radiation	config_radt_cld_scheme	cld_fraction	Xu and Randall (1996)
		cld_incidence	0/1 cloud fraction depending on $q_c + q_i$
Gravity wave drag by orography	config_gwdo_scheme	bl_ysu_gwdo	YSU (WRF 3.6.1)

MPAS-Atmosphere will adopt and use the Community Physics Framework (CPF) being developed to access both WRF and CESM/CAM physics.

MPAS V6.0 release

What is *not* in MPAS-Atmosphere V6:

- Regional MPAS.
- MPAS-Atmosphere in CESM/CAM
- Any GPU/accelerator capabilities in MPAS-Atmosphere.
- Mesh generation
- Open development

MPAS Development Plans

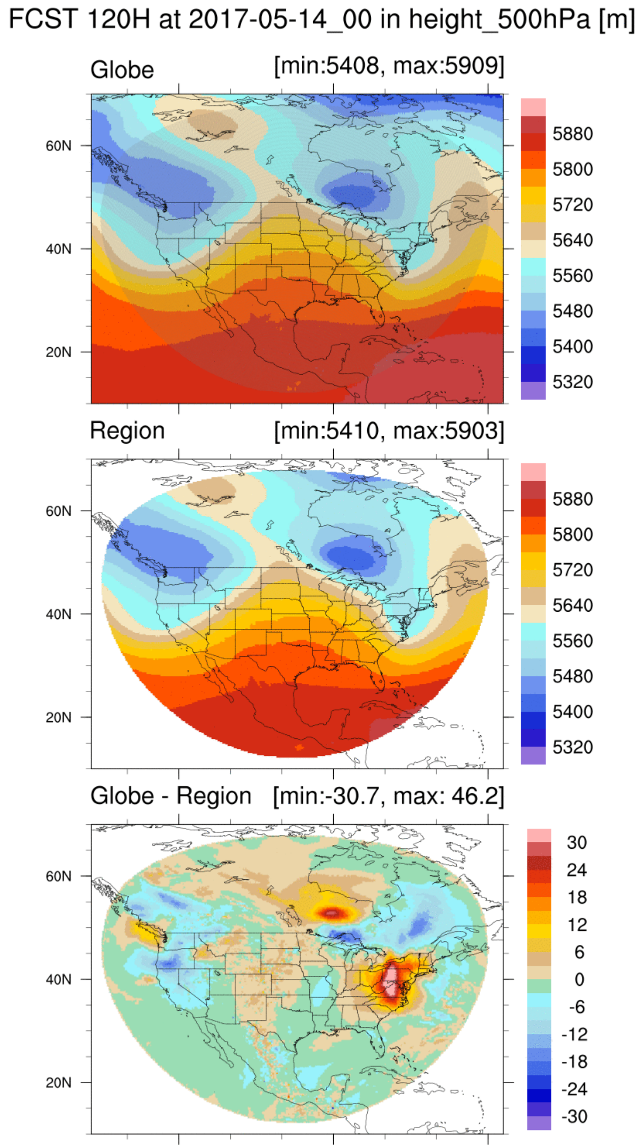
Regional MPAS-Atmosphere

We hope to release the regional version of MPAS-Atmosphere before the next WRF/MPAS workshop.
(core clean-up, SE work on regional utilities)

Regional MPAS can be driven by other MPAS global or regional simulations, by GFS, by CFSR, IFS forecasts, etc.

Regional WRF can be driven by global MPAS simulations now.

See the talk by Michael Duda later this morning:
Progress towards a regional capability in MPAS-Atmosphere.



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MPAS Development Plans

MPAS-Atmosphere in CESM/CAM

Community Earth System Model (CESM)

- MPAS-A Version 4 is an atmospheric dynamical core in CAM
- NWP and climate testing is ongoing
- Coupled model simulations are being performed (w/ocean, ice)
- Physics evaluation for NWP is major focus of early testing

A clean, supportable implementation of MPAS-A into CESM will be engineered later this year. MPAS-A will be a CESM external (like the new CESM ocean core MOM). Builds of MPAS-A in CESM/CAM will pull MPAS-A directly from the MPAS development/release github repository.

The new MPAS-Atmosphere port to CESM is part of the *Singletrack* project to unify atmospheric modeling at NCAR (weather, climate and geospace).

MPAS-Atmosphere will adopt and use the Community Physics Framework (CPF) being developed to access both WRF and CESM/CAM physics.

Regional MPAS-A capabilities should be available in CESM/CAM.

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MPAS Development Plans

GPU/accelerator capabilities in MPAS-Atmosphere

A version of MPAS-A using GPUs through OpenACC directives is being developed.

Participating organizations: The Weather Company, IBM, NCAR, Univ. Wyoming, KISTI, NVIDIA

Questions being addressed in this development:

- Can we achieve significant performance enhancement on GPUs using OpenACC?
- Can we maintain and evolve a single-source code (CPU/GPU) in our development and for release and support to the community?

For further information see:

PU developments for the WRF and MPAS Models.

Adie et al, Wednesday morning.

Plans for a GPU-accelerated MPAS-driven forecast system.

Todd Hutchinson et al, Wednesday morning.

MPAS Development Plans

MPAS
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MPAS mesh generation

Mesh generation utilities are not in the MPAS V6 release.

Mesh generation is expensive (expensive algorithms, parallelization issues, etc). Variable high-resolution meshes can take months to generate with existing utilities.

Recent development efforts suggest we may be able to speed-up our existing algorithms by an order of magnitude or more.

Mesh generation tools will appear in the public MPAS-Tools repository:
https://github.com/MPAS-Dev/MPAS-Tools

MPAS
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MPAS Development Plans

MPAS Github repository

https://github.com/MPAS-Dev/MPAS-Model

As of the MPAS V6 release, the release and development repository are public.

Advantages:

- It's easier for everyone to maintain their own branches of MPAS, since they can incrementally integrate changes to the main (single) code base.
- It simplifies the process for community members to contribute changes. Contributions should be developed under git, and pull requests made.
- If more people are able to see pull requests as they are made, there's a higher likelihood that bugs or oversights can be caught earlier.

However…

- We need a contributors' guide to set expectations for contributing to the project.
- Open development doesn't guarantee any pull request made to the project will be approved.
- We can't support development code except as necessary to directly support development.
- Anyone wishing to develop a new capability (e.g., a physics scheme) in private will need to manage a small amount of complexity in pushing code between different git repositories (private and public).

WRF and CESM are not public, but they may become public in the near future.