Developing MPAS Earth System Model Capabilities - an Update.

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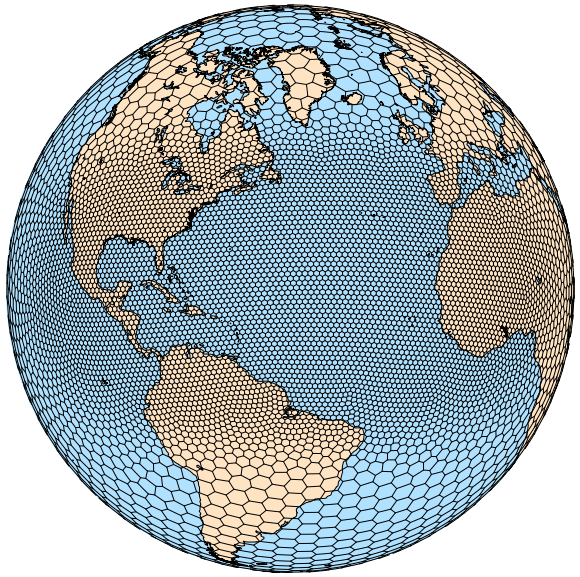
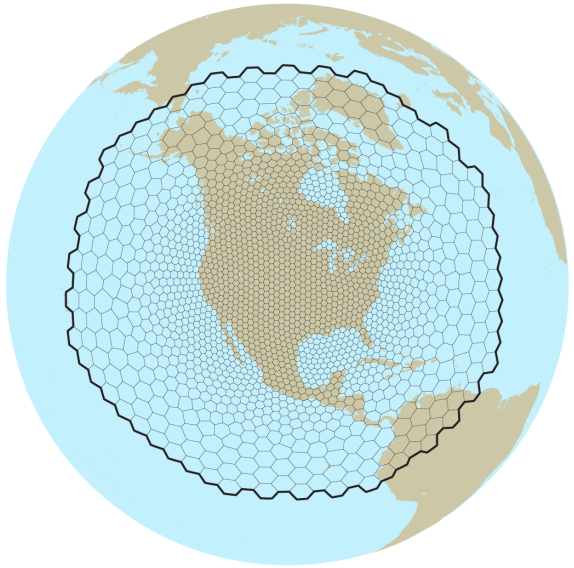




Model for Prediction Across Scales (MPAS)

Current release – Version 7.3

- Atmosphere and land only
- Open Source: https://mpas-dev.github.io/
- Global and regional, variable-resolution capabilities
- Annual tutorials; new releases as needed
- GPU-enabled for some configurations (V6.1, October 2020)
- DA – both DART and JEDI

Last major release June 2019 (V7) - What have we been doing?

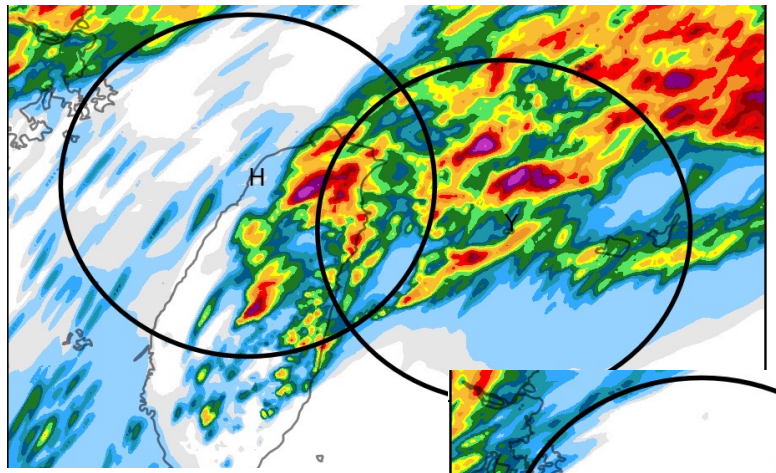
Physics unification – see *Fowler et al* talk today, *Wong et al* talk Thursday
Deep-atmosphere extensions – see *Klemp* talk tomorrow.
LES extensions – not quite ready for a talk
MPAS in an Earth System Model (ESM) – part of today's talk
GPU development – another part of today's talk

Many of these developments will become available in the coming year

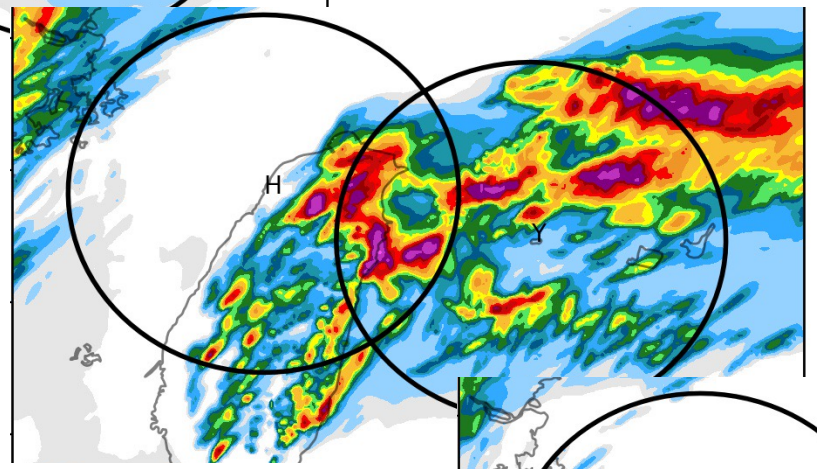
PRECIP field campaign real-time forecasts

Rosimar Rios-Berrios, NCAR lead
MPAS 60-3 km mesh
Daily 5-day forecasts, IFS analysis initial conditions
https://www2.mmm.ucar.edu/projects/real-time-forecasts/

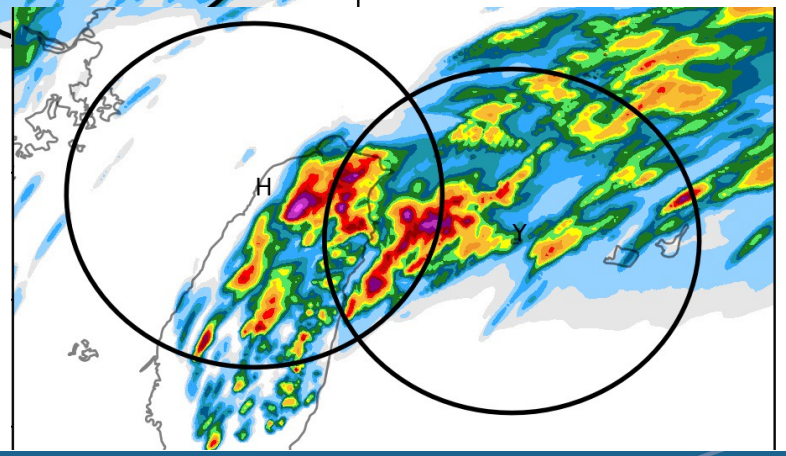
12-36 hour forecast precipitation

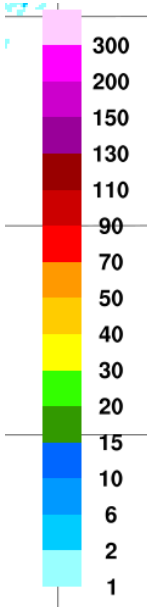


36-60 hour forecast



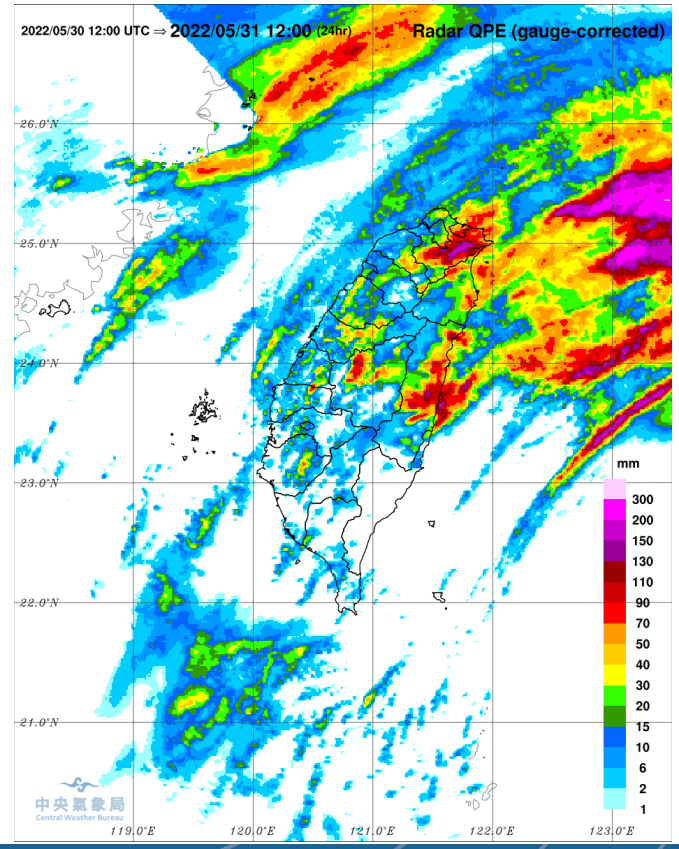
60-84 hour forecast





24 hour accumulated precipitation (mm)
ending 1200 UTC 31 May 2022

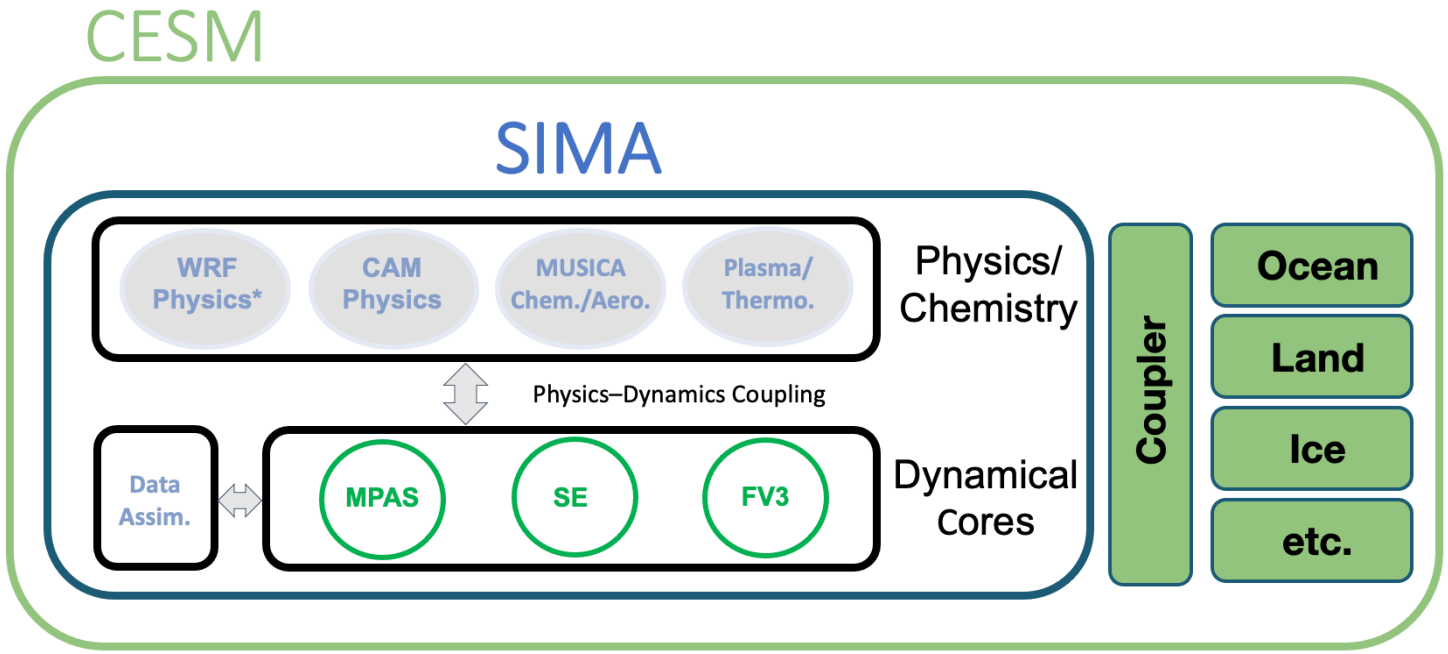
Radar QPE



MPAS Earth System Model Capabilities

System For Integrated Modeling of the Atmosphere (SIMA)

SIMA is the effort to unify NCAR-based community atmospheric modeling across Weather, Climate, Chemistry, and Geospace applications



* where needed to augment CAM physics

https://sima.ucar.edu

MPAS – Atmosphere brings nonhydrostatic modelling capabilities to CESM.

- We have a clean port of MPAS that is pulled from the MPAS github development repository at build time.
- We have test results that show MPAS-CAM6 produces credible climate results at O(1 degree) resolution.
- We are currently testing MPAS and CAM6 physics at convection-permitting resolution.
- We are working on resolving issues associated with CESM and CAM infrastructure within high-resolution configurations (i.e. memory and cost).

We hope to release these capabilities within the coming year (before the next WRF/MPAS workshop)

Accelerators (GPUs) and MPAS-Atmosphere

We will be releasing configurations of GPU-enabled MPAS-Atmosphere for NCAR's new supercomputer *Derecho*

We anticipate releasing significant updates to GPU-enabled MPAS-A as a result of GPU ports of physics at NCAR and at other organizations

We are working on merging the GPU release with our main release

EarthWorks

Five-year project led by
CSU: Randall PI, Hurrell
NCAR: Gettelman, Hauser, Skamarock
Funded by NSF CSSI.

Enabling new science in an earth-system-model for both weather and climate, in a unified framework

- A global coupled configuration of CESM
  - A single ~ 4 km global mesh for all components
- GPU-enabled MPAS Atmosphere & MPAS-Ocean
- GPU physics (augmented CAM6)
- Goal: ~0.5 SYPD for the coupled system in 2025

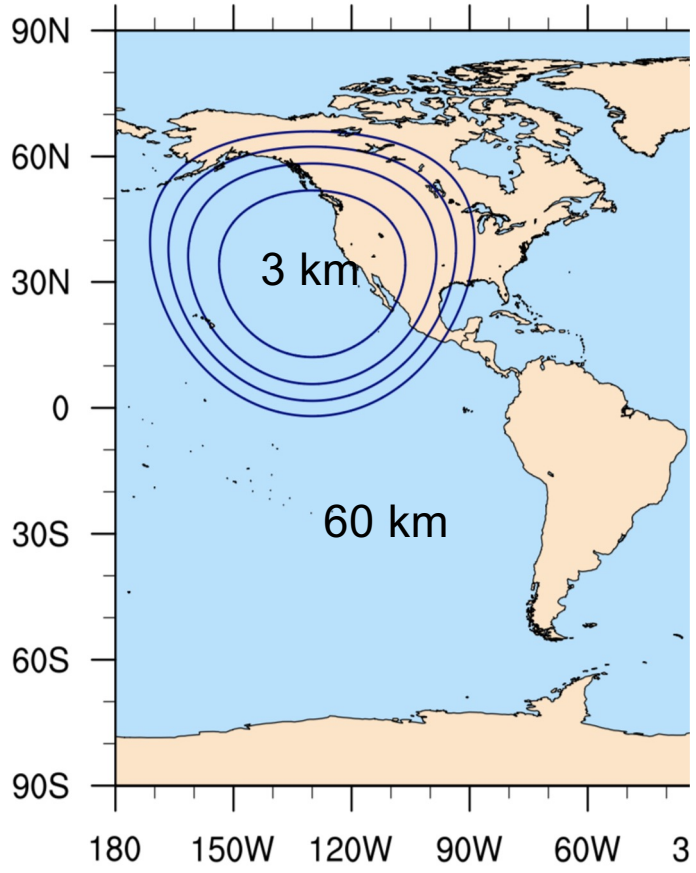
Goal is to release EarthWorks configurations in 2025

http://hogback.atmos.colostate.edu › earthworks

MPAS Earth System Model Capabilities

Western US wet season simulations
(Xingying Huang, NCAR/CGD)

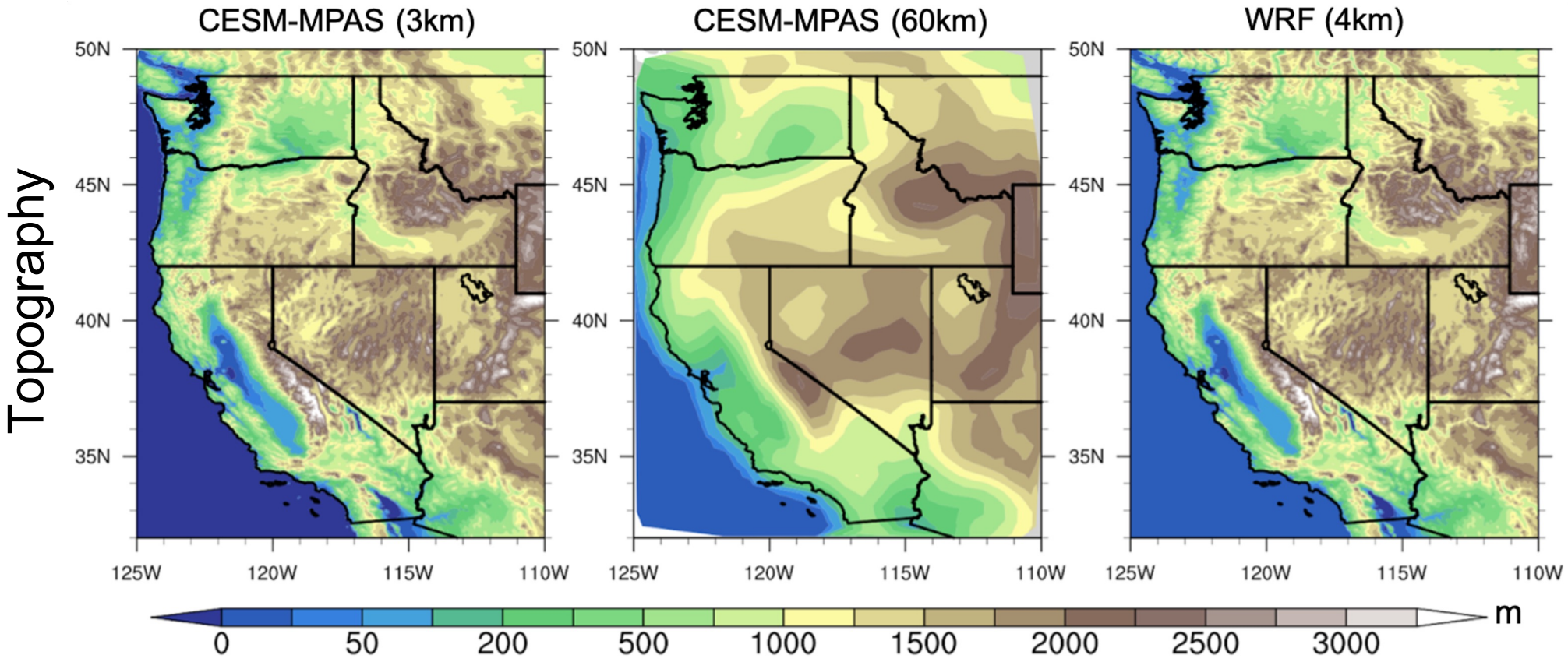
- Configurations
  - CESM-MPAS simulations at 60-3km variable resolution over Western US: 58 vertical layers up to 43 km
  - CESM-MPAS simulations at 60km (58 vertical layers; 2000-2002; Nov. to March)
- Nov-March simulations, years 1999-2004
- Initialized with CFSR
- CAM6 physics, CTSM (land model)
- Data ocean (specified SSTs), ice



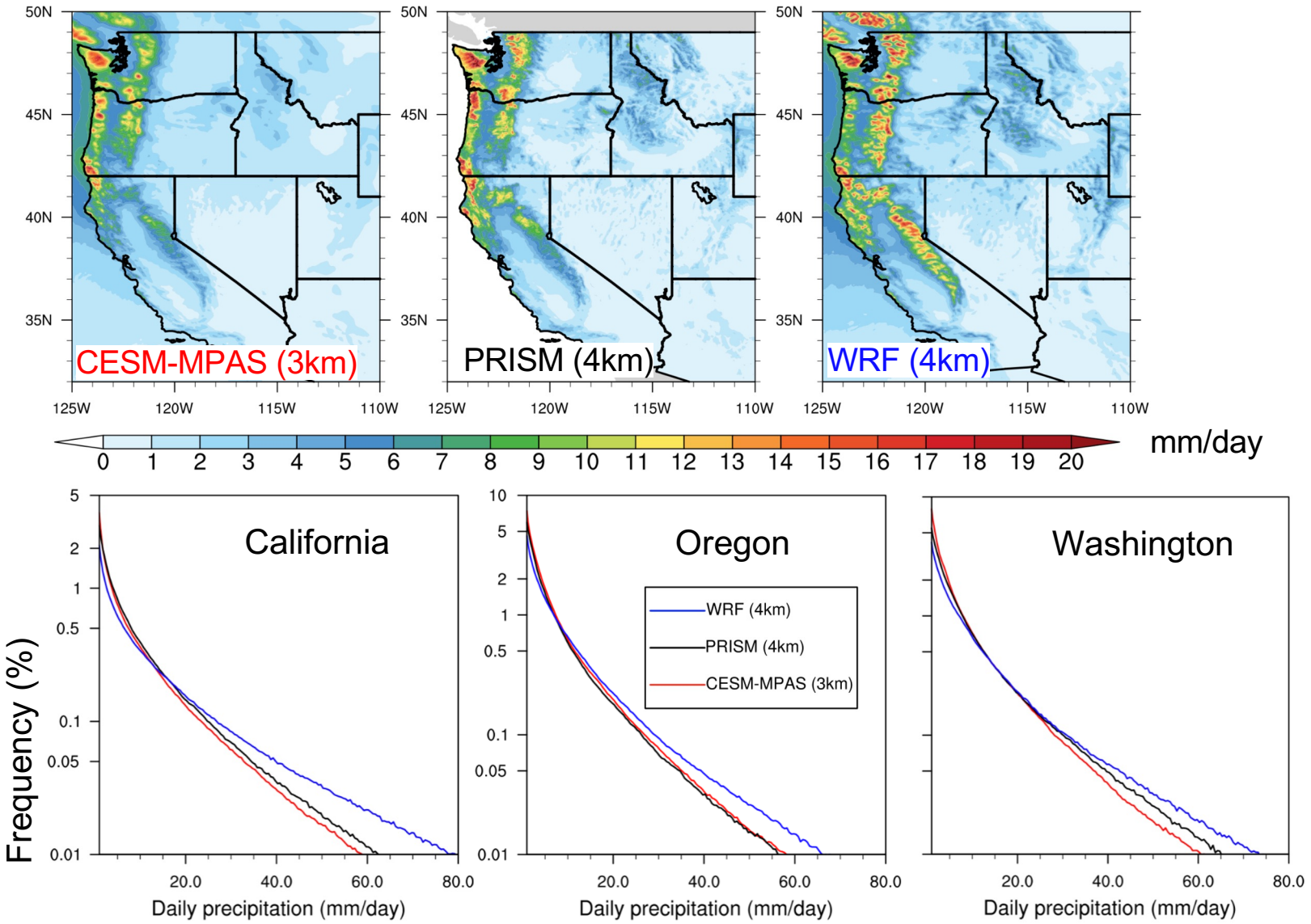
Grid mesh configuration in 60-3km experiments
(**835586** grids, mpas_dt **20s**, **58** vertical layers)

Variable resolution MPAS (60-3 km)

- Observational dataset: PRISM 4km (Daly et al., 2017) (T2, T2min, T2max, Precip.); Daymet 1km (Thornton et al., 2020) (SWE)
- Regional climate modeling data: WRF (CONUS) 4km (Rasmussen et al., 2021).



Variable resolution MPAS (60-3 km): Results



Wet-season (Nov-March) precipitation over western US (1999-2004)

- CESM-MPAS results are overall well represented compared to obs. and WRF model
- CESM-MPAS tends underestimate and WRF here tends overestimate in most regions

Probability distribution of daily precipitation

- Daily precip. features reinforces the mean performance shown above
- CESM-MPAS captures PDF better than WRF here, especially for more extreme precipitation (upper tail)

Variable resolution MPAS (60-3 km): Results

0 UTC 26 April 2017 init from GFS-FNL
60-3 km variable-resolution mesh
3 global simulations:
(1) Stand-alone MPAS (WRF physics)
(2) MPAS-CAM, CAM6 physics
(3) CAM6 physics, MG3 microphysics

Physics differences

MPAS-CAM6 physics
CLUBB PBL and shallow convection
MG2 and MG3 microphysics
CLM land model

MPAS-Atmosphere physics
MYNN PBL, GF shallow convection
Thompson microphysics
NOAH land model

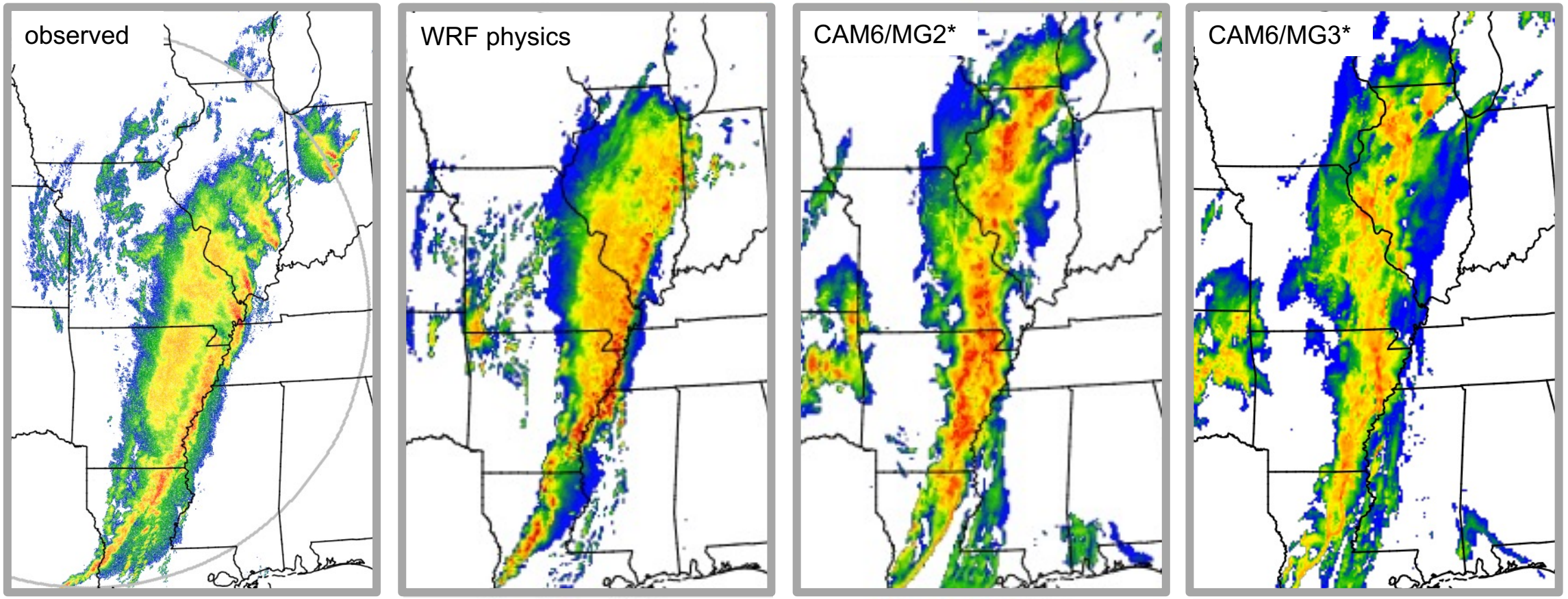
Initialization

The atmospheres have identical initializations for winds, density, temperature and vapor (no clouds or precipitates in the ICs).

Other atmospheric components, e.g. aerosols, etc are different.
Land model initializations are different.
SSTs are different.

MPAS - CAM6 physics at convection-permitting scales

Central US spring test case, 24 hour forecast valid 0 UTC 27 April 2017



(* Computed using single-moment reflectivity diagnostic)

MPAS - CAM6 physics at convection-permitting scales

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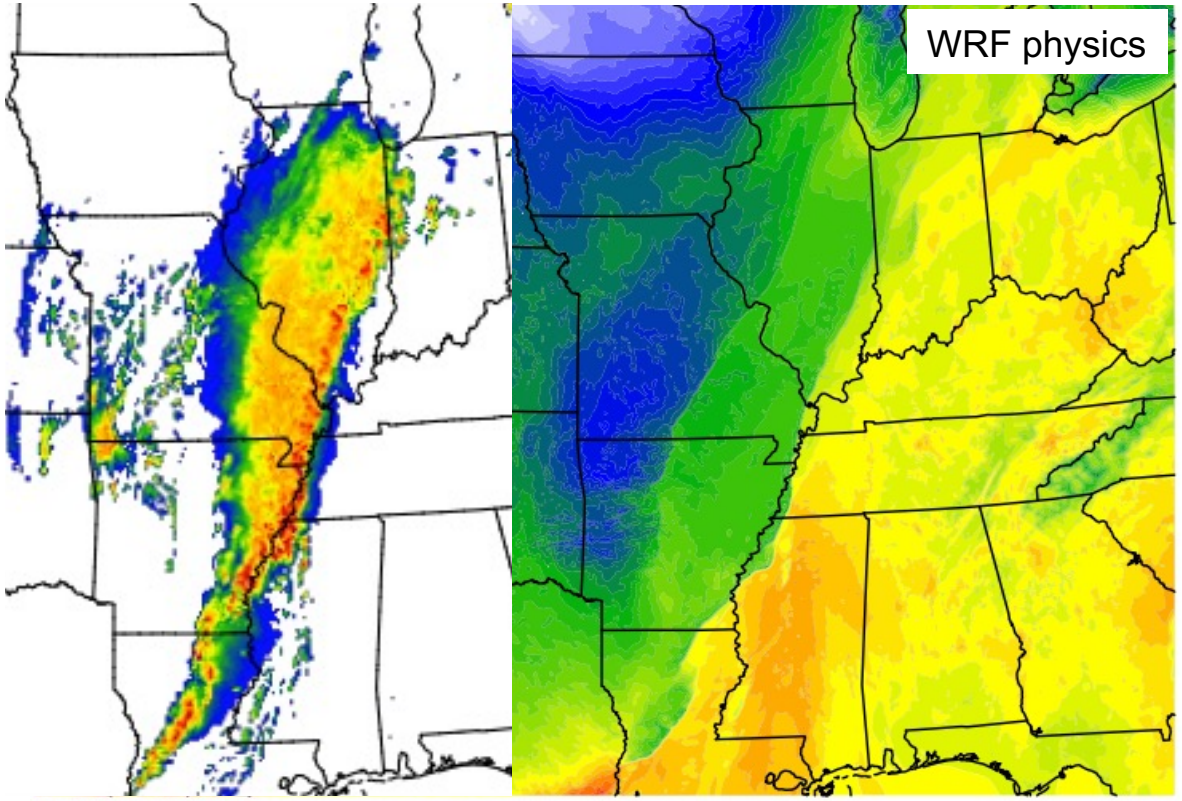
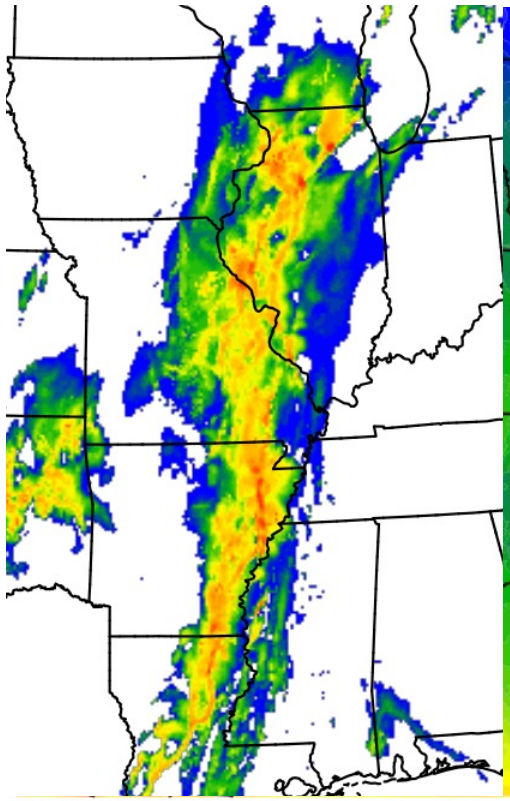


Reflectivity (dBZ)

Lowest model level temperature (K)



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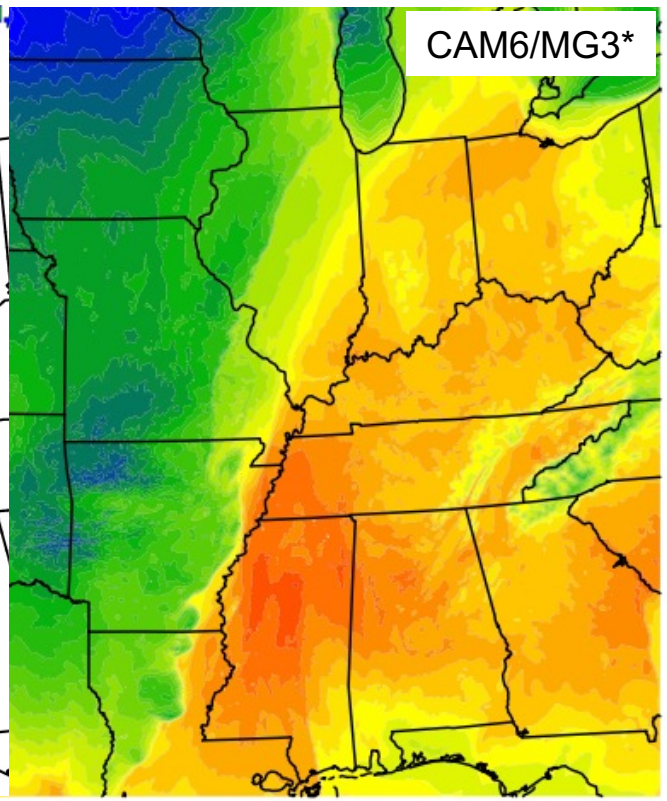

Lowest model level temperature (K)

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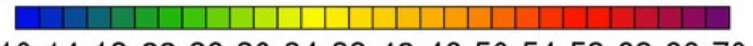
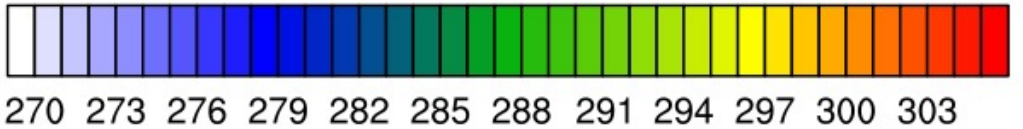
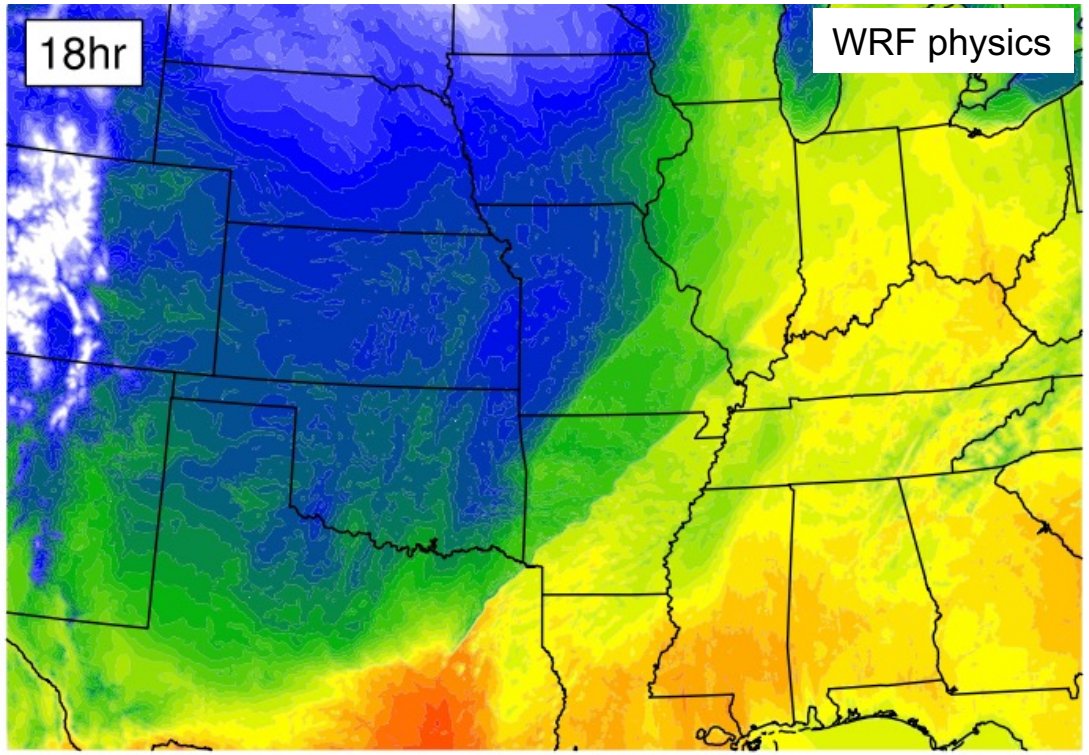
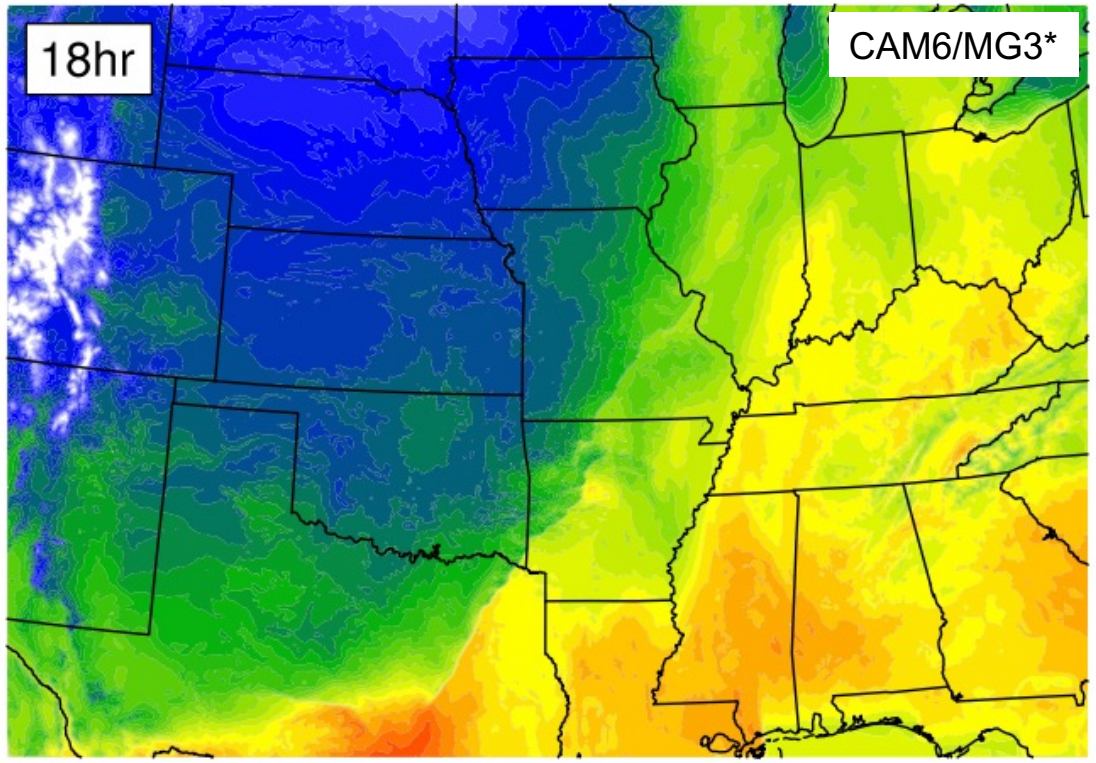




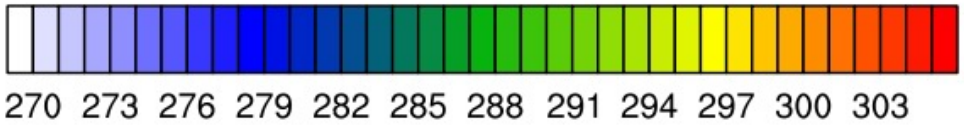
MPAS - CAM6 physics at convection-permitting scales

Central US spring test case, 18 hour forecast valid 18 UTC 26 April 2017





Temperature (K)



Summary

MPAS developments proceeding in many areas
- Deep-atmosphere applications (Klemp talk)
- Data assimilation (Liu talk)
- Shared physics with WRF (Fowler talk, Wong talk)

MPAS GPU capabilities, GPU physics
- We expect to release Derecho configurations in the coming year
- GPU updates this coming year
- New GPU-enabled physics also coming

ESM capabilities
- We are now testing MPAS in CESM/CAM
- Physics, initialization need work for convective-scale applications.
- CESM-MPAS configurations will be released soon