Simulations with EarthWorks

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COLORADO STATE UNIVERSITY

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

NCAR

See also the EarthWorks presentations by Rich Loft and Sheri Mickelson, at 11:45 and 12:00 on Thursday.

They will focus on the computational aspects of EarthWorks.

EarthWorks

EarthWorks is a five-year university-based project, supported by NSF CISE, to develop a global storm-resolving coupled model that uses a single nearly uniform global grid for the atmosphere, ocean, sea ice and land surface.

Earthworks consists of:

- CAM6 with the MPAS non-hydrostatic dynamical core
- The MPAS ocean model developed at LANL
- The MPAS sea ice model, based on CICE
- The Community Land Model (CLM)
- The Community Mediator for Earth Prediction Systems (CMEPS)

Earthworks will preserve compatibility with evolving CESM code base and engage with the CESM community.

EarthWorks

GOAL:

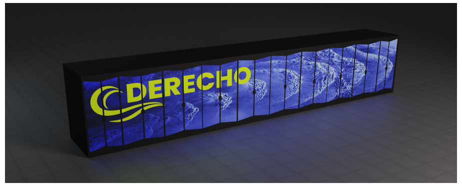
- Capability to perform 3.75 km fully coupled simulations utilizing GPU-enabled components with end-to-end workflow portability across US leadership computing systems

SOME INITIAL OBJECTIVES:

- Port MPAS Ocean and Sea Ice models into the CESM framework ✓
- Assemble a working CPU version of the EarthWorks configuration ✓
- Complete fully coupled simulations at relatively coarse grid resolutions ✓
- Test MPAS-CAM6 physics at convection-permitting spatial scales (Very good progress)
- Port critical-path portions of EarthWorks to GPUs (Very good progress)

Earthworks Initial Target Platforms

- NSF Systems:
  - *NCAR:* Cheyenne[1] ➞ Derecho*
  - *Texas Advanced Computing Center:* Frontera[1] ➞ Hor



- DoE Systems:
  - *Argonne National Lab:* ThetaGPU* ➞ Pol
  - *NERSC:* Perlmutter

*AMD + NVIDIA GPU

[1]Intel CPU architecture

[2]Unknown architecture

EarthWorks is currently pursuing workflow portability across these systems.

The simulations shown in this talk have all been carried out on Cheyenne.

Available simulations

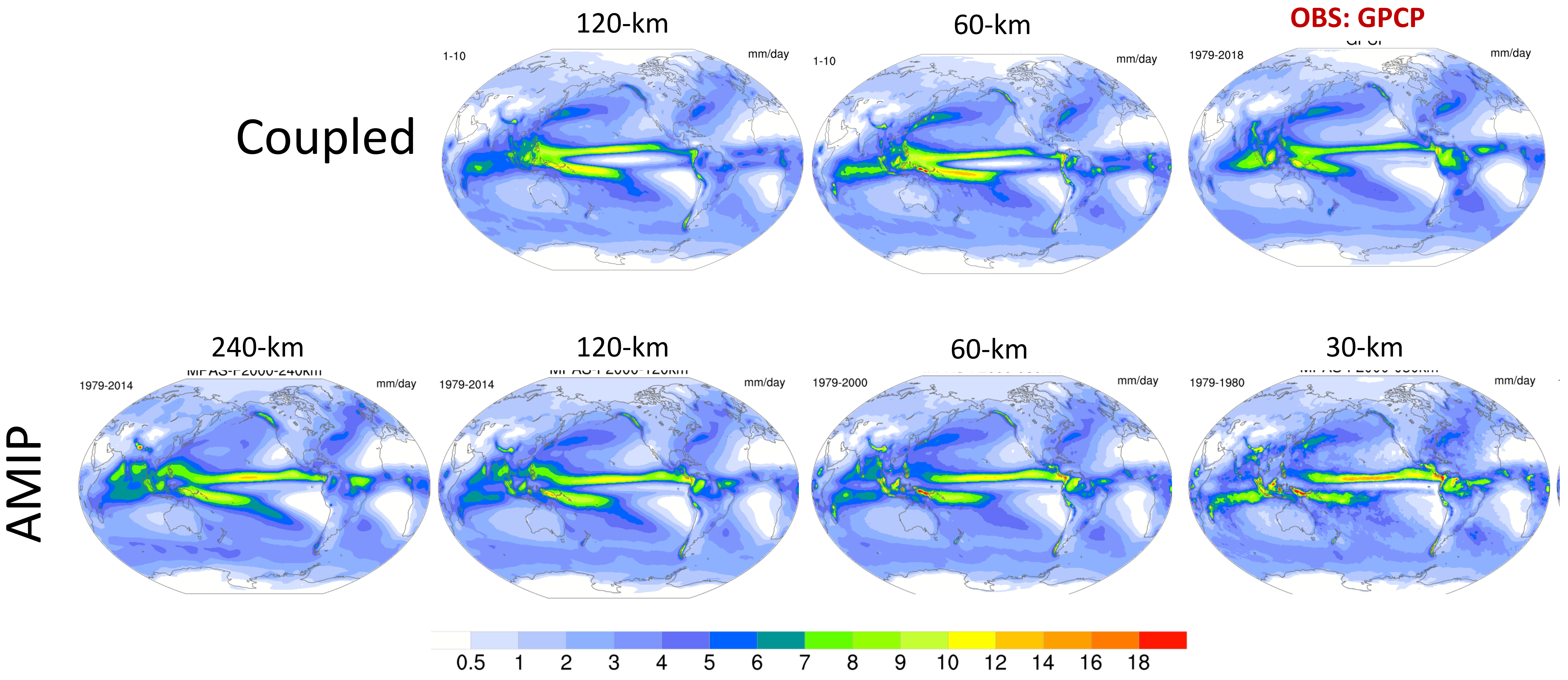
- Coupled simulations (B2000)
  - 120 km (10 years)
  - 60 km (10 years)
  - 30 km (1 year)

- AMIP simulations (FHIST)
  - 240 km (1979-2014)
  - 120 km (1979-2014)
  - 60 km (1979-2000)
  - 30 km (1979-1980)

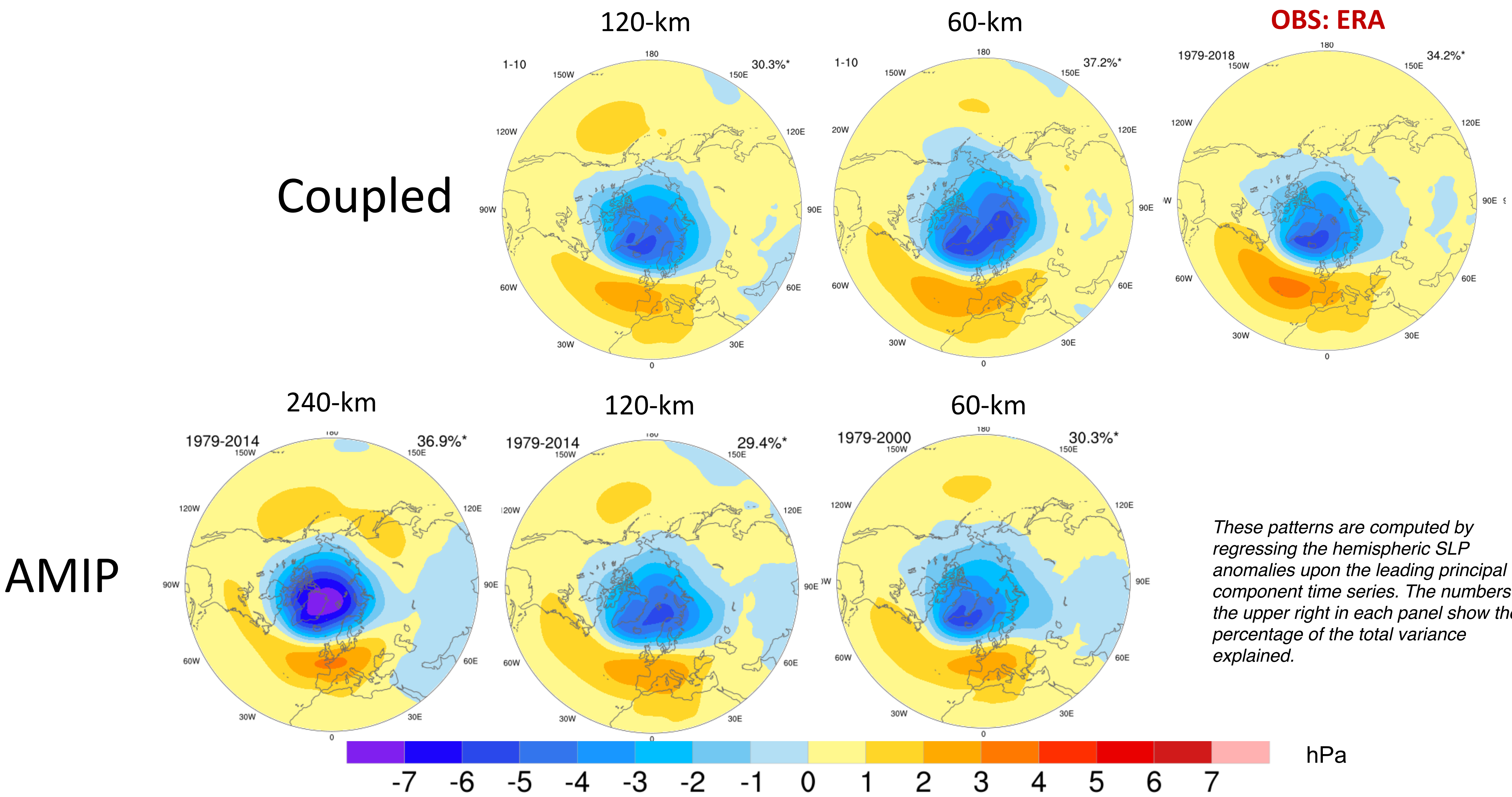
- Regionally refined simulations
  - Pacific NW
  - Midwest

- Aquaplanet simulations (QPC6)
  - All grids from 120 km to 3.75 km
  - Not shown in this talk

Annual-mean precipitation



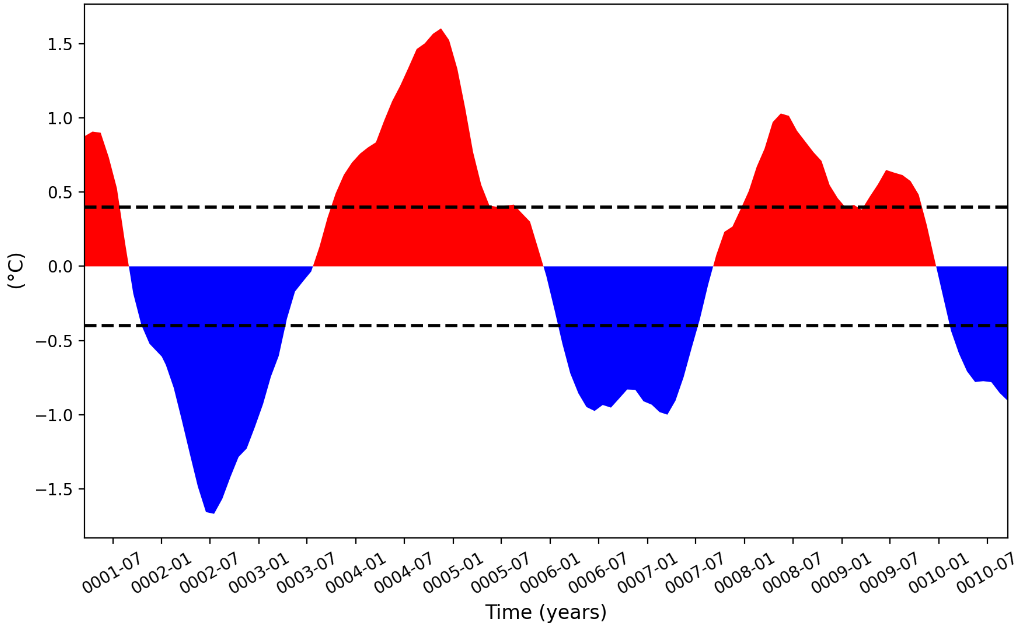
North Atlantic Oscillation



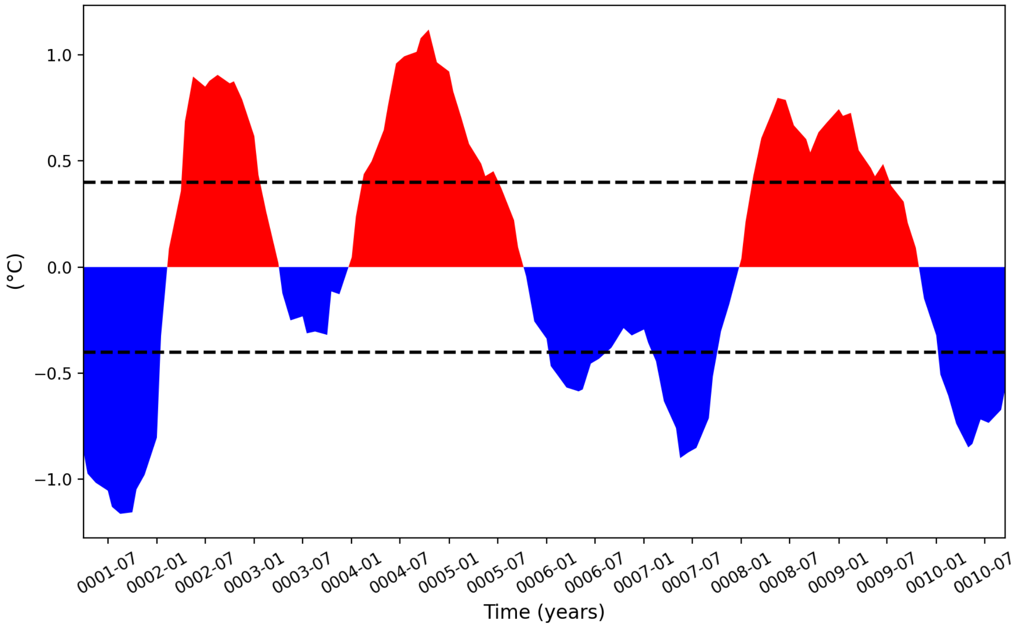
These patterns are computed by regressing the hemispheric SLP anomalies upon the leading principal component time series. The numbers at the upper right in each panel show the percentage of the total variance explained.

Coupled Niño3.4 index

120 km



60 km



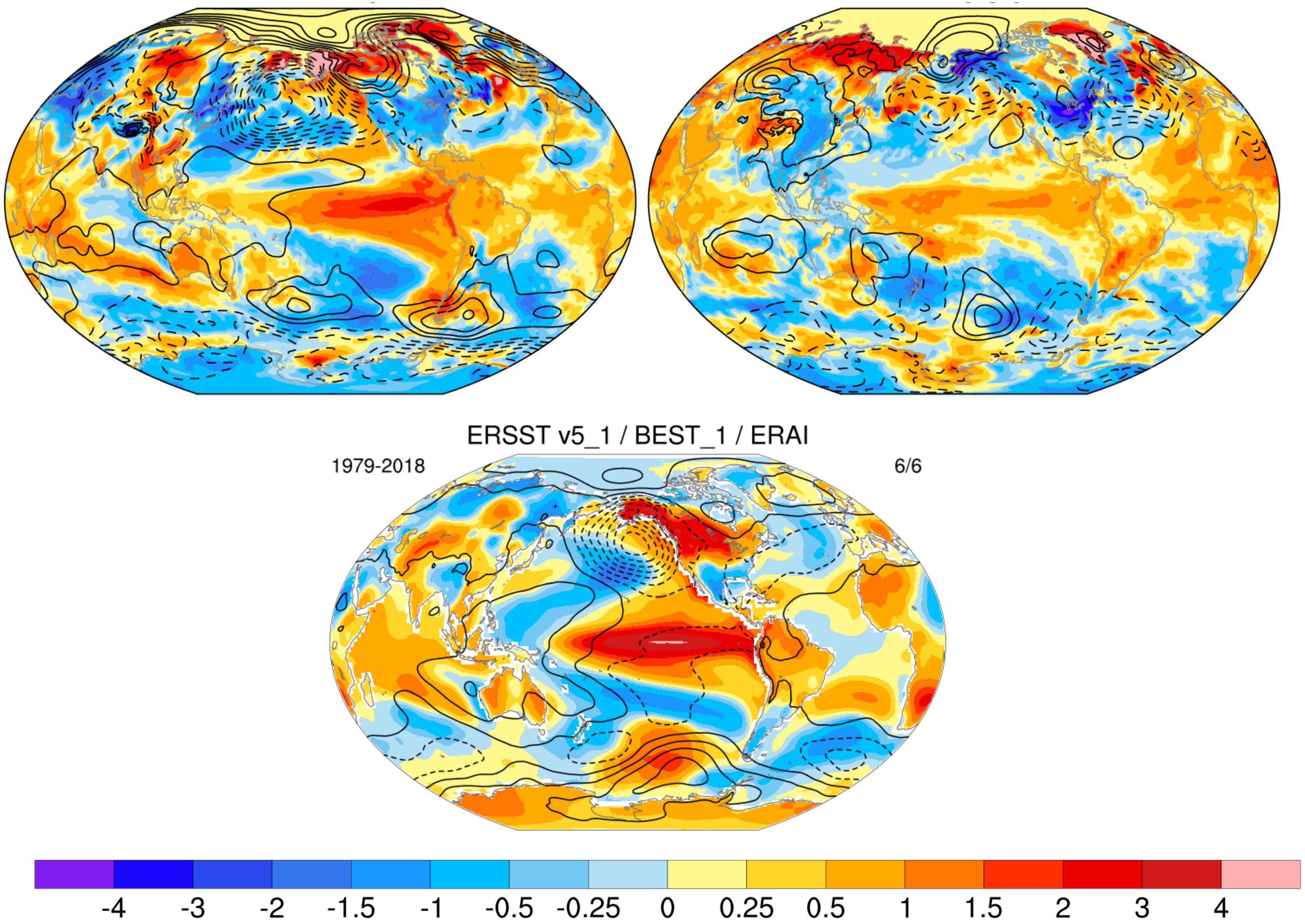
Surface temperature and SLP anomalies

(El Niño minus La Niña)

120 km

60 km

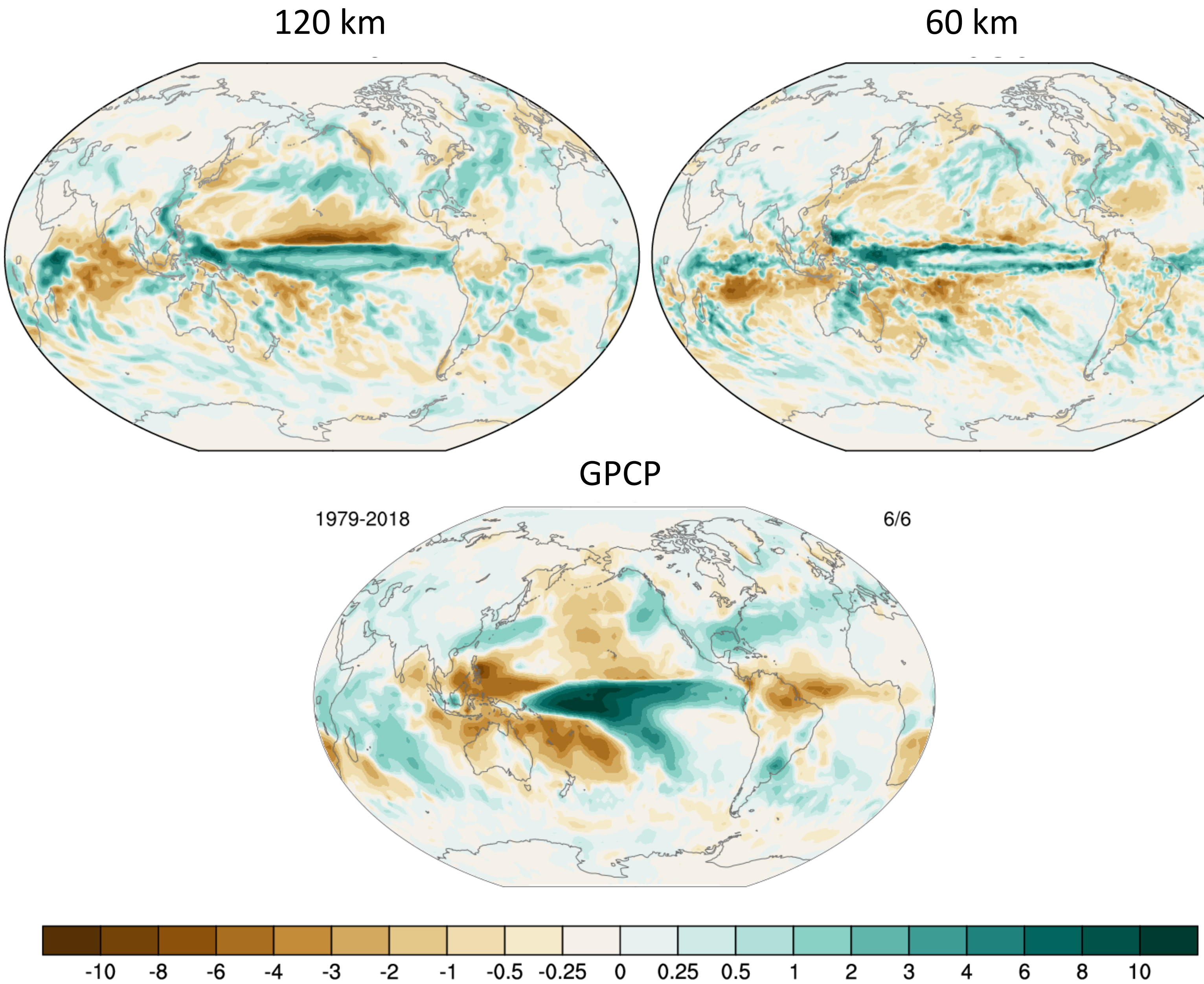
One DJF
(years 4/5)



Precipitation anomalies

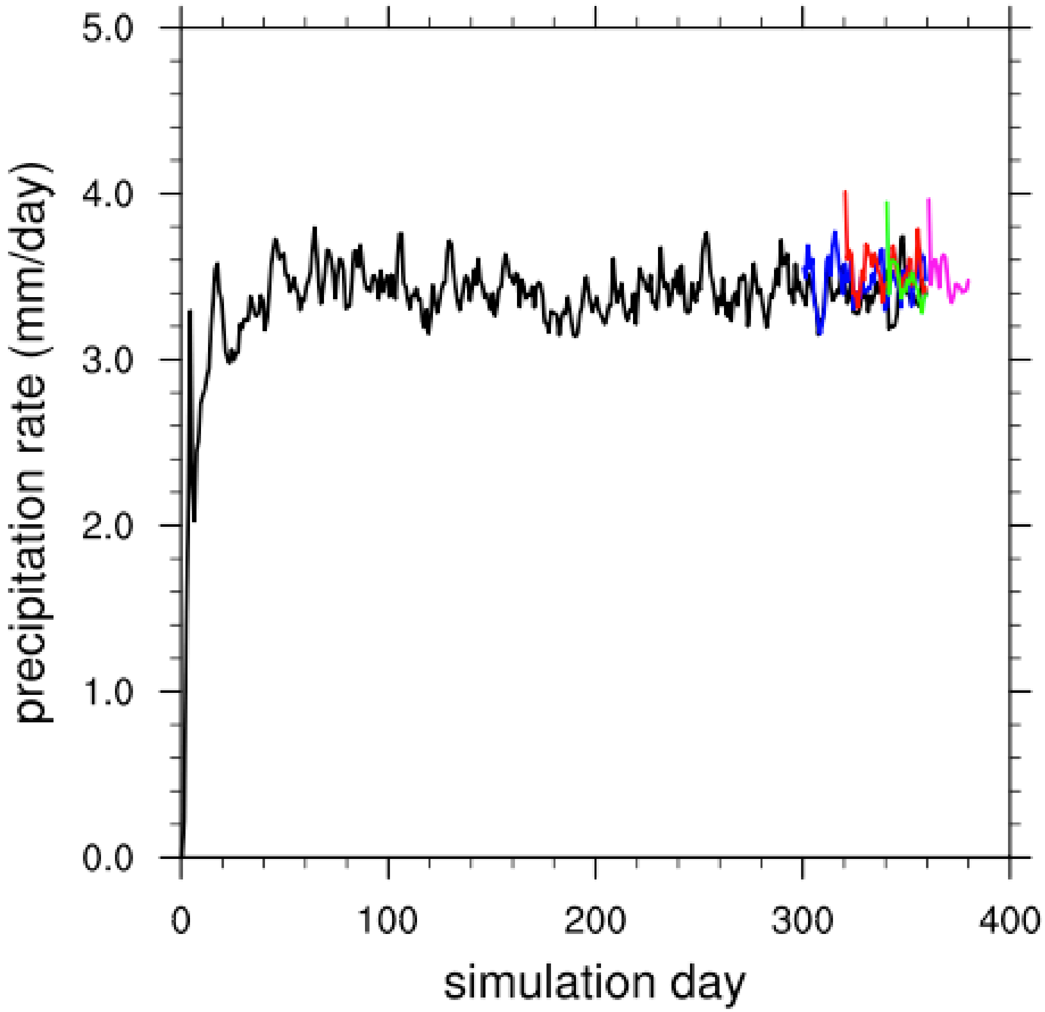
(El Niño minus La Niña)

One DJF
(years 4/5)

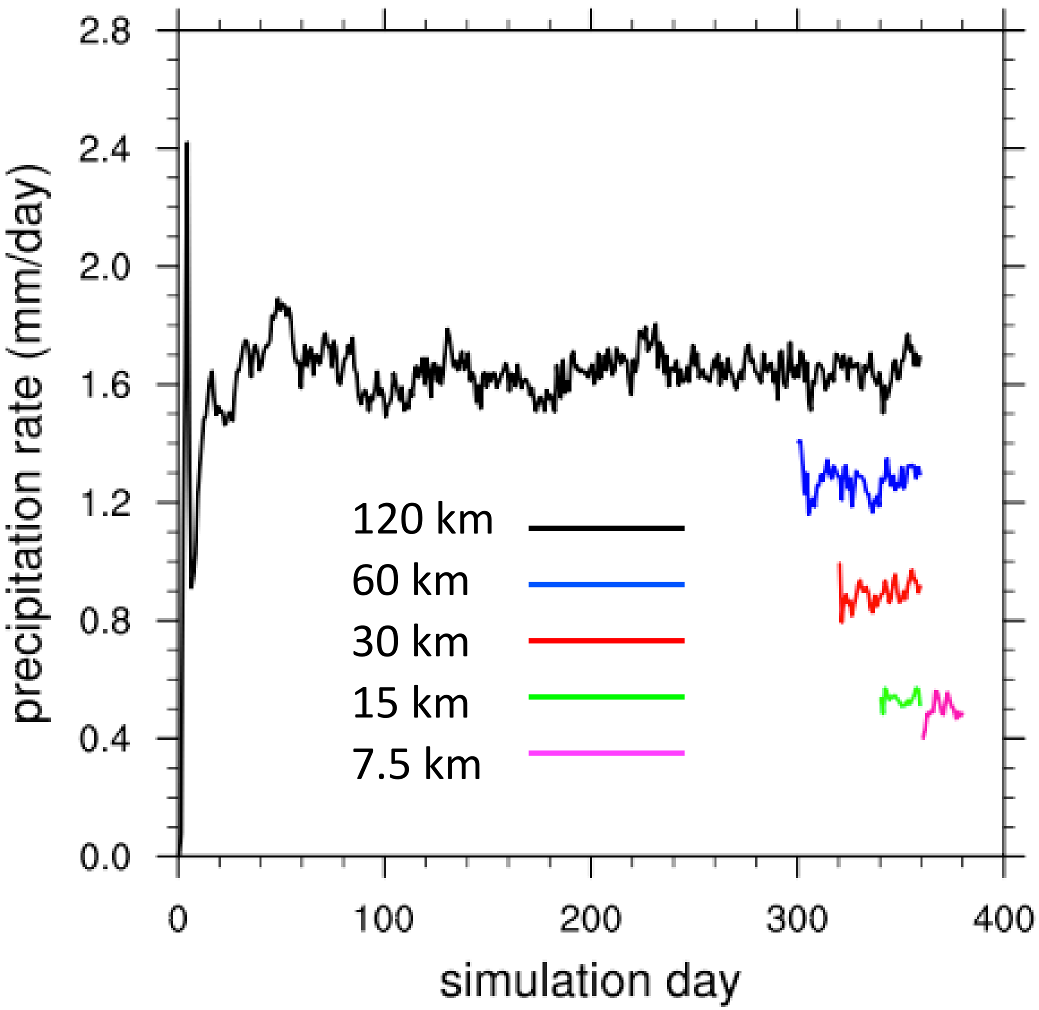


Aquaplanet results: Global precipitation

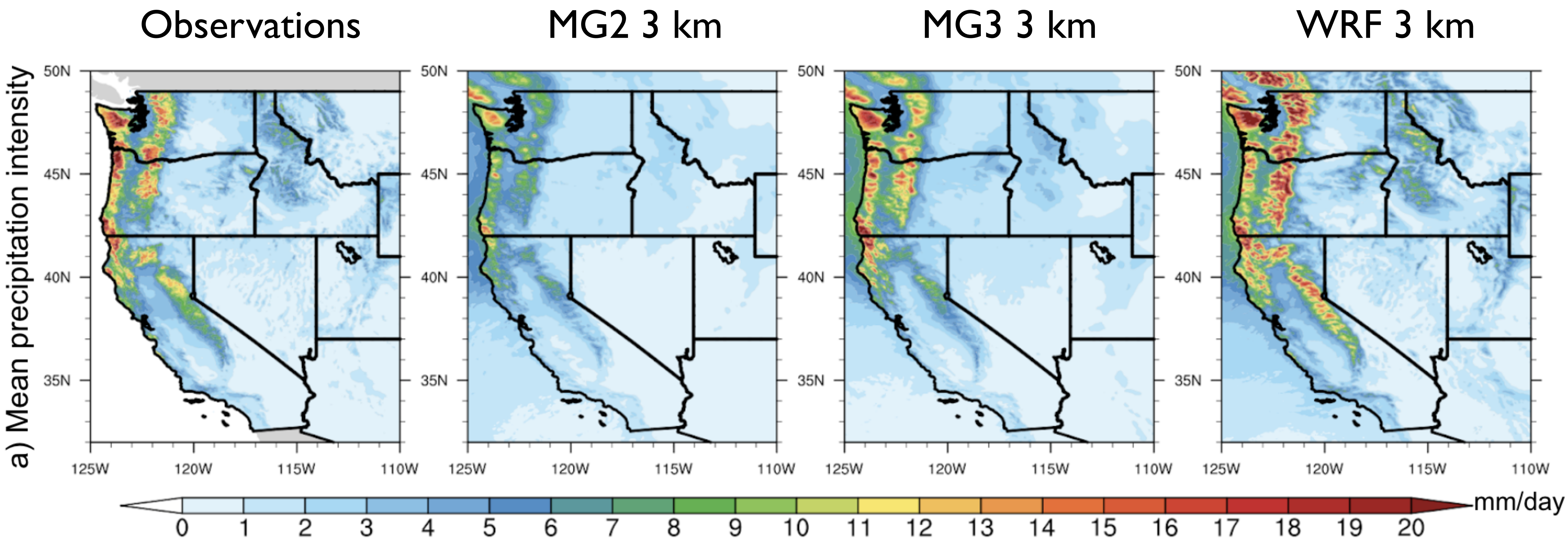
Global mean total precipitation

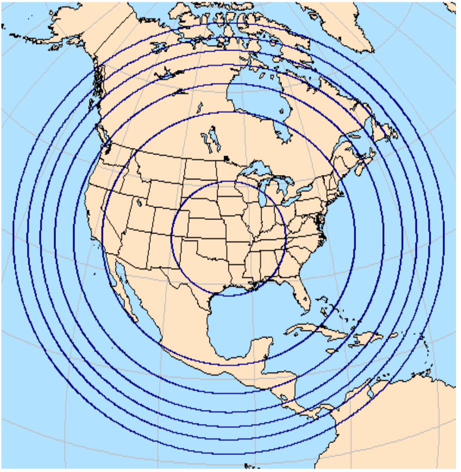


Global mean convective precipitation



What does CAM physics do at high resolution?





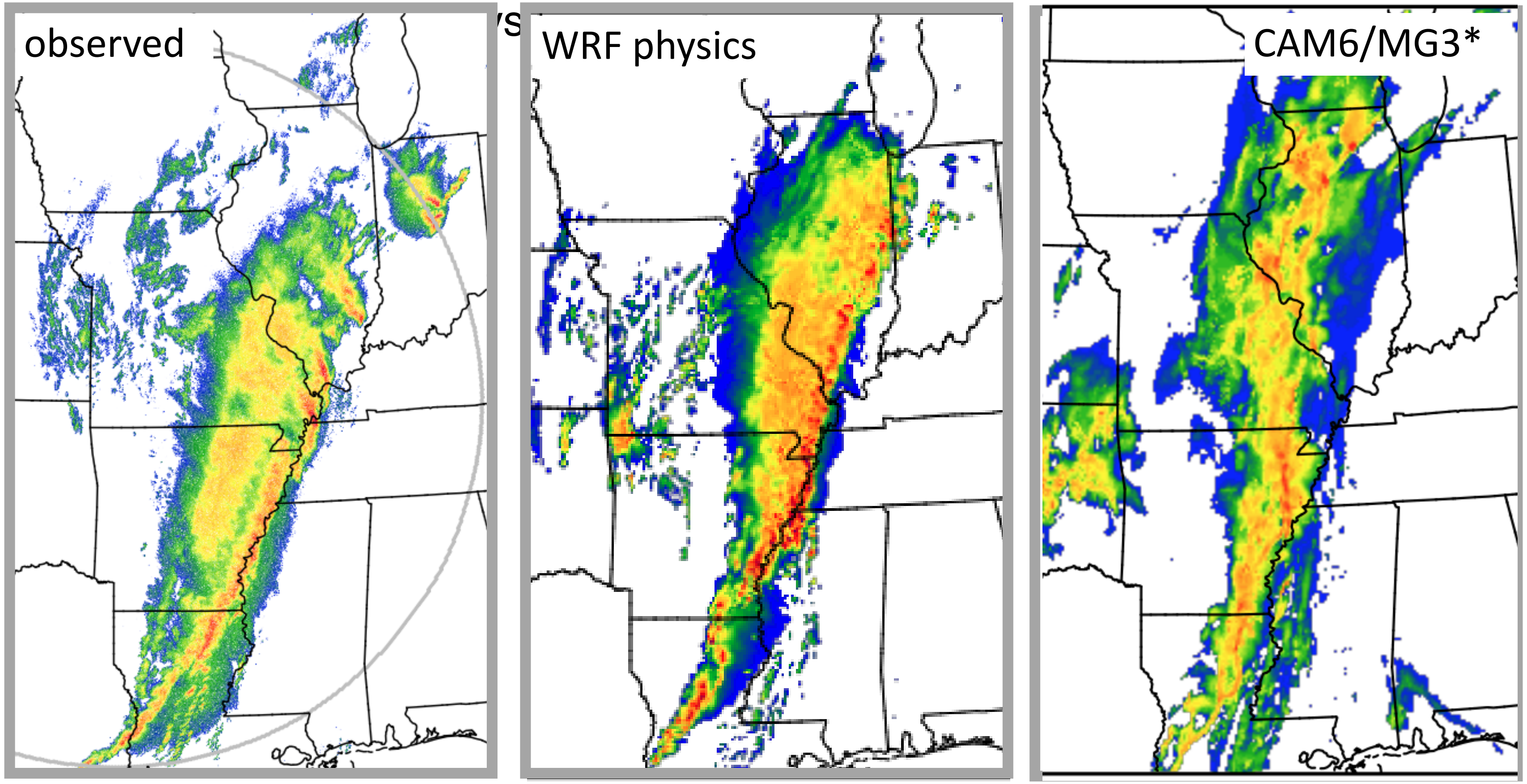
Testing MPAS with CAM6 physics on a convection-permitting grid

0 UTC 26 April 2017
60-3 km variable-resolution mesh

3 global simulations:
(1) Stand-alone MPAS (WRF physics)
(2) MPAS-CAM, CAM6 physics
(3) CAM6 physics, MG3 physics

See Skamarock talk at WRF-MPAS Workshop

Central US spring test case
24 hour forecast



Reflectivity (dBZ)

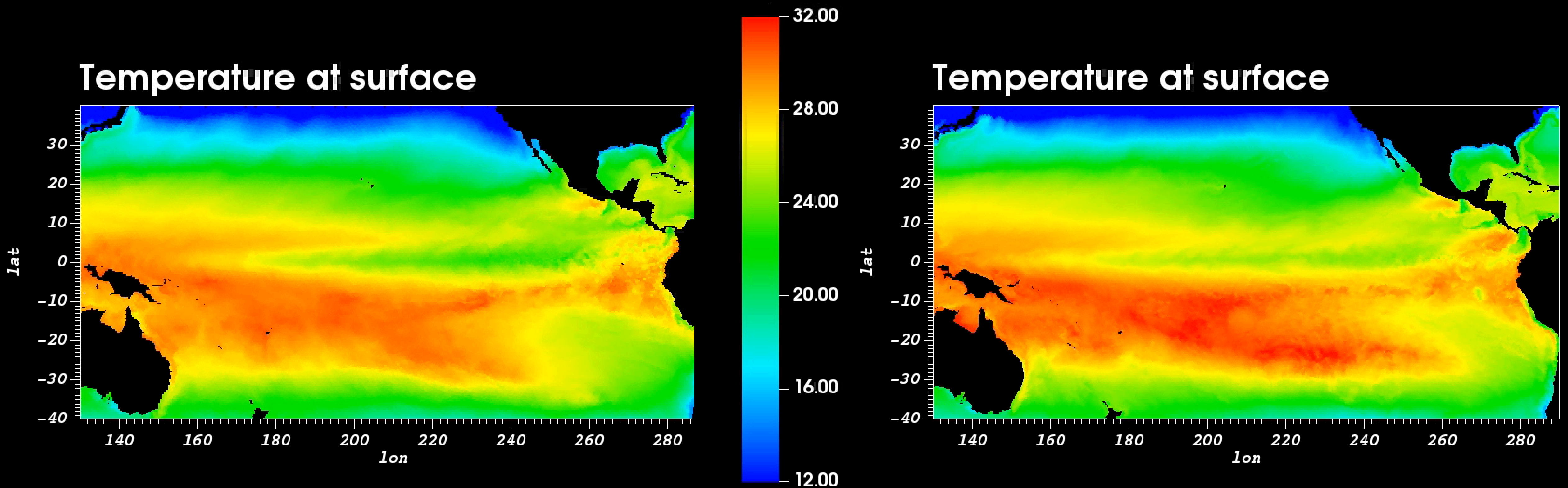
(* Computed using single-moment reflectivity diagnostic)

Takeaways:

- CAM6 physics is stable at 3 km *for this case*
- MG3 is an improvement over MG2 (not shown)
- There are other issues with the initialization or the physics that need to be sorted.

Early in two coupled simulations

Both started from rest on January 1



60 km grid
Days 65-220

30 km grid
Days 65-230

Summary

- MPAS ocean and sea ice have been successfully ported into the CESM framework.
- Fully coupled 60-km simulation has finished ten years, and a 30-km simulation has completed its first year.
- MPAS atmosphere and ocean can now be run on GPUs.
- Once CLUBB has been ported to GPUs, CAM6 physics will run on GPUs as well.
- CAM6 physics is being tested at convection-permitting scales.
- Our goal is that EarthWorks will produce at least one simulated year per day on a 3.75 km grid by the