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# DYAMOND simulations with CESM

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Kilometer-scale capabilities in CESM result from a joint collaboration between the SIMA Project (System for Integrated Modeling of the Atmosphere), CESM (Community Earth System Model) and EarthWorks

A special thanks to the CISL support & consultation teams!

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# CESM3 kilometer-scale configuration

CAM:

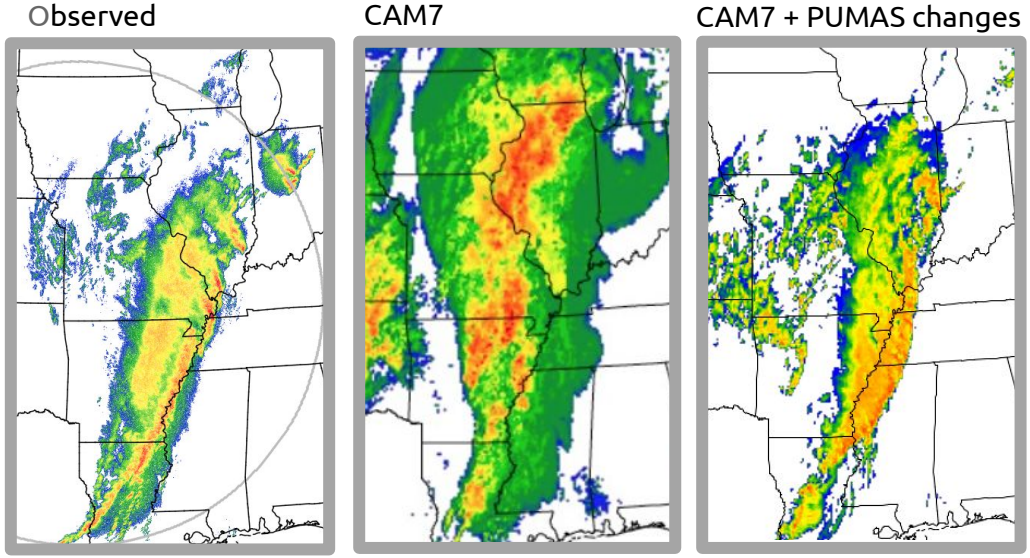
- ❏ CAM-MPAS NH dycore @ dx=3.75 km
- ❏ 58 vertical levels & 42 km top
- ❏ Modified CAM7 physics
  - ❏ Turn off ZM deep convection scheme
  - ❏ Modify CLUBB (all-or-nothing cloud frac)
  - ❏ Modify PUMAS (microp_uniform)

CLM:

- ❏ Runs on the MPAS 3.75 km grid
- ❏ Source datasets range from 1 km → 0.5˚

Data ocean and sea-ice:

- ❏ Runs on the MPAS 3.75 km grid
- ❏ DYAMOND protocol datasets




*W. Skamarock, A. Gettelman*

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# DYAMOND simulations with CESM

**DYAMOND = DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains**

- Provides a framework for the intercomparison of global storm-resolving models (Stevens et al., 2019)

- DYAMOND1 (summer) 40-day run starting on 1 August 2016
  - Completed in May
  - Bug in diagnostic pressure field, add'l sponge layer diffusion
- DYAMOND2 (winter) 40-day run starting on 20 January 2020
  - 30 of 40 days completed
  - Snow depth bug in CLM
- DYAMOND3 (annual) 1-year run starting on 1 March 2020
  - NSC allocation awarded (A. Herrington, Y. Tian, H. Li, D. Leung, P. Lauritzen, F. Judt)
  - Plan to start in the winter, after an extensive tuning & calibration phase

Model Initialization

- ERA5 for meteorology
- WACCM output (dx=1°) for aerosols and prescribed oxidant fields
- Anthropogenic emissions represent 2014 (from CMIP emissions)
- Land from (dx=1°) AMIP run (climatology)

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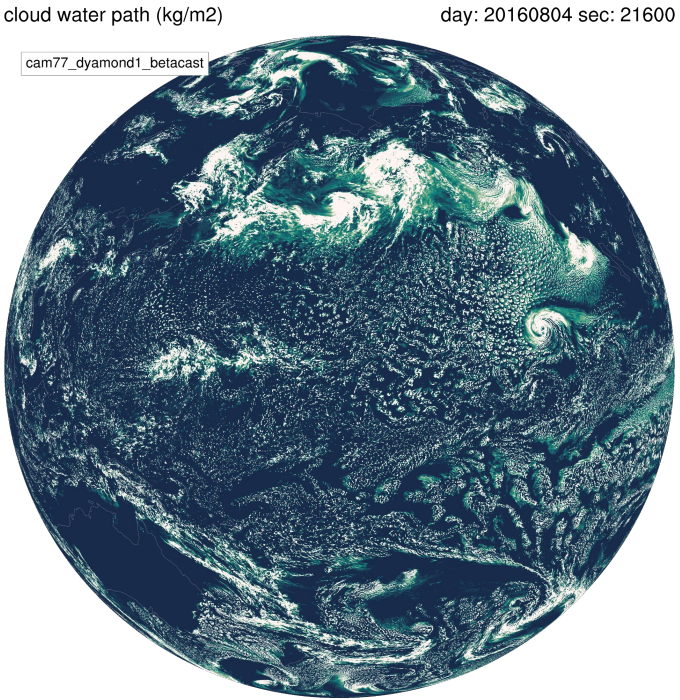
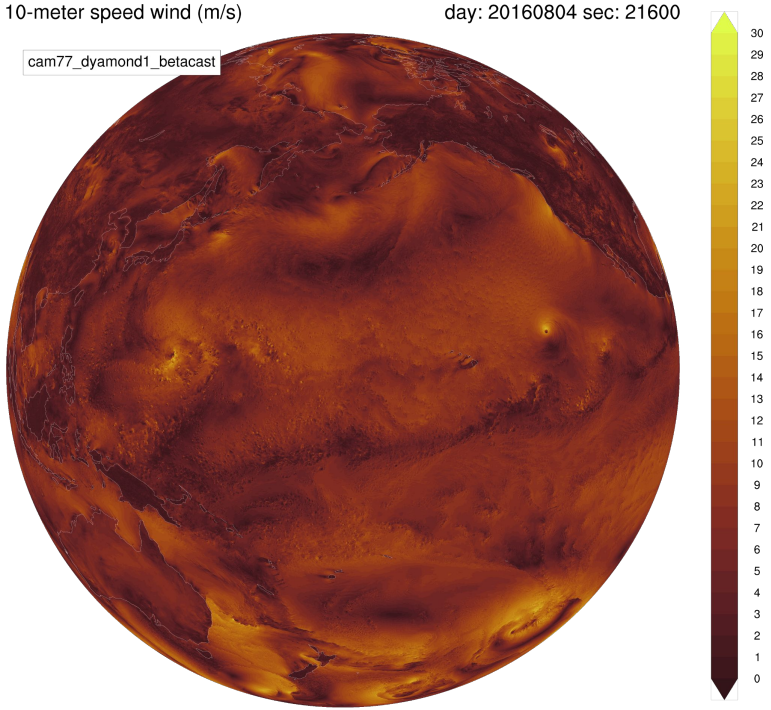
# Snapshots from DYAMOND1

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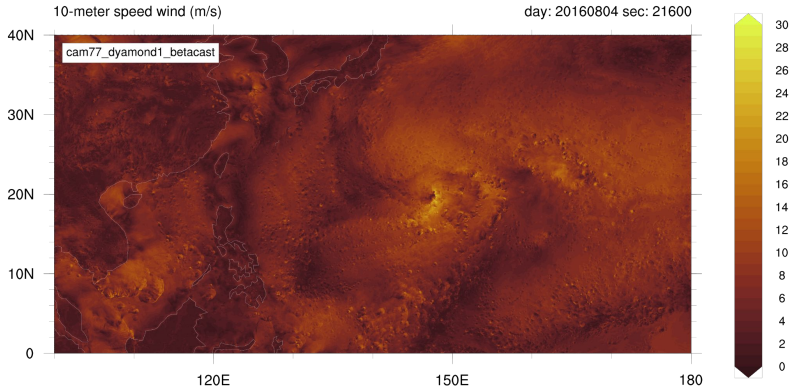
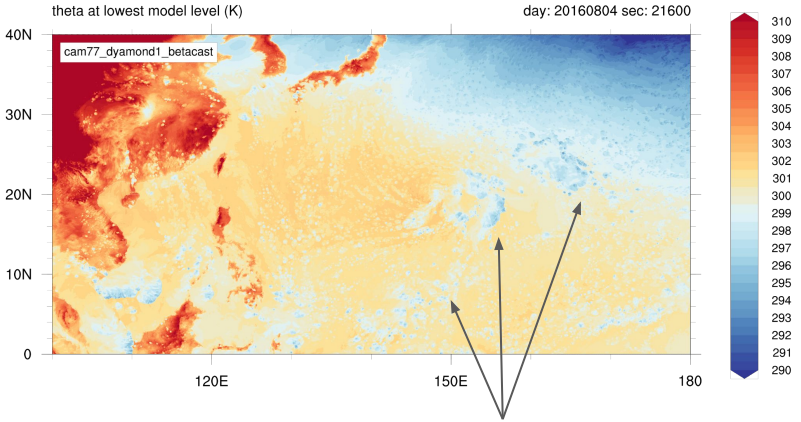
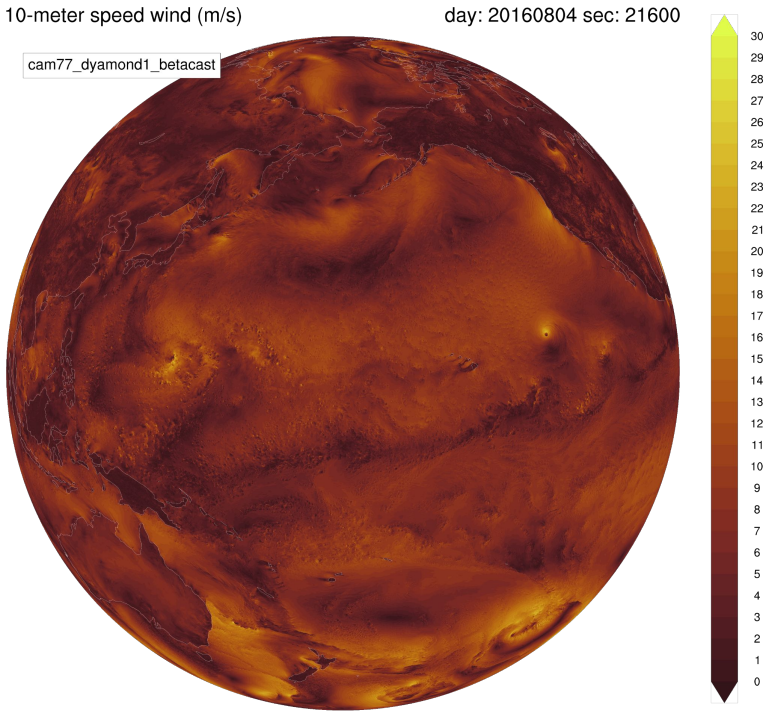
# Snapshots from DYAMOND1




We're resolving cold pools in CESM!

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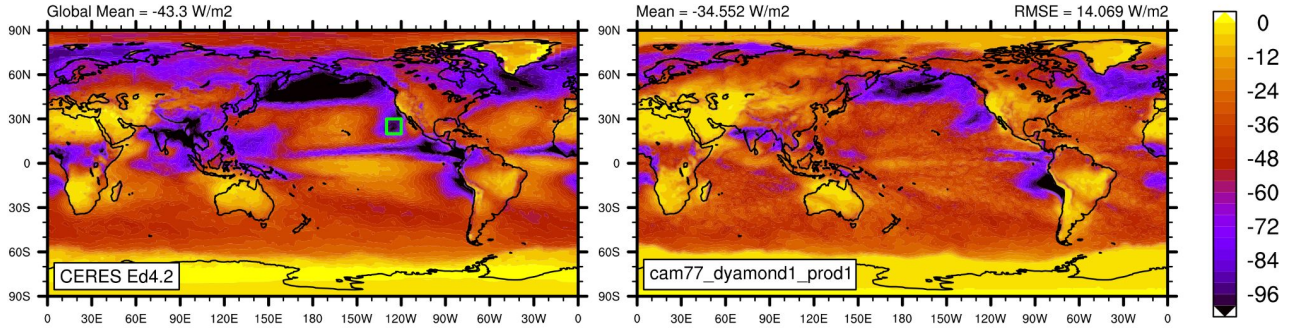
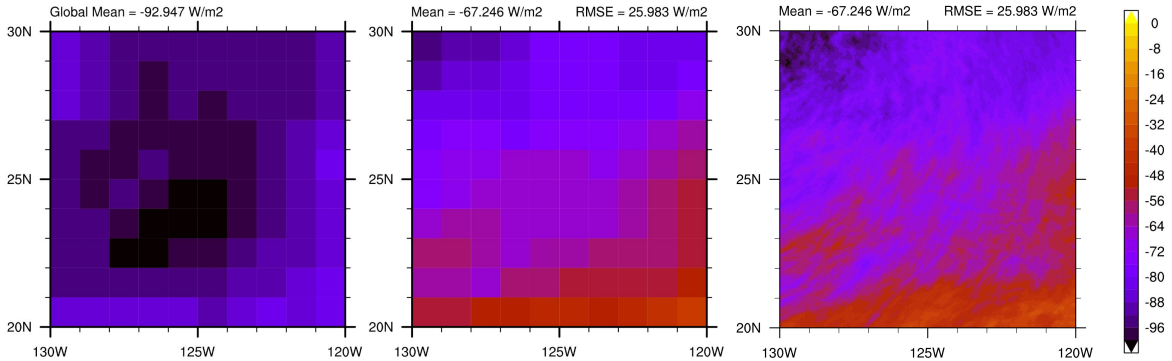
# Cloud Radiative Forcing (August)

Figures show the time-mean shortwave cloud forcing from DYAMOND1 compared to Aug. climatology from CERES Ed4.2

- ❏ Insufficiently bright in many places
- ❏ MarineSc simulated along eastern boundary currents




- ❏ MarineSc off the coast of California doesn't extend far enough south




CERES Ed4.2 DYAMOND1 (regridded) DYAMOND1 (native)

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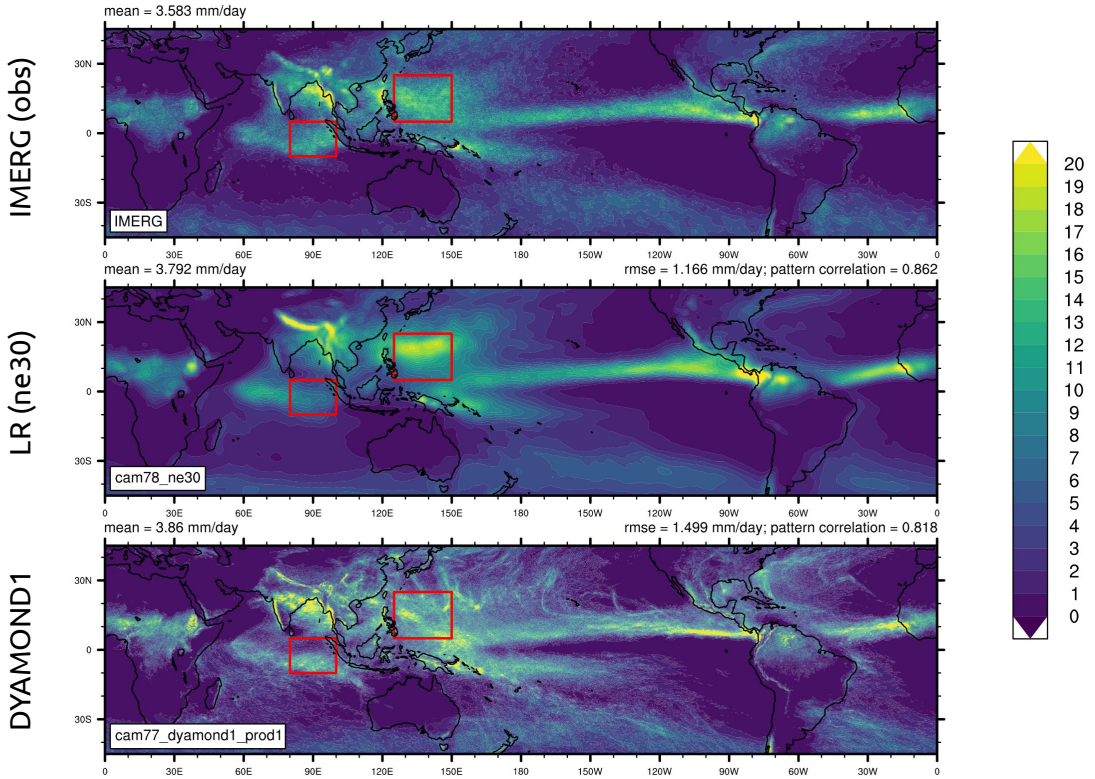
# Precipitation Rate (August)

Figures show the time-mean precipitation rate from DYAMOND1 compared to Aug. climatology from a low-res run (LR) & IMERG observations

- ❏ Several improvements over LR (e.g., W. Pac and Indian Ocean)
- ❏ SPCZ extends too far east

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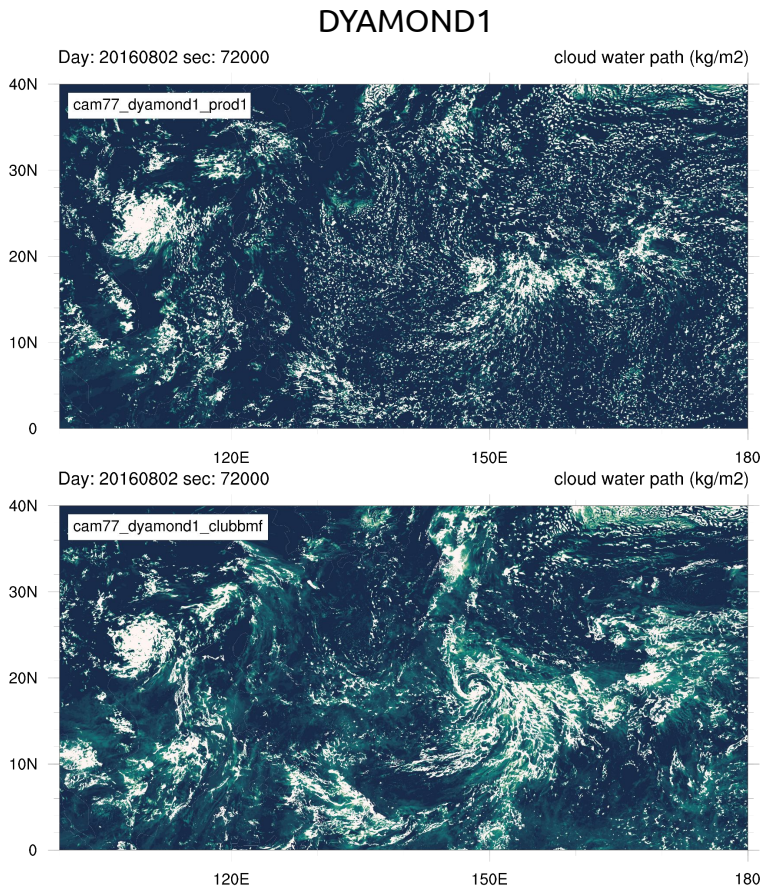
# More parameterized convection?

In ~3 km models, lateral entrainment is not resolved, rather it's "parameterized" by divergence damping (Smagorinsky). This representation of convection can only support an undilute deep mode, and therefore parameterized convection is still necessary to represent transitional regimes (e.g., shallow cumulus, mid-level congestus).

*CLUBB+MF is CLUBB augmented with an ensemble of plumes (Suselj et al. 2019; Witte et al. 2022)




In the control (top panel), CLUBB is the only convection scheme active (CAM's deep scheme is off)

Turning on *CLUBB+MF (bottom panel) results in less 'patchy' deep convection and a more realistic spectrum of clouds

Click here for a precipitation viz

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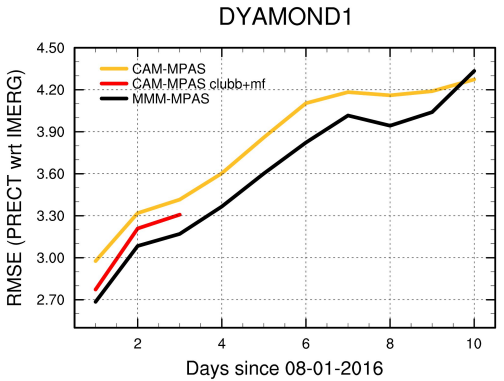
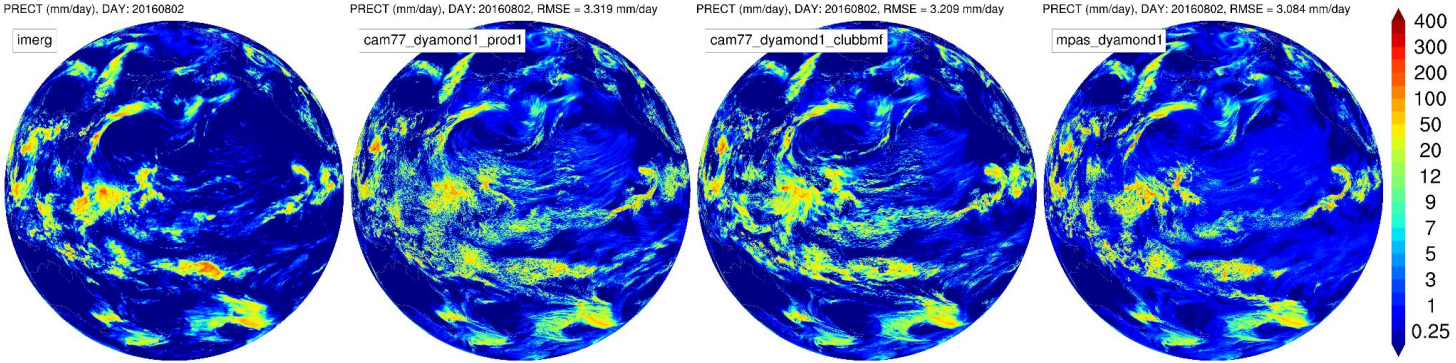
# Improved precipitation skill with CLUBB+MF

- CLUBB+MF results in smaller RMSE wrt to IMERG 0.1˚ precip. dataset
- Precip. skill more similar to MMM's DYAMOND1 simulation (courtesy F. Judt)



# What's Next?

- Software Rule: Something that "works" is a starting point, not an ending one
  - Land initialization times
  - GPFS vs. Lustre file systems
  - Regridded input files & higher core-counts
- Continue analysis, science calibration & tuning (e.g., CLUBB+MF)
- Submit DYAMOND3 run
- Implement 'FDYAMOND' compsets in CESM3