

Sensitivity of Atmospheric Parametric Formulations to Regional Mesh Refinement in the Community Earth System Model (CESM)

Richard Neale

National Center for Atmospheric Research, Boulder, Colorado

David Neelin and Mickael Chekroun

Atmospheric and Oceanic Sciences, UCLA

Brian Mapes

Rosenstiel School of Marine and Atmospheric Science, University of Miami



UNIVERSITY
OF MIAMI
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ATMOSPHERIC SCIENCE



SciDAC Proposal

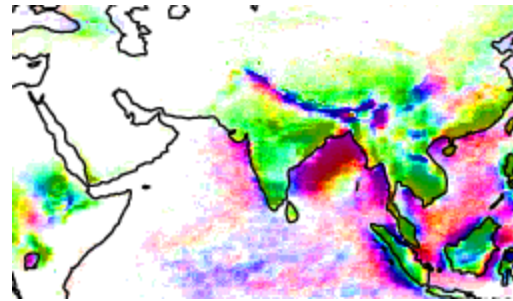
- Determine regional resolution refinements for (non-local) **origin** and (local) **target** regions
- Estimate **sensitivity** of parameter selections
- Develop simple **scale-aware** parameterization augmentation to minimize these sensitivities

High Resolution

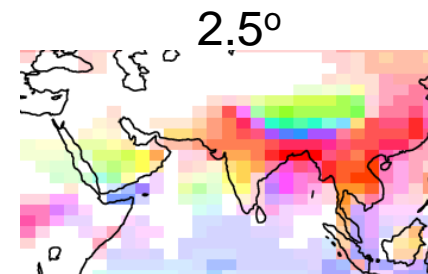
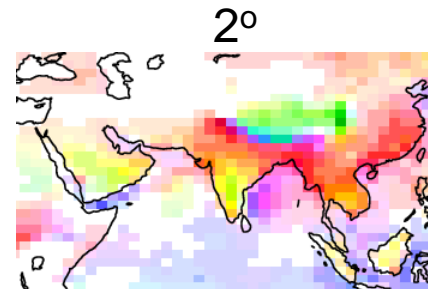
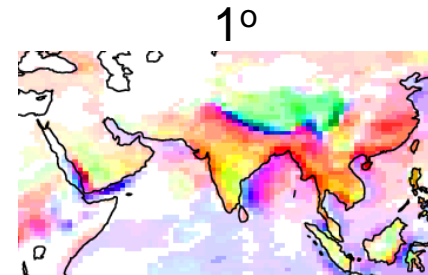
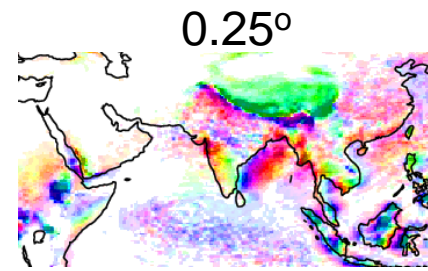
Precipitation Features



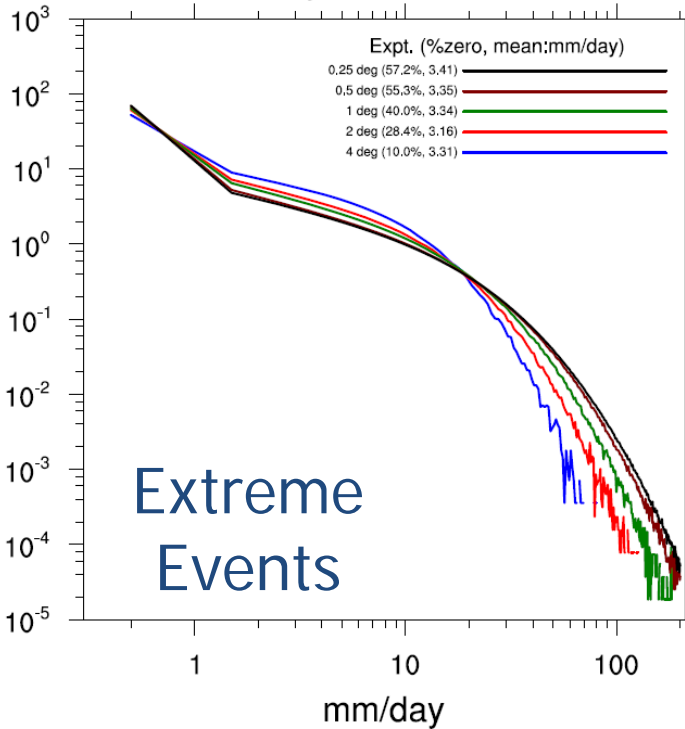
Diurnal Cycle Timing (hour)/Amp. (mm/day)



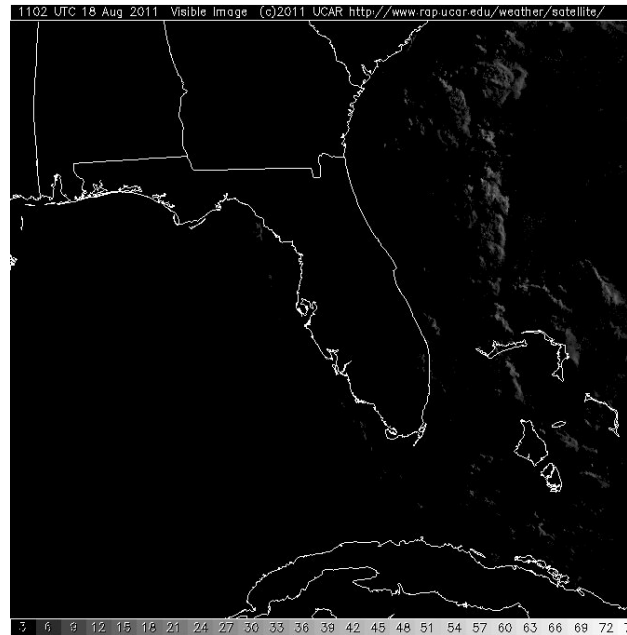
TRMM



20S-20N - Land only



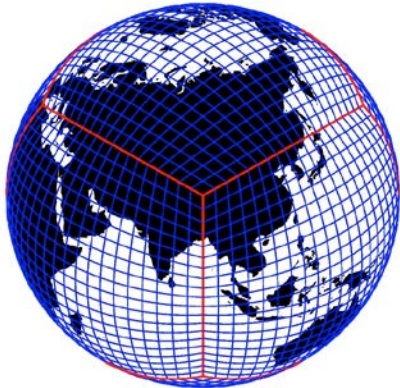
Extreme
Events



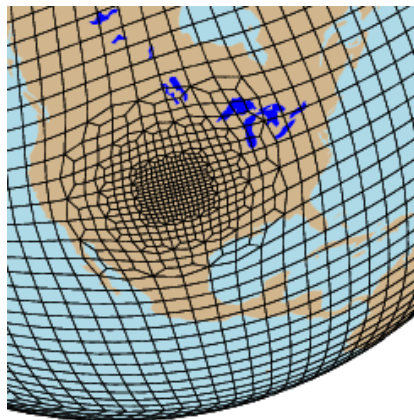
Multiscale Organization

Community Earth System Model

Hierarchy of Experiments

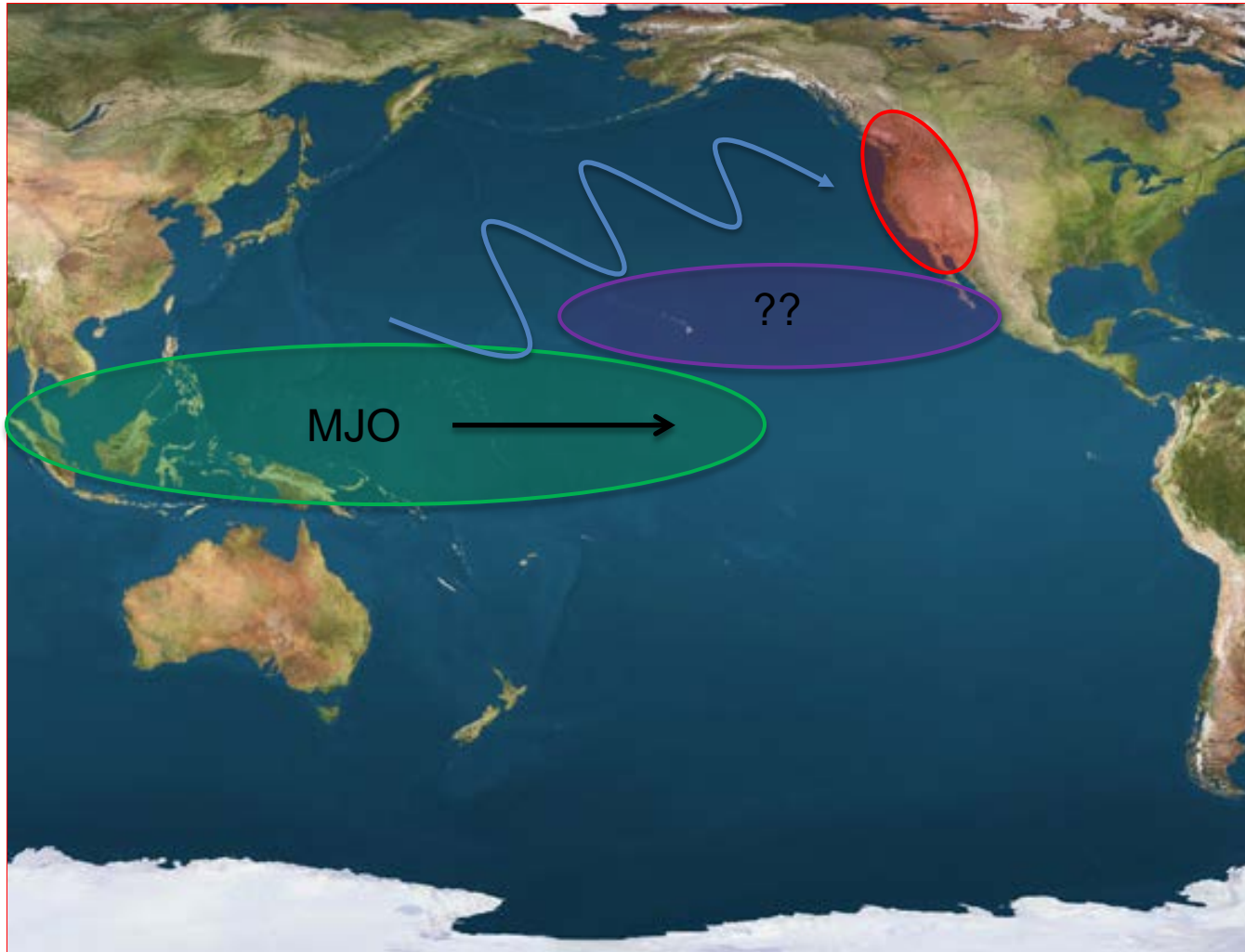


- CAM5-SE
- Aqua-planet prototyping regional refinement
- AMIP and CAPT experiments
- Perturbed parameter experiments for developing metamodel equivalents



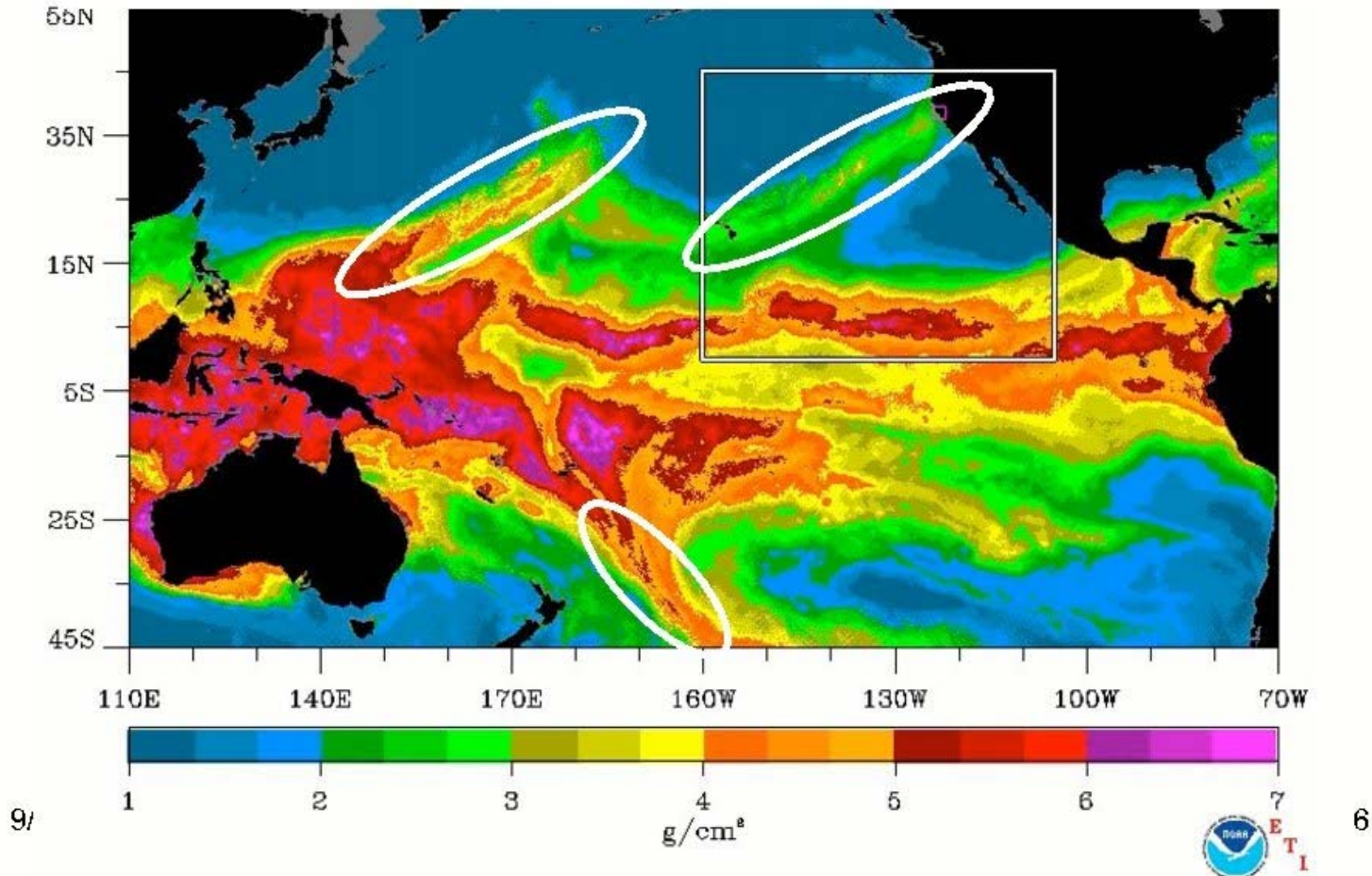
Regional High Resolution

Target and **Origin** regions



Atmospheric Rivers

A key to understanding West Coast extreme precipitation events

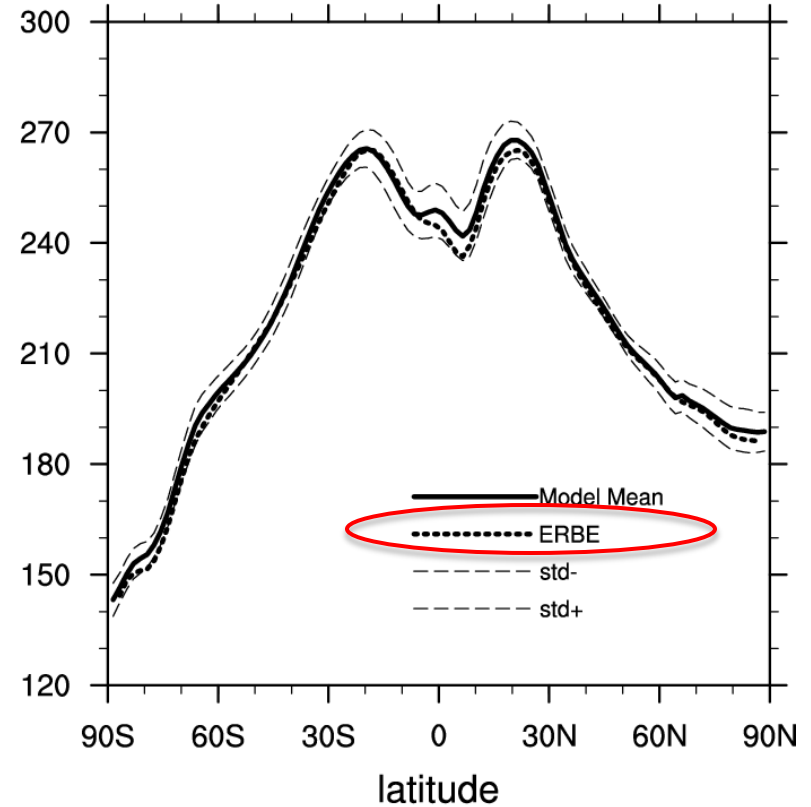
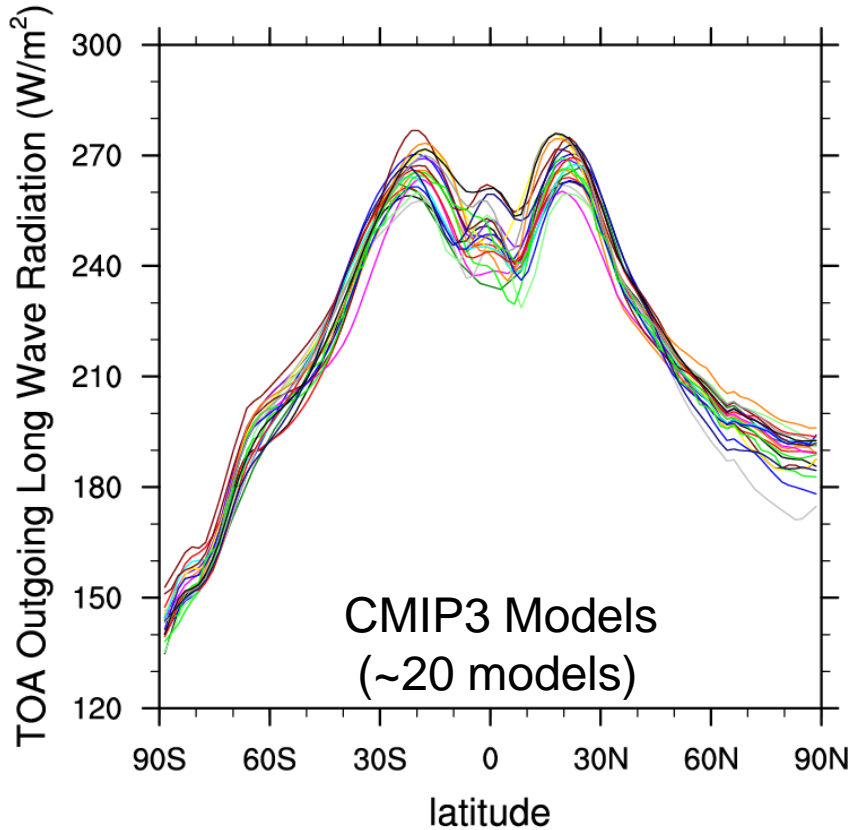


Credit: Darren Jackson/CIRES, NOAA

Structural Uncertainty in GCMs

State of the Art from CMIP3

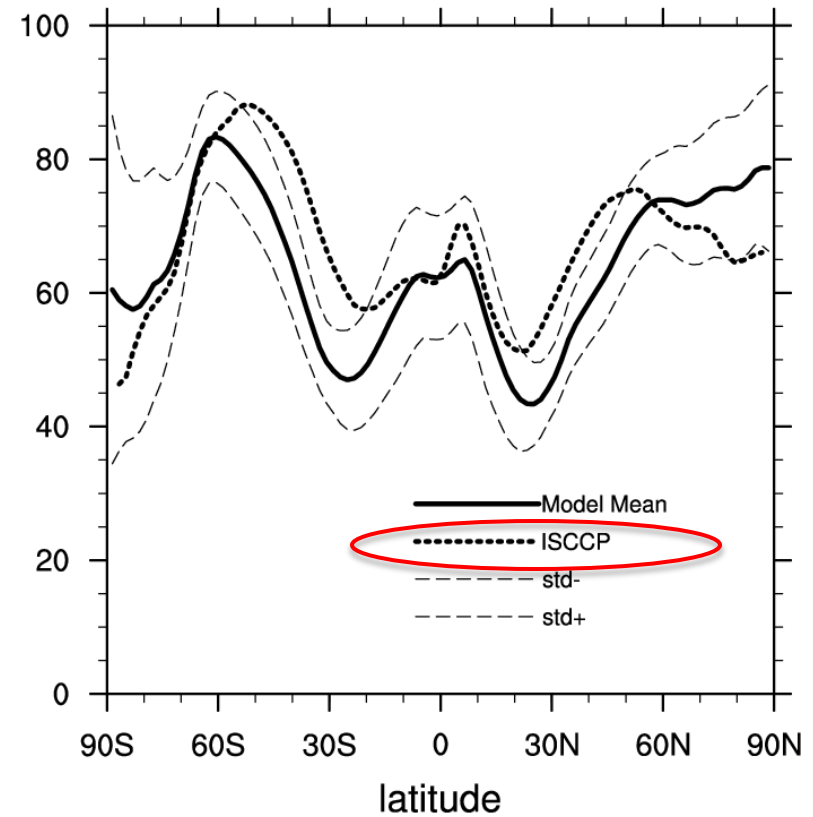
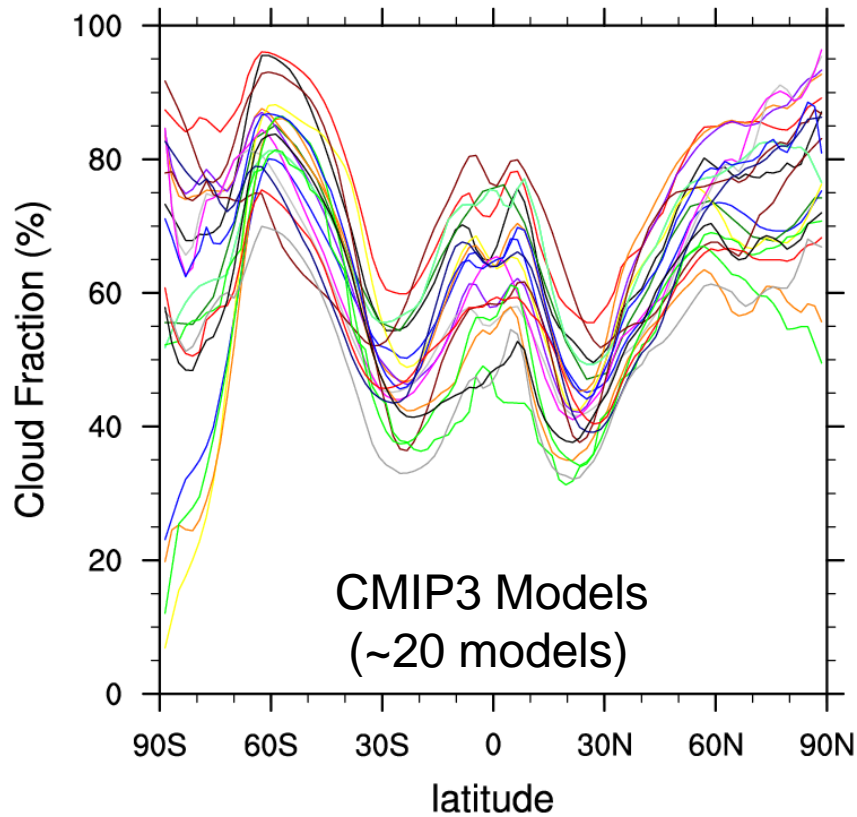
Outgoing Long-wave Radiation
(Annual, 1990-1999)



Structural Uncertainty in GCMs

State of the Art from CMIP3

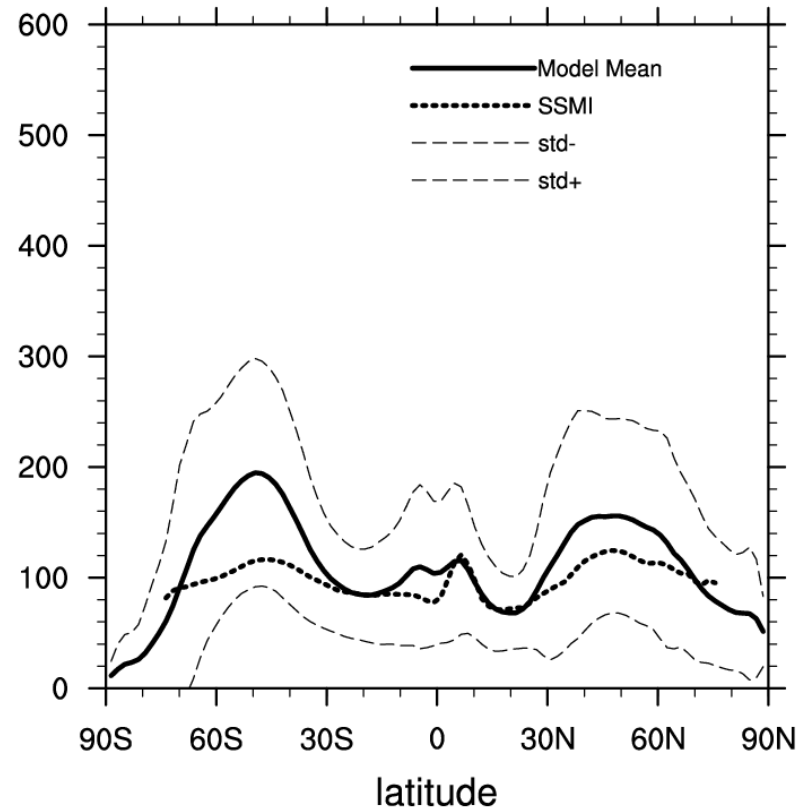
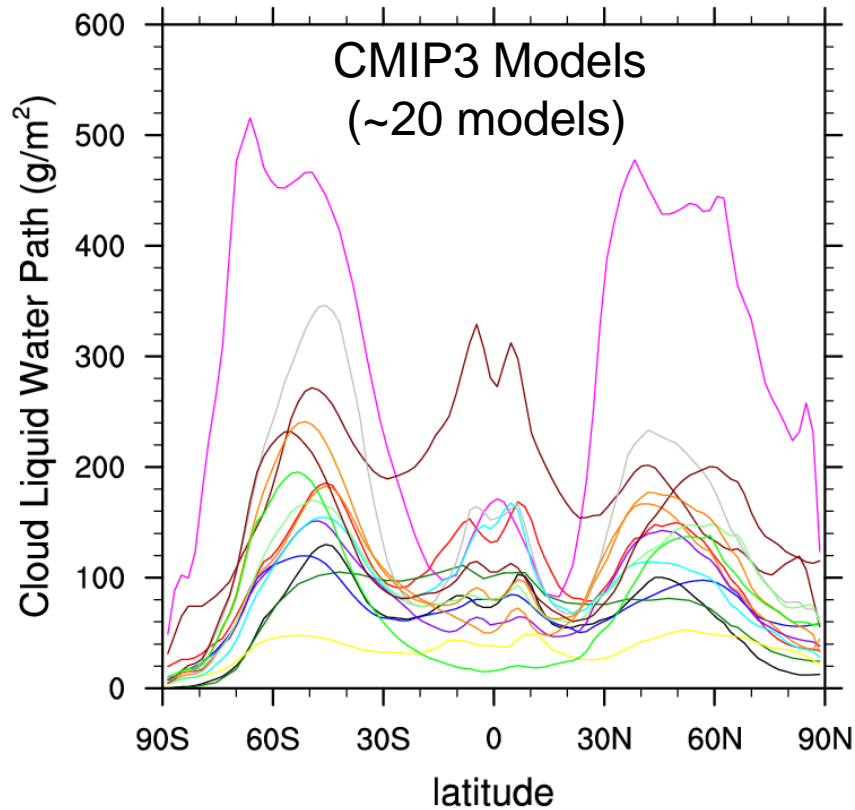
Total Cloud Fraction
(Annual, 1990-1999)



Structural Uncertainty in GCMs

State of the Art from CMIP3

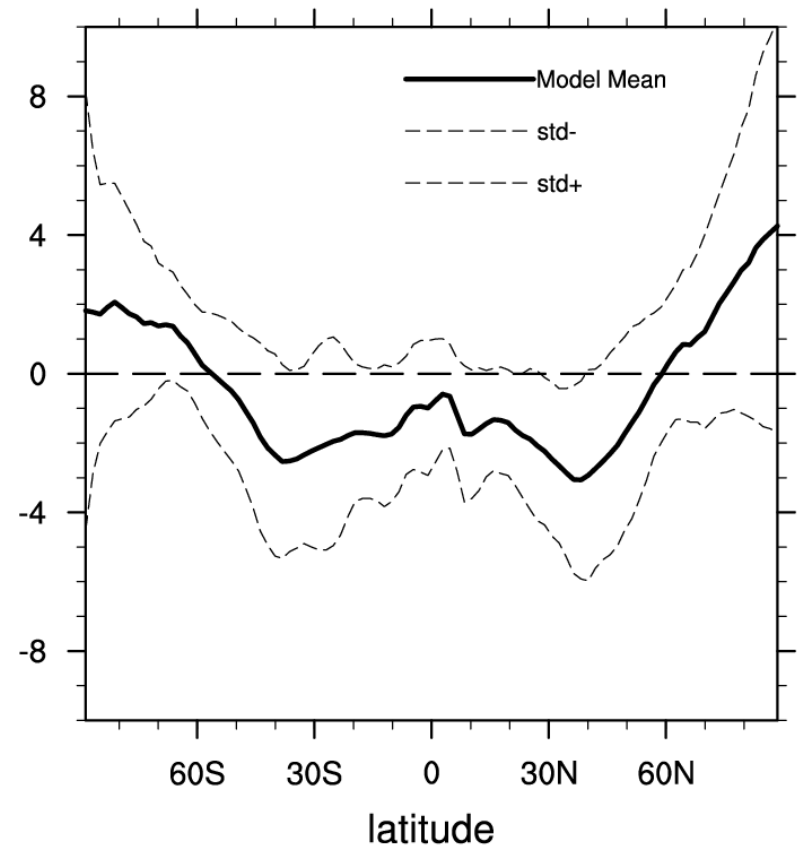
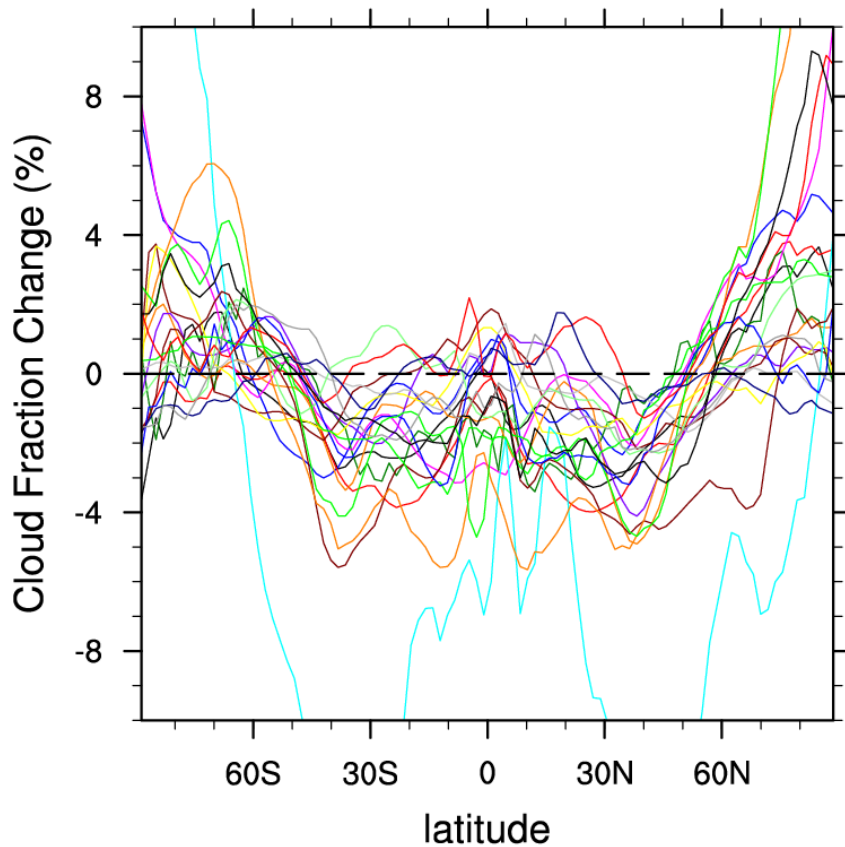
Liquid Water Path
(Annual, 1990-1999)



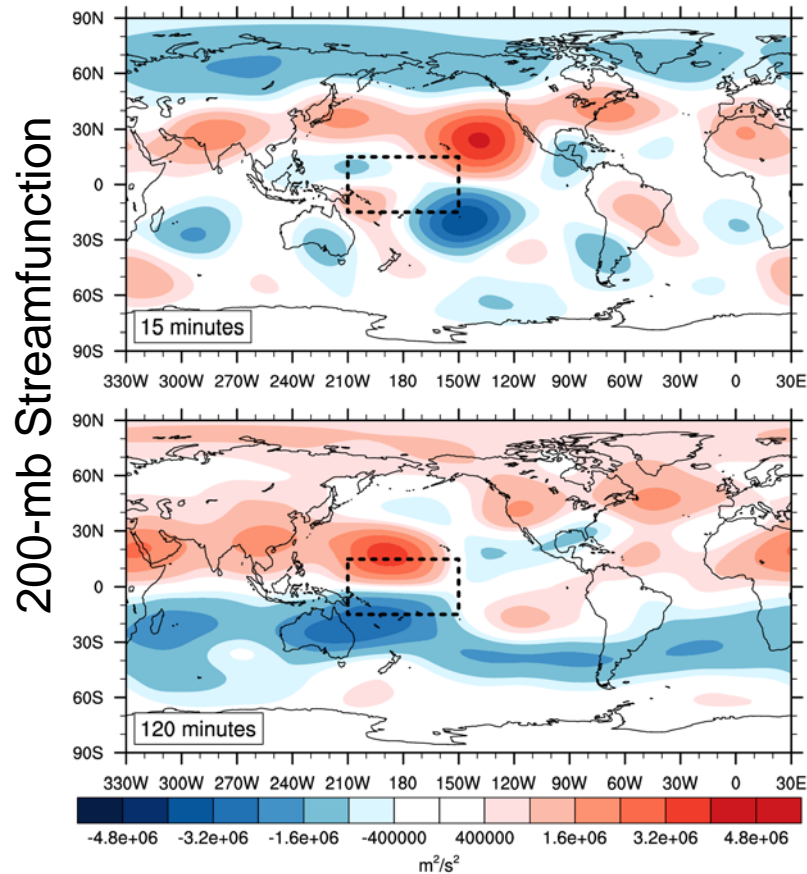
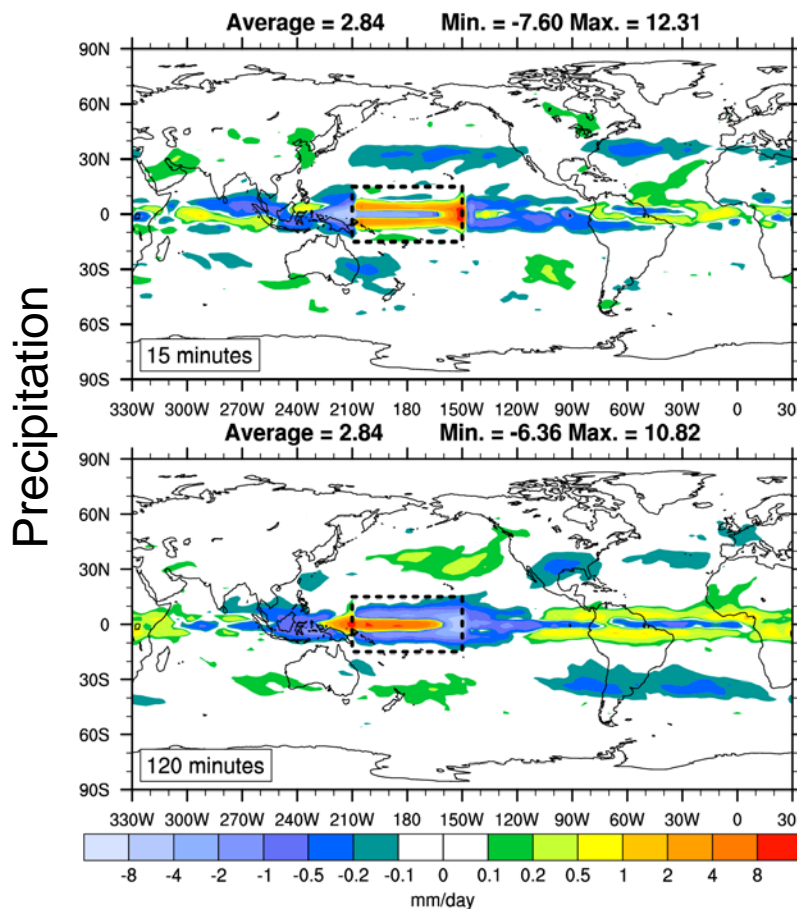
Future Clouds in GCMs

State of the Art from CMIP3 – response to climate change

Total Cloud Fraction Change
(Annual, SRES A1B: 2090-2099 minus 1990-1999)



Structural Sensitivity Convective Timescale

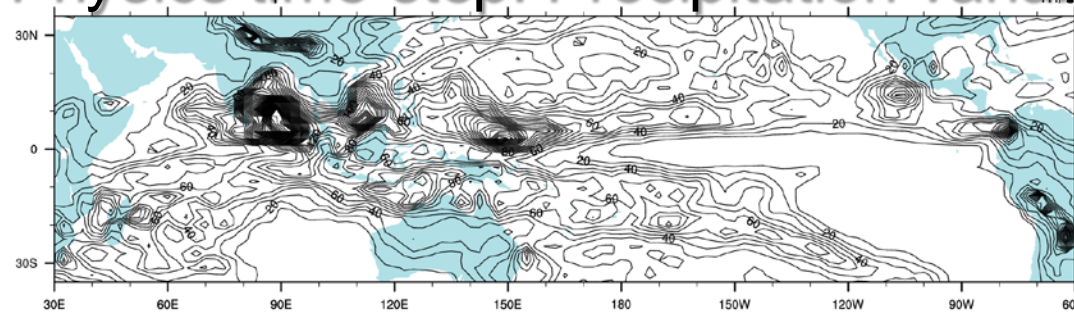


CAM4-FV Aqua-planet simulations (10 years, 2°)

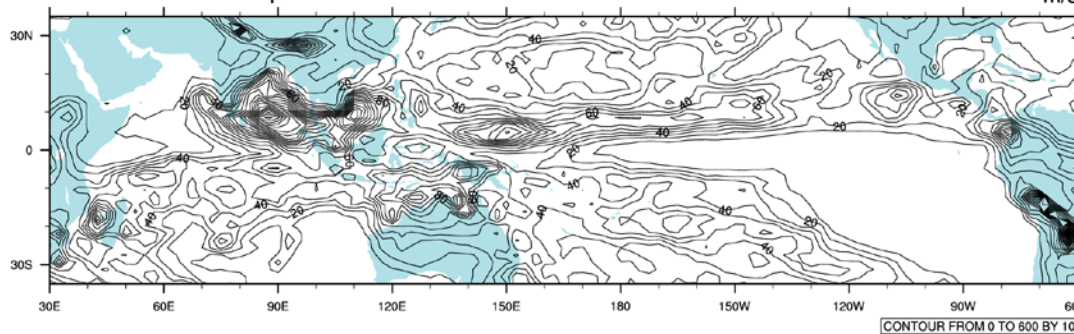
- Response to local differences in parametric settings
- Deep convection timescale (default = 60mins)
- Strong anomaly perturbations; response non-linear locally and remotely)

Structural Sensitivity

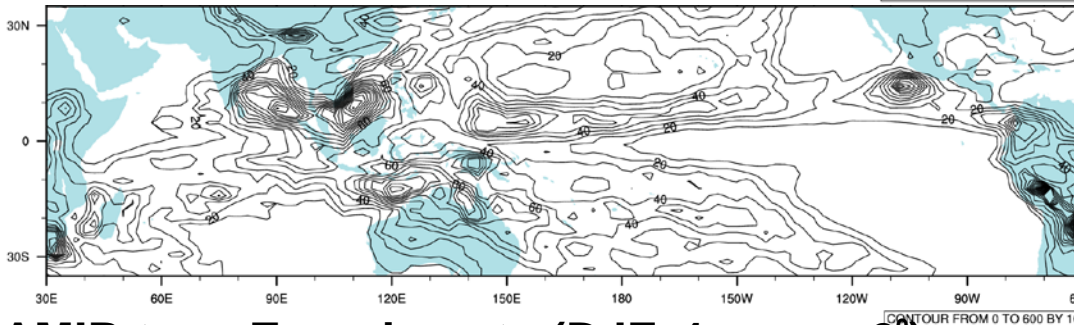
Physics time-step: Precipitation variance



DT = 15min



DT = 30min



DT = 60min

CAM4-FV AMIP-type Experiments (DJF, 4 years, 2°)

- Sensitivity to physics timestep masked by the mean simulation
- Variance of daily precipitation
- Shorter time step has large variance (factor of 2)

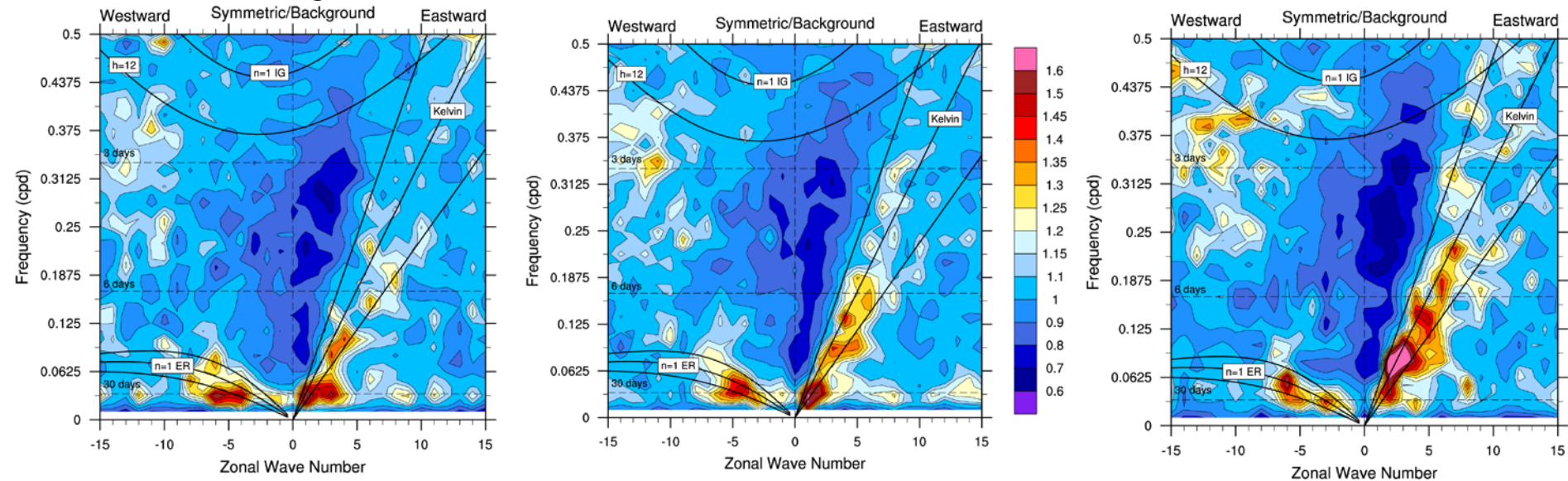
Structural Sensitivity

Physics time-step: Tropical waves

DT = 15min

DT = 30min

DT = 60min

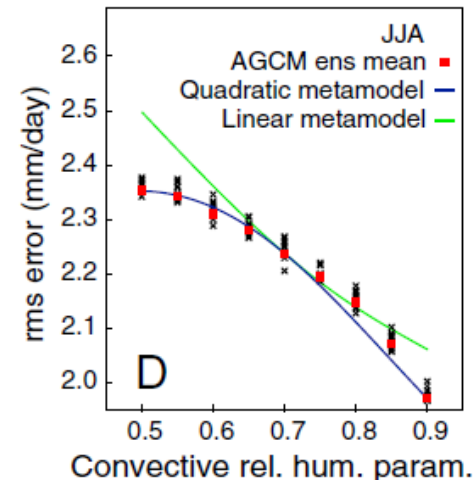
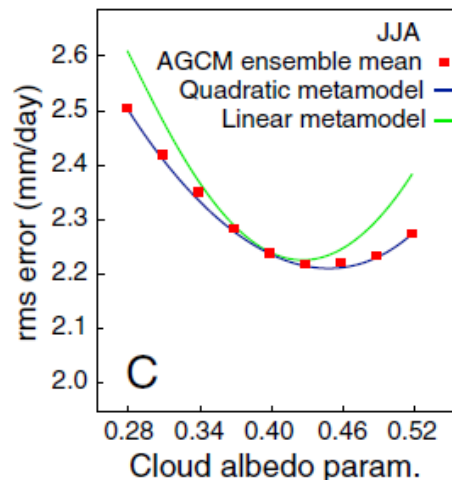
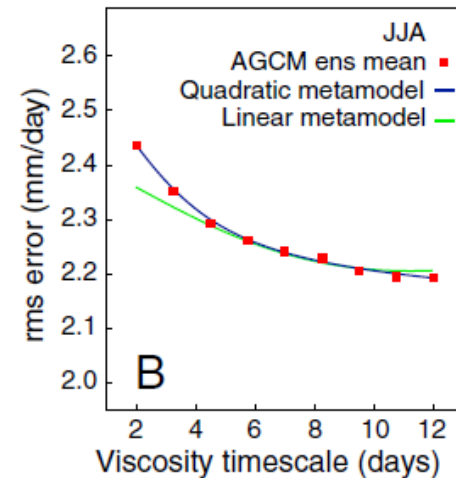
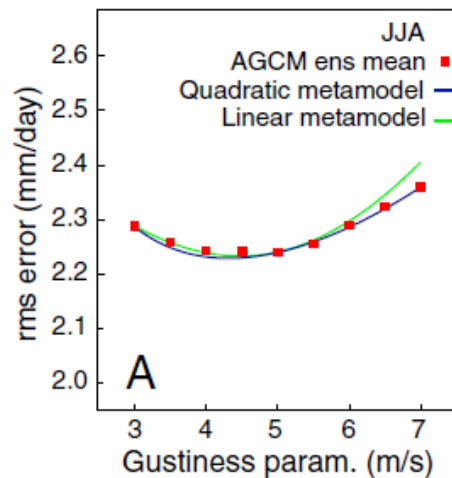


Meta-model Equivalents of CESM

Examine Regional Robustness

GCM Solution Sensitivity

- Neelin et al (2010)
- Accuracy and sensitivity
- Determine sensitivity of RMSE to parameter choices
- Globally uniform and regionally refined resolution
- Proximity to local minima in RMSE
- Potential for greater regional sensitivity to parameter selection



ICTP GCM, T30

Scale Aware Augmentation

Zhang McFarlane Deep Convection

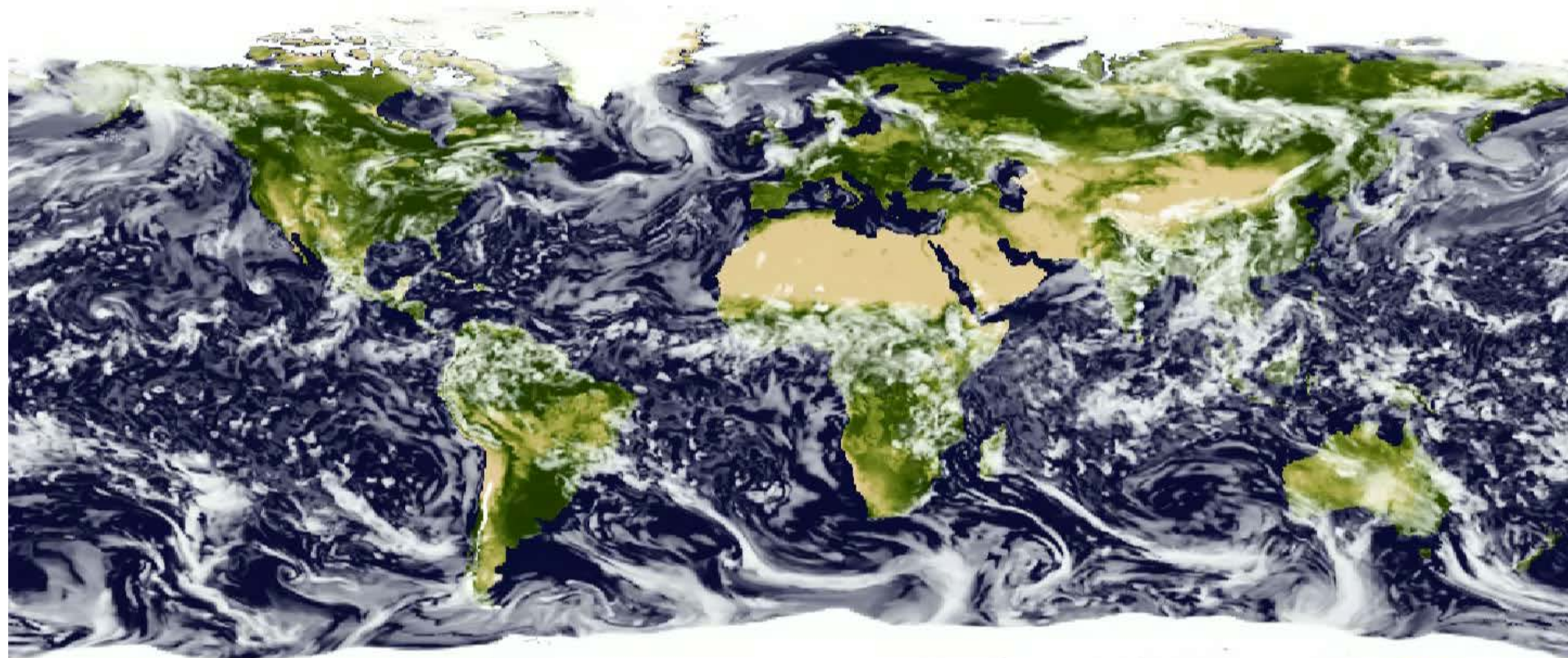
Possibilities

- ✓ Plume organization (Mapes and Neale, 2011)
- ✓ Dynamic convection entrainment (Sahany et al., 2011)

$$\frac{\partial \omega_u^2}{\partial p} = -\frac{C}{2} \omega_u^2 + aB \quad \chi_k = \chi_{min} + \frac{(\omega_k - \omega_{k-1})}{\Delta p(\omega_k + \omega_{k-1})/2}$$

- ✓ Stochastic truncation (Peters et al. 2009)

Questions?



20 Jul 00 h

