High-resolution runs with CAM5 FV and CAM5 SE

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NESL's Climate & Global Dynamics

U.S. DEPARTMENT OF ENERGY

NSF

AMWG Meeting, 1-3 February, 2012

Existing High-Resolution Experiments

CAM 4:

FV dycore 0.23x0.31

- 1979-present. 2 runs, 1 with GFDL tracking data available 6-hrly, 1 with everything recoverable but U850,V850.
- Future time-slice 2080-2100 (present day climo SSTs)+(CMIP5 RCP8.5 perturbation)

CAM5:

FV dycore 0.23x0.31

- 1979-present (*Michael Wehner LBNL, <u>prescribed BAM aerosols</u>*)
- 18 month runs (2005-6) *(Both prescribed BAM and predicted MAM aerosols)*
- 18 month run w/out deep convection scheme
- 18 month runs w/precipitation loading effects

Spectral element (SE) dycore ~25km

- Short AMIP and climo runs examining different surface topography datasets

Spectral element (SE) dycore ~12.5km

- Ongoing AMIP run 2004-

Outline

Choosing topography and damping in SE – momentum flux analysis

Topographic effects on mean precipitation

Precipitation statistics in SE and FV

Multivariate relationships between precipitation and other fields

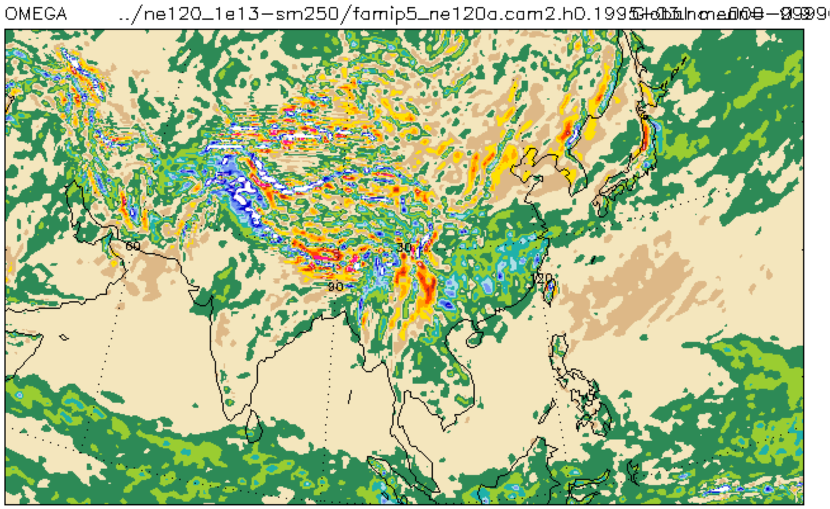
Choosing Topography and/or explicit damping for CAM-SE

(Lauritzen et al. ...)

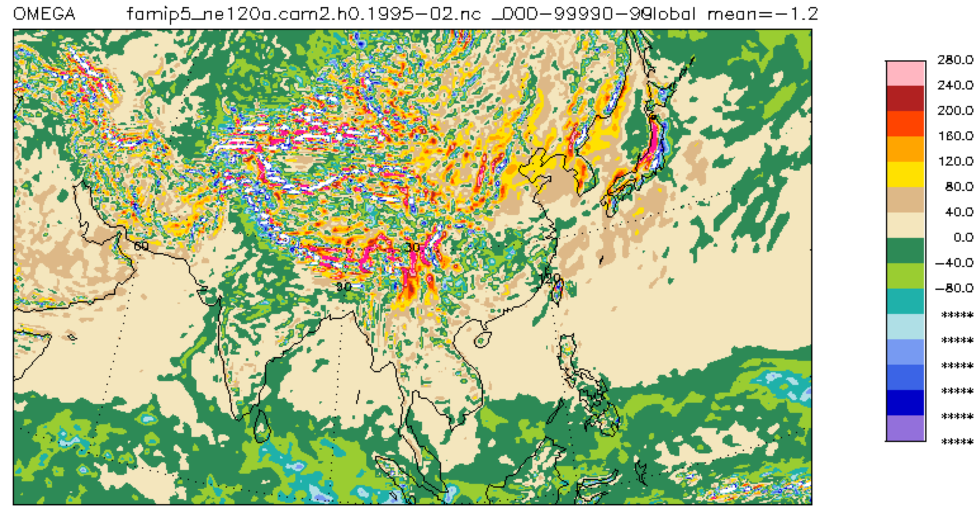
Paucity of observational validation methods. One possibility – stratospheric long-duration super-pressure balloons (Hertzog et al. 2008)

http://www.lmd.polytechnique.fr/VORCORE/campagneE.htm

Monthly mean ω at σ~0.5 (~500 hPa)

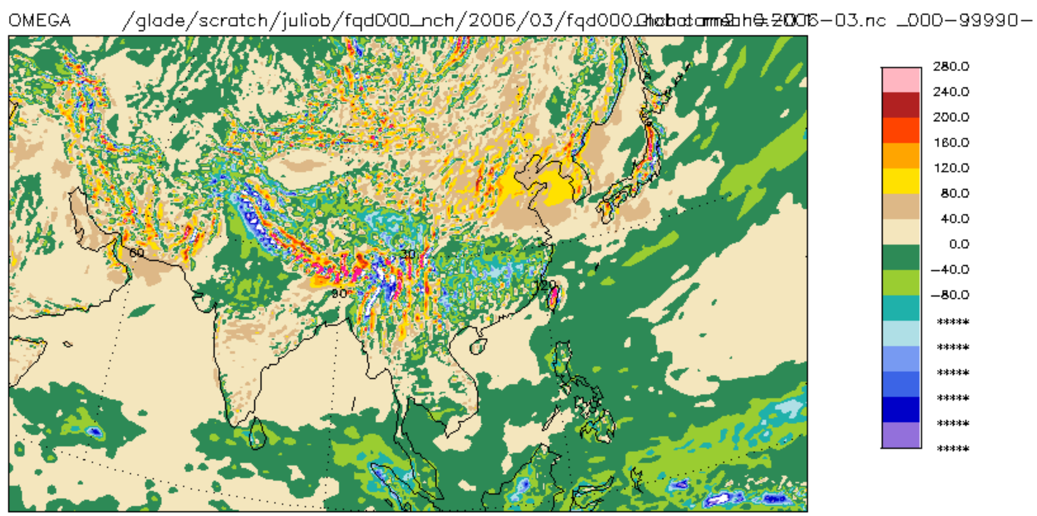


CAM-SE 25 km
Rough topography

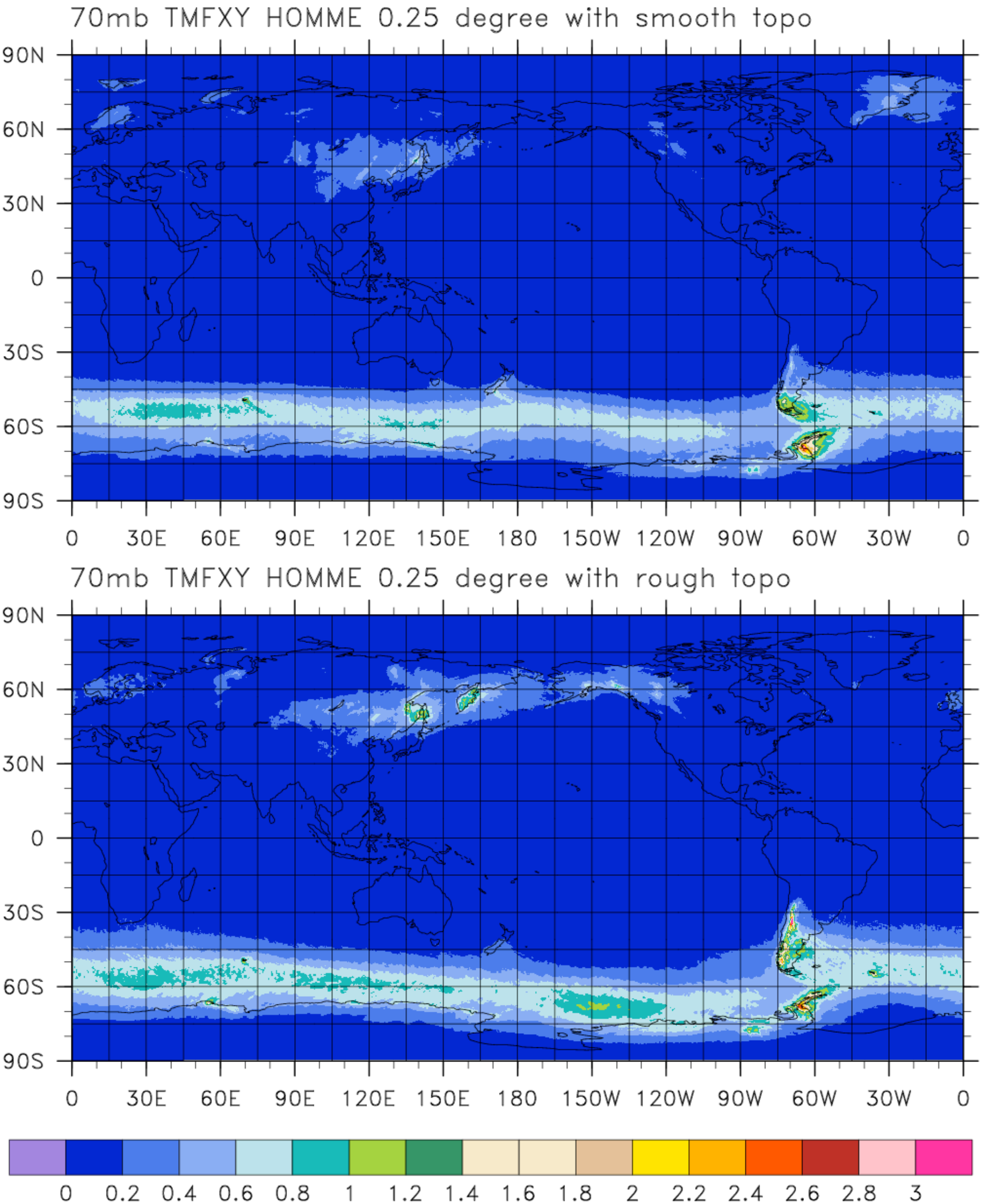


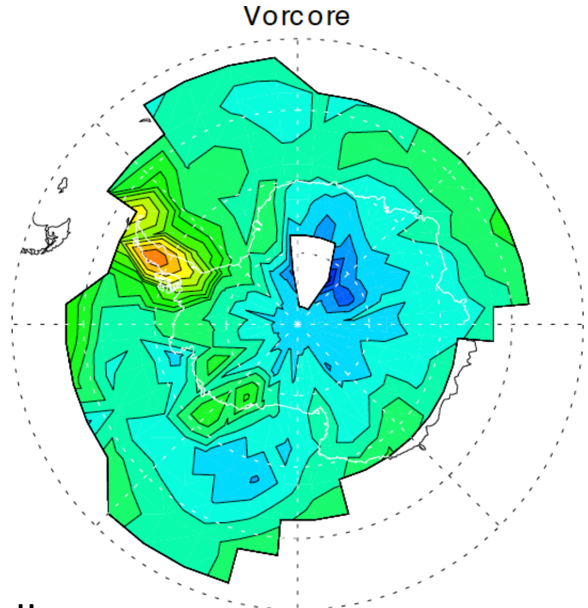
CAM-SE 25 km
Roughest topography

FV latlon
0.23x0.31



Resolved gravity wave momentum flux -October 2005, 70 hPa





Basically

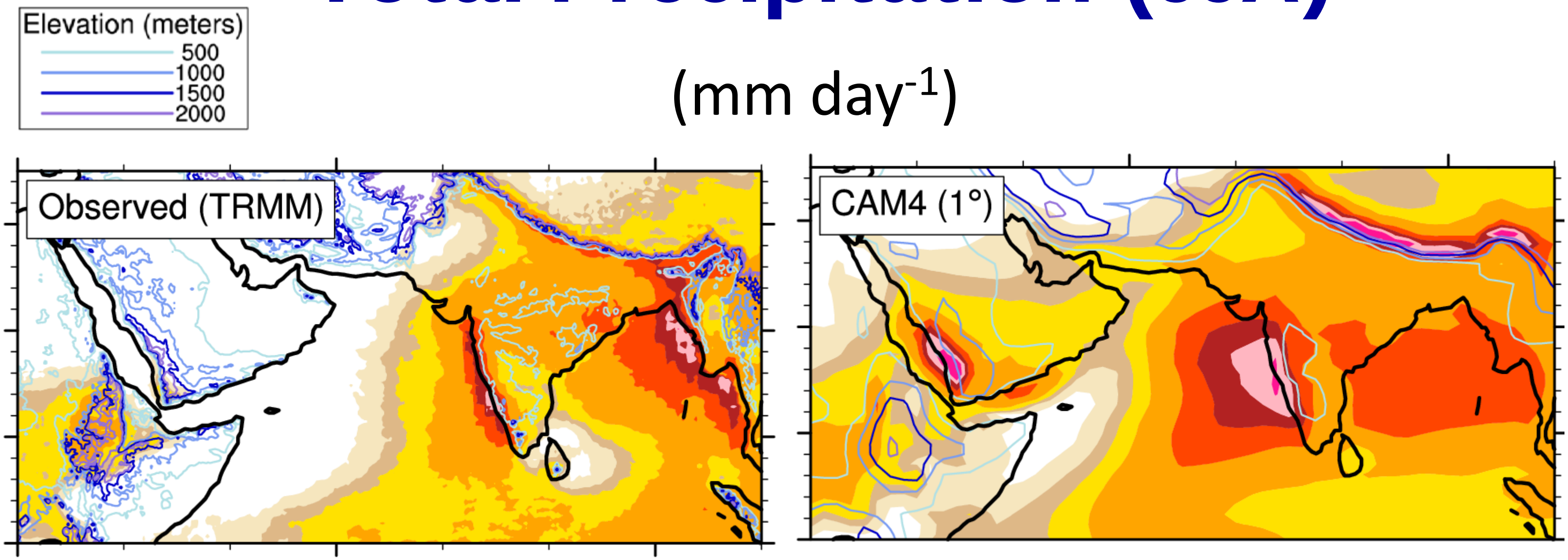
$$\overline{\rho\sqrt{(u'^2+v'^2)w'^2}}$$

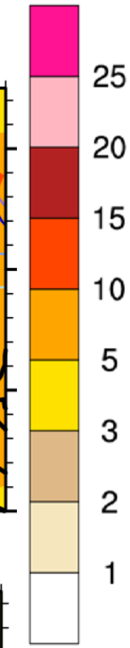
where ()'s are deviations from ~500 km means and overbar is a horizontal/time average.

Unfortunately momentum flux at 70 hPa doesn't discriminate between rough and smooth topo. May be useful for tuning internal explicit dissipation. – TBD.

Topographic effects on precipitation with increasing resolution

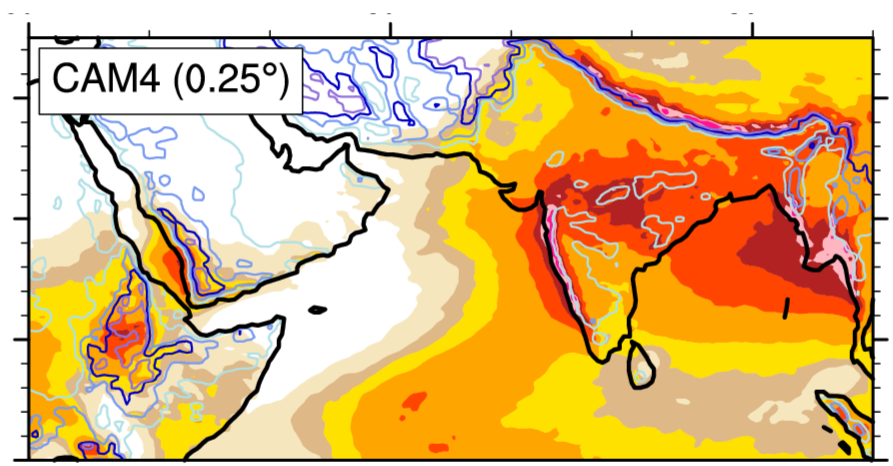
Total Precipitation (JJA)



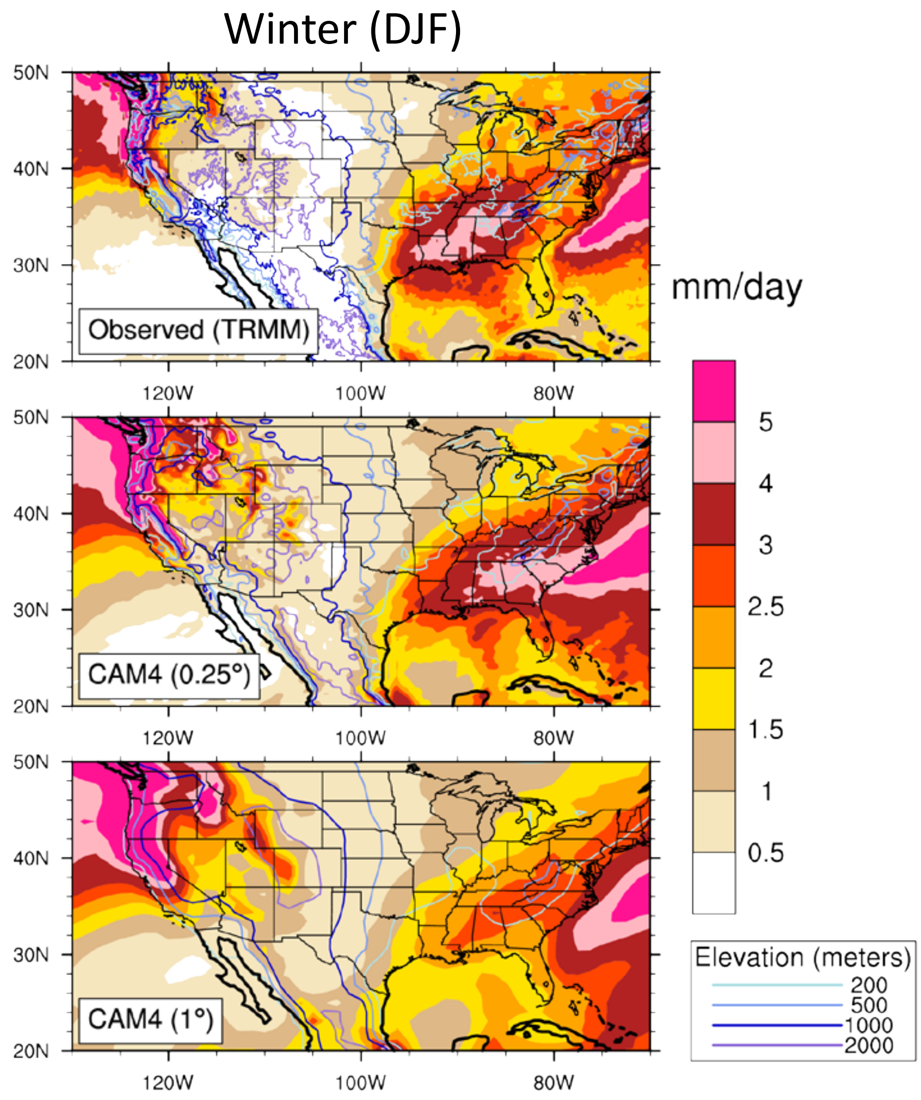


Much improved spatial pattern and magnitude of rainfall

- Western India and Bay of Bengal
- Longstanding wet bias over Yemen, Oman and Saudi Arabia
- Somali jet more realistic

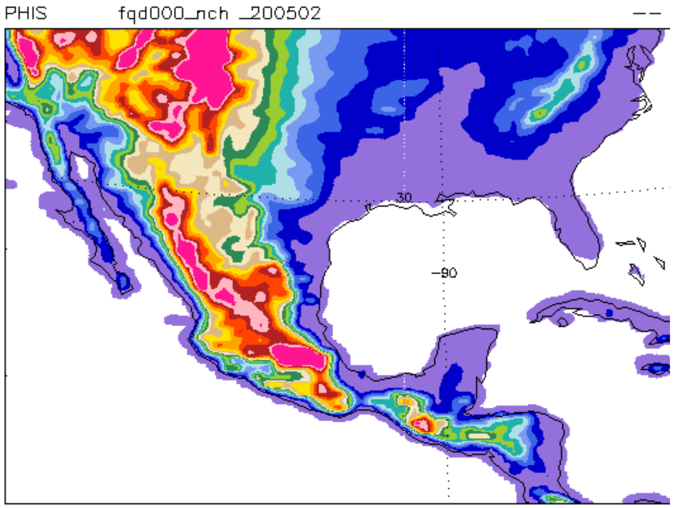


CAM4 US Precipitation

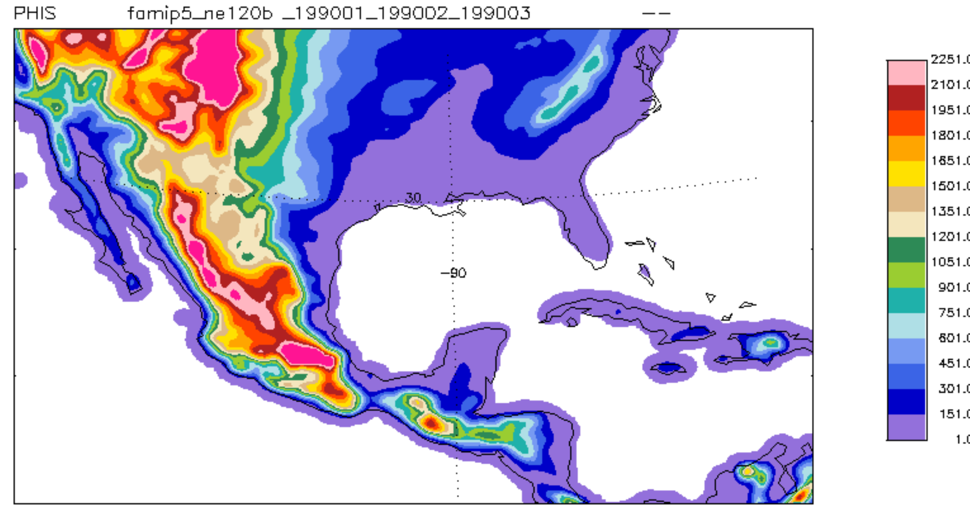


Surface elevation (m)

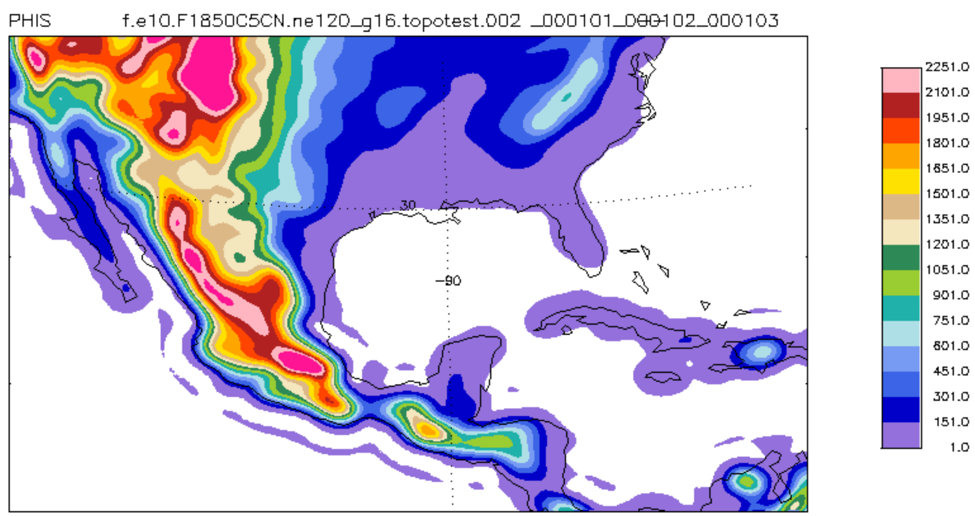
FV 0.25 degree



SE ne120 “rough” topography

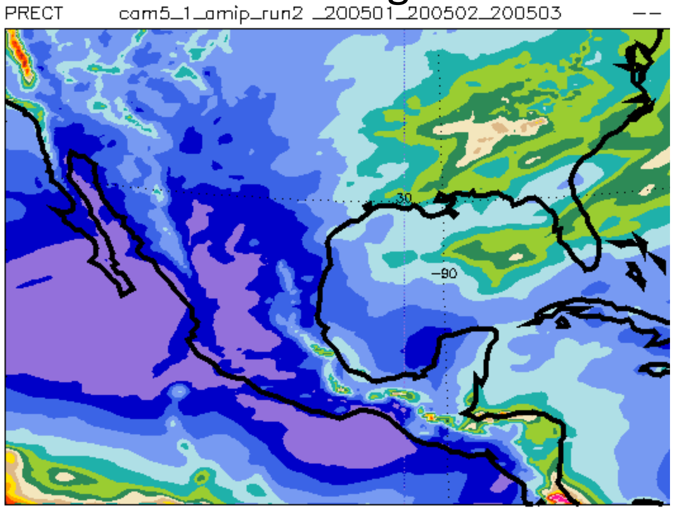


SE ne120 “smooth” topography

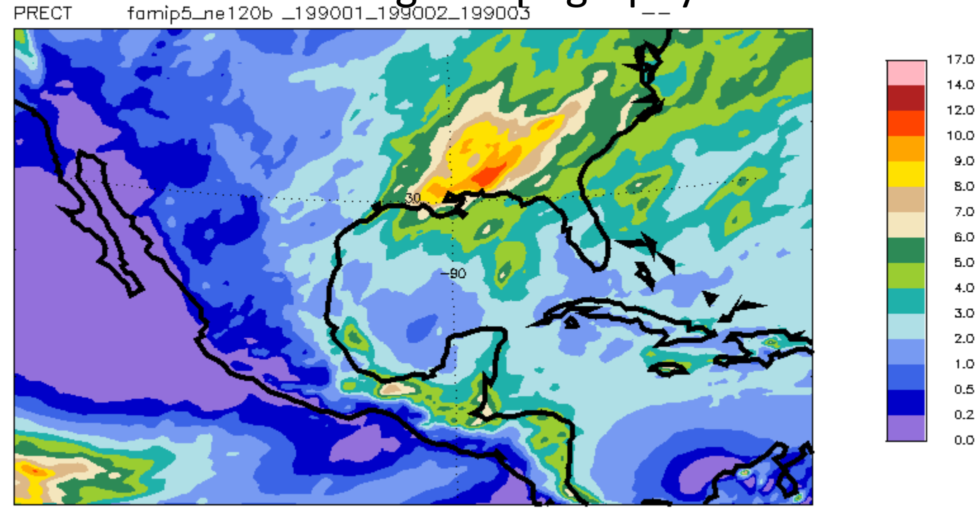


DJF precipitation (mm d^{-1})

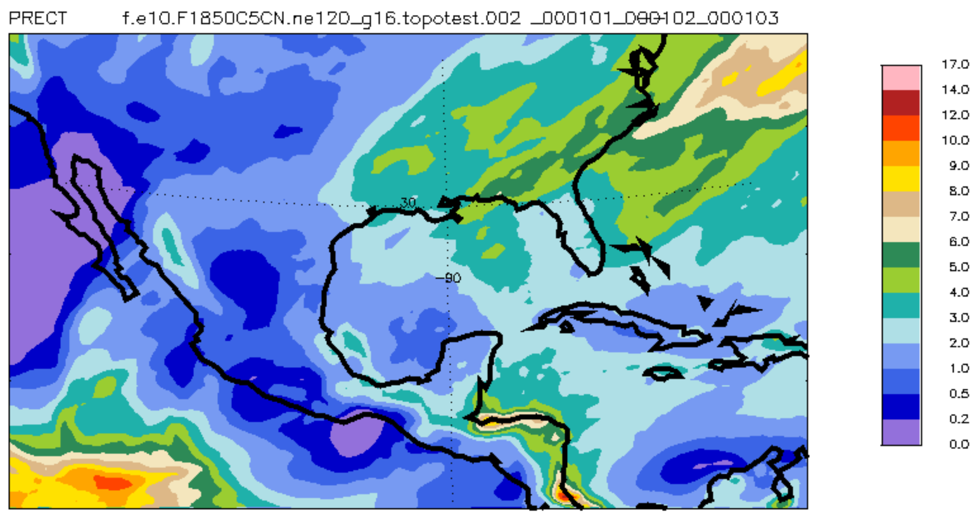
FV 0.25 degree



SE ne120 “rough” topography

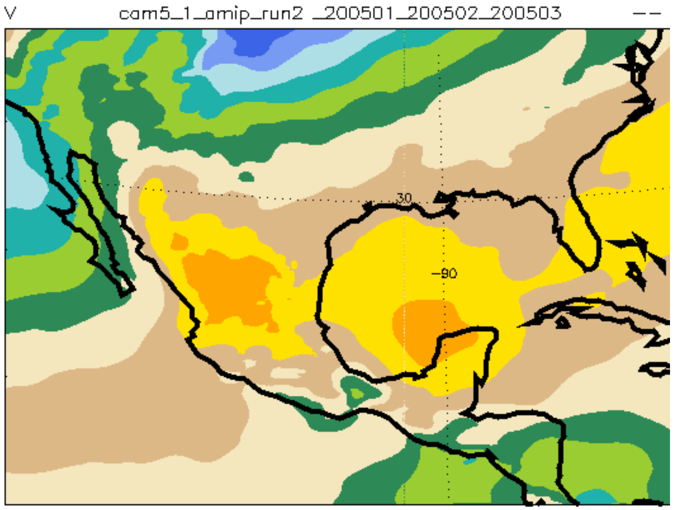


SE ne120 “smooth” topography

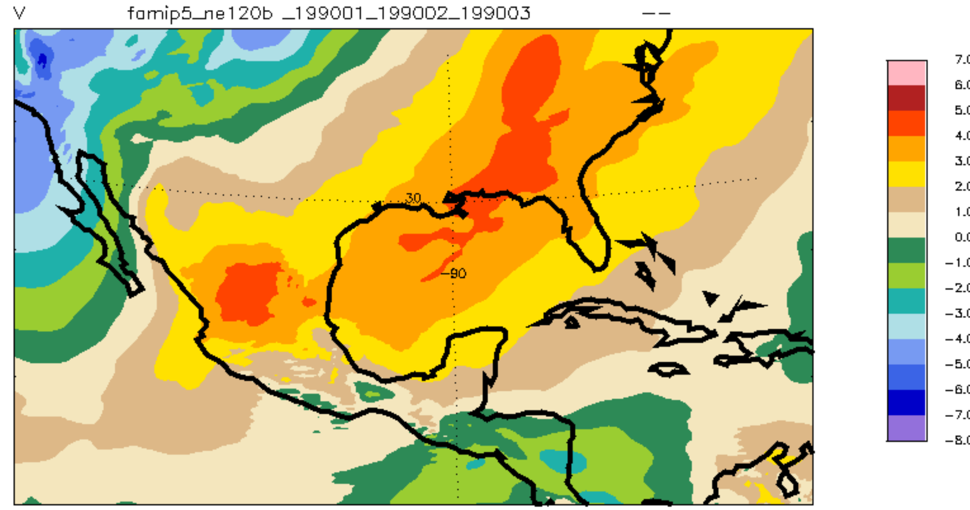


DJF meridional wind (m s^{-1})

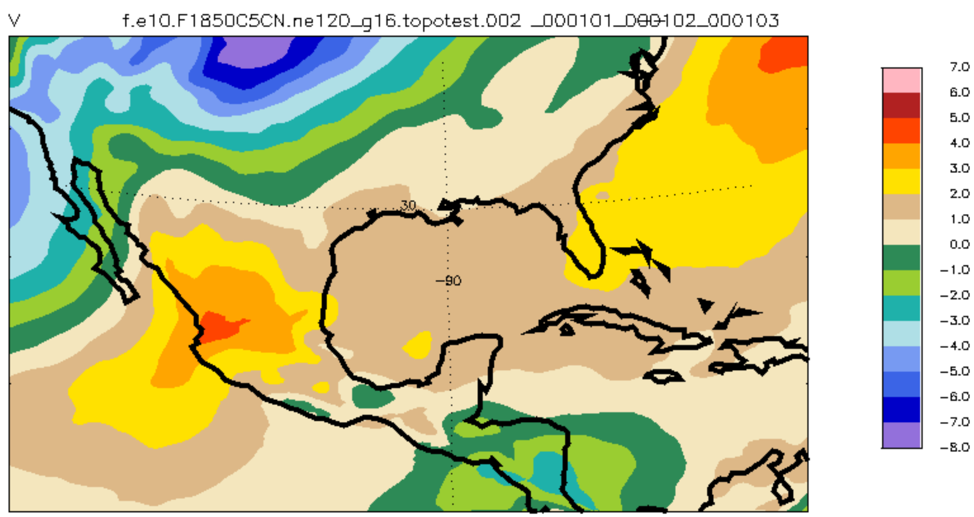
FV 0.25 degree



SE ne120 “rough” topography



SE ne120 “smooth” topography

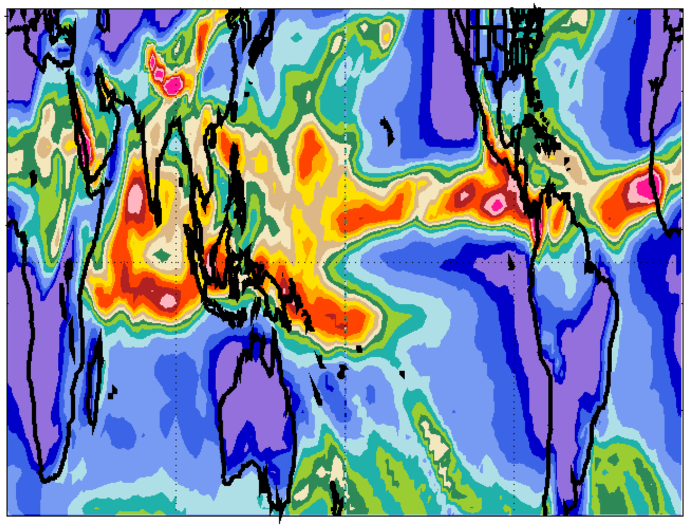


High-resolution/rough topography. Flow steered north into SE US carrying moisture

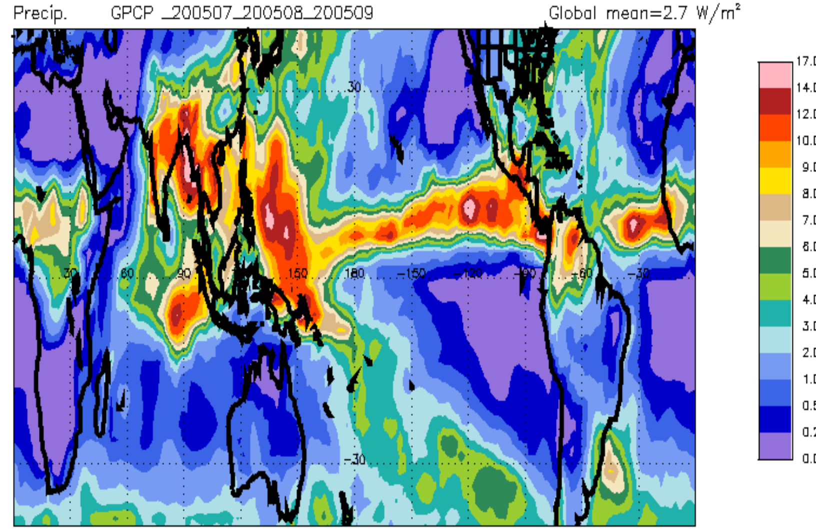
Precipitation statistics at high-resolution

JJA Precipitation (one season)

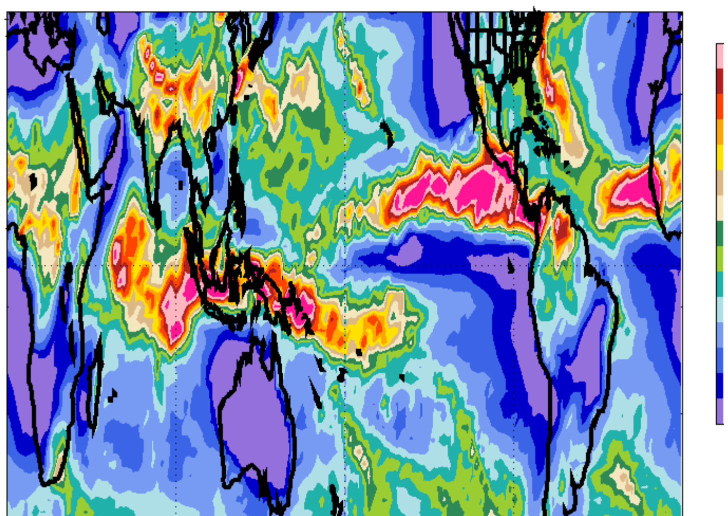
2 degree CAM5



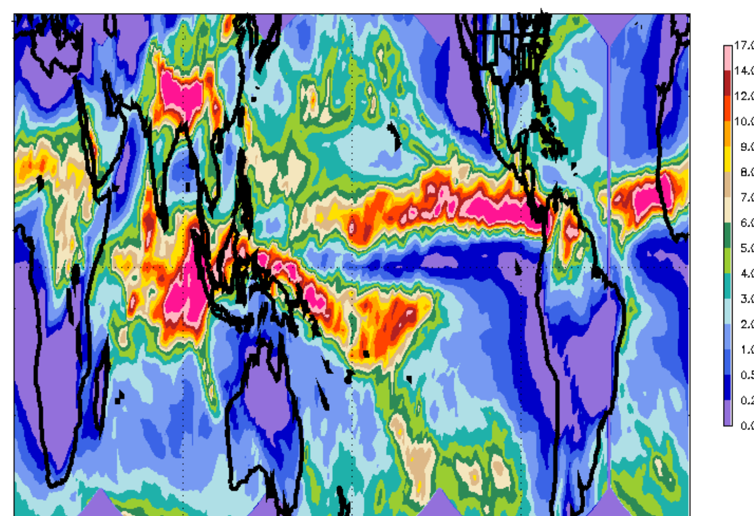
GPCP



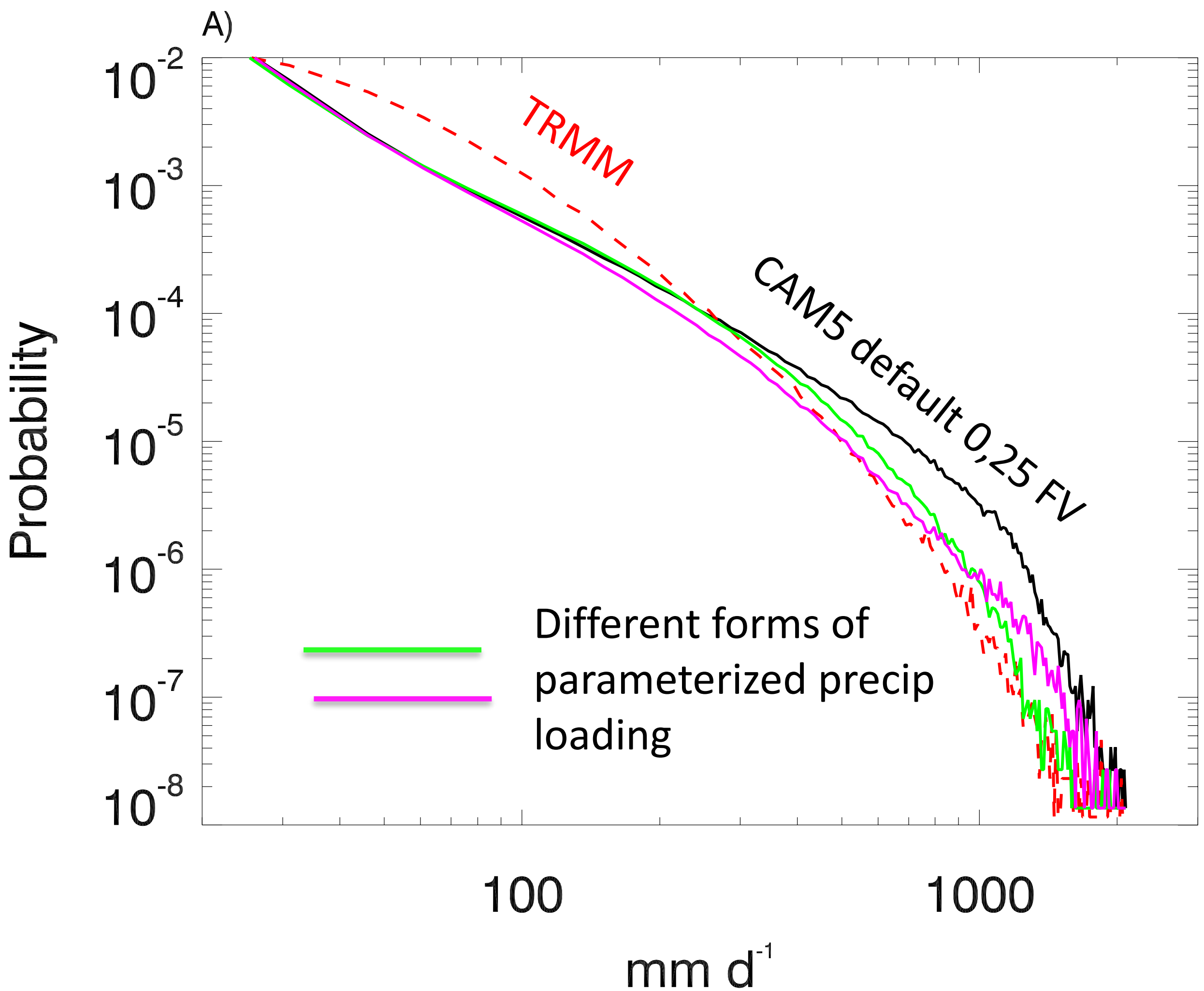
0.25 degree CAM5 coarsened to 2 degrees



SE ne120 => 200km

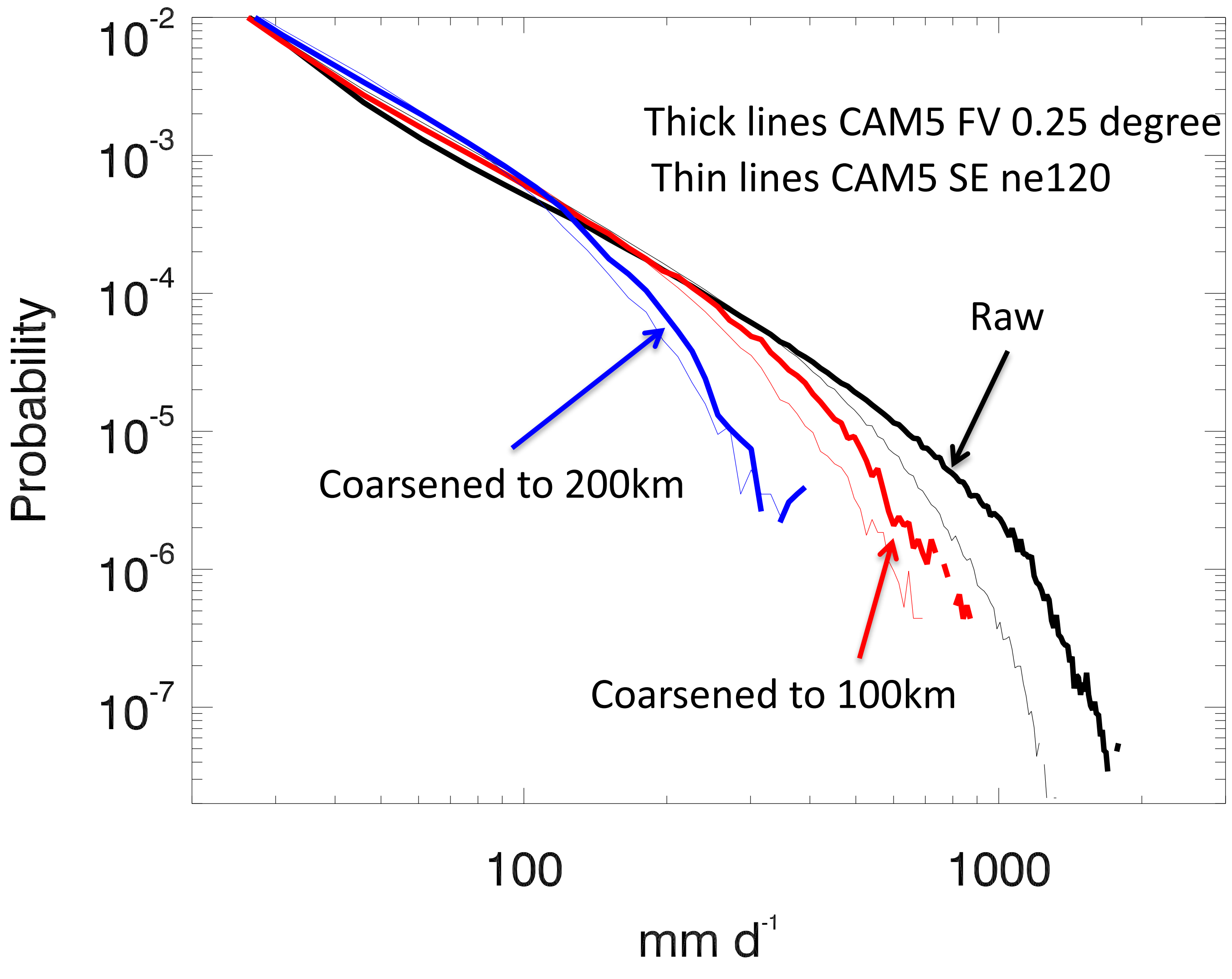


Precipitation Intensity Statistics for August (instantaneous 3hrly data)

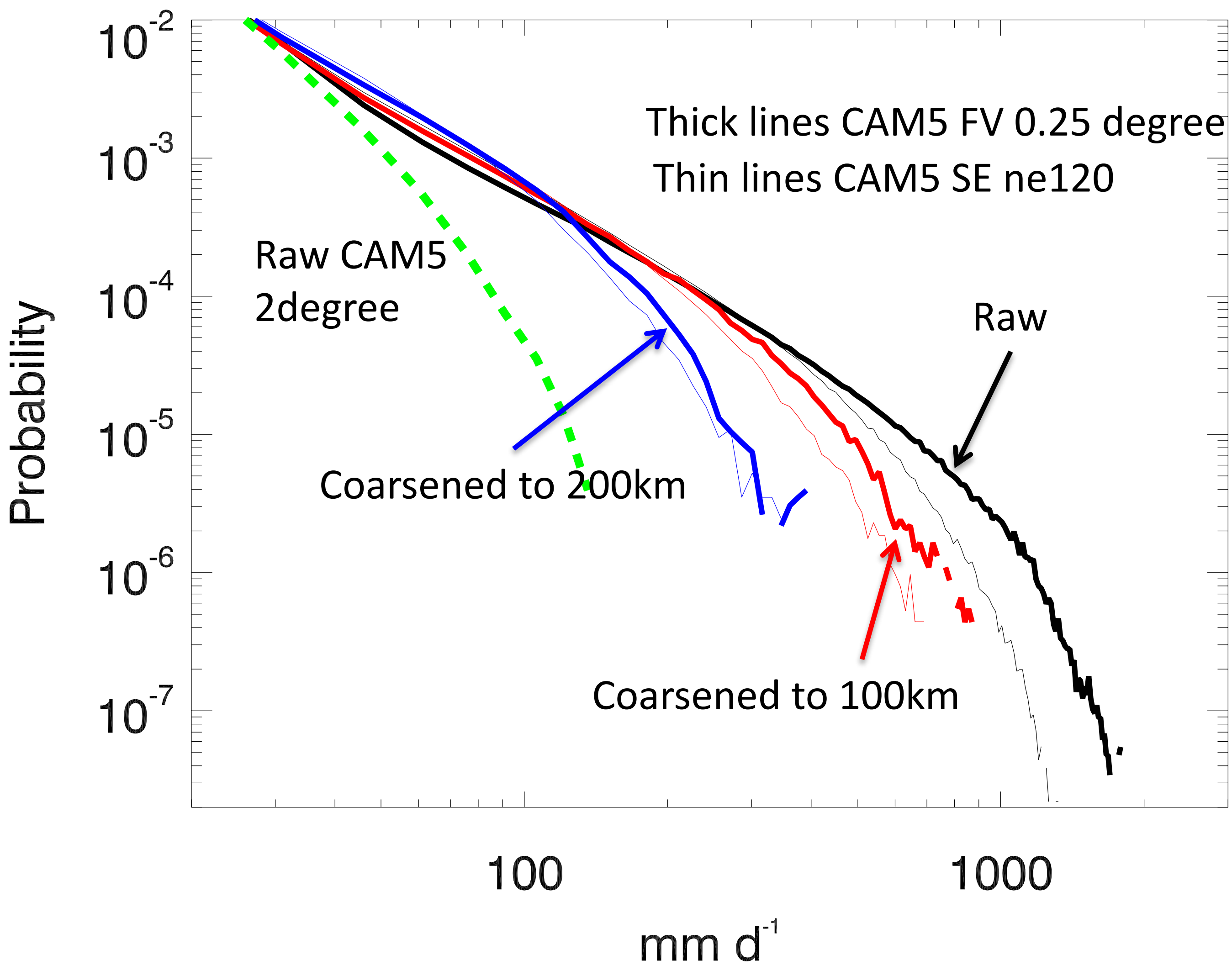


(Bacmeister et al 2012, GRL)

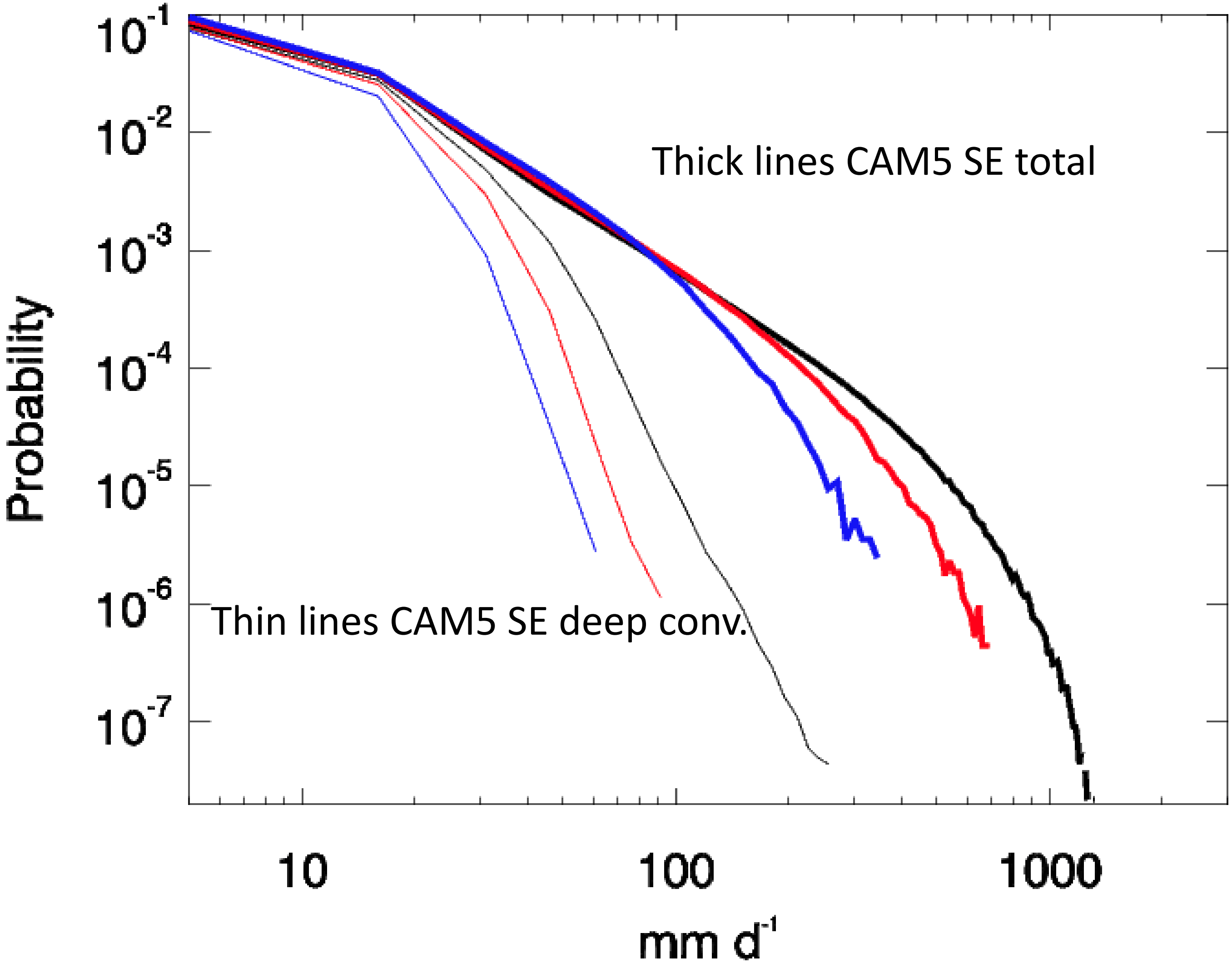
Precipitation Intensity Statistics for JJA (instantaneous 3hrly data)



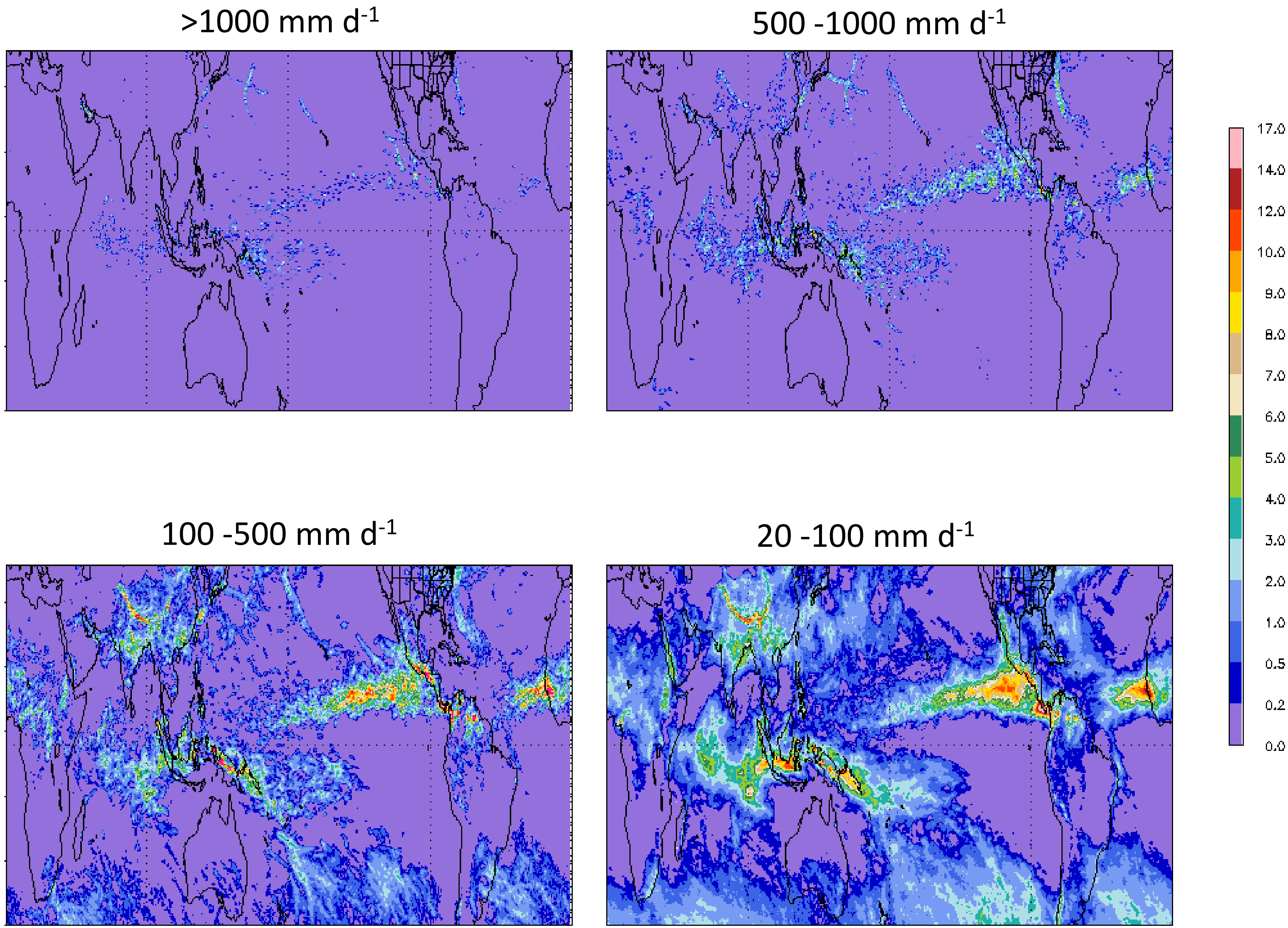
Precipitation Intensity Statistics for JJA (instantaneous 3hrly data)



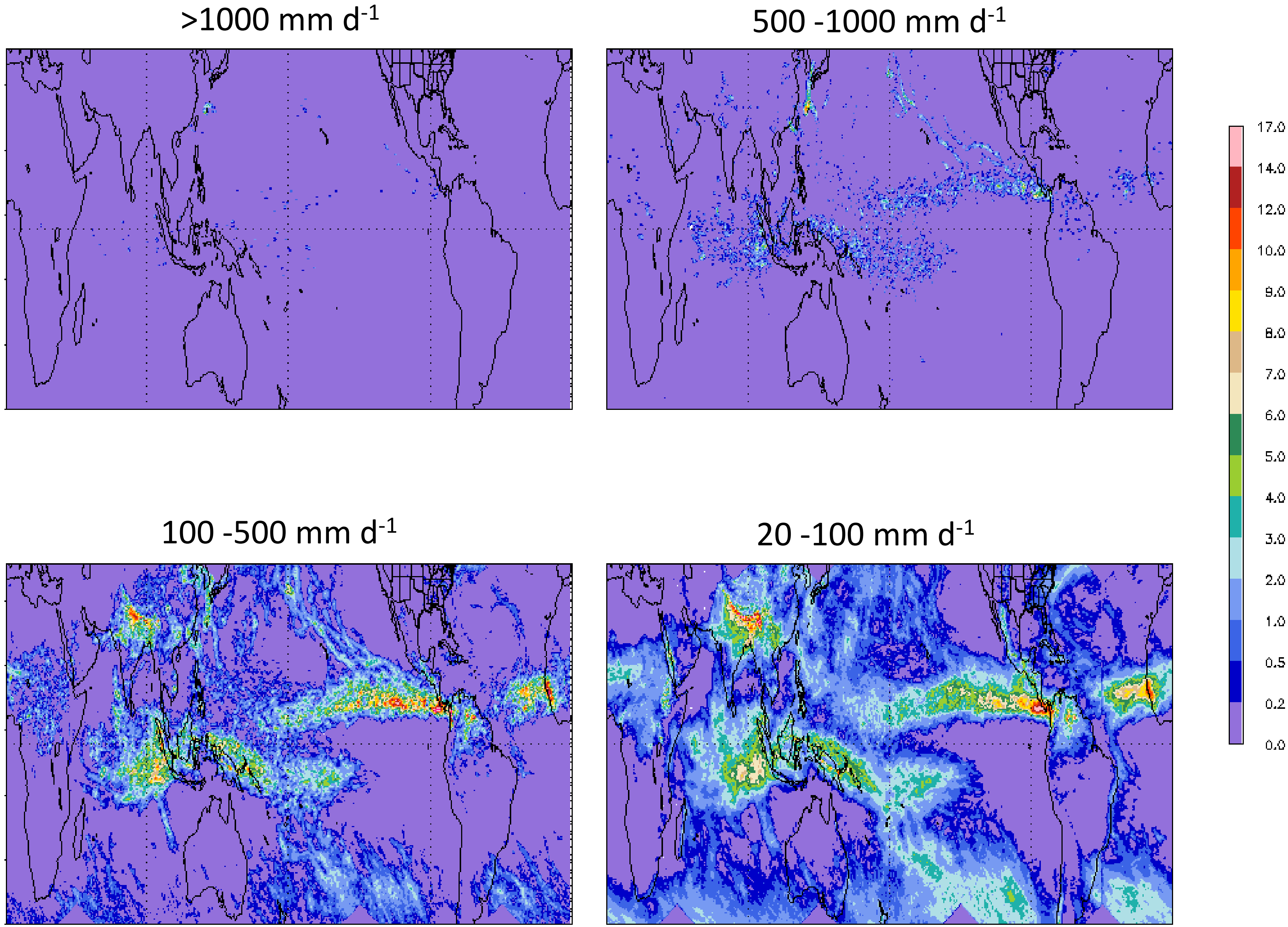
Convective versus total precipitation statistics



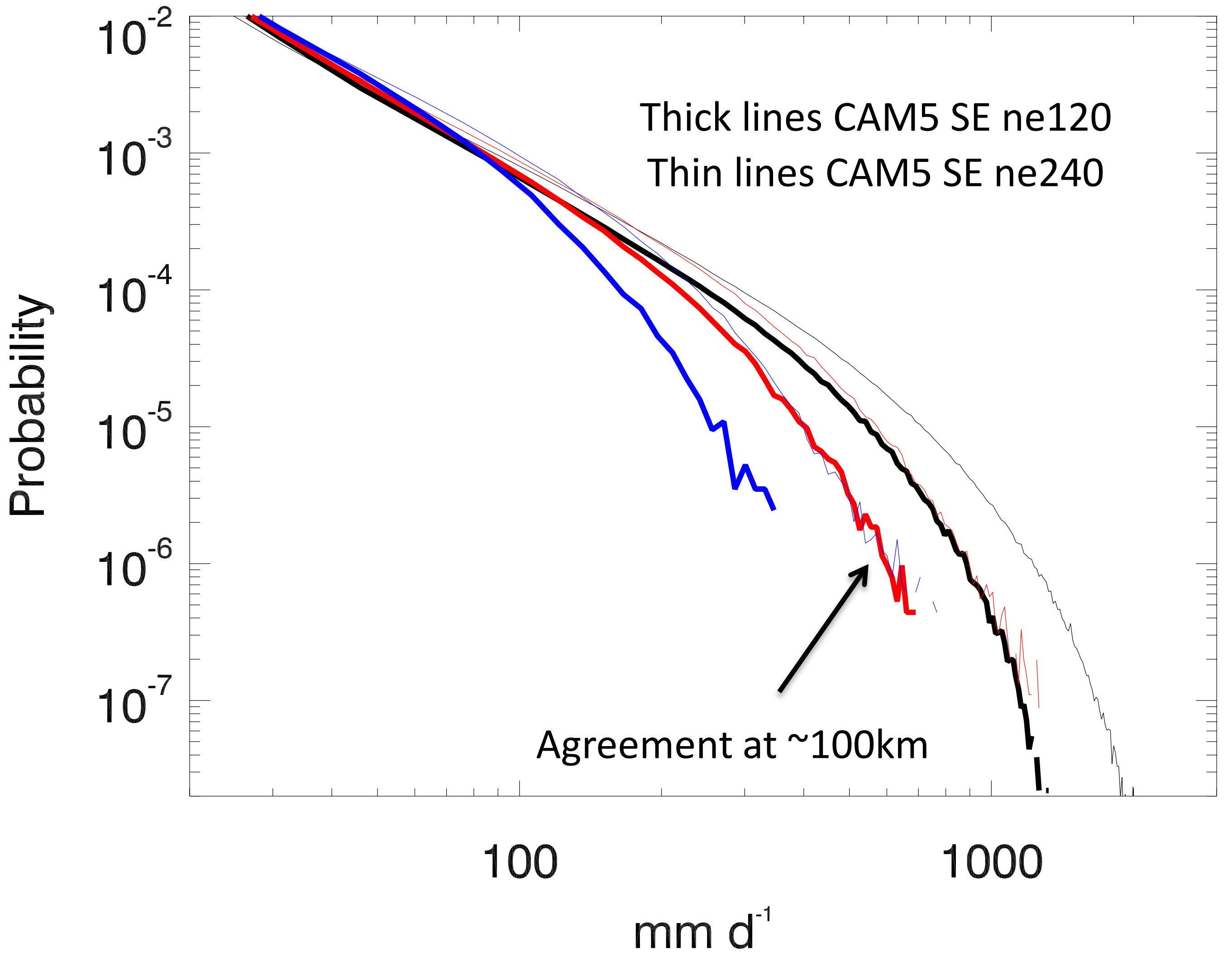
Where do various intensity regimes fall? CAM-FV



Where do various intensity regimes fall? CAM-SE

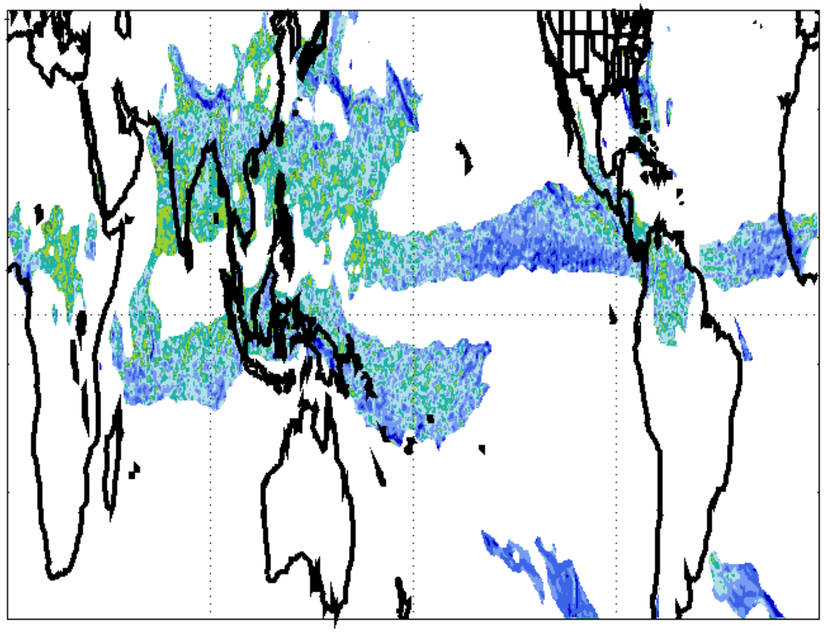


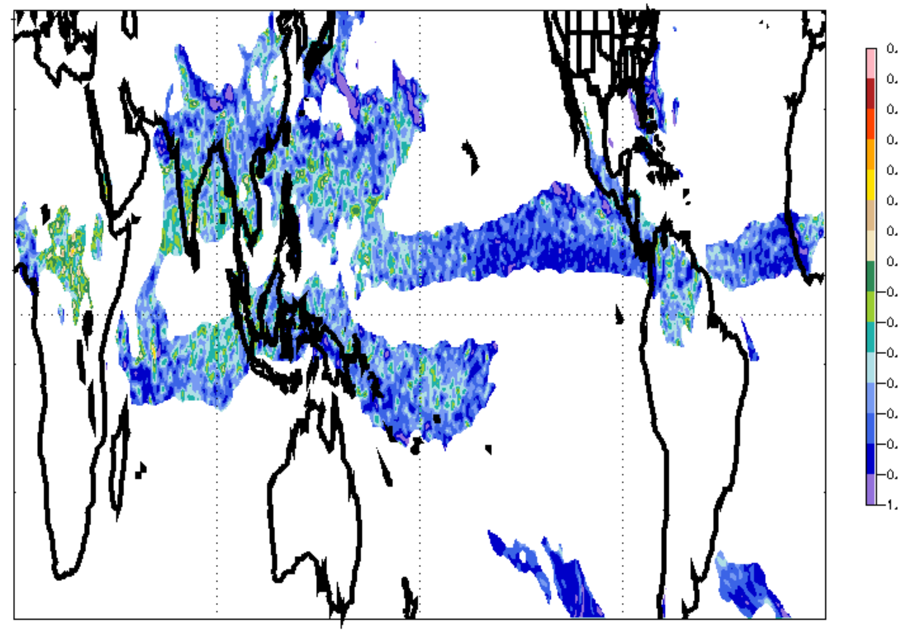
Precipitation Intensity Statistics for JJA (instantaneous 3hrly data) in CAM-SE ne240 (12.5km) vs ne120 (25km)



Multivariate precipitation statistics at high-resolution

Attempt to find dynamical relationships, perhaps new quantities for validation

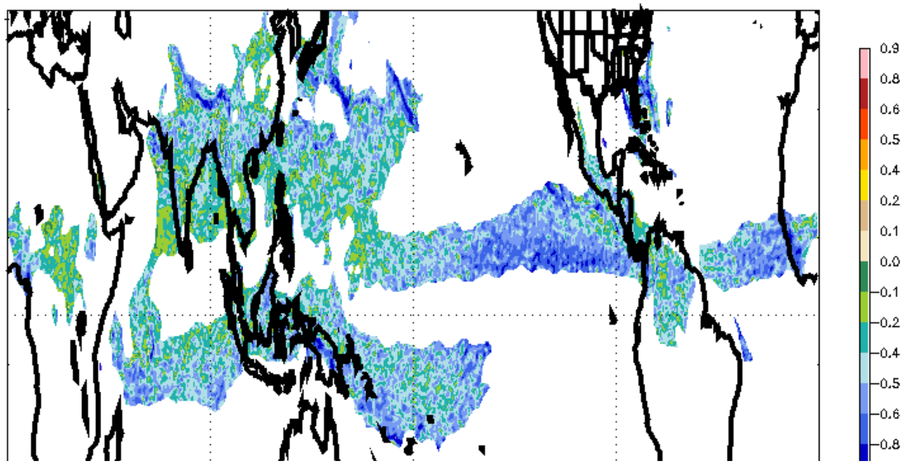


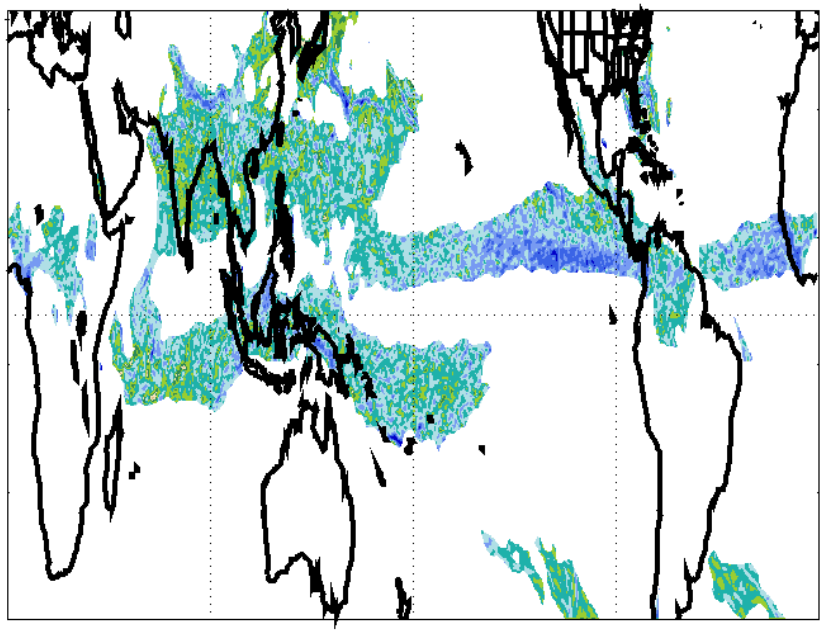


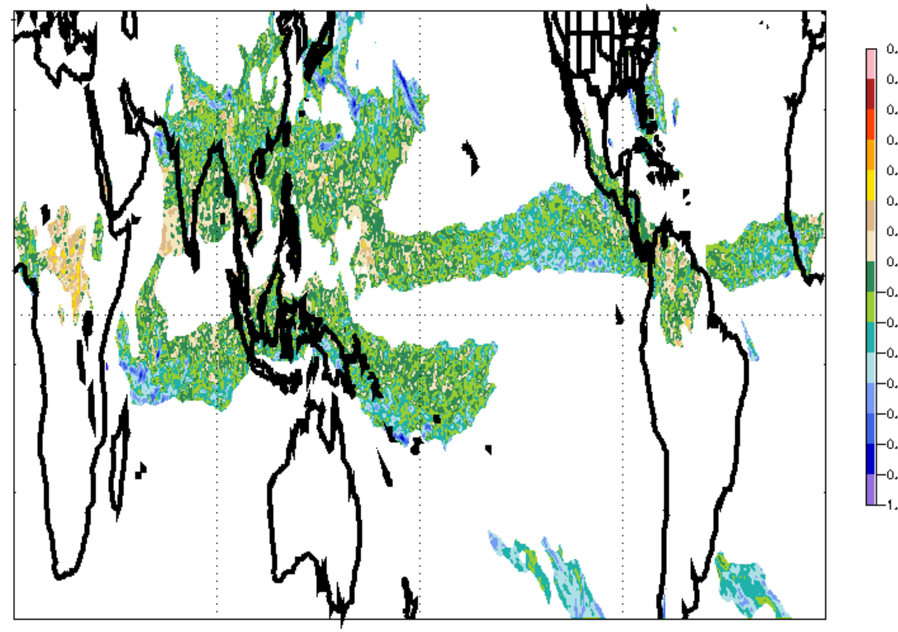
Raw 3-hrly 0.25 degree

Binned to daily 1 degree

Correlation of 90-day precipitation and ω_{850} time-series

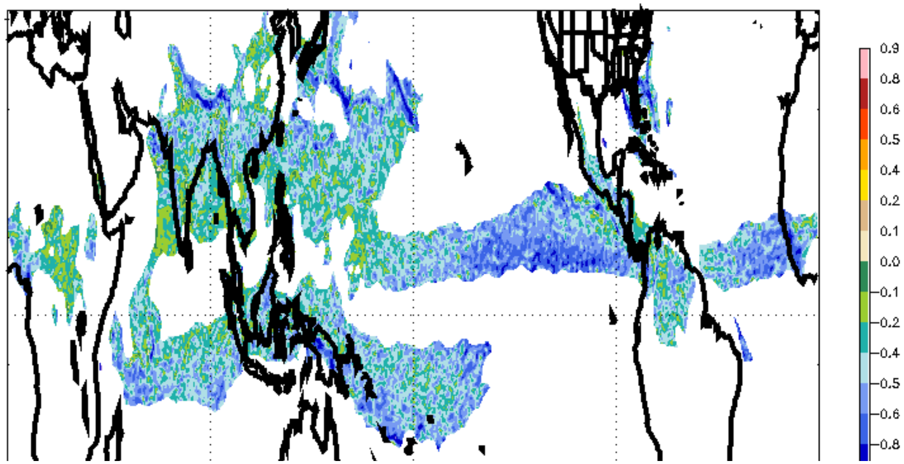




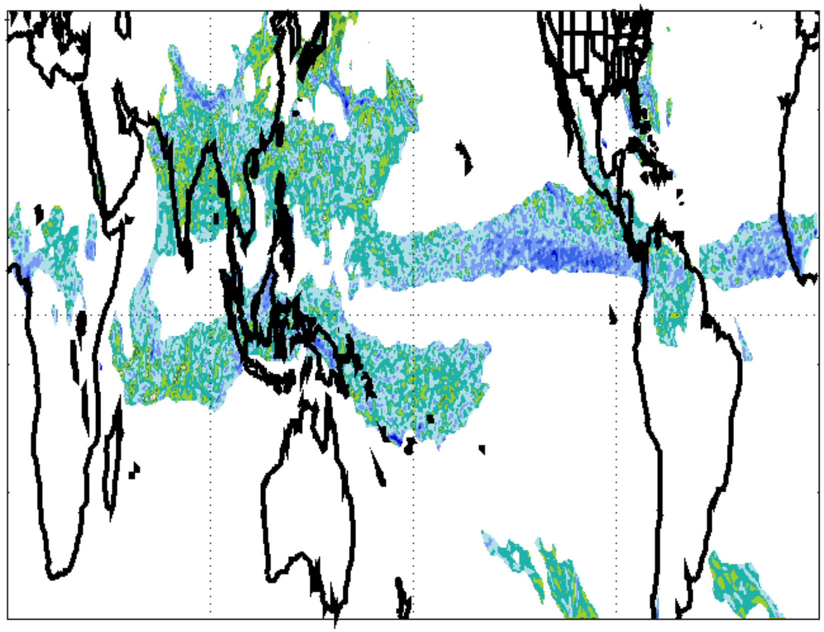


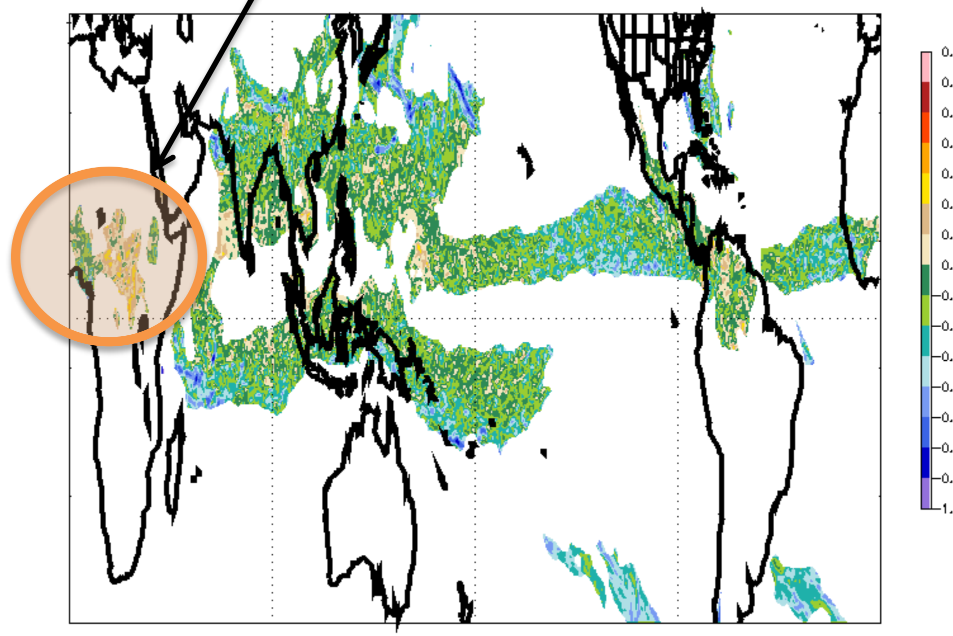
Precipitation lags ω_{850} by 3hours

Precipitation leads ω_{850} by 3hours



Precipitation induced downdrafts?





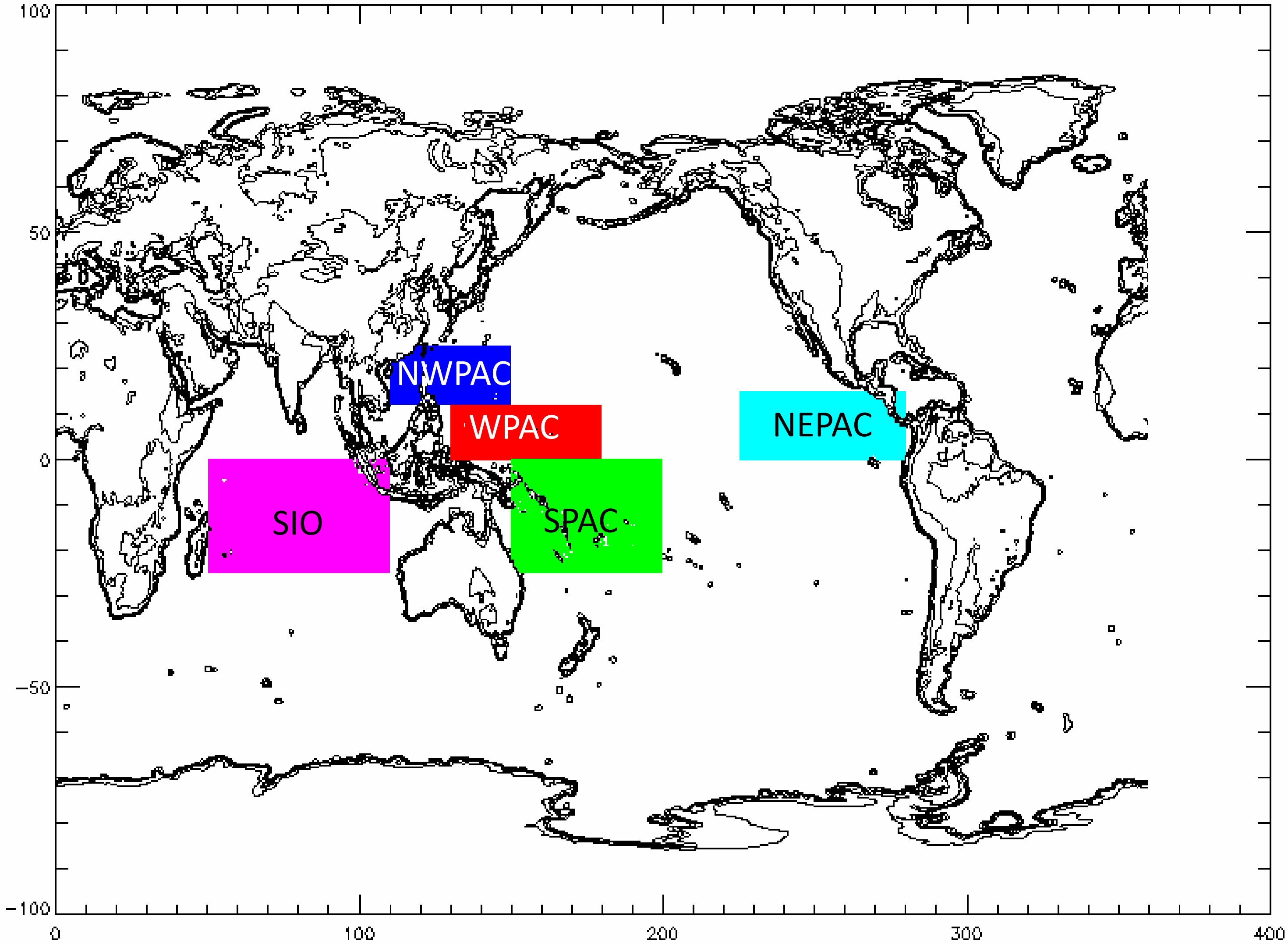
Precipitation lags ω_{850} by 3hours

Precipitation leads ω_{850} by 3hours

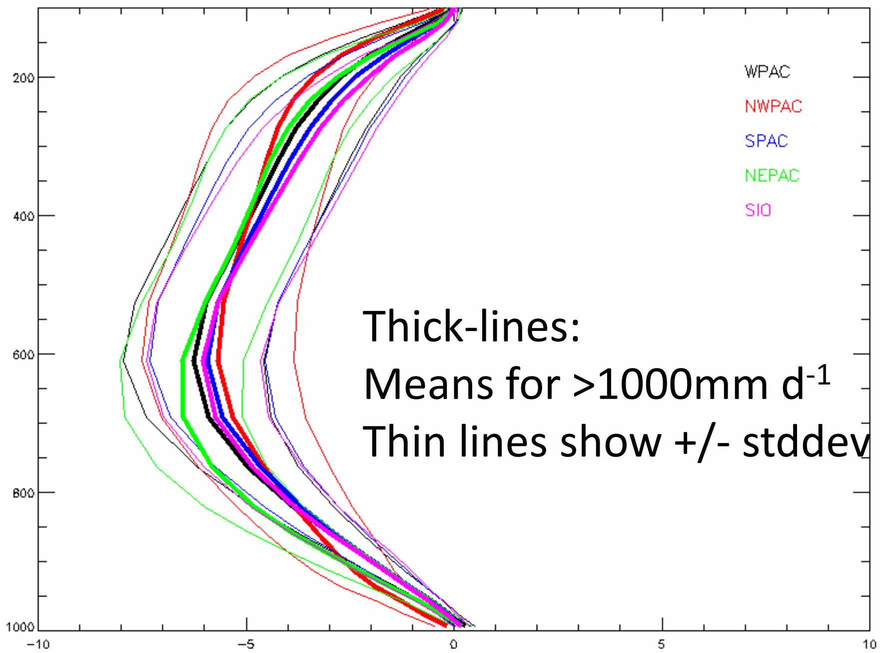
Composites conditioned on precipitation rates

e.g., *Sahany, Neelin and co-workers*

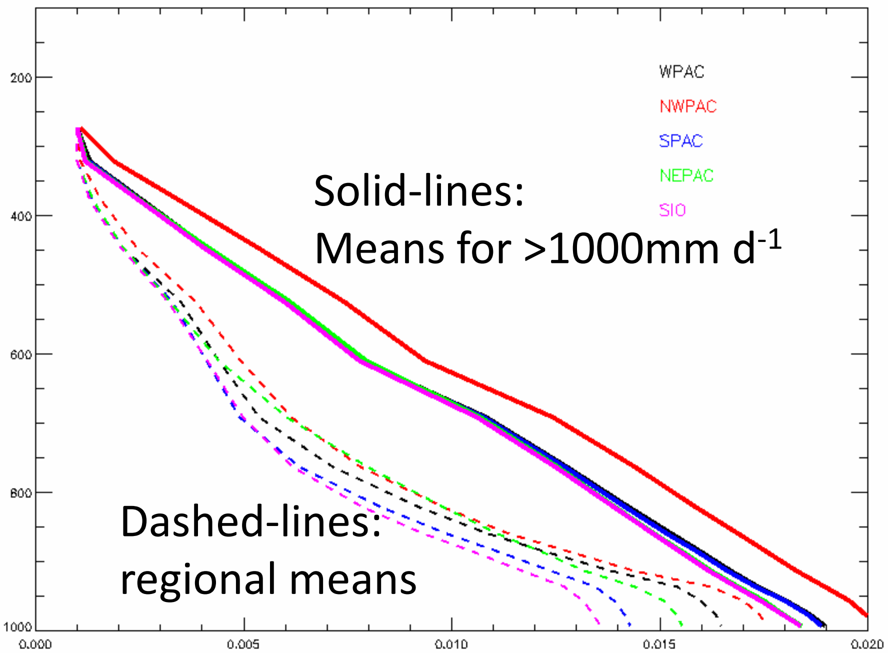
Domains for composite analysis



ω profiles



water vapor profiles



Conclusions and Future developments

Trade-off between topographic smoothing and regional improvements in precipitation in CAM-SE. With rough topo mean ω fields become noisy.

Exploring divergence damping for SE combined with rough topography. Looking for "sweet spot" yielding good precipitation and moderate ω noise

Precipitation intensity statistics in SE and FV are different. Counterintuitively, SE shows fewer events with >1000 mm d^{-1}

Exploring multivariate analyses techniques

Physics/dynamics coupling in SE on uniform grid, UINCON, CLUBB

Questions and Future Work

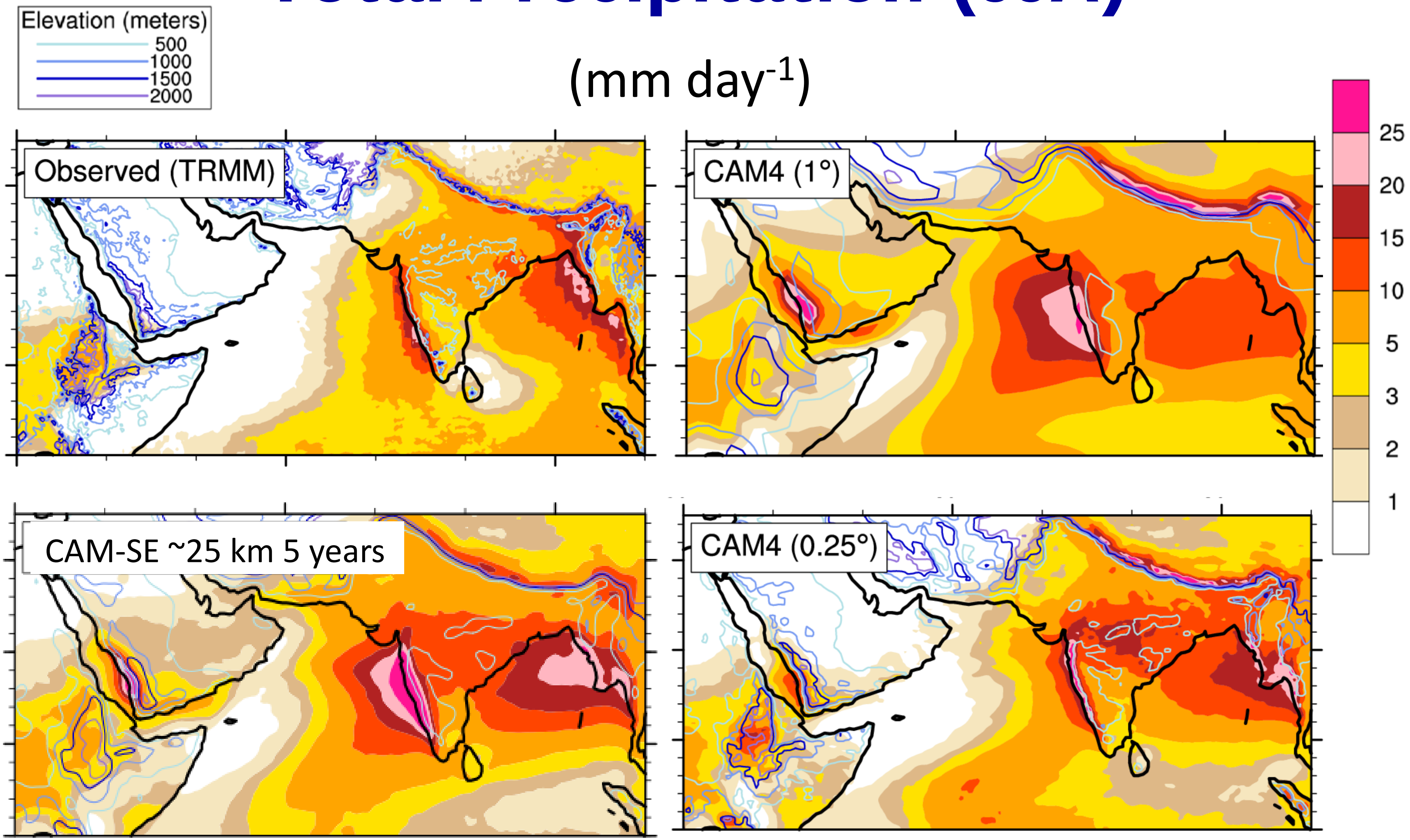
Time slices with CAM5

Is weak cyclogenesis with CAM4 physics vs CAM5 related to large-scale variables or to physics? *Calculate potential intensity diagnostics etc..*

Implement GFDL cyclone tracking codes

Total Precipitation (JJA)

(mm day^{-1})



Courtesy Rich Neale

Initial implementation of CAM-SE uses very smooth topography. Reduces improvement in precipitation patterns related to topography