

Nudging and moist physics quantities in CAM

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 NESL's Climate & Global Dynamics

CGD



SciDAC
Scientific Discovery through
Advanced Computing



AMWG Meeting, Boulder CO, 10 February 2014

Overview

- We should have been more skeptical that moist quantities looked so good in nudging runs.
 - Now we are
- Can we learn from our mistake(s)?
- Future work

“Physics-side” Nudging in CAM SE

YOTC re-analyses 5/2008-5/2010

Nudging terms,

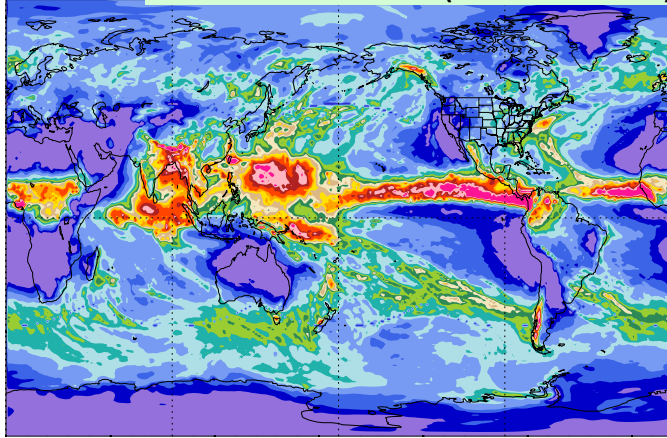
$$\dot{\chi}_{ndg}(t) = R(x, y, p, t) \left(\frac{\chi(t) - \chi_{ana}}{\tau_{ndg}} \right); \quad \chi = [u, v, q, T]; \quad \tau_{ndg} = 6 \text{ hrs (here)}$$

are added to RHS of model prognostic equations. The $\dot{\chi}_{ndg}$'s are calculated on the “physics side”.

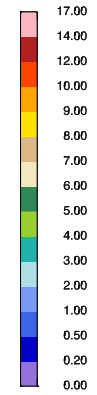
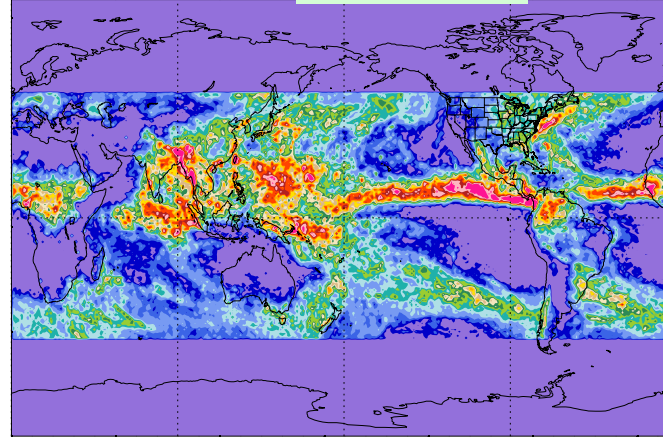
- Lots of machinery to restrict nudging in space
- independently specifiable time-scales τ_{ndg} for each variable.

Precipitation 2009/8 (nudged)

CAM5 simulated (2.97 mm d⁻¹)

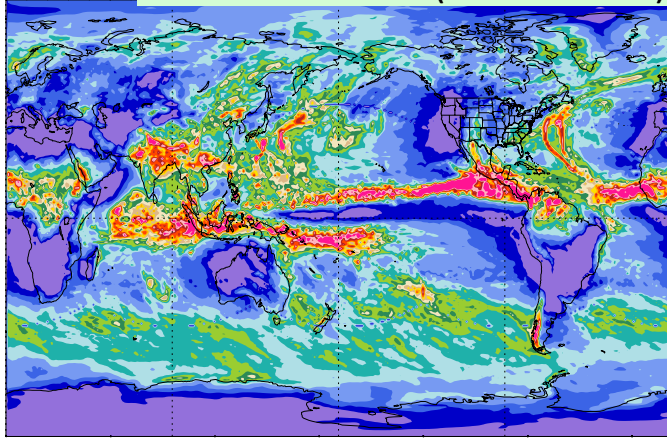


TRMM 3B42¹ Global Mean=2.87

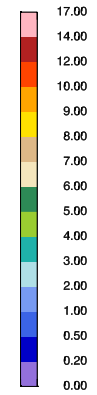
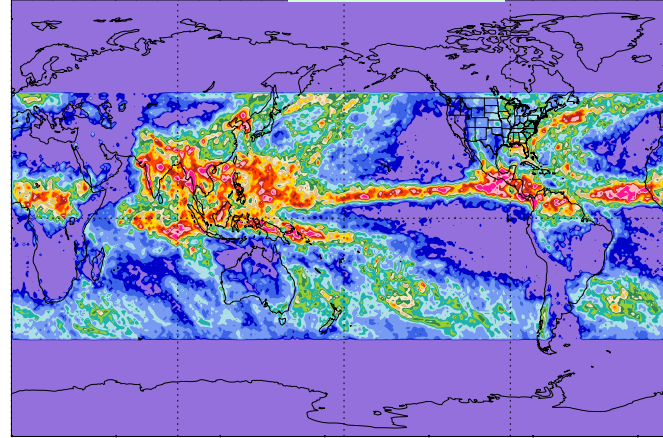


Precipitation 2010/8 (free running)

CAM5 simulated (3.18 mm d⁻¹)



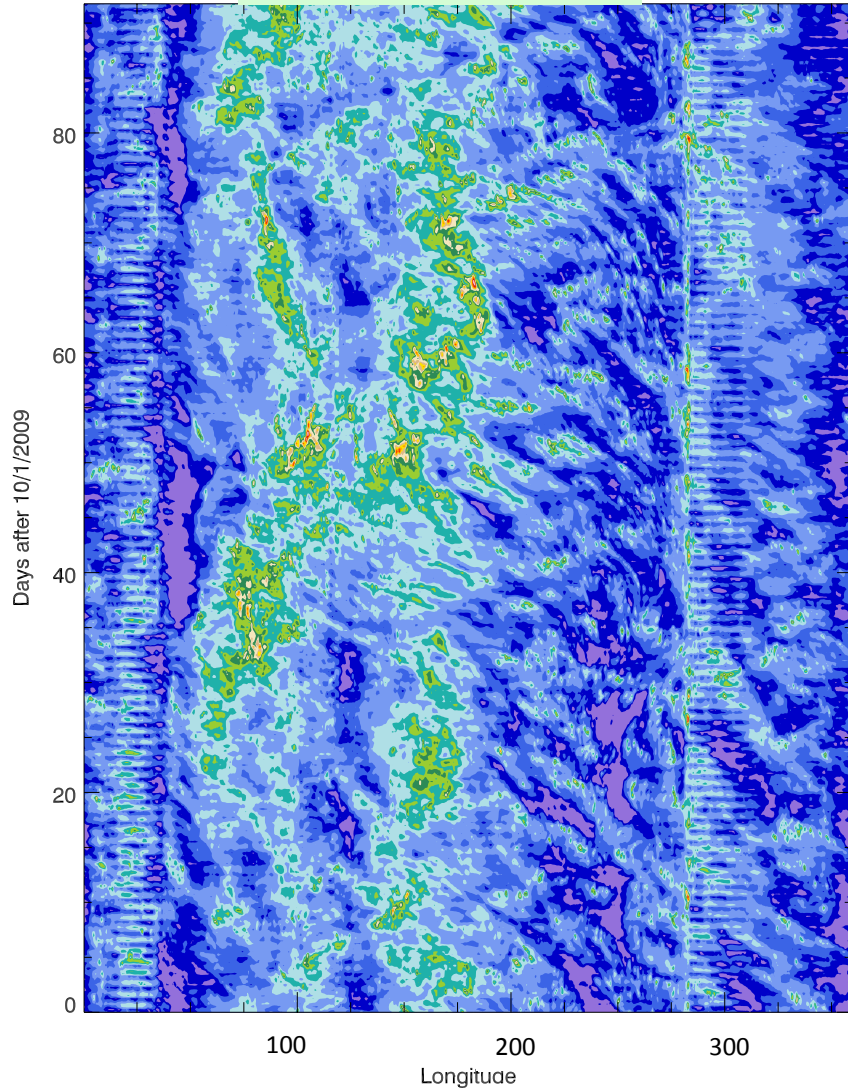
TRMM 3B42 Global Mean=2.99



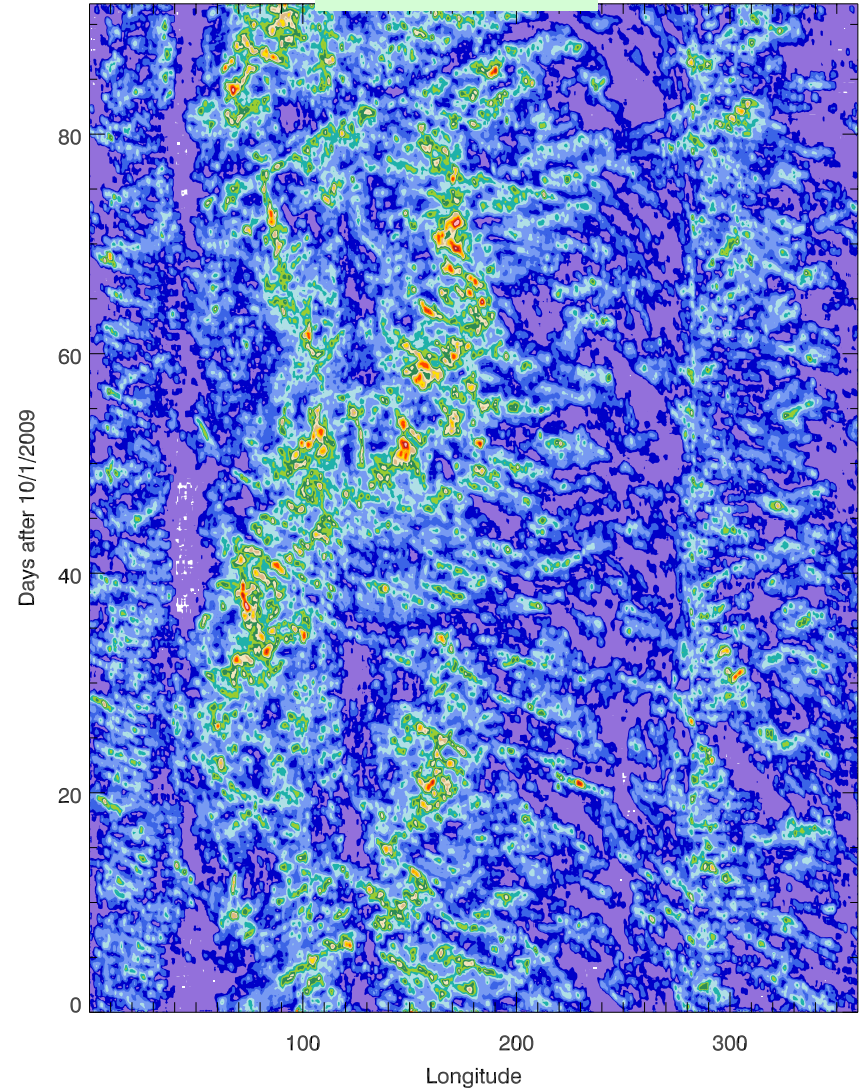
Precipitation Hovmueller diagrams Oct 1-Dec 31 2009

Averaged 10°S-10°N

Nudged CAM5 run



TRMM 3B42



“Physics-side” Nudging in CAM SE

YOTC re-analyses 5/2008-5/2010

Nudging terms,

$$\dot{\chi}_{ndg}(t) = R(x, y, p, t) \left(\frac{\chi(t) - \chi_{ana}}{\tau_{ndg}} \right); \quad \chi = [u, v, q, T]; \quad \tau_{ndg} = 6 \text{ hrs (here)}$$

are added to RHS of model prognostic equations. The $\dot{\chi}_{ndg}$'s are calculated on the “physics side”.

- Lots of machinery to restrict nudging in space
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“Physics-side” Nudging in CAM SE

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$$\dot{\chi}_{ndg}(t) = R(x, y, p, t) \left(\frac{\chi(t) - \chi_{ana}}{\tau_{ndg}} \right); \quad \chi = [u, v, q, \mathbf{X}]; \quad \tau_{ndg} = 6 \text{ hrs (here)}$$

are added to RHS of model prognostic equations. The $\dot{\chi}_{ndg}$'s are calculated on the “physics side”.

- Lots of machinery to restrict nudging in space
- independently specifiable time-scales τ_{ndg} for each variable.

Temperature nudging was inadvertently reduced by factor of c_p

Hmmm....

- Distribution and magnitude of precipitation is good
- Cloud forcings look fine
- Correlation of monthly-mean T with re-analysis is over 0.95 at most altitudes

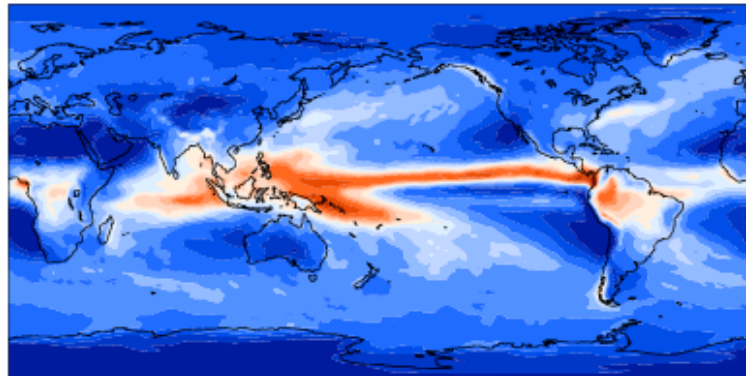
If we fix T -nudging things are going to get even better

Following results are with corrected nudging in CAM-SE at ne30 (~1 degree)

Nudge u, v, q ,
but **NOT** T

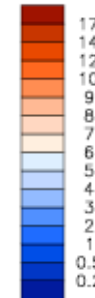
f.e13b6.FAMIPC5.ne30_ne30.NudgeV2_E004 (yrs 2009)

Precipitation rate mean= 2.85 mm/day



ANN

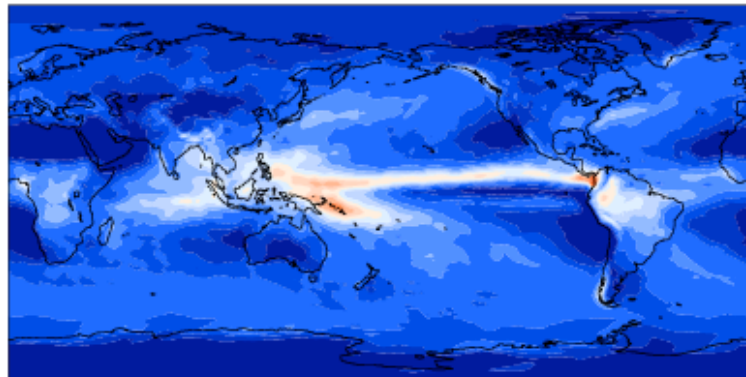
Min = 0.00 Max = 24.79



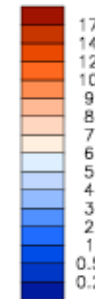
u, v, q , and
corrected T -
nudging

f.e13b6.FAMIPC5.ne30_ne30.NudgeV2_E001 (yrs 2009)

Precipitation rate mean= 1.57 mm/day

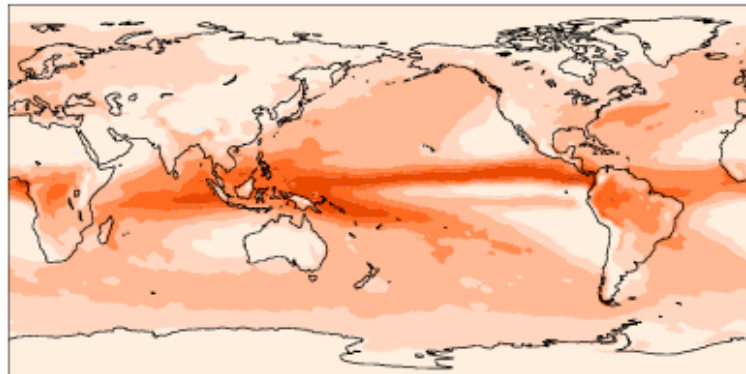


Min = 0.00 Max = 16.59

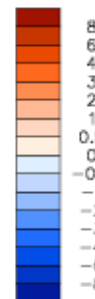


f.e13b6.FAMIPC5.ne30_ne30.NudgeV2_E004 - f.e13b6.FAMIPC5.ne30_ne30.NudgeV2_E001

mean = 1.28 rmse = 1.63 mm/day



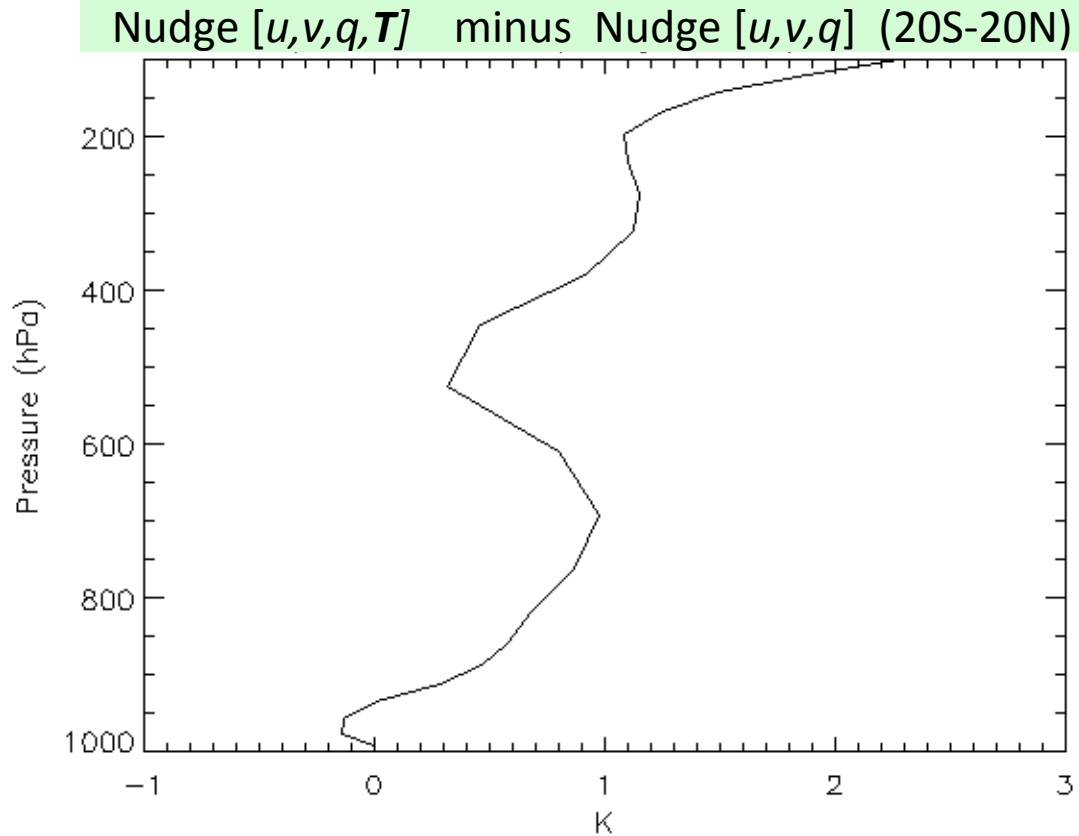
Min = -0.22 Max = 8.82



Moist physics quantities

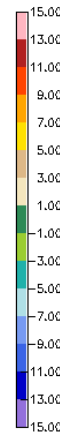
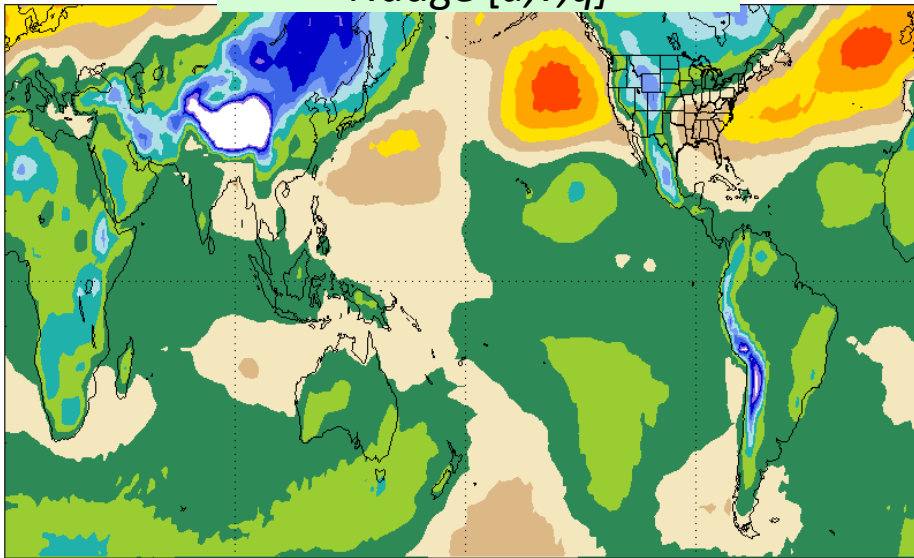
	<i>No nudging</i>	<i>Nudge[u,v,q]</i>	<i>Nudge[u,v,q,T]</i>
PREC (mm d ⁻¹)	3.07	2.85	1.57
LWCF (W m ⁻²)	21.4	21.7	11.6
SWCF (W m ⁻²)	-49.1	-44.8	-35.2
CLDLOW (%)	41.1	37.2	33.8
CLDHIGH (%)	35.9	43.3	25.0
LWP (g m ⁻²)	43.2	36.4	34.0
IWP (g m ⁻²)	16.5	17.9	8.8

Temperature bias profile (Aug 2009)

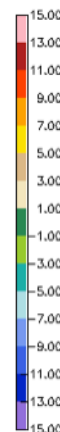
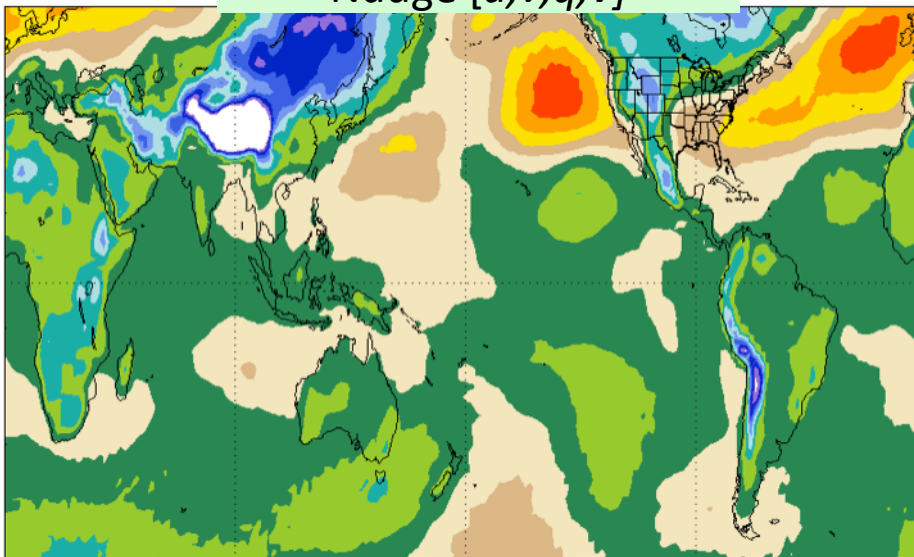


Temperature anomalies at 500 hPa (Dec 2008)

Nudge [u, v, q]



Nudge [u, v, q, T]



$r > 0.99$

Even without T-nudging
temperature fields are
well constrained

What is this saying about CAM(5) physics?

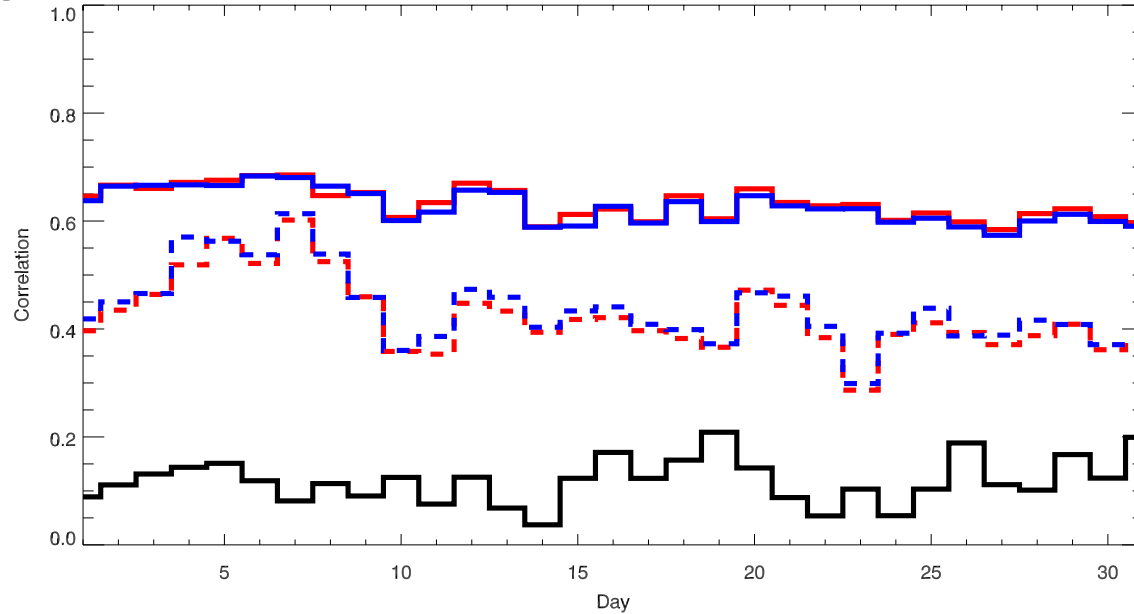
- Simply that ERA/YOTC physics like different T profile?
- ERA/YOTC analyses already “adjusted”?
- CAM physics are biased?

Should nudging give good global means of moist physics quantities?

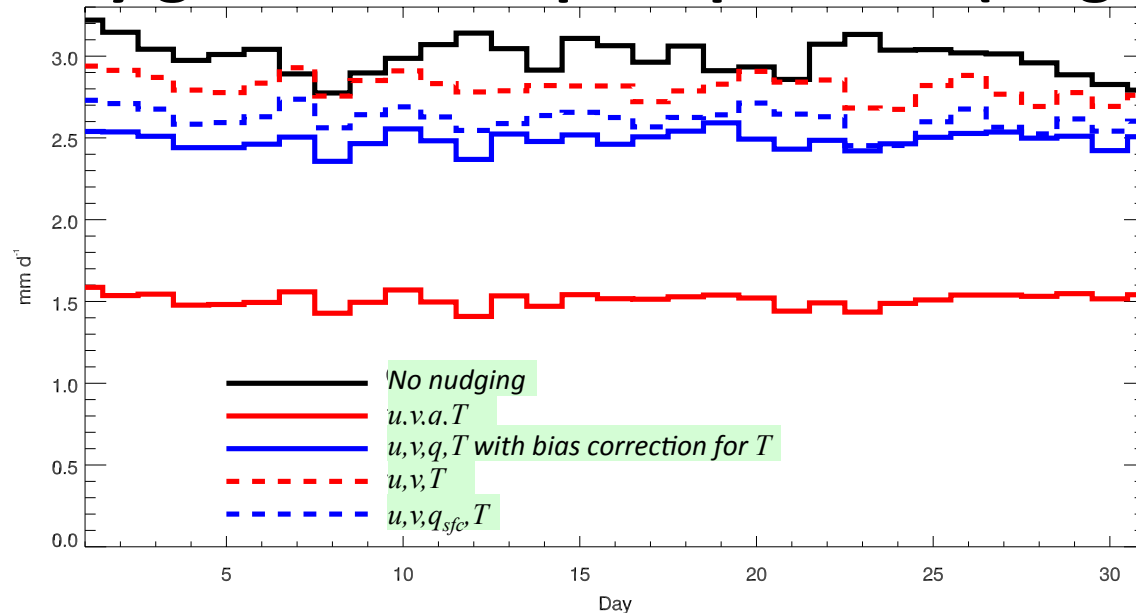
Nudging configurations that yield reasonable global means of precipitation, cloud-forcing ...

- Nudging u, v
- Nudging u, v, q
- Nudging u, v, T ($+q_{sfc}$ gives best agreement with GPCP)
- Nudging u, v, q, T (*with bias correction added to T -nudging*)

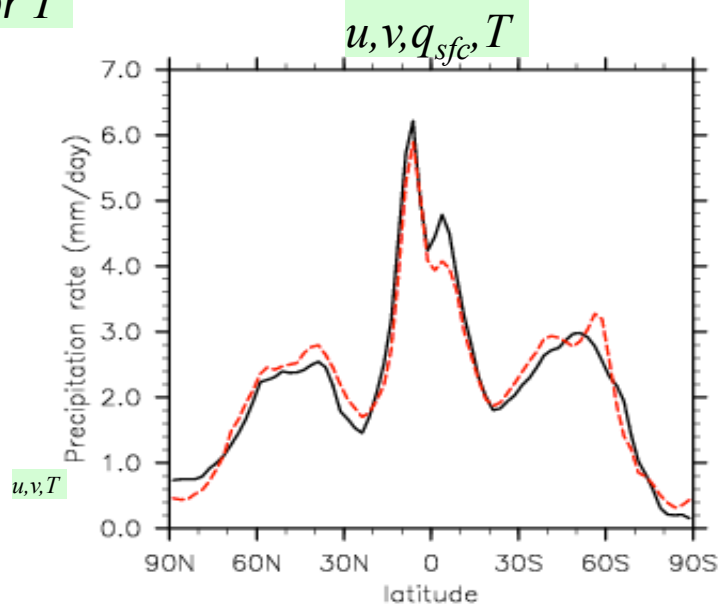
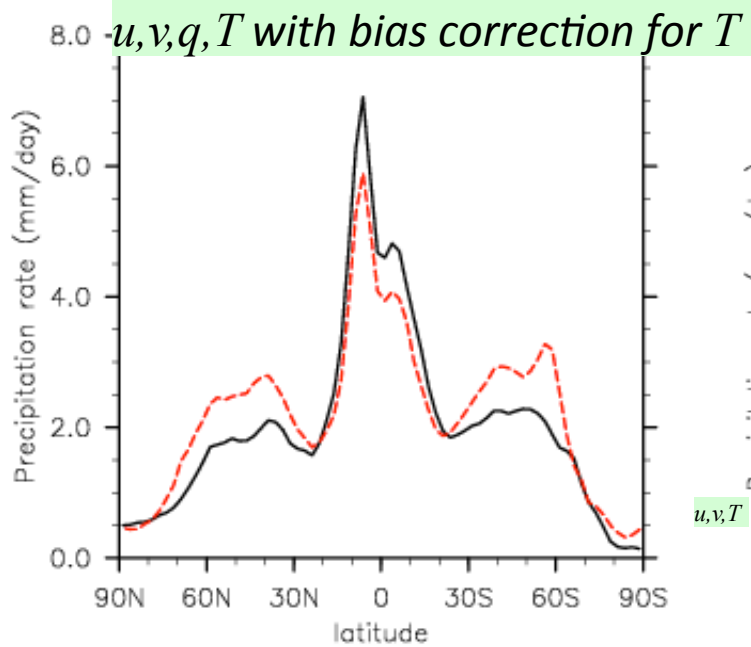
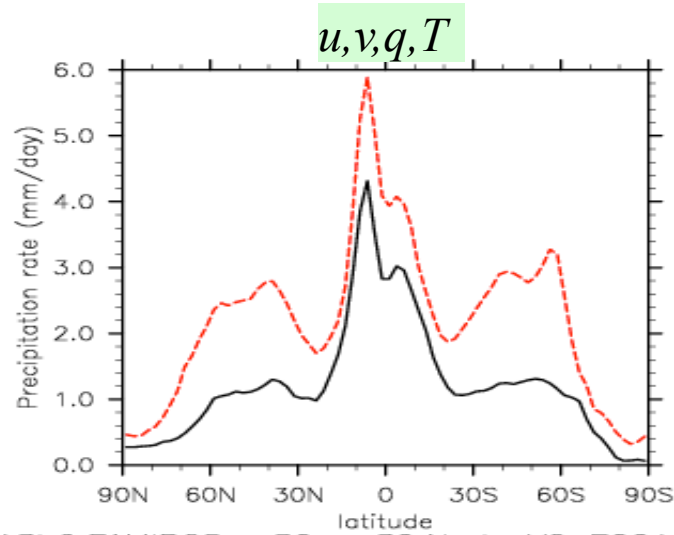
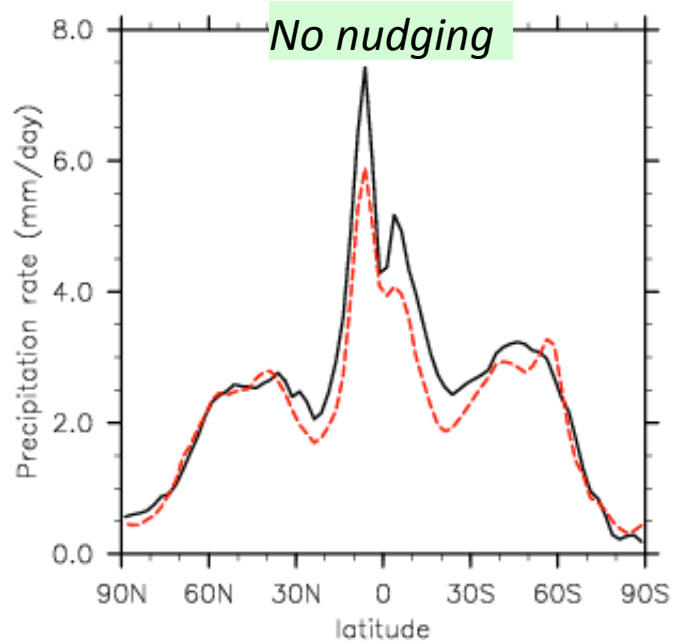
Daily correlation of CAM w/ TRMM (Aug 2009)



Daily global mean precipitation (Aug 2009)



Zonally-averaged annual mean precipitation



— CAM
- - - GPCP

Summary and Questions

- Several ways to obtain reasonable mean precipitation and other moist quantities in nudged runs
 - Can't nudge both q and T to straight ERA
 - Mean biases in T -profile are critical (haven't looked at q yet)
 - Pattern correlations are insensitive to mean
 - Temperature fields well constrained even without direct nudging
- Why do we want good precipitation in nudged runs?
 - Should convection schemes fire when presented with "observed" state?
- Will different re-analyses yield different results?
 - What about own reanalysis (DART)?

Future Work

- (Re-)run coupled and high-resolution nudged simulations
- Understand large-scale/convection partitioning
- Coordinate with “dynamics-side” nudging development in ACD/CGD (Lauritzen, Lamarque, Witt).
 - Implement divergence-free momentum nudging

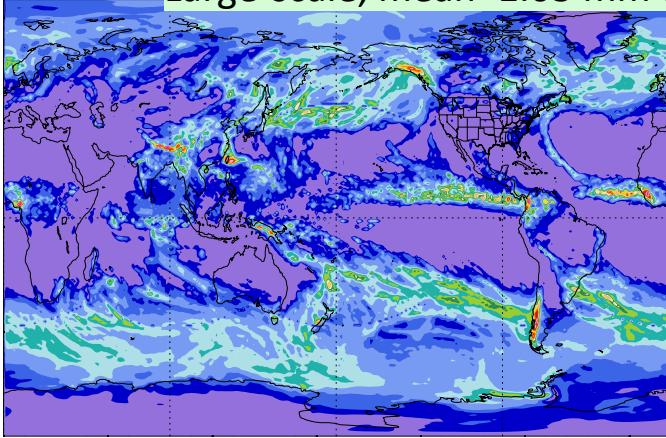


Thank You

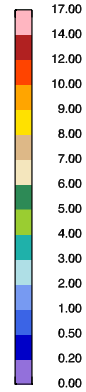
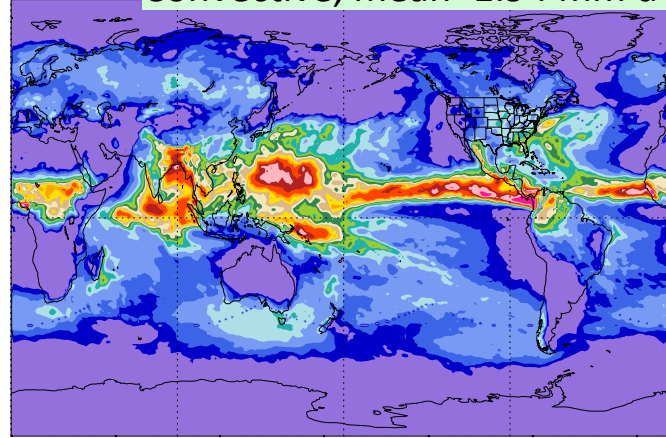
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Precipitation *types* 2009/8 (nudged)

Large-scale, mean=1.03 mm d⁻¹

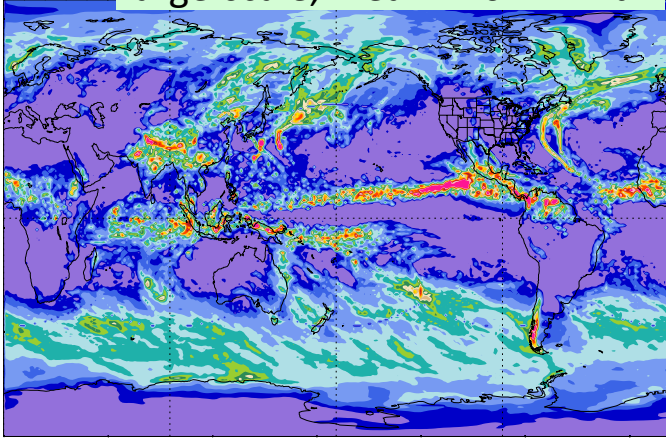


Convective, mean=1.94 mm d⁻¹

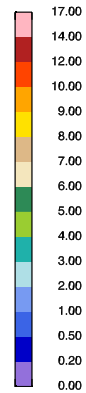
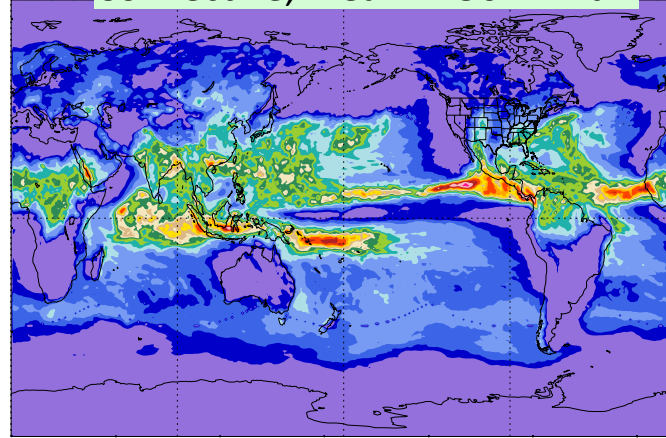


Precipitation *types* 2010/8 (free running)

Large-scale, mean=1.62 mm d⁻¹



Convective, mean=1.56 mm d⁻¹



Precip fractions in nudged run are more convective