



# Towards Climate Simulations at Regional Resolution: NCAR Cooperative Agreement Subproject

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Also in collaboration with Jerry Olson, Dave Williamson, Rich Neale, Julio  
Bacmeister, and the NRCM project team



One focus of the NCAR Cooperative Agreement is on climate simulations with sufficient horizontal resolution to simulate climate on regional scales.

We take a two-path approach to exploring this:

1. High resolution modeling in nested configurations
2. Globally uniform high resolution models



## High resolution nested configurations:

The NRCM project (Nested Regional Climate Model)  
WRF regional model forced with NCEP data in tropical channel domain

Tropical channel configuration in CAM nudged by NCEP  
Perfect model approach, tropical channel domain

NRCM Nested in CCSM, north America channel domain



## Method: Nudging CAM with NCEP data (devised by Dave Williamson and Jerry Olson)

We interpolate the 6-hourly sigma-level NCEP1 data to desired horizontal resolution using cubic interpolation for T, U, V, Ps and space-preserving cubic interpolation for Q

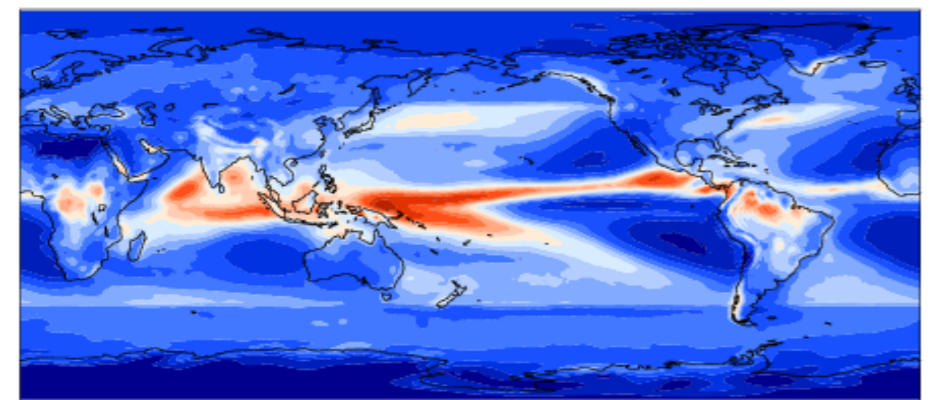
A relaxation time of 6-hours (tendencies) was assumed and model was nudged every time-step.

We use a linear taper near the boundary to smooth the transition between NCEP state and model state.

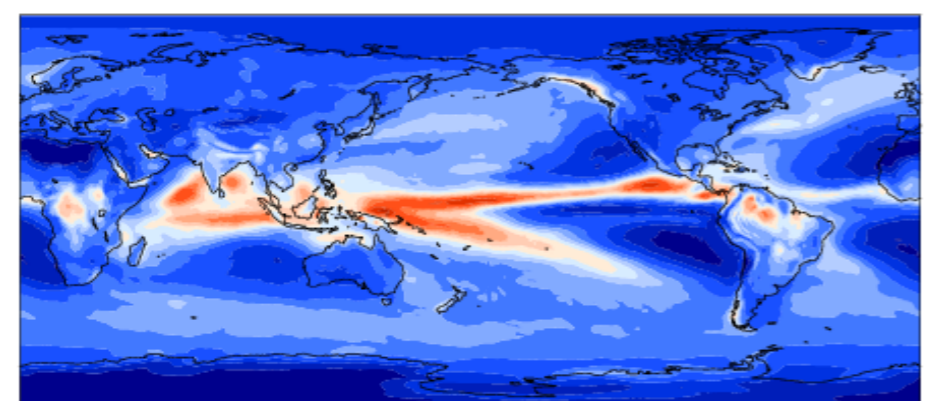
This closely matches the NRCM forcing framework.

# Impact of nudged CAM channel framework

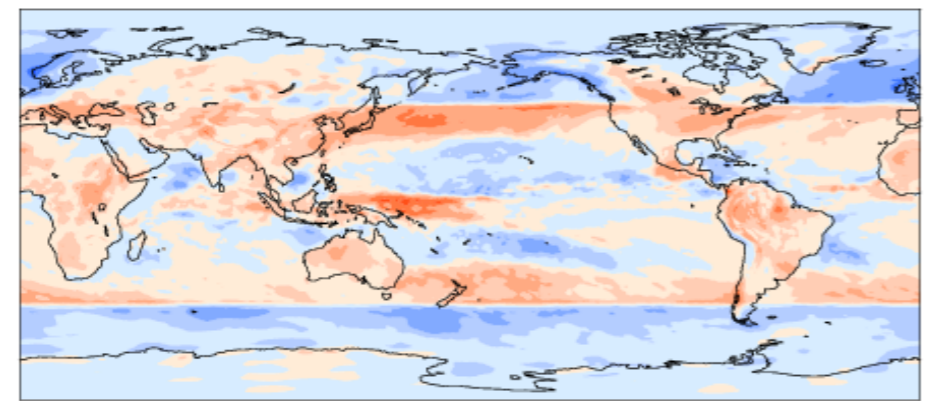
t170chan50S50N\_00\_06\_ens\_avg (yrs 2001-2005)  
Precipitation rate mean= 3.04 mm/day



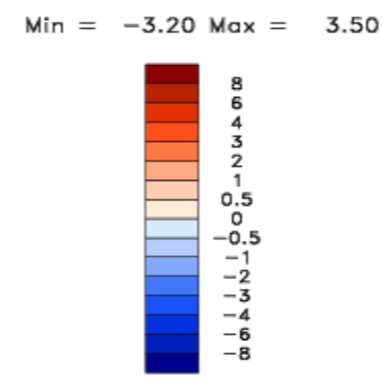
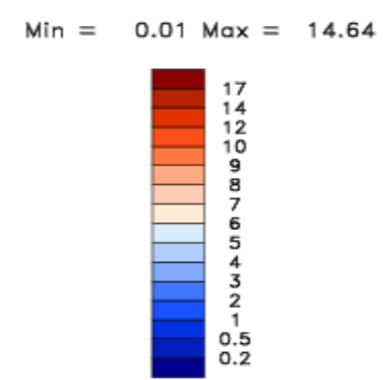
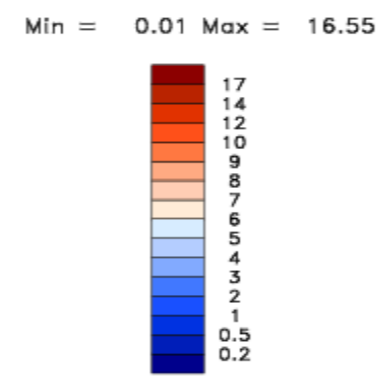
t170amipctrl\_01\_06 (yrs 2001-2005)  
Precipitation rate mean= 2.94 mm/day



t170chan50S50N\_00\_06\_ens\_avg - t170amipctrl\_01\_06  
mean = 0.10 rmse = 0.64 mm/day

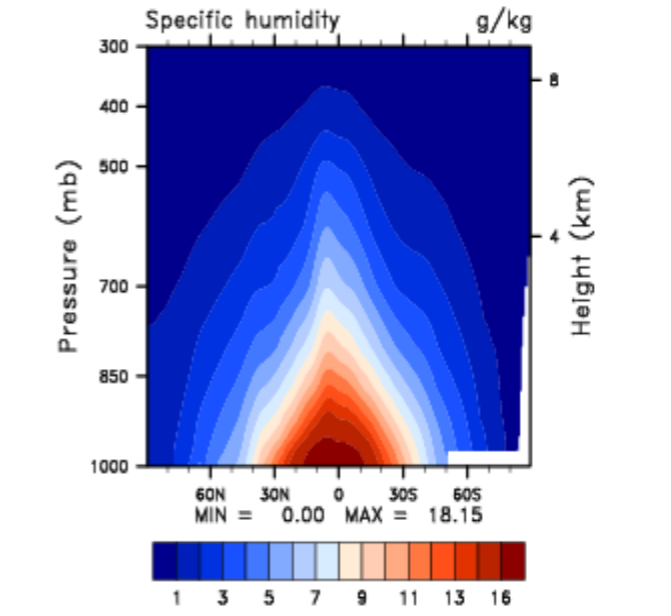


**ANN**

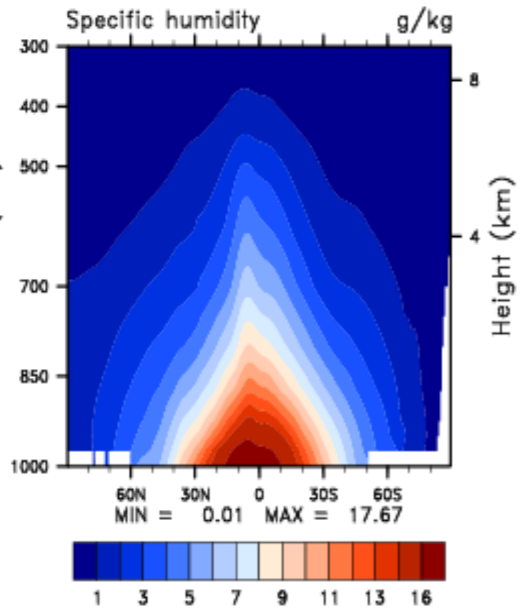


**ANN**

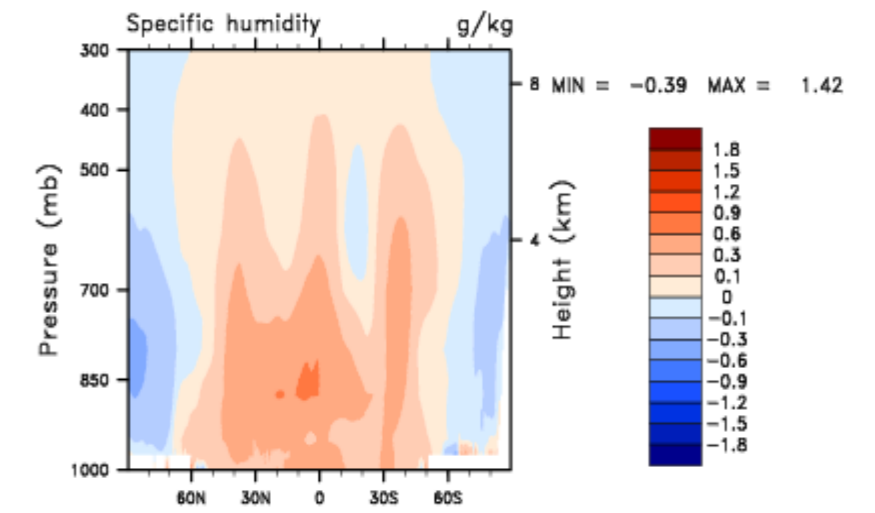
t170chan50S50N\_00\_06\_ens\_avg (yrs 2001-2005)



t170amipctrl\_01\_06 (yrs 2001-2005)

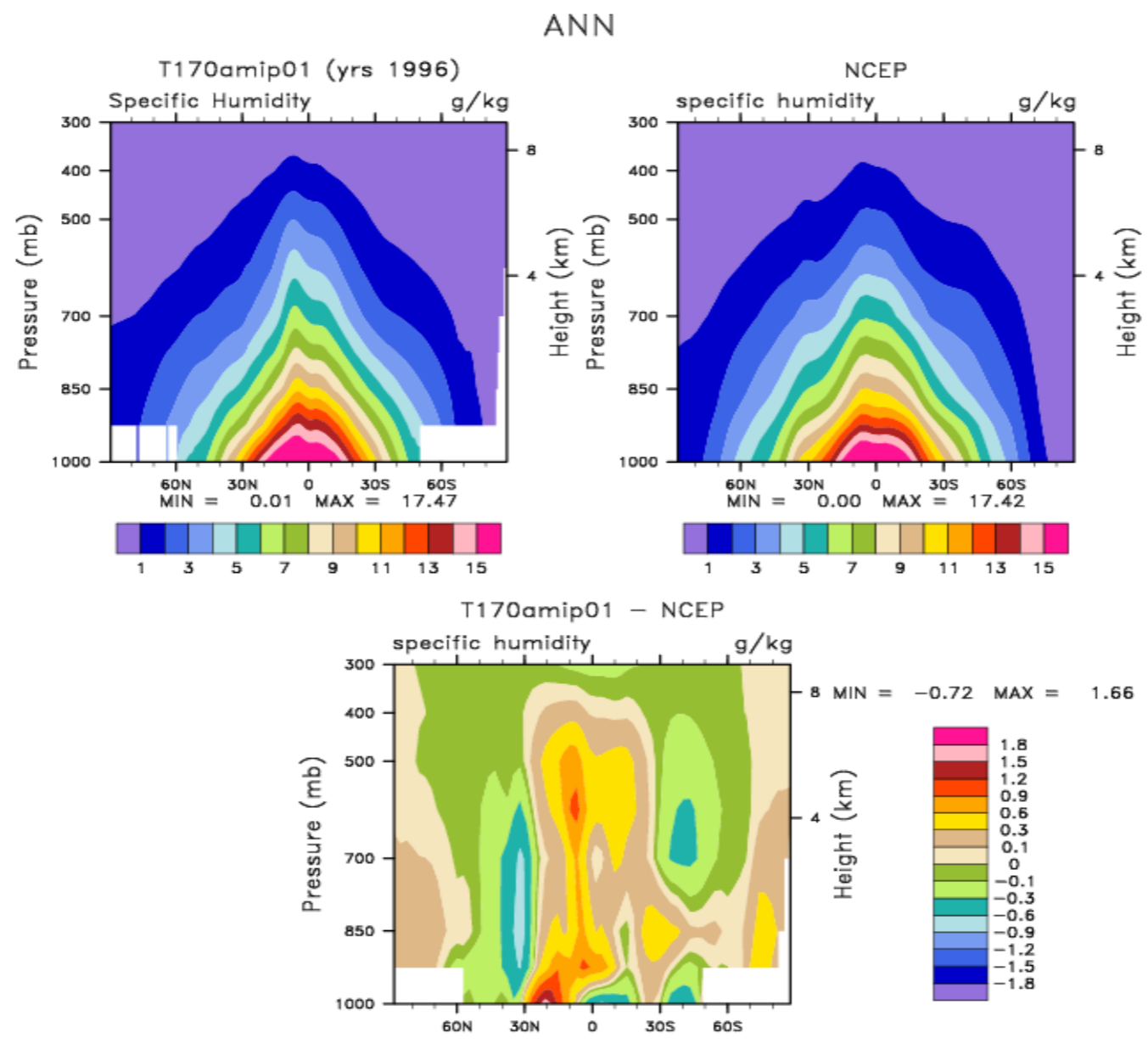


t170chan50S50N\_00\_06\_ens\_avg - t170amipctrl\_01\_06

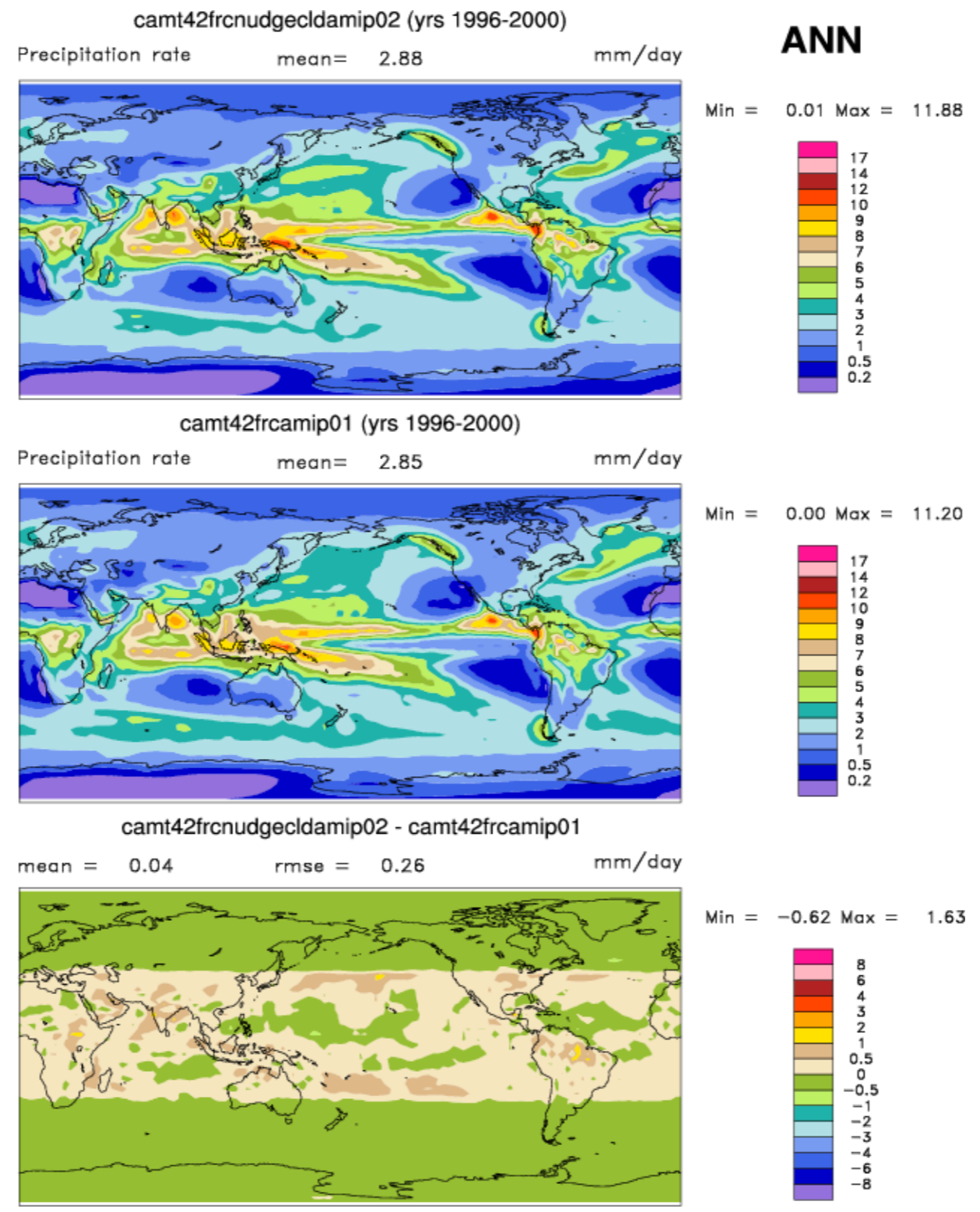




# State is more moist in NCEP than CAM near boundaries



# Perfect model test (CAM nudged by CAM)





## Summary of CAM tests:

Part of the moisture bias is due to the framework itself. Part is due to the forcing data.

Aside from biases in the forcing and small biases due to the framework, the perfect model and nudging tests imply that CAM behaves like CAM inside the channel.

So we expect that if biases are minimized (due to framework and forcing), the regional climate will be as well represented as the WRF model allows.



# NRCM nested in CCSM framework/forcing bias reduction

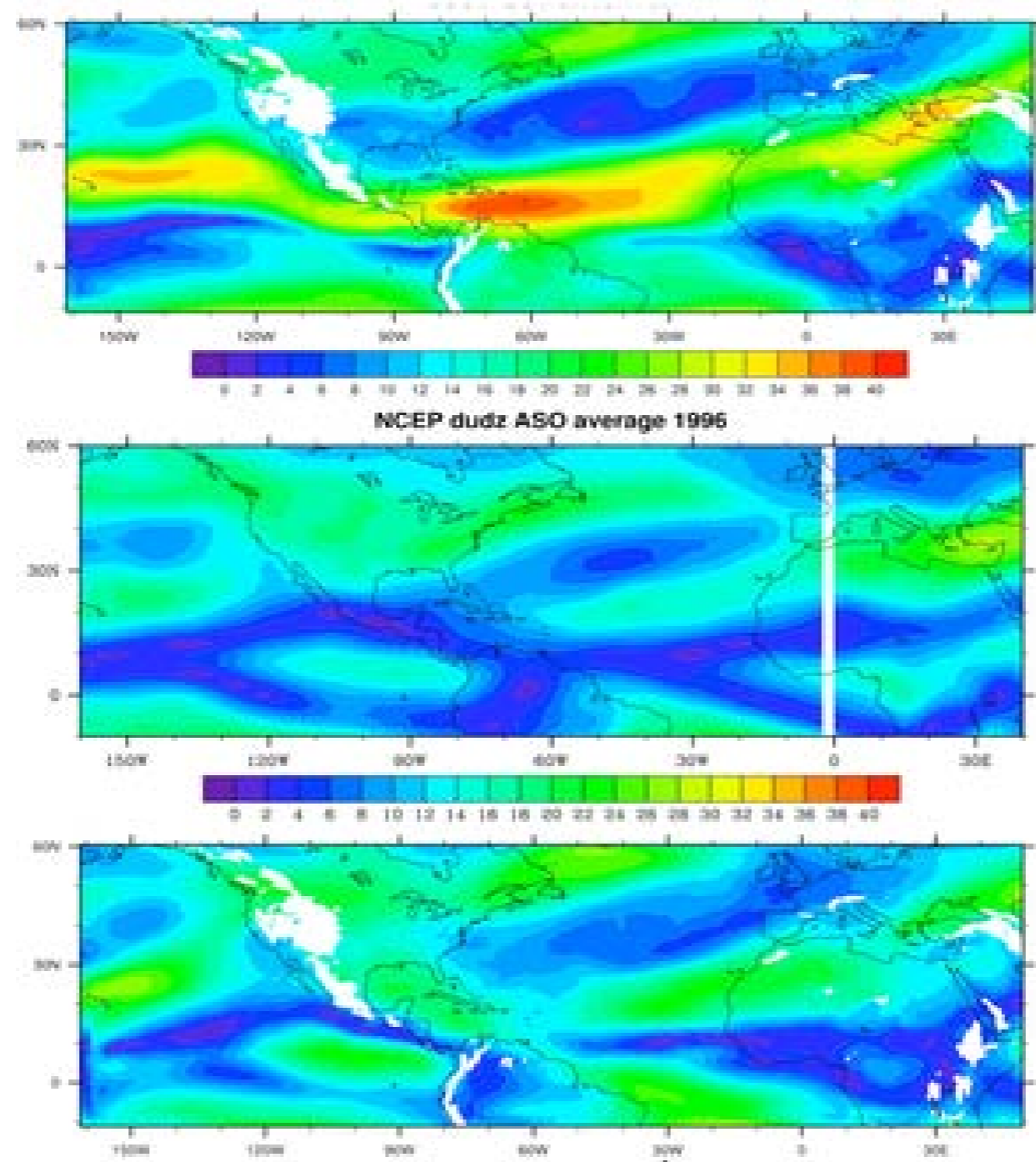


Fig. 2: Three-month average vertical shear ( $\text{ms}^{-1}$ ) for the period August-October 1996 for: (top) NRCM driven by raw CCSM output; (middle) NCEP-NCAR reanalysis data; and (bottom) NRCM driven by revised CCSM output.

From Holland et. al. 2011



# Globally Uniform High Resolution Modeling

T341 (Eulerian)

FV  $\frac{1}{4}$  degree (SL, Lin and Rood '96, '97)

CAM-SE NE120NP4 (HOMME, cubed sphere)

Plan to do runs to compare each of these directly (in collaboration also with Kate Evans, Mark Taylor, and Rich Neale)

We just completed time-slice runs with CAM4 FV  $\frac{1}{4}$  degree for present-day and 2080-2100.

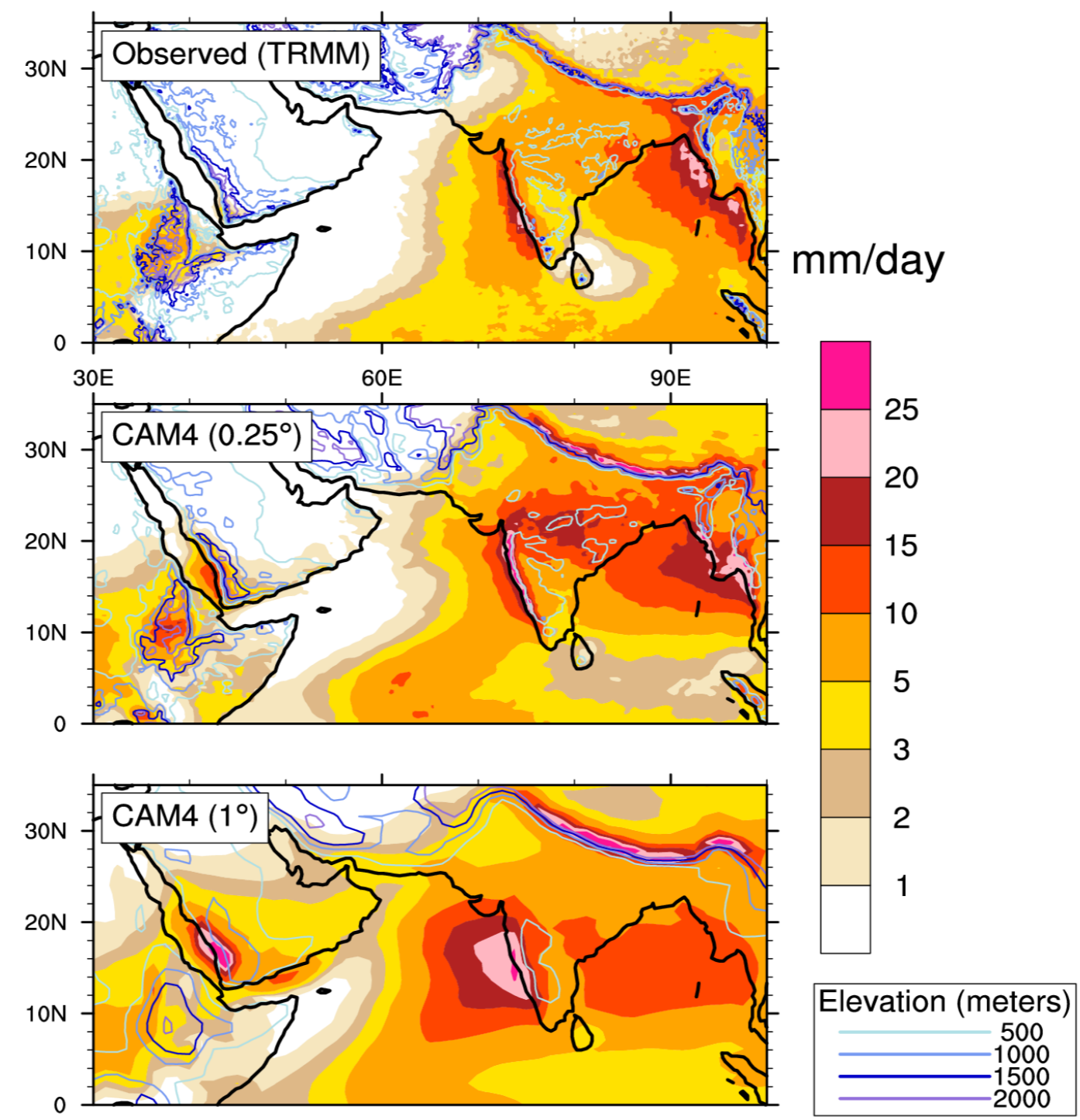


Generally, the higher resolution global simulations show

improvements in regional climate due to better resolved topography in areas with varied terrain, including coastal regions.

We can also improve global high resolution model's representation of regional climate phenomenon using the nudging configuration that we've developed, and what we learn from NRCM.

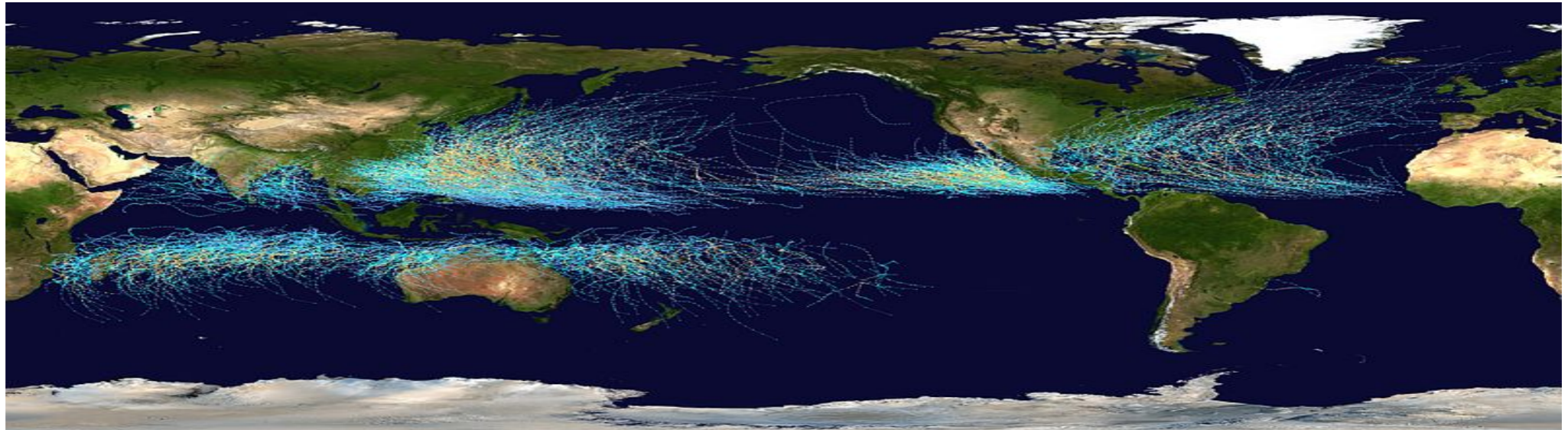
# JJA Precipitation in 0.25 degree CAM4



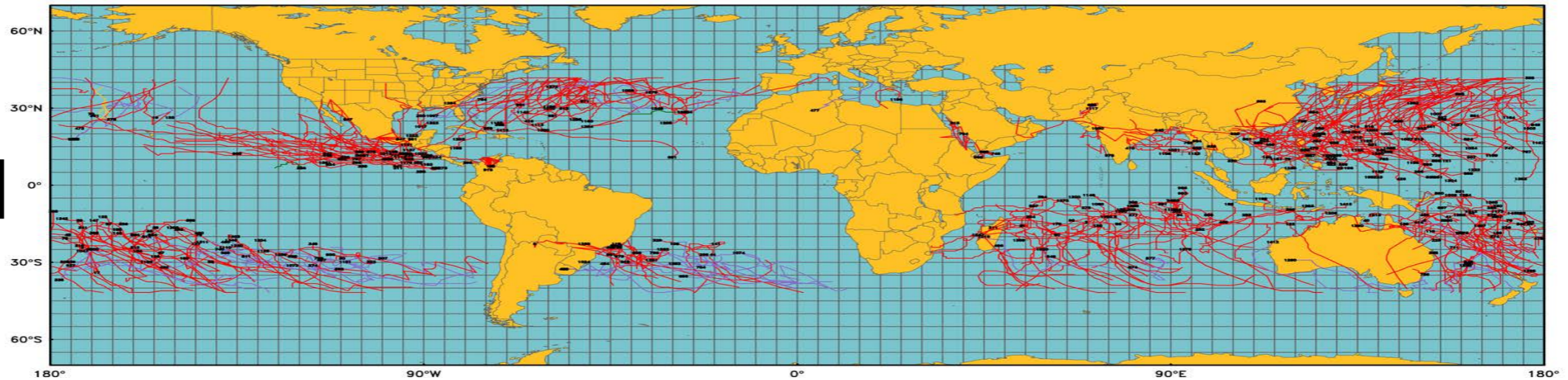
from Rich Neale

# Hurricanes in T341 Global Model

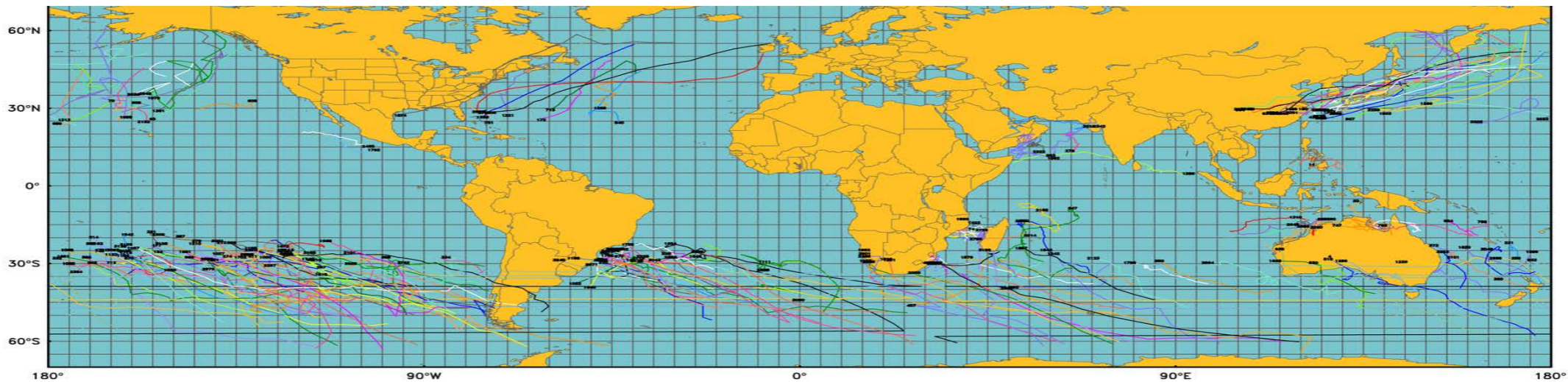
OBS



NRCM



T341  
CAM



(from John Truesdale)



## Future work:

Global high resolution runs and comparisons among different dynamical cores.

Further analyses of framework and forcing biases to improve nested models and global high resolution models for regional climate applications.

$\frac{1}{4}$  degree CAM time-slice experiments to assess regional climate changes between present-day and future scenarios.



# UCAR-DOE Cooperative Agreement

DOE/SC/BER Climate Change Prediction Program



The End.



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DOE/SC/BER Climate Change Prediction Program







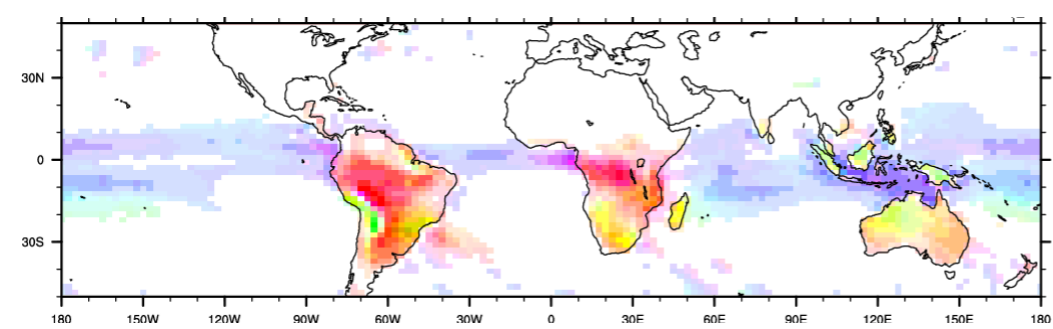
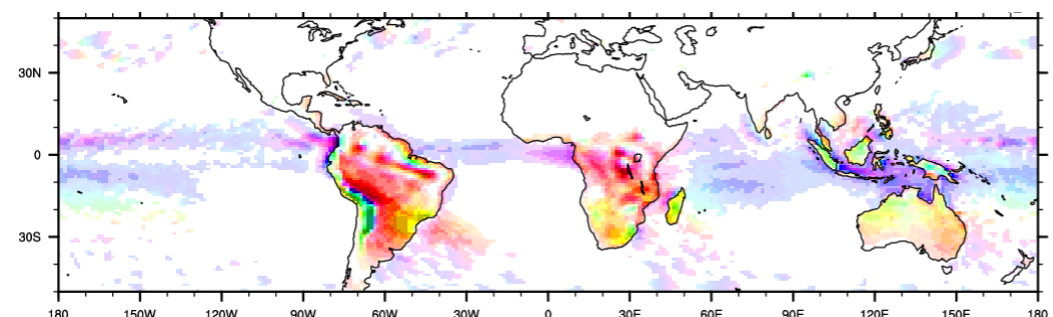
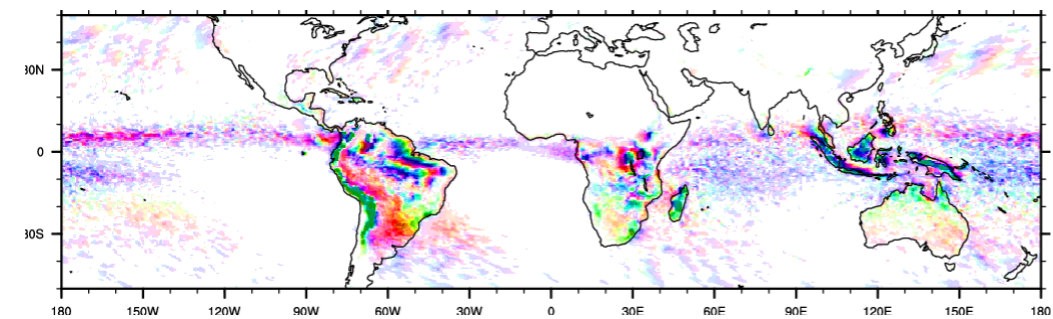
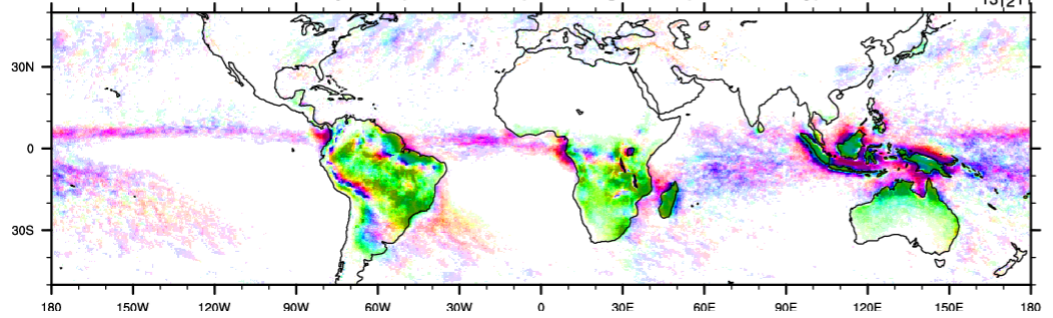
# UCAR-DOE Cooperative Agreement

DOE/SC/BER Climate Change Prediction Program



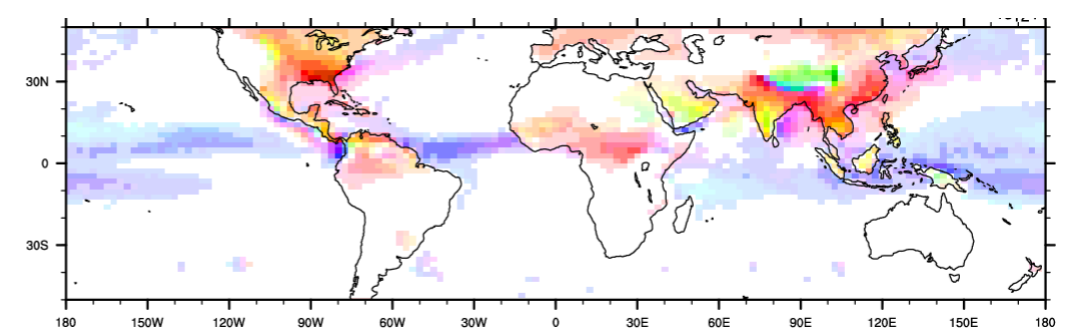
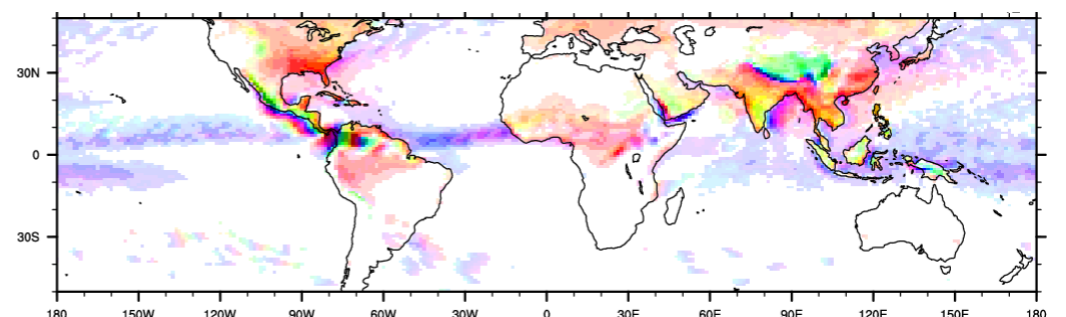
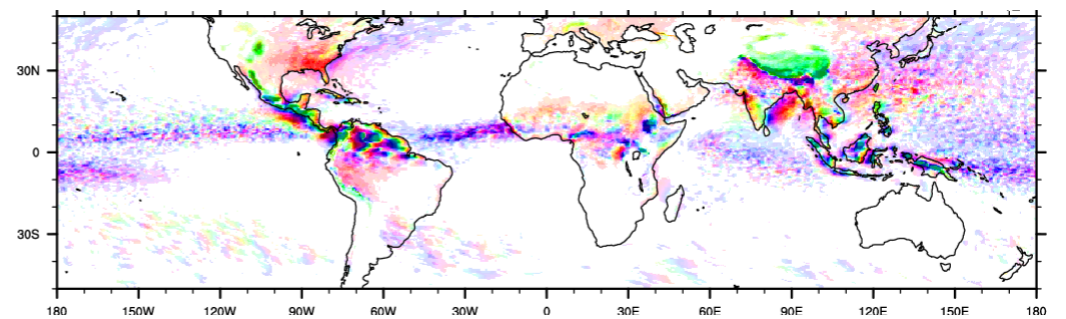
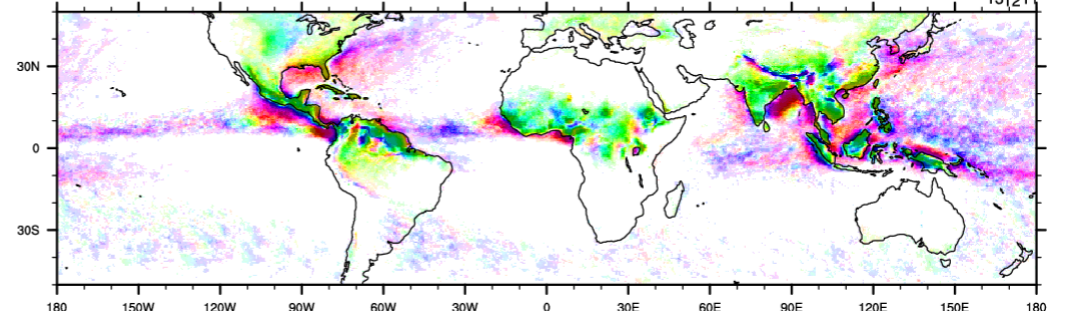
TRMM-3B42 - DJF (2000-2009)

Diurnal phase (color, hours) and magnitude (hue, mm/day)



TRMM-3B42 - JJA (2000-2009)

Diurnal phase (color, hours) and magnitude (hue, mm/day)



TRMM

0.25 deg

1 deg

2 deg

(from Rich Neale)



## T341 hurricane analyses

Not a good representation.

Now that the capability is in place; however, we can

Do the same type of correction to the wind stress bias as in NRCM for North American channel domain to see if that improves the hurricane simulation.