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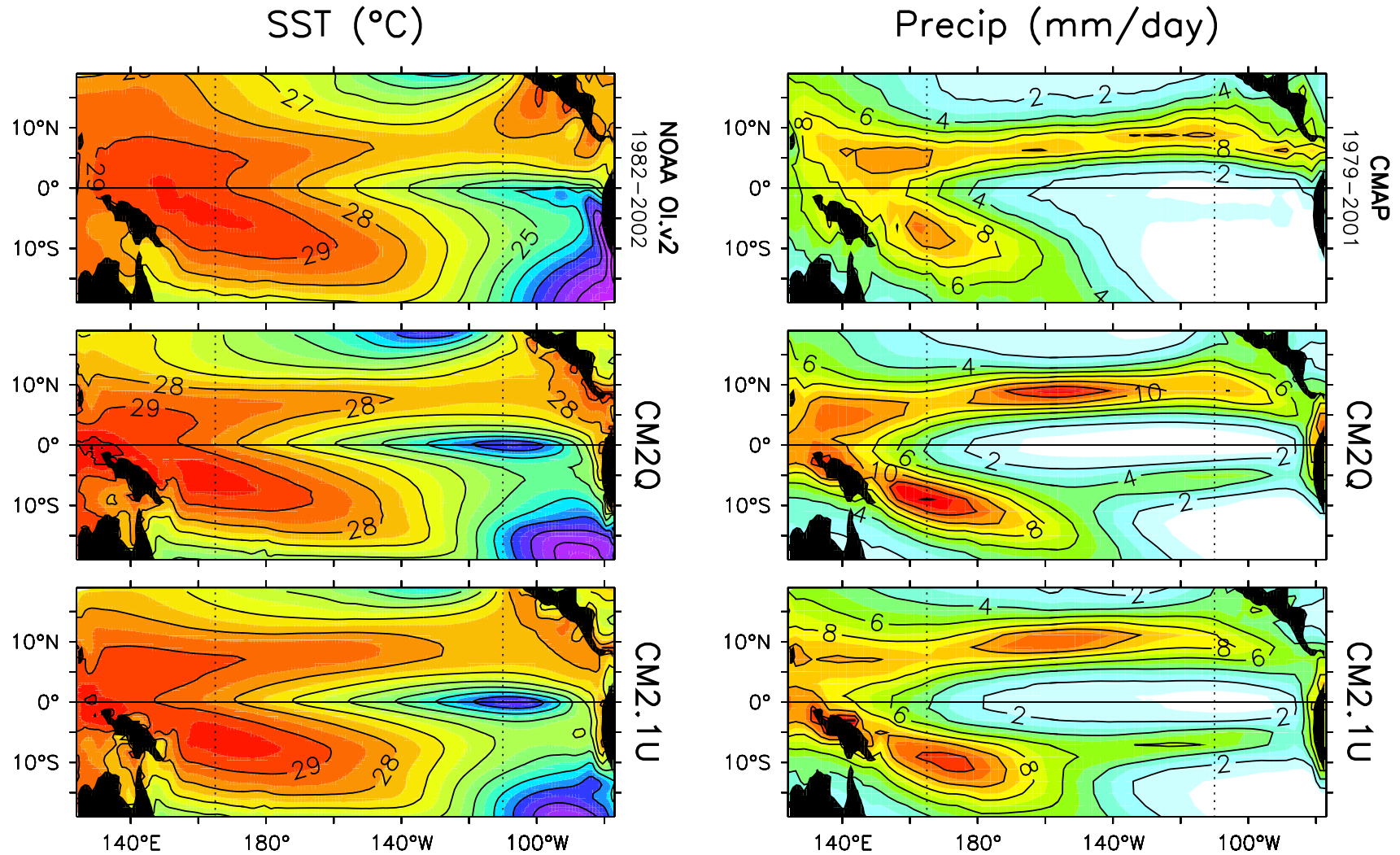
# **Tropical Pacific Climate & ENSO**

*in the GFDL CM2/2.1 control simulations*

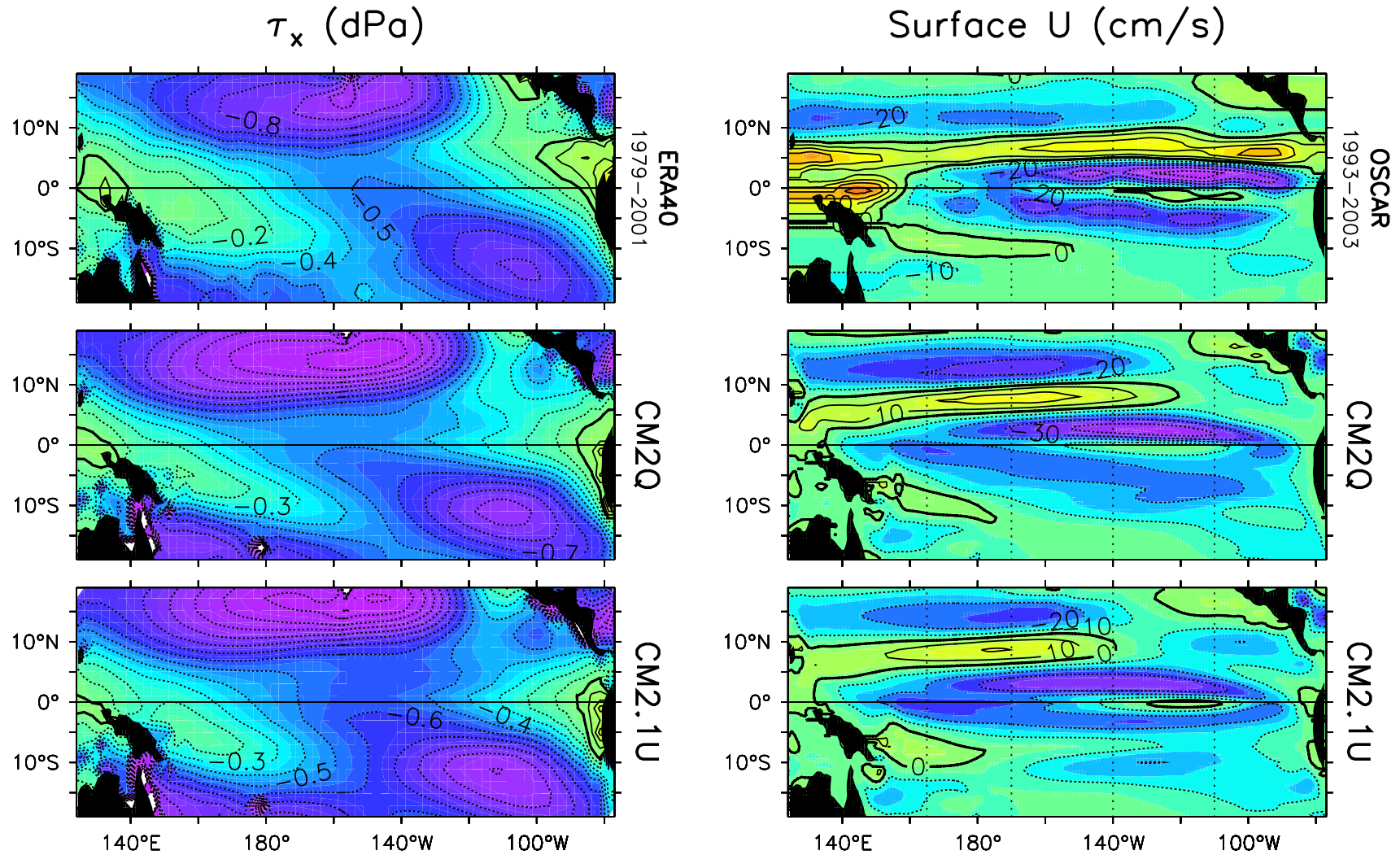
Andrew Wittenberg & Tony Rosati

GFDL/NOAA  
Princeton, NJ

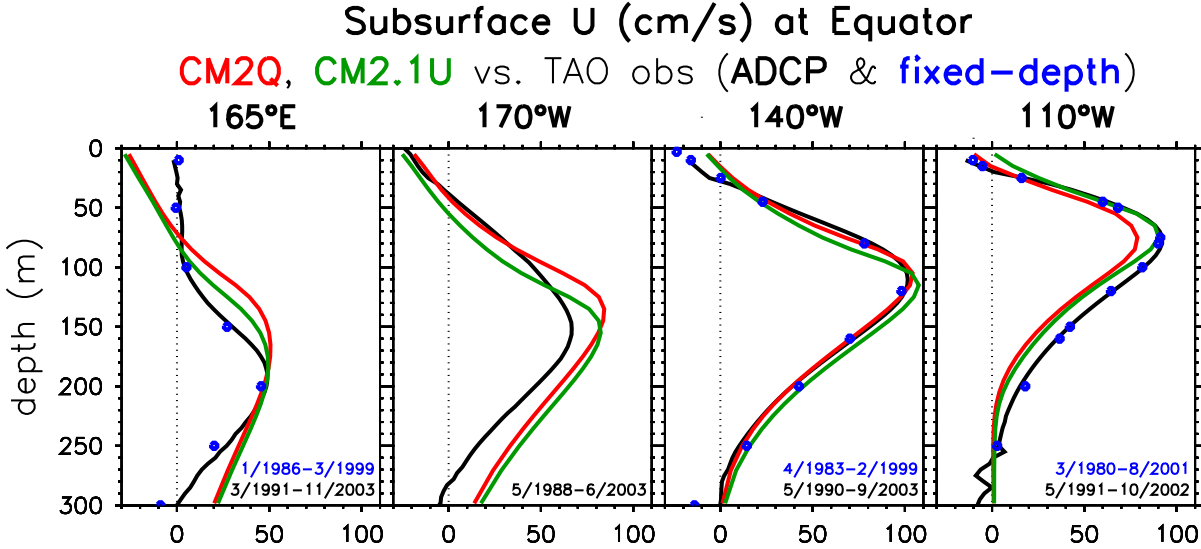
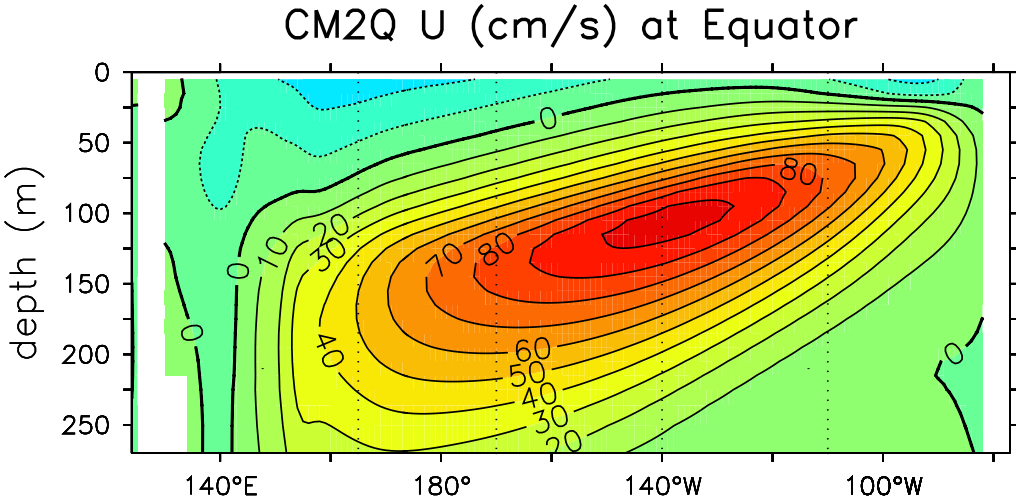
# Annual Mean: SST & Precip



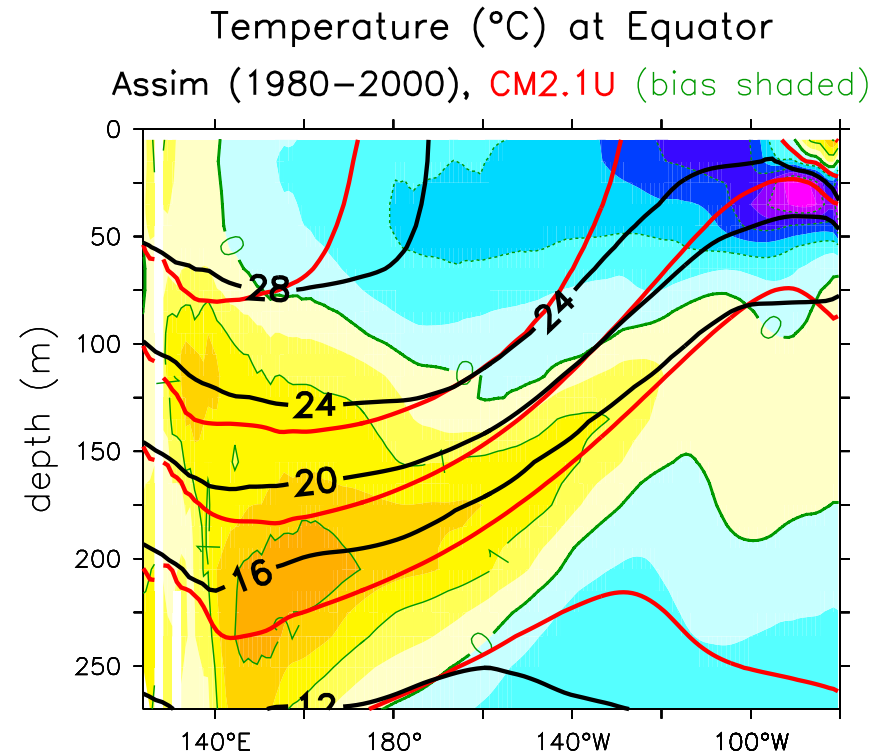
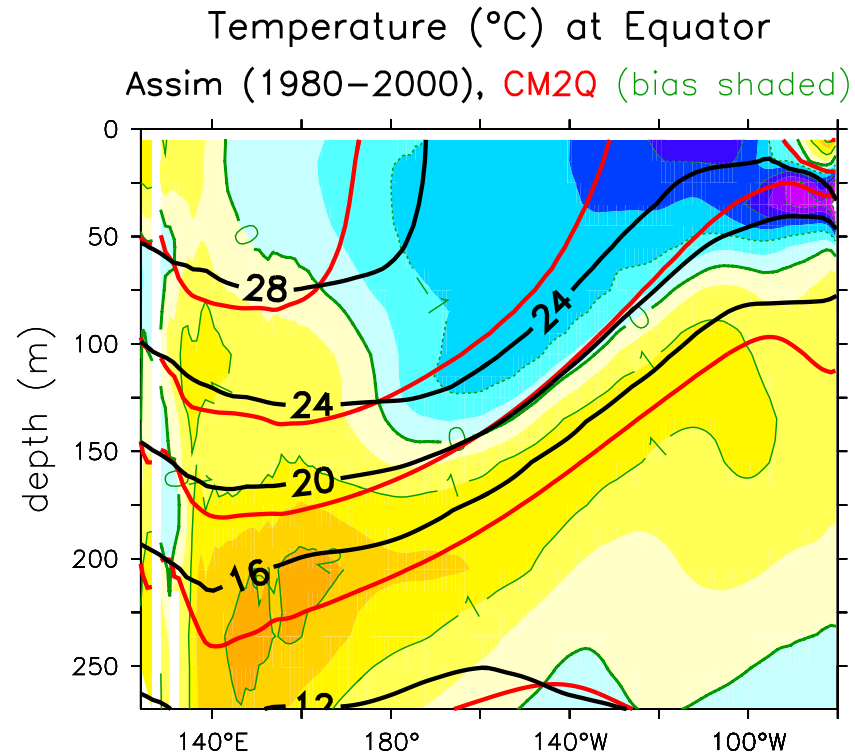
# Annual Mean: Zonal Stress & Surface Current



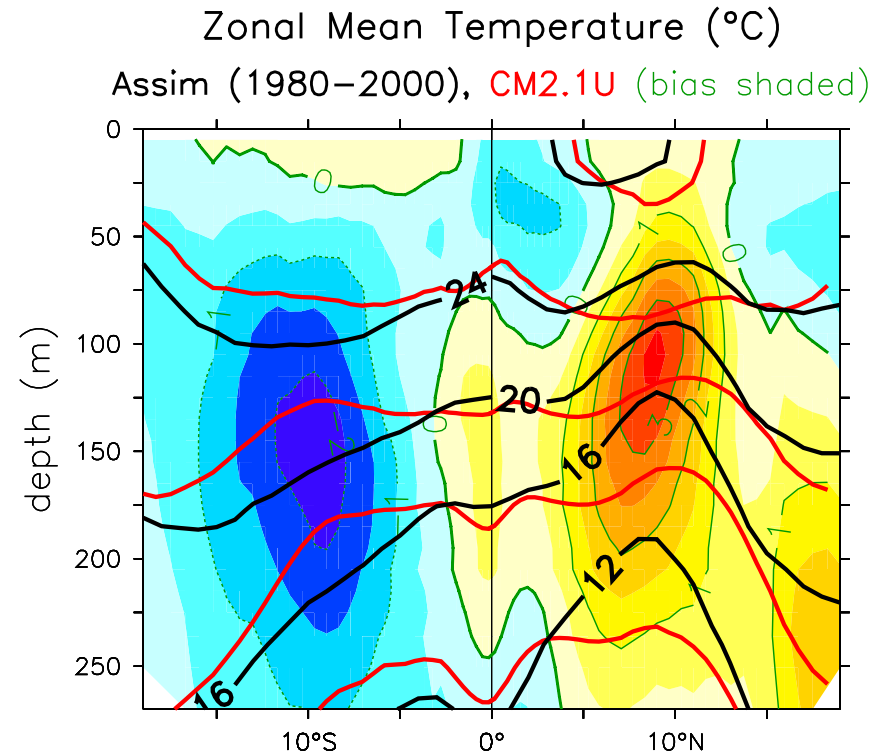
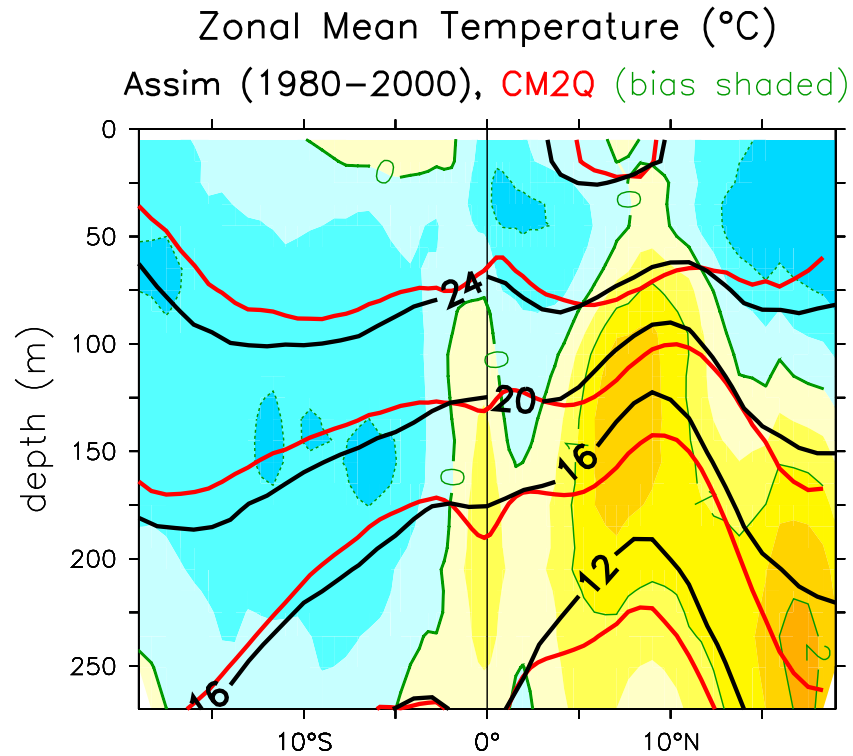
# Annual Mean: EUC



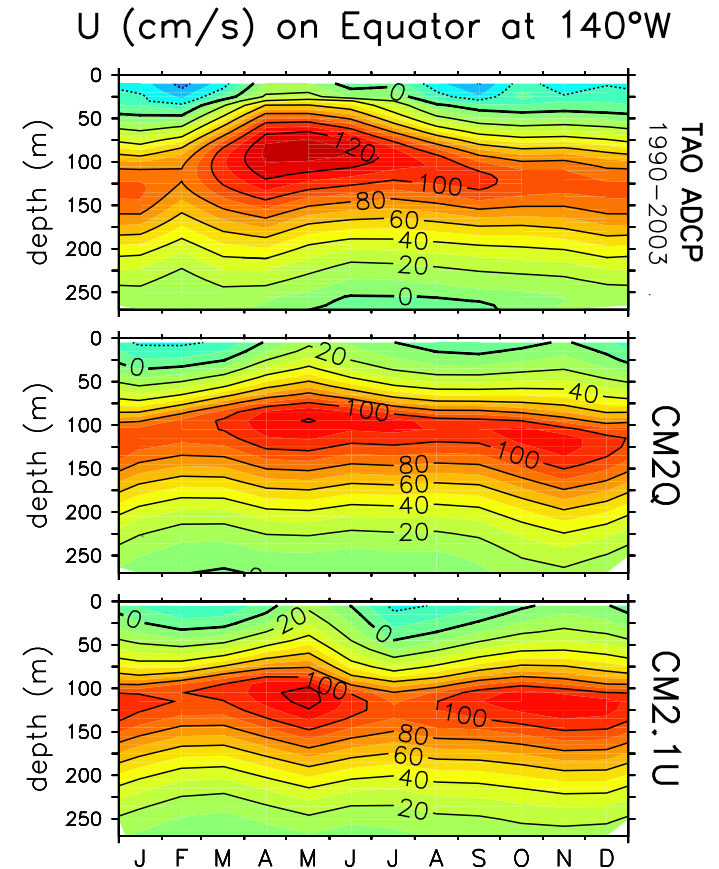
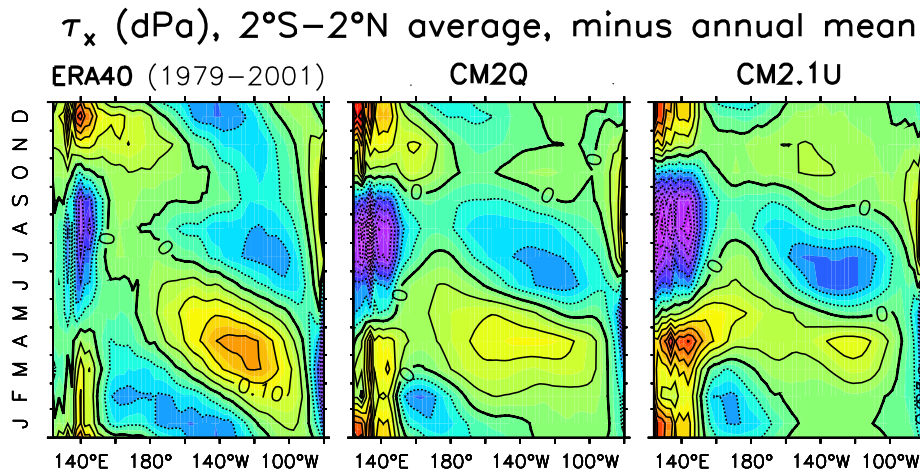
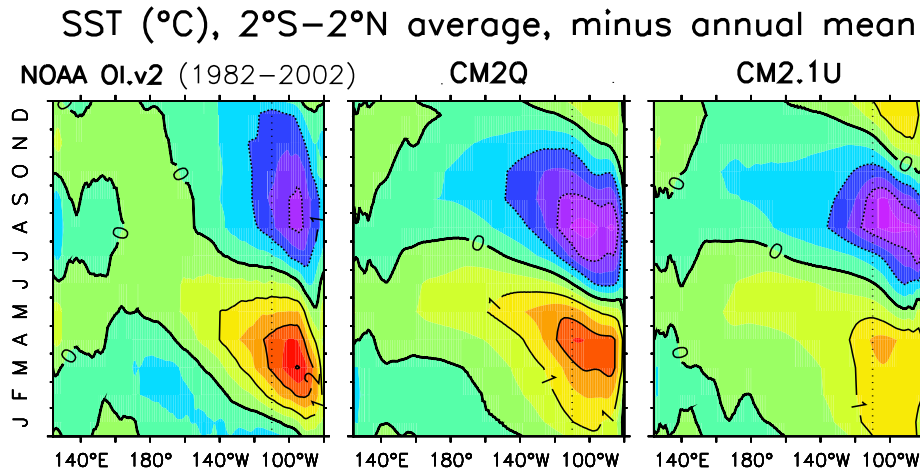
# Annual Mean: Equatorial Temperature



# Annual Mean: Zonal Mean Temperature

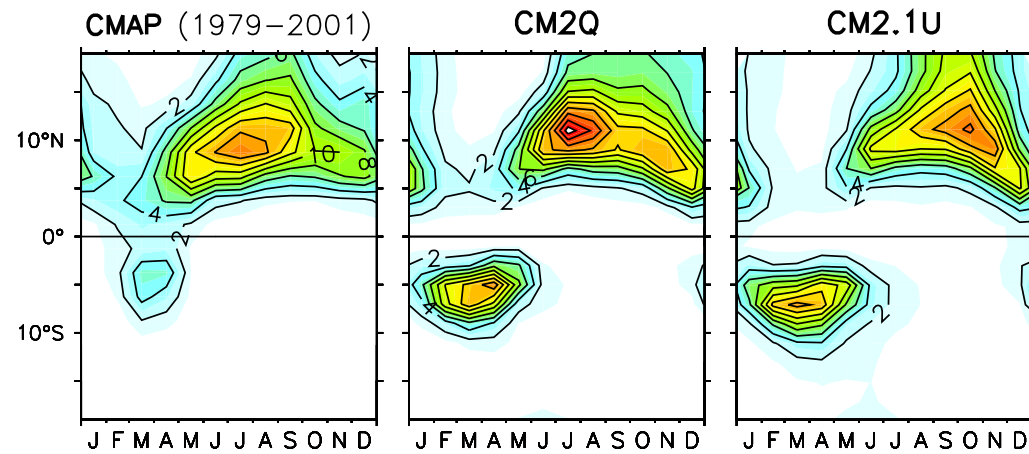


# Seasonal Cycle at the Equator

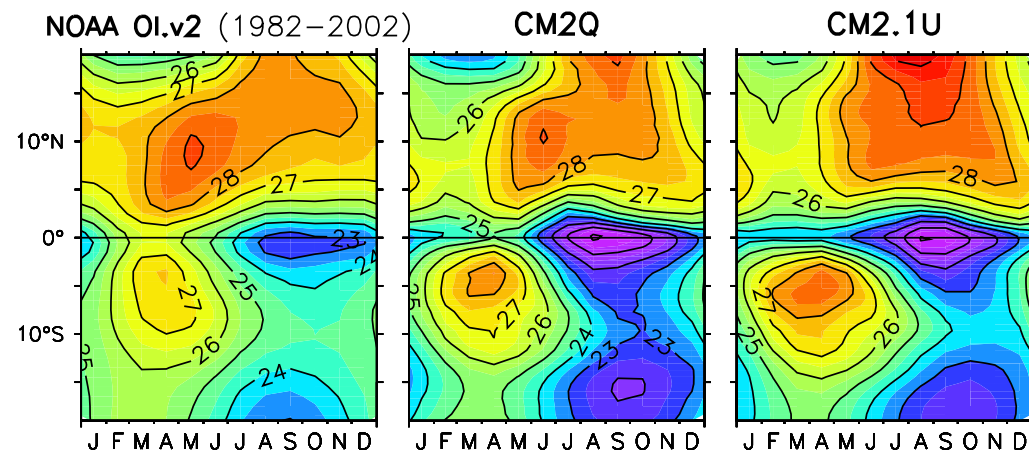


# Seasonal Cycle at 110°W

Precip (mm/day) at 110°W



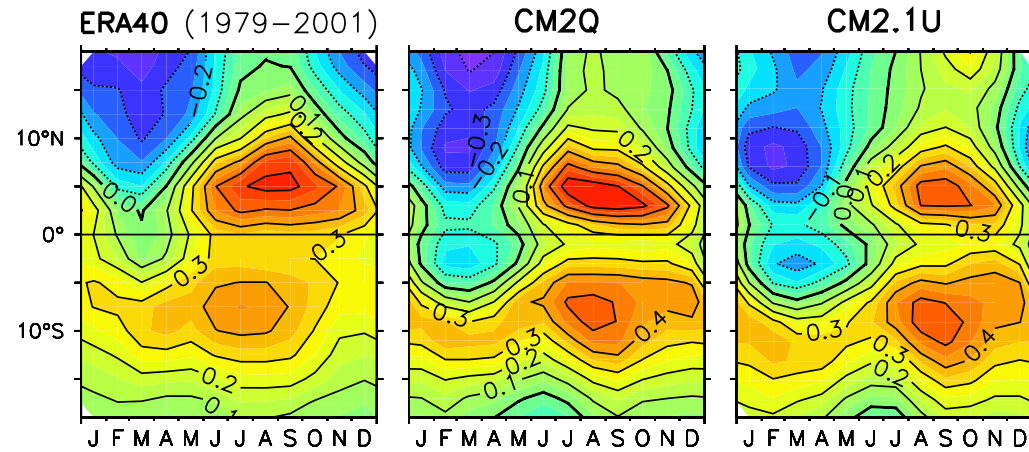
SST (°C) at 110°W



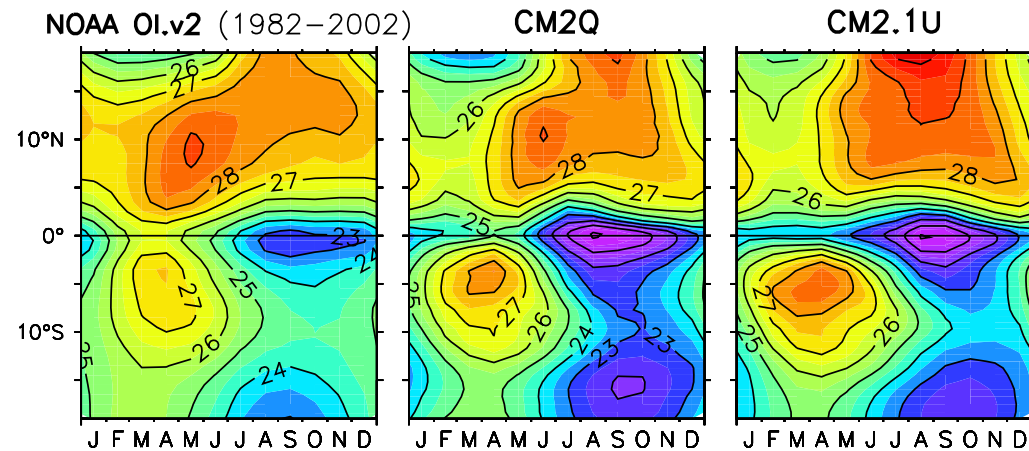


# Seasonal Cycle at 110°W

$\tau_y$  (dPa) at 110°W

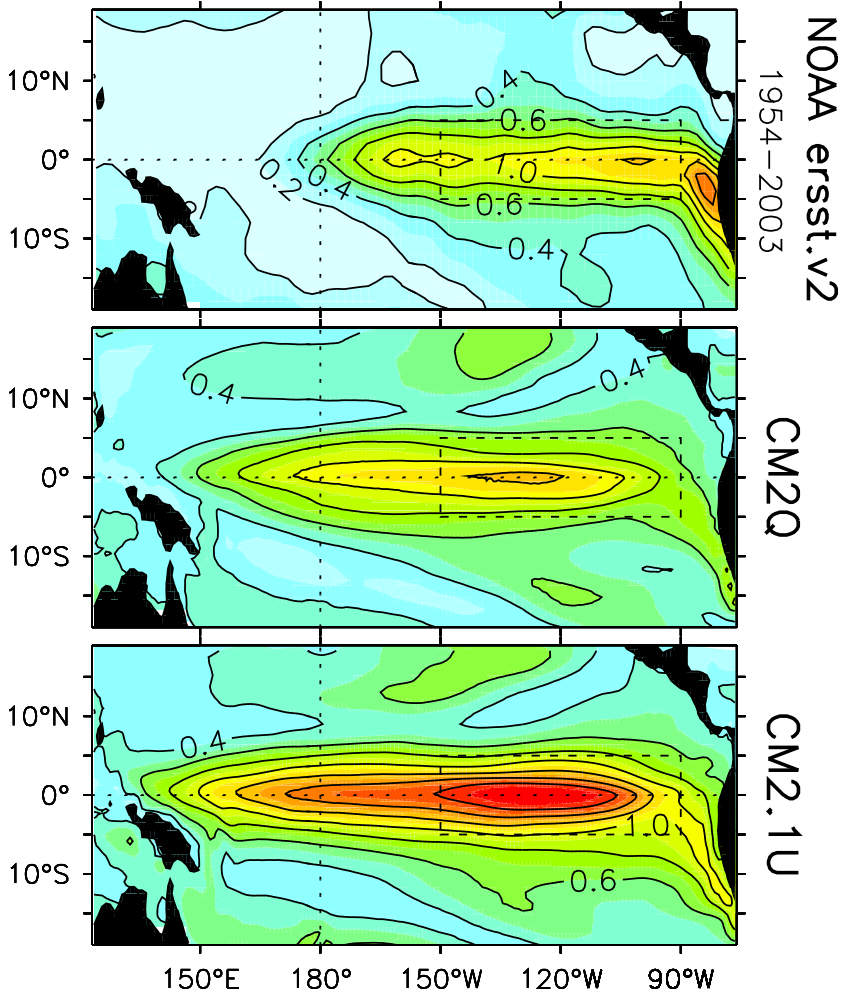


SST (°C) at 110°W

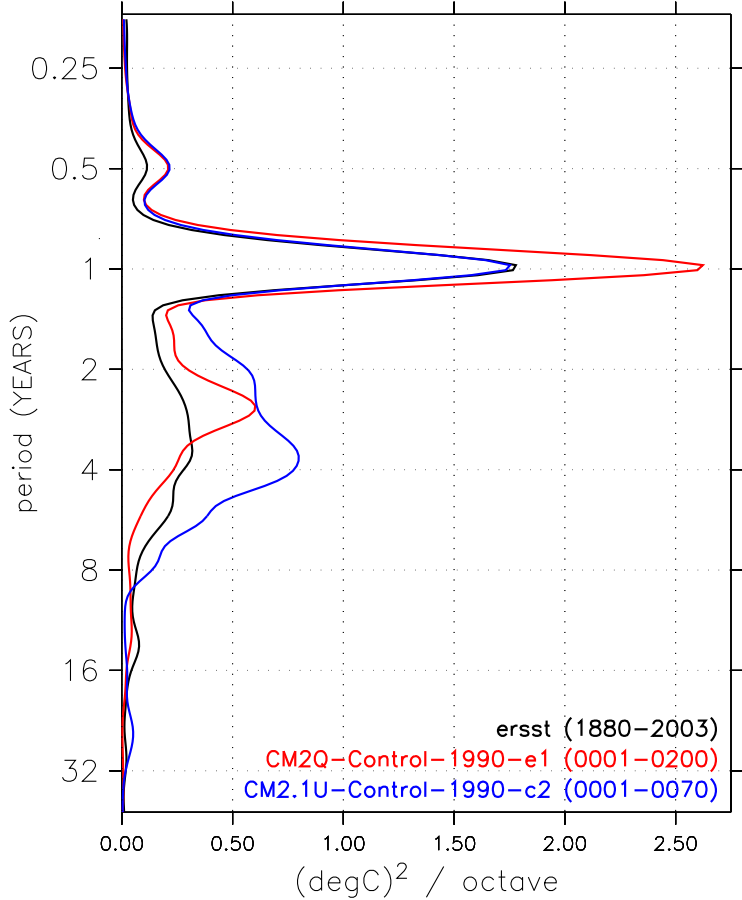


# ENSO Variability

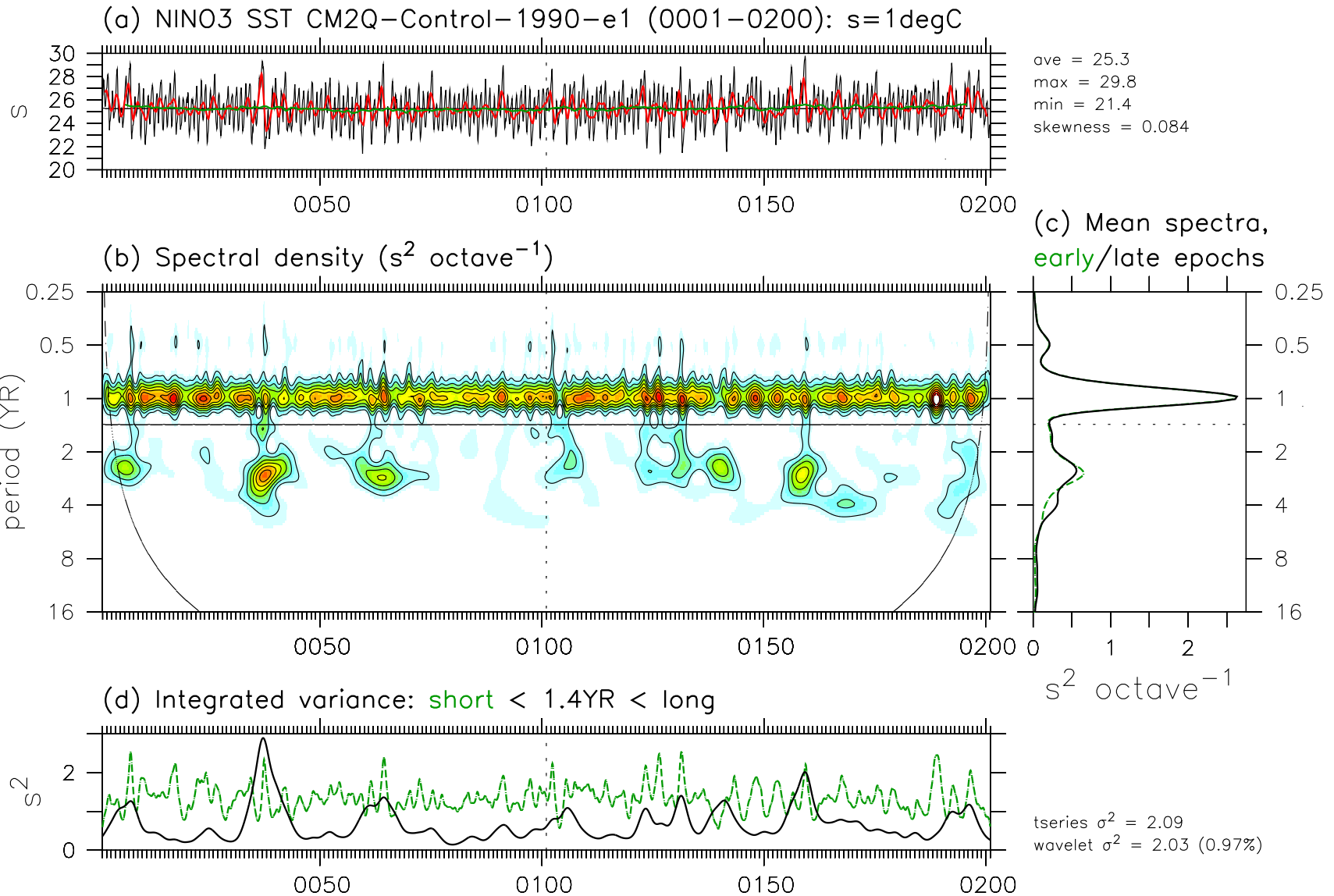
Stddev of Interannual SSTA (°C)



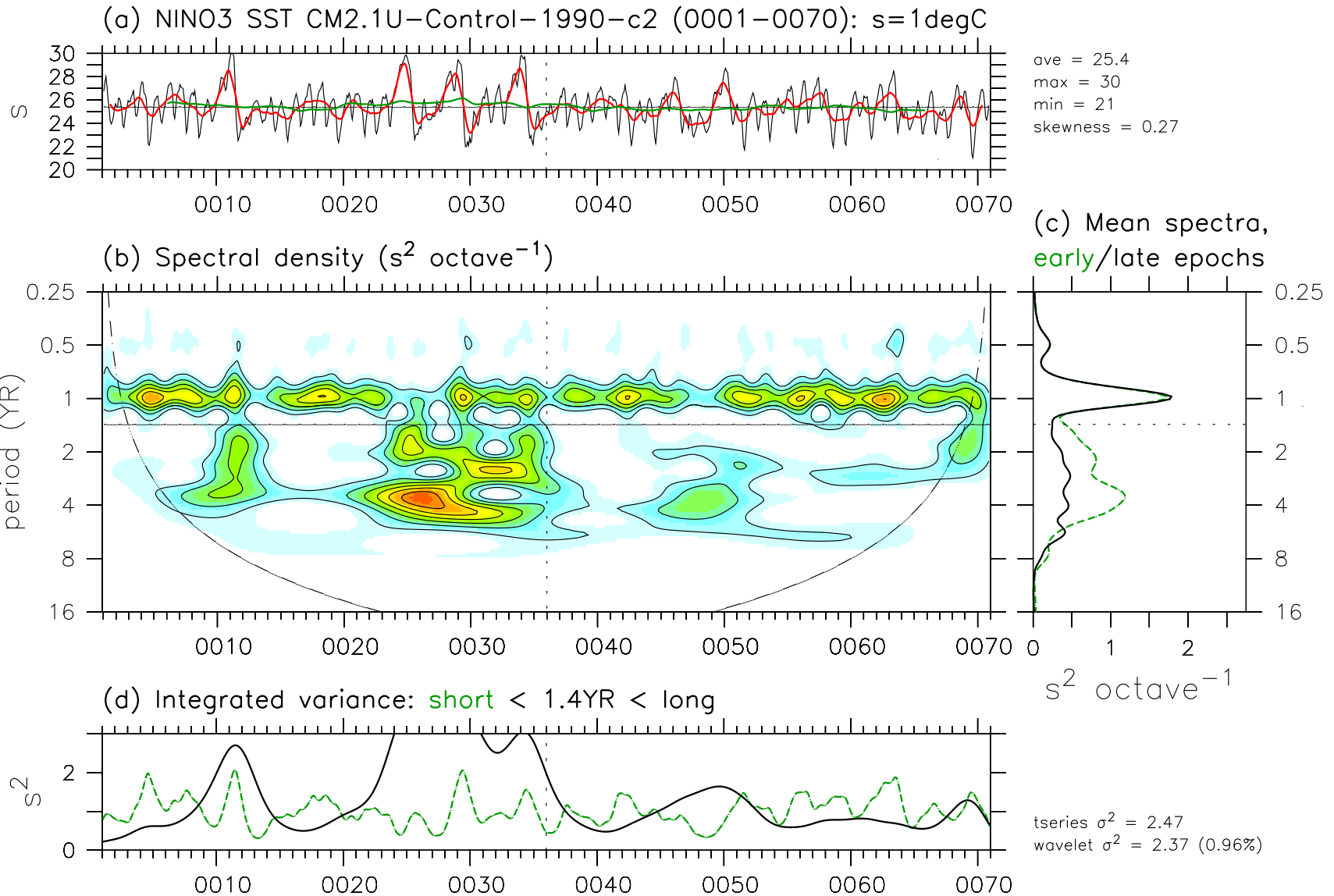
NINO3 SST spectra



# CM2Q: NINO3 SST Timeseries

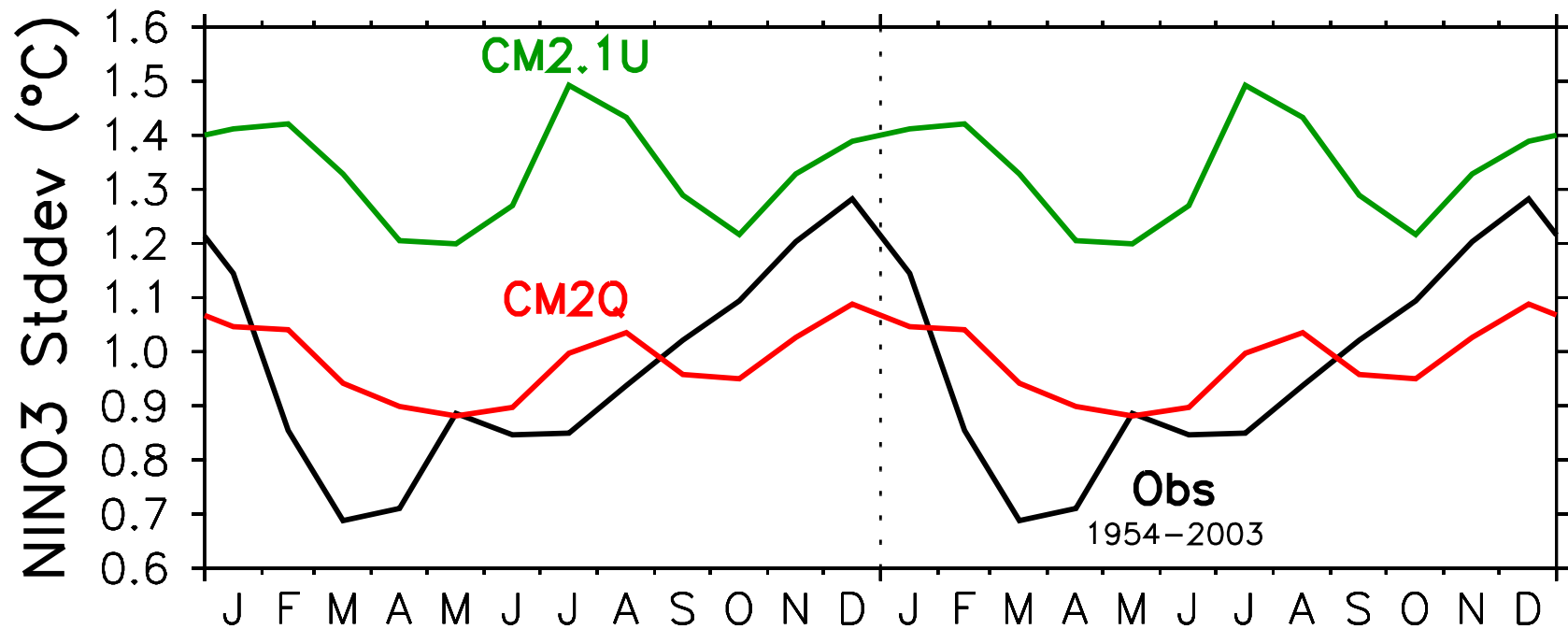


# CM2.1U: NINO3 SST Timeseries



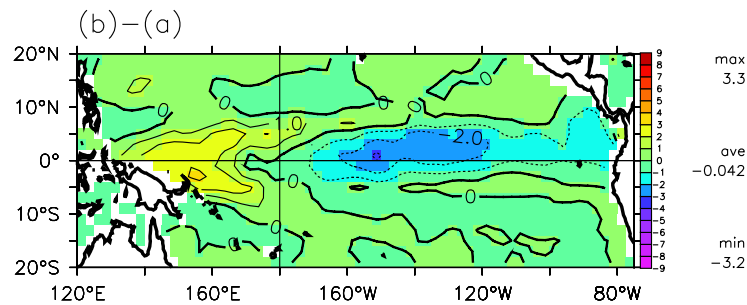
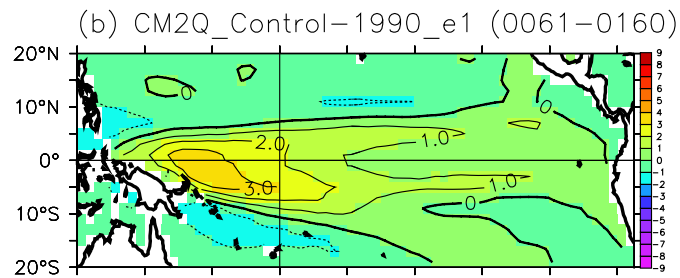
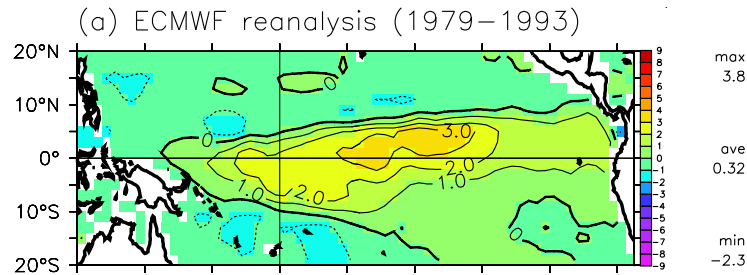
# ENSO Phase Locking to Seasons

## Phase Locking of SST Anomalies



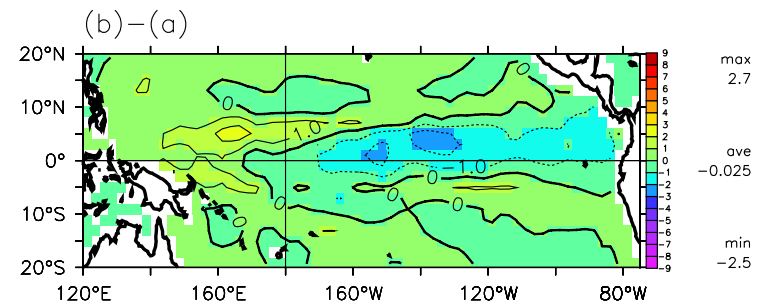
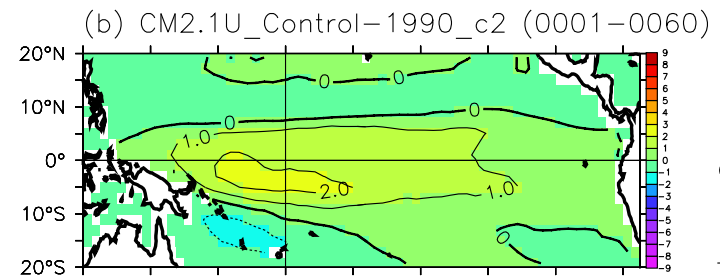
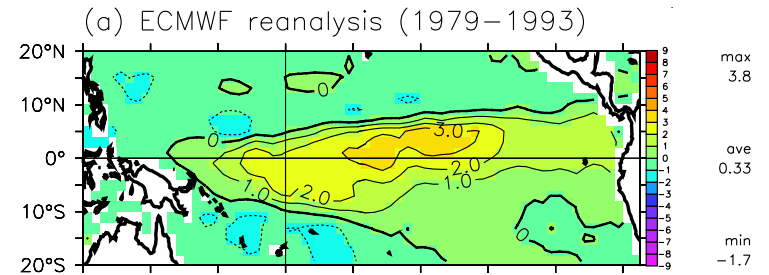
# ENSO Precip Anomalies

total precip (mm/day)  
all months, regressed onto NINO3 SSTA (°C)



correl(a,b) = 0.64      RMSD(a,b) = 0.93

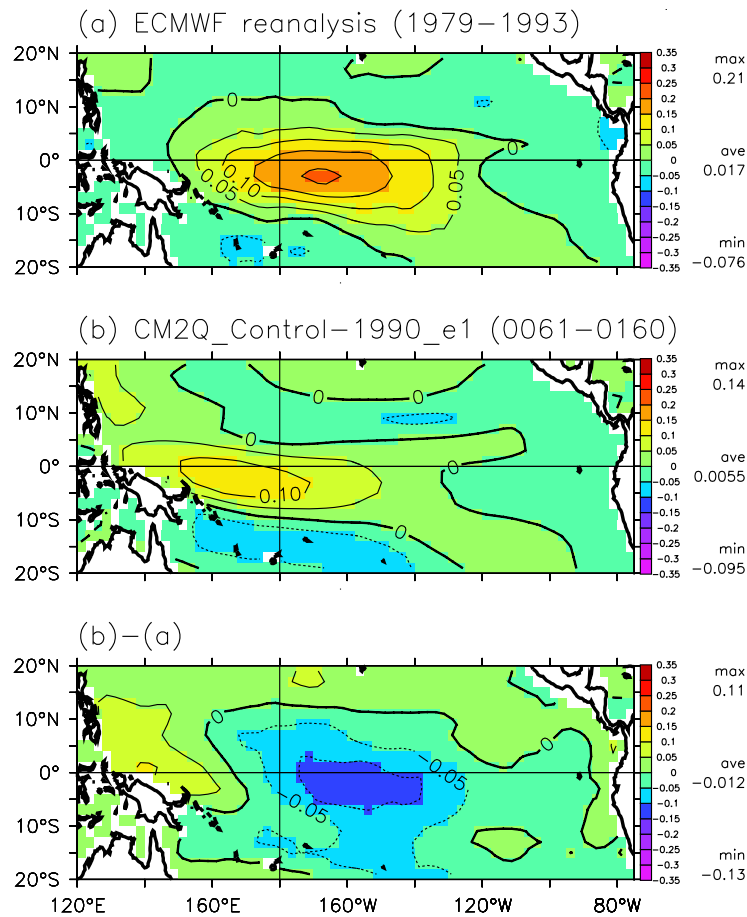
total precip (mm/day)  
all months, regressed onto NINO3 SSTA (°C)



correl(a,b) = 0.78      RMSD(a,b) = 0.74

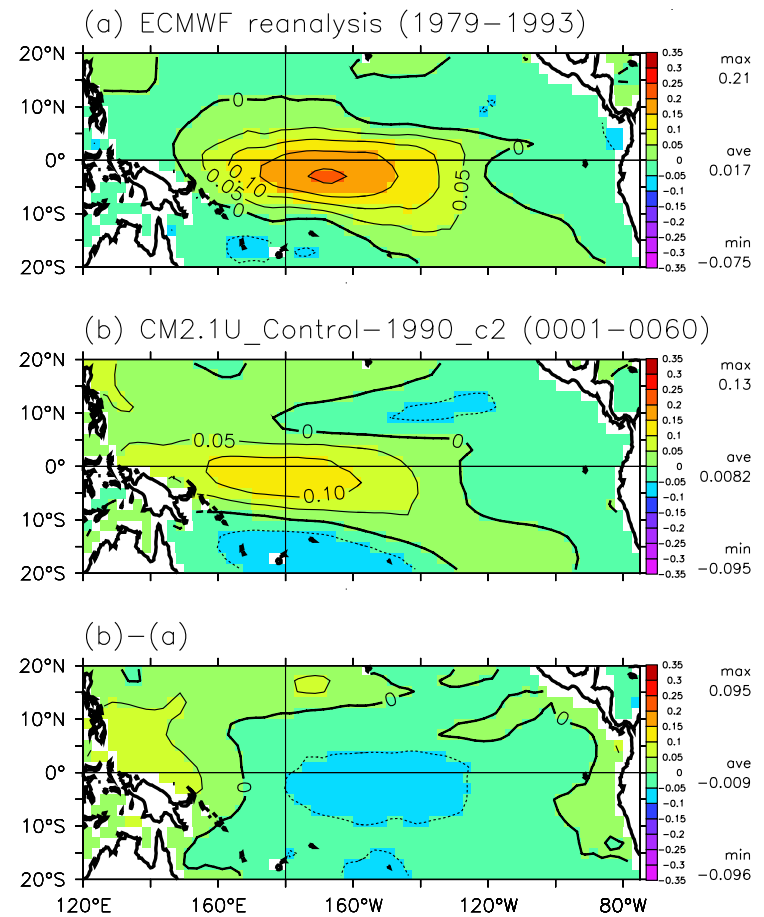
# ENSO Zonal Stress Anomalies

zonal wind stress (dPa)  
all months, regressed onto NINO3 SSTA (°C)



correl(a,b) = 0.64      RMSD(a,b) = 0.047

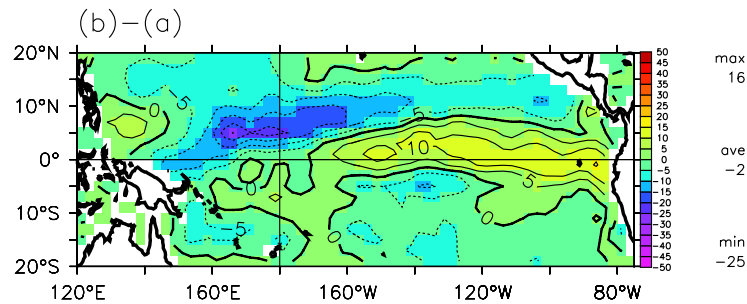
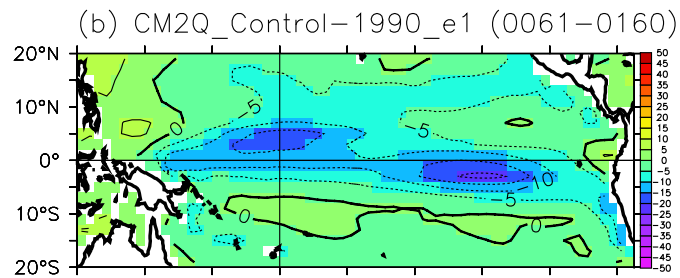
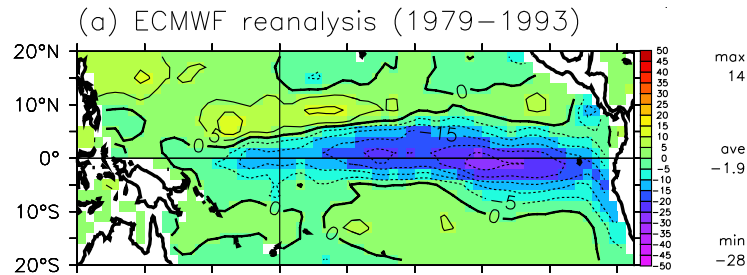
zonal wind stress (dPa)  
all months, regressed onto NINO3 SSTA (°C)



correl(a,b) = 0.78      RMSD(a,b) = 0.038

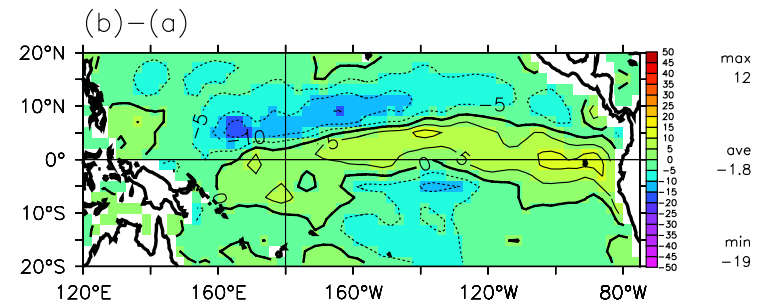
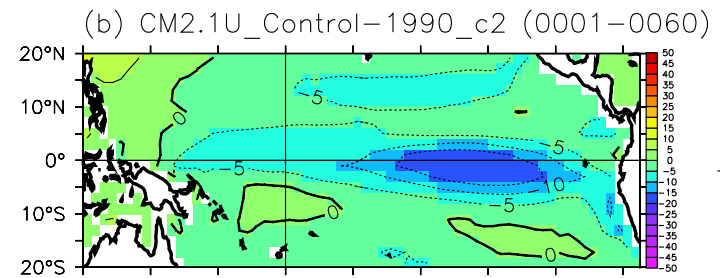
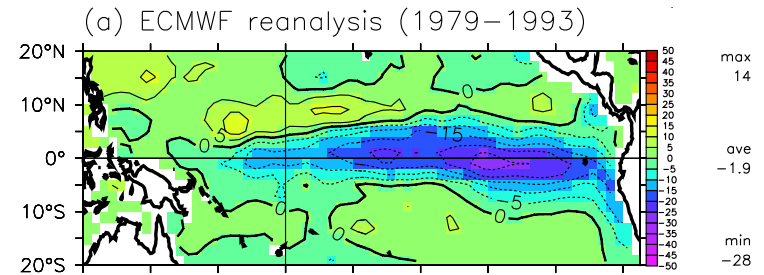
# ENSO Heat Flux Anomalies

net heat flux down ( $\text{W/m}^2$ )  
all months, regressed onto NINO3 SSTA ( $^{\circ}\text{C}$ )



correl(a,b) = 0.56      RMSD(a,b) = 6.6

net heat flux down ( $\text{W/m}^2$ )  
all months, regressed onto NINO3 SSTA ( $^{\circ}\text{C}$ )

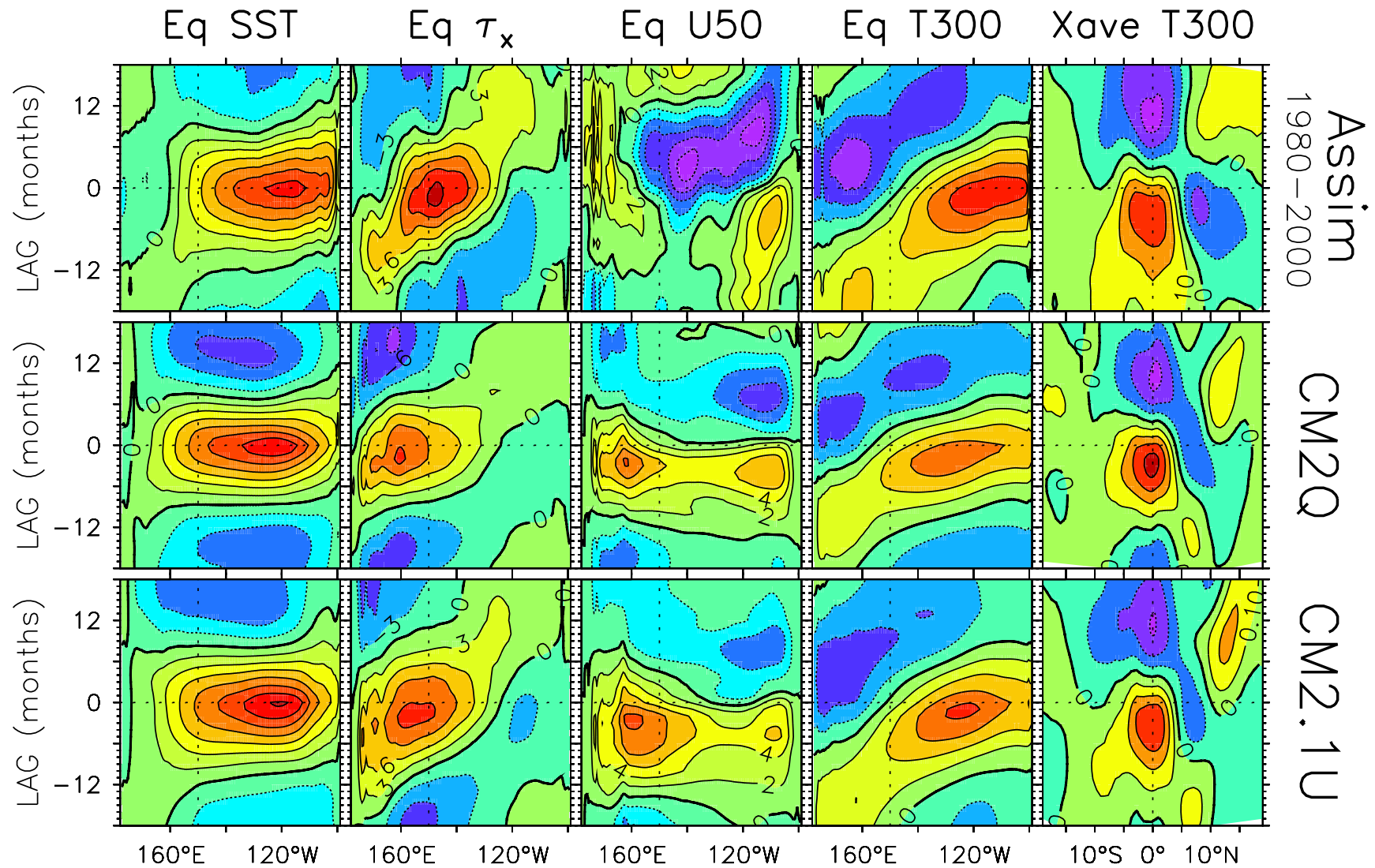


correl(a,b) = 0.75      RMSD(a,b) = 5.4



# ENSO Evolution

Lag-Regression onto NIN03 SSTA



# Summary

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- Successes:
  - reduced biases, reasonable ENSO
  - a top CGCM for the tropical Pacific
- Challenges:
  - cold equator, double ITCZ, weak NECC
  - diffuse thermocline
  - surface waters too stable near Peru
  - ENSO too strong, too far west
  - ENSO not phase locked to seasons

# Toward a Better Coupled Model

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- Analyses!
  - Heat/momentum budgets
  - Uncoupled & flux-adjusted runs
  - Data override, sponged & restored runs
  - Additional tests: ENSO hindcasts, paleo
- Development
  - Atmosphere: convection, PBL, clouds, resolution
  - Ocean: vertical mixing, TIWs, color, resolution

# Further Information

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[http://www.gfdl.noaa.gov/~atw/research/cm2/  
CM2Q/poster.pdf](http://www.gfdl.noaa.gov/~atw/research/cm2/CM2Q/poster.pdf)  
[CM2.1U/poster.pdf](http://www.gfdl.noaa.gov/~atw/research/cm2/CM2.1U/poster.pdf)  
[CM2Q\\_vs\\_CM2.1U/talk\\_30min.pdf](http://www.gfdl.noaa.gov/~atw/research/cm2/CM2Q_vs_CM2.1U/talk_30min.pdf)