

Seamless Climate Prediction from Days-to-Decades

Ben Kirtman

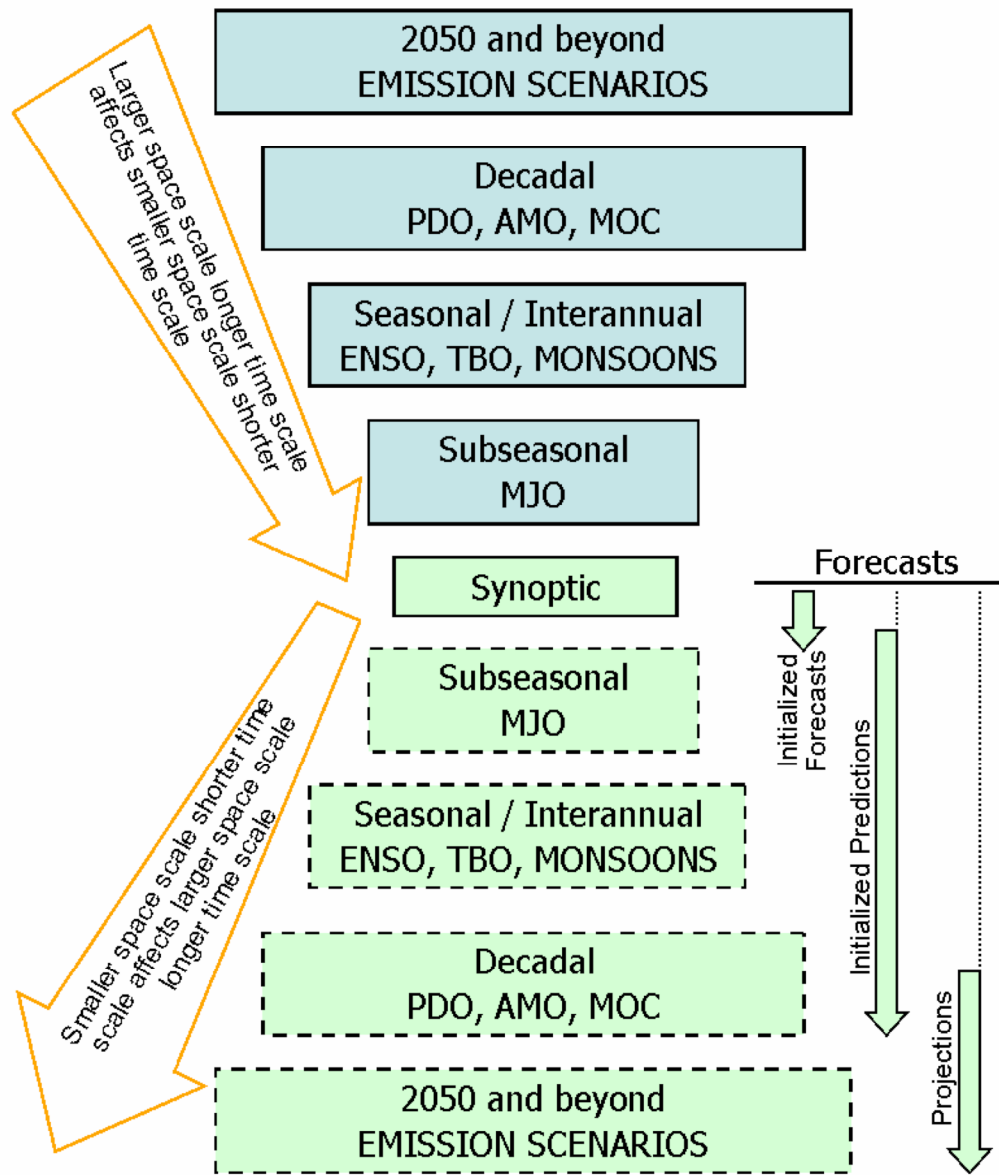
University of Miami - RSMAS

**Center for Ocean-Land-
Atmosphere Studies**



Prediction/Predictability Continuum

- **Blurring of the Distinction Between Short Term Prediction and Long Term Climate Projection**
- **(Some) Common Processes and Mechanisms**
- **Interactions Across Time and Space Scales Fundamental to Environmental Prediction**
- **Need for Initialized Predictions Across Space and Time Scales**
 - **Climate Change Commitment**
- **Benefits: Improved Predictions, Collaborations, Shared Knowledge, Infrastructure, Capabilities**



TIME AND SPACE SCALE

Seamlessness

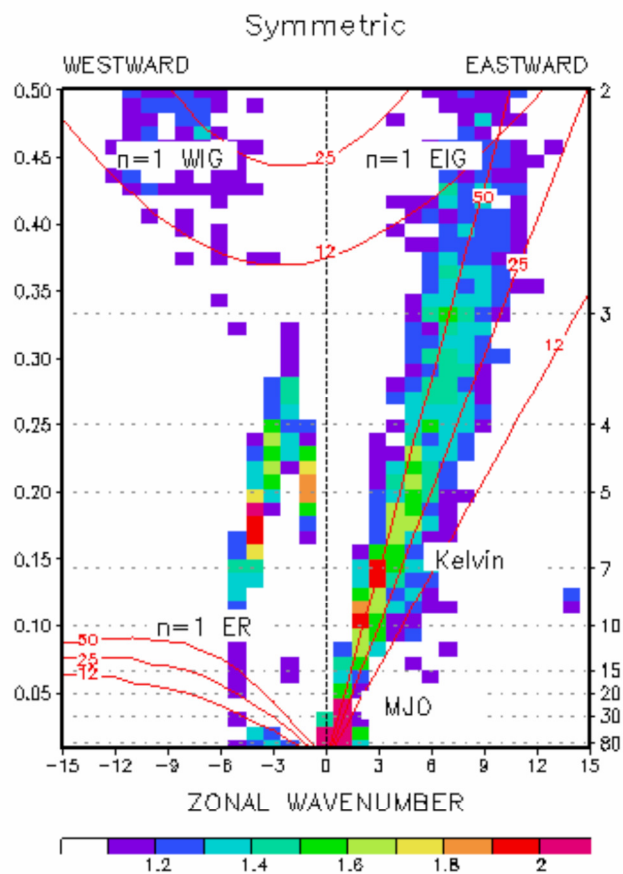
- **Unified Modeling:**
 - Processes Oriented View
 - Ex: Air-Quality, Hydrology ...
 - Clearly Linked to Multi-Scale Modeling
- **Multi-Scale Modeling:**
 - Both Space and Time
 - Ex: Clouds System Resolving → MJO
 - Clearly Linked to Unified Modeling
- **Economies and Costs**
- **Focusing on the “Seams”**
 - THORPEX - **Sub-Seasonal** - Seasonal
 - CHFP - **Decadal** - Climate Change

Prediction/Predictability Across Time-Scales

- **Initialized(O-L-A) Hindcasts/Forecasts from Days-to-Decades**
 - Sub-Seasonal (Open Seam!)
 - Seasonal-to-Interannual Forecast Quality
- **Decadal Predictability**
 - Mechanisms, Limits
 - Annual Means, Decadal Means?
- **Decadal Prediction**
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- **Prediction and Predictability Need to be Linked**

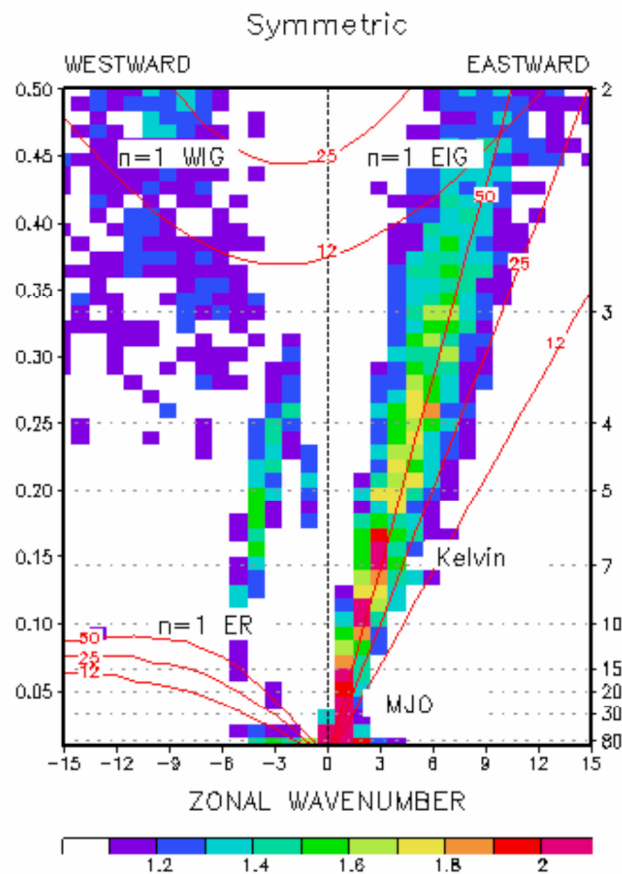
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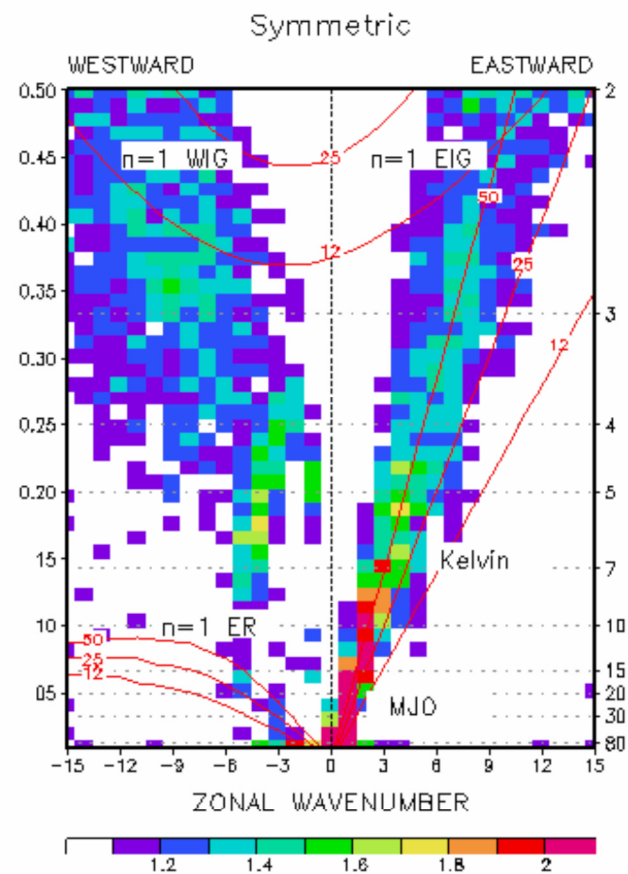


Observations

CCSM3



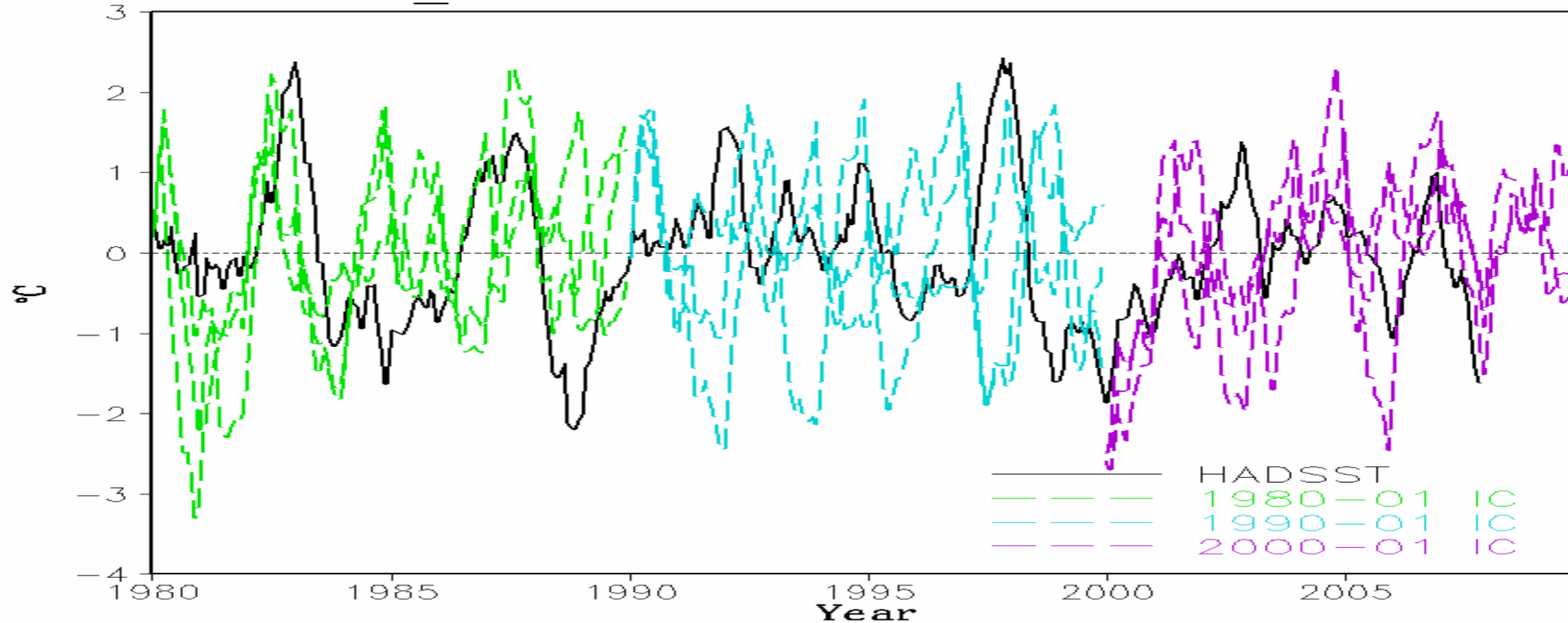
SP-CAM



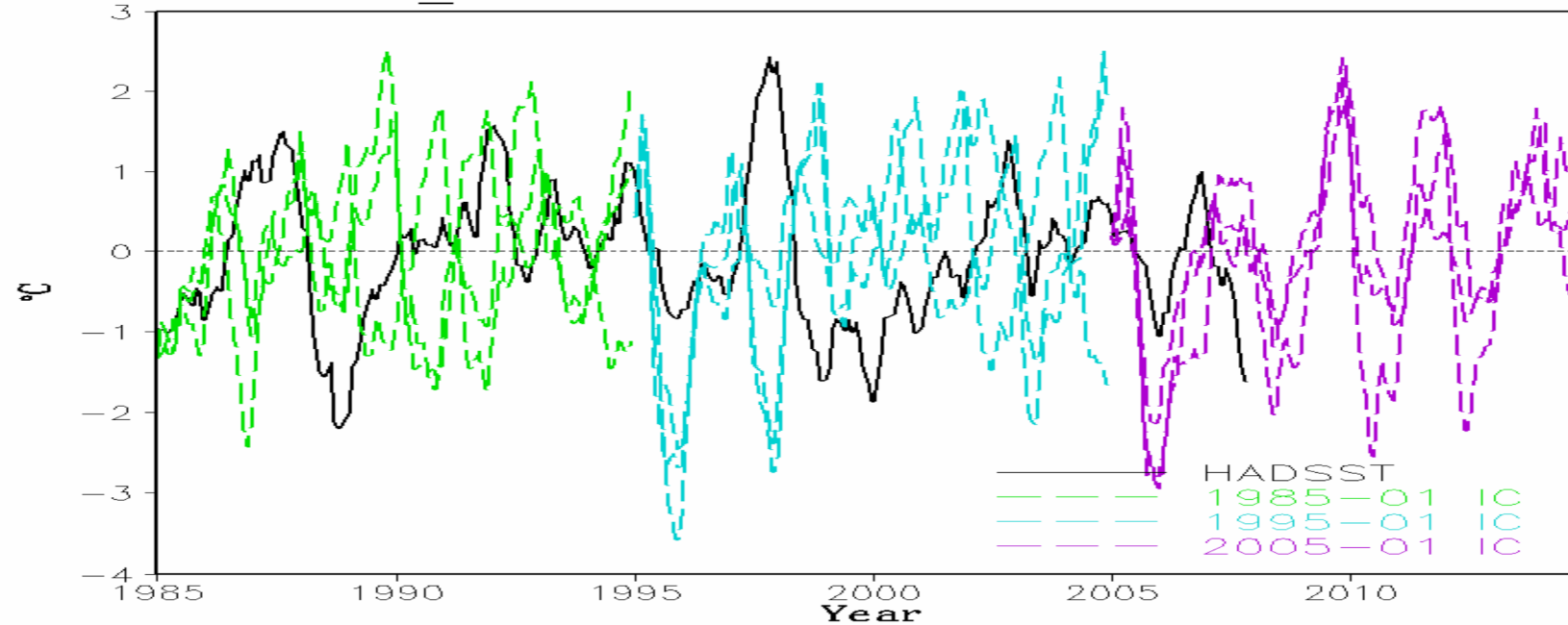
Predictability/Prediction from Days-to-Decades

- **CCSM 3.5 and CCSM 3.0 (T85, 1x1)**
- **Hindcast/Forecast each January 1980, 1985, 1990, 1995, 2000, 2005**
 - **Additional Cases: 1960, 1965, 1970, 1975, Argo Era**
- **3-Member ensembles (expanding to 10)**
- **Initialized Ocean-Land-Atmosphere**
 - **ERA40, GFDL Ocean Data Assimilation**
 - **Initialization Shock**
- **Systematic Error Estimate from Hindcast Mean**

CCSM3_0 3 Ensembles NINO3.4 Time Series

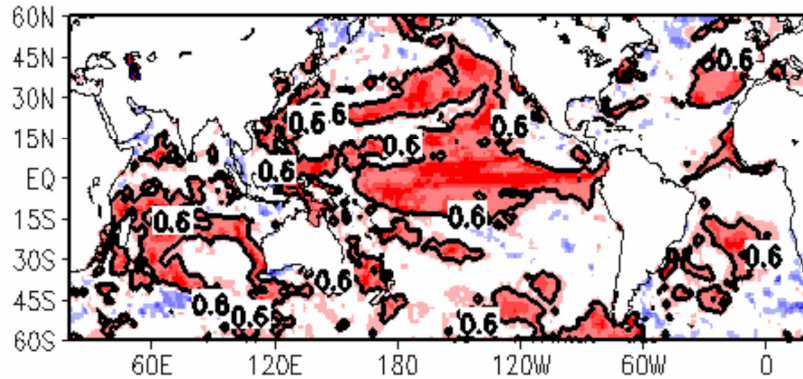


CCSM3_0 3 Ensembles NINO3.4 Time Series

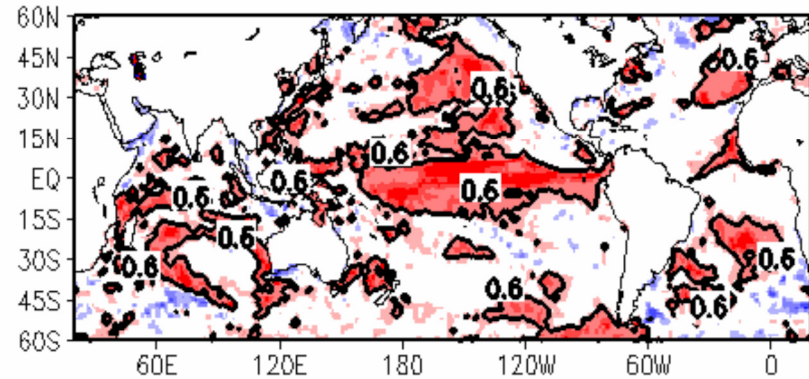


SSTA Anomaly Corr. (0 Month Lead)

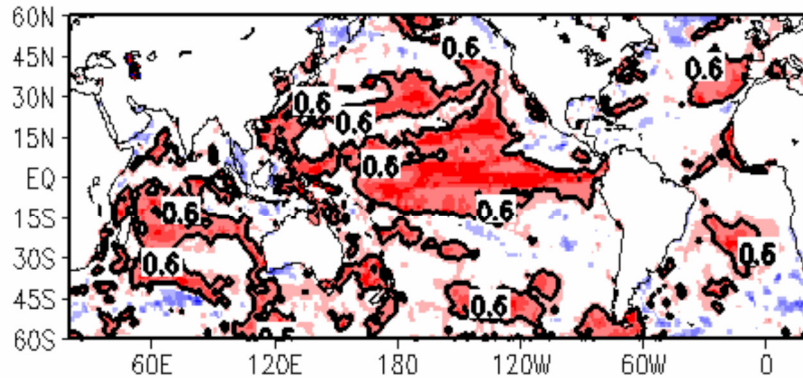
Ens. Mean



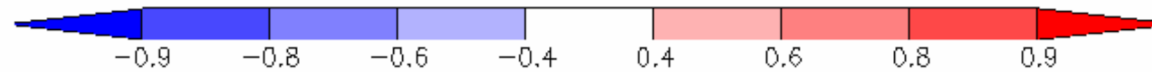
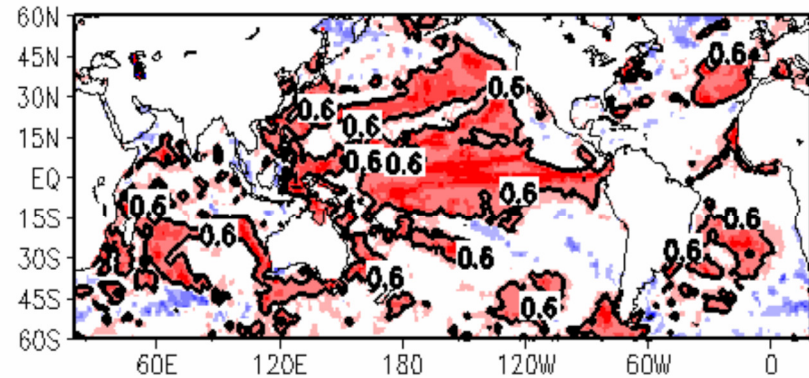
E1



E2

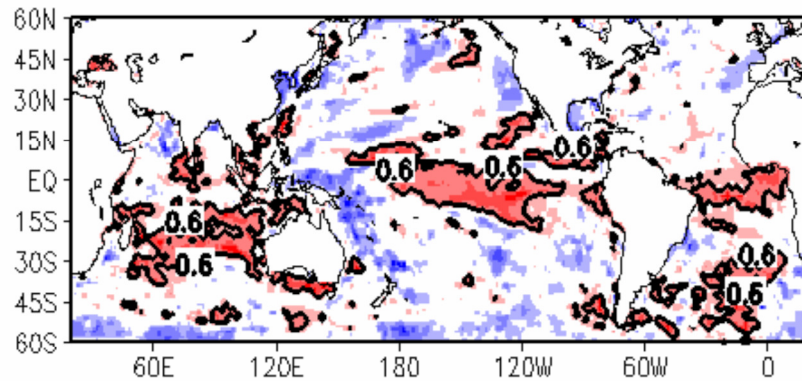


E3

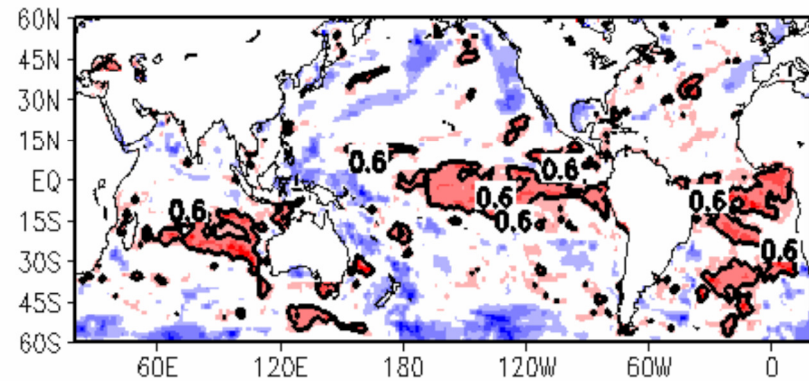


SSTA Anomaly Corr. (12 Month Lead)

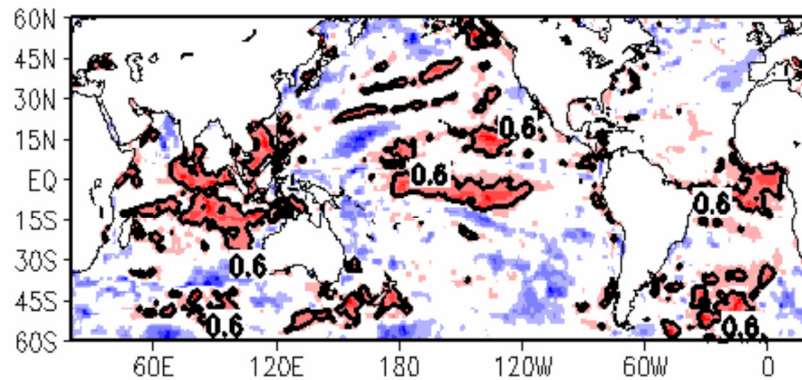
Ens. Mean



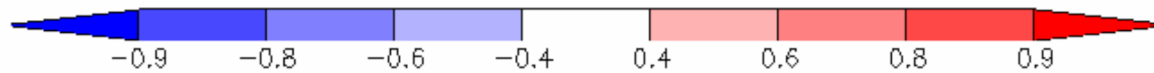
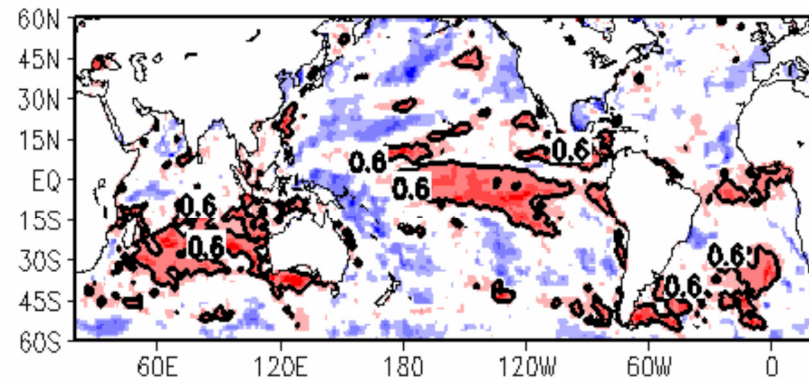
E1



E2

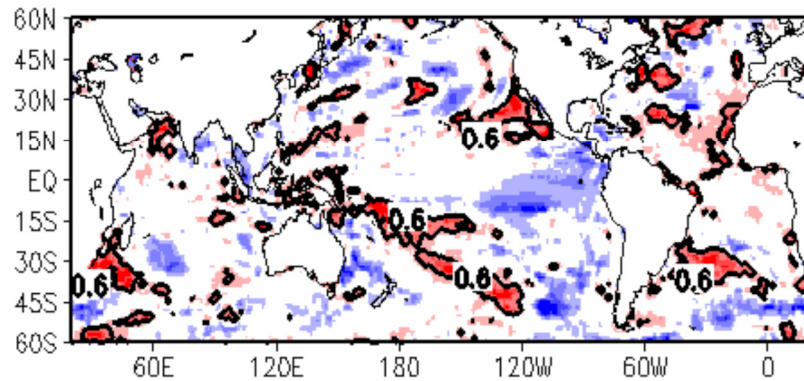


E3

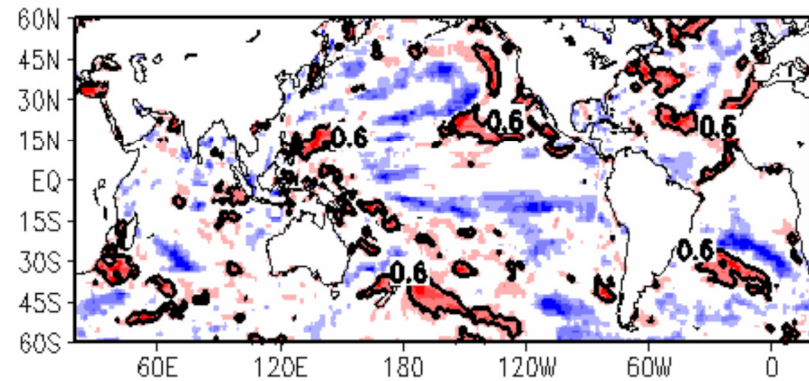


SSTA Anomaly Corr. (60 Month Lead)

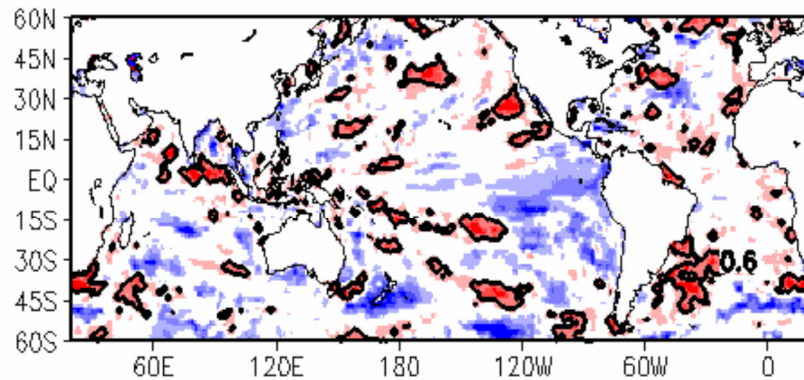
Ens. Mean



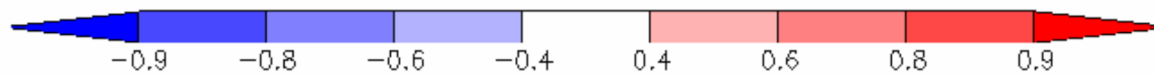
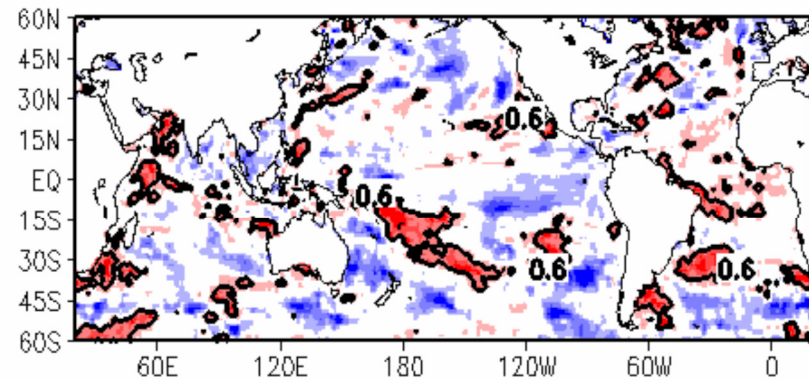
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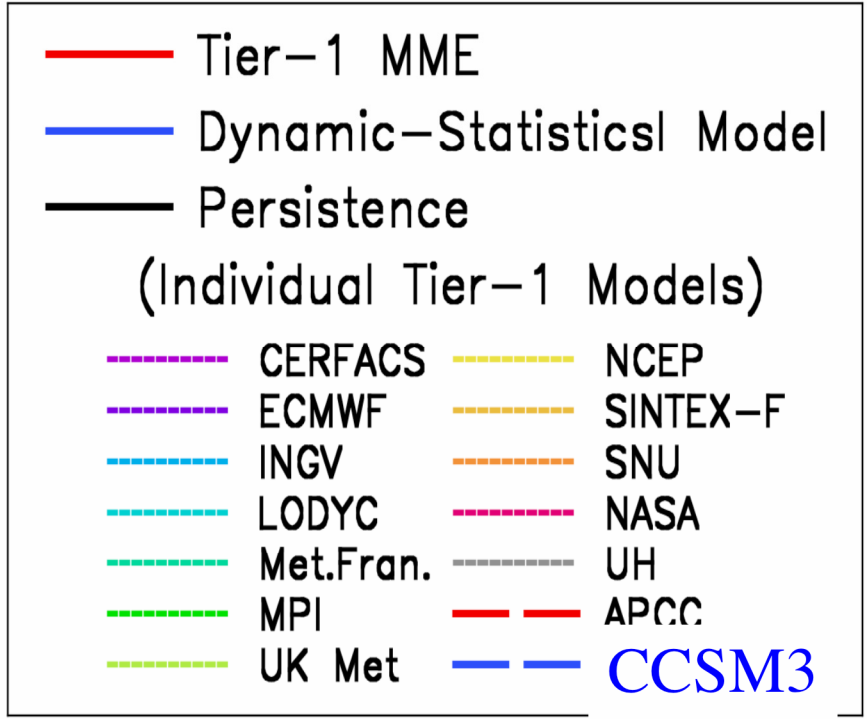
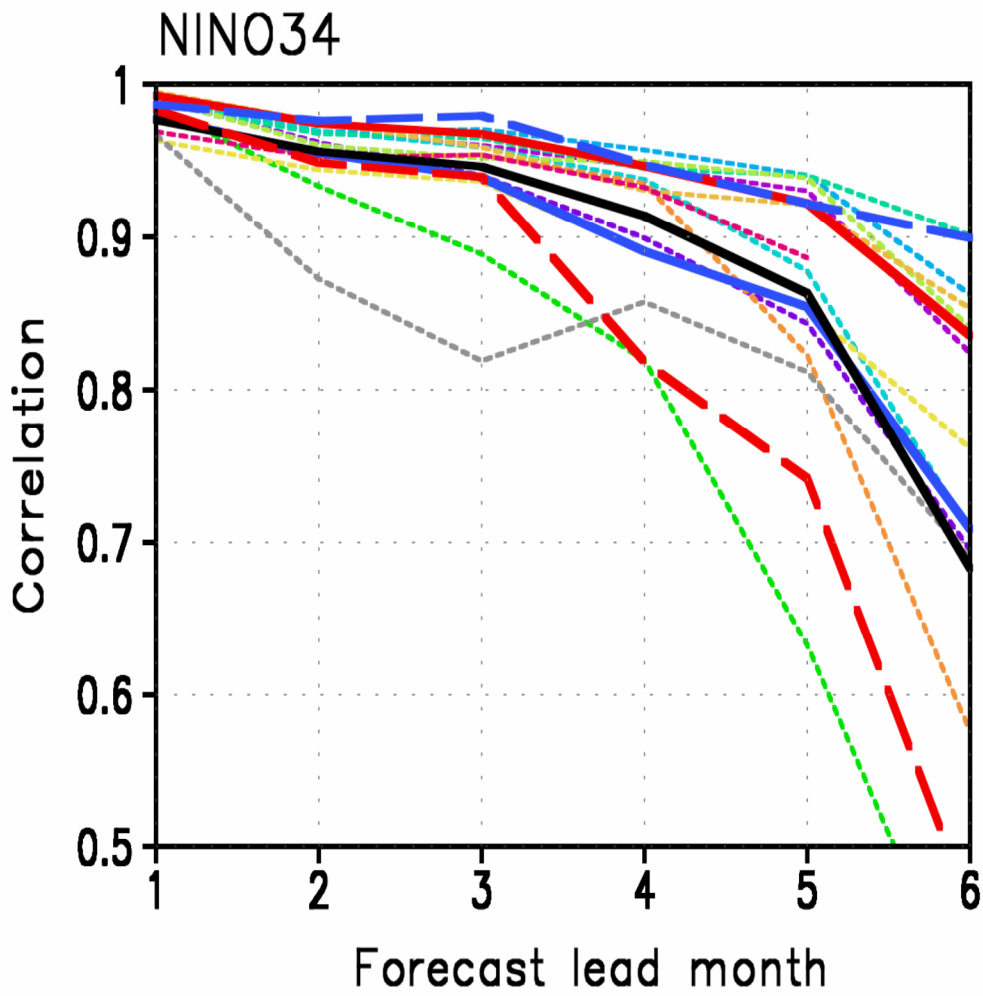


E2



E3



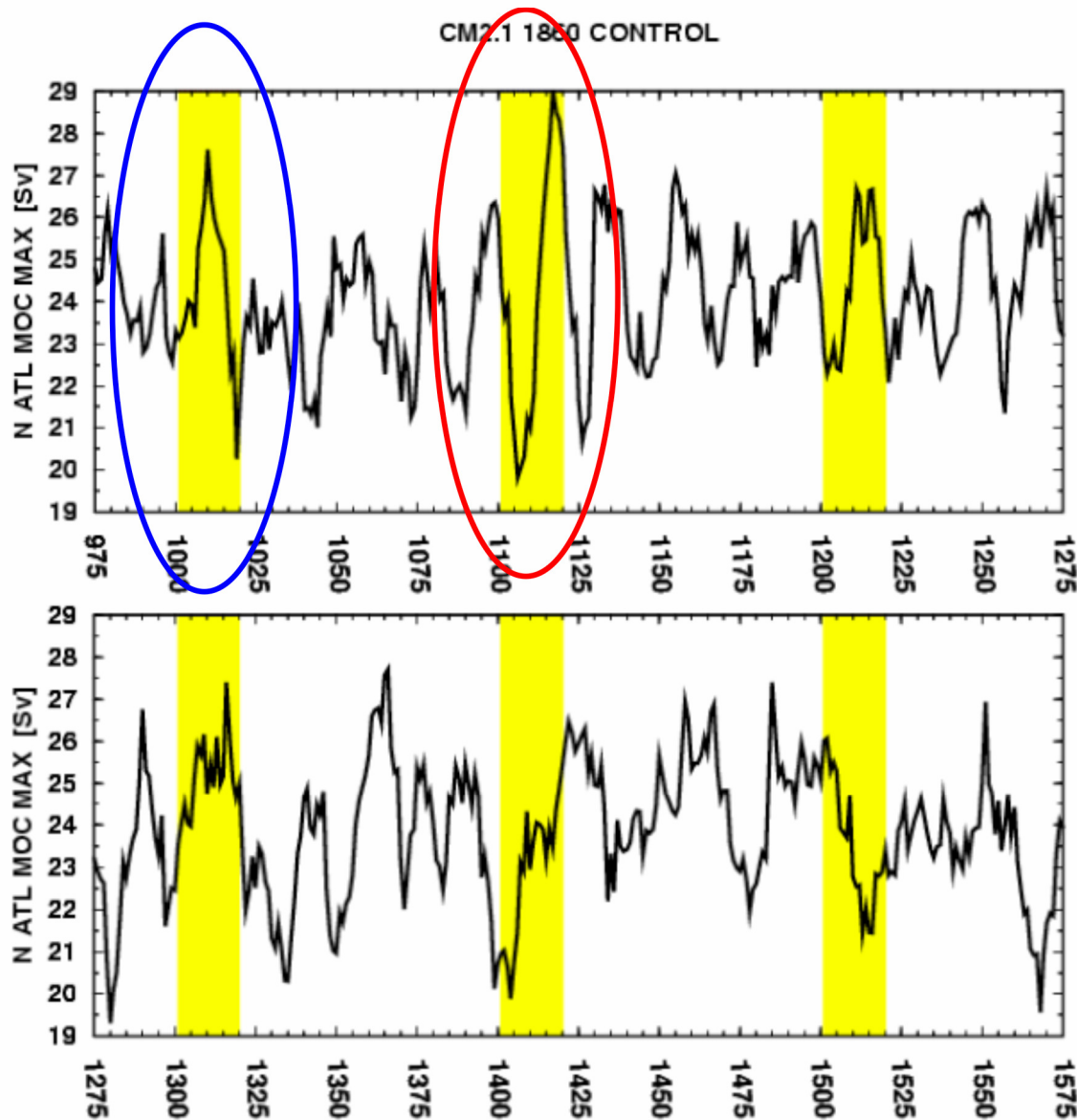


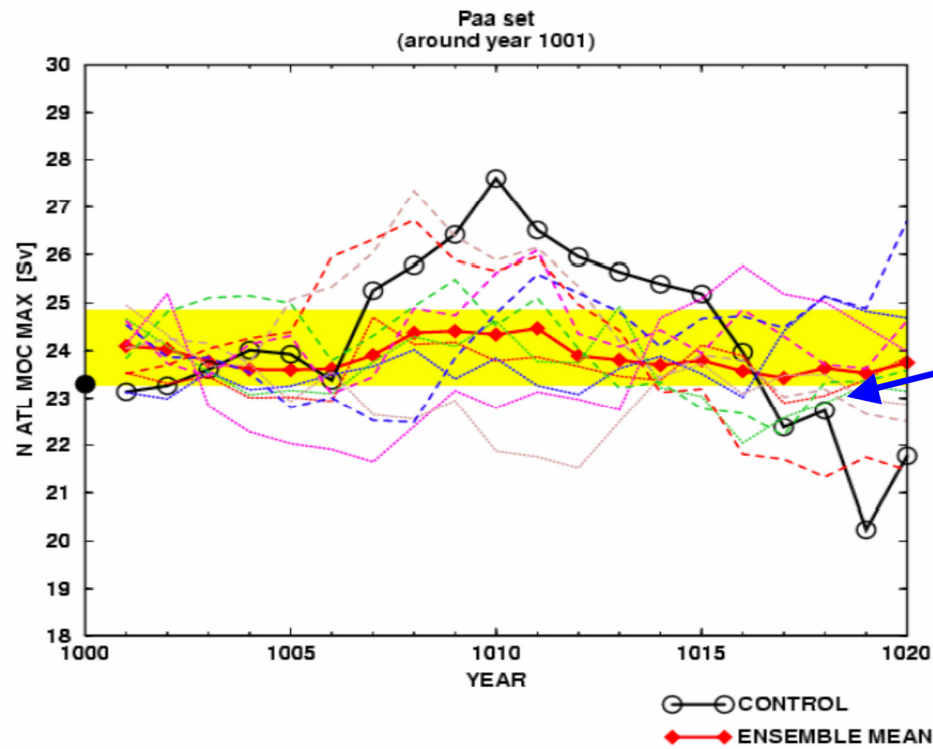
Prediction/Predictability Across Time-Scales

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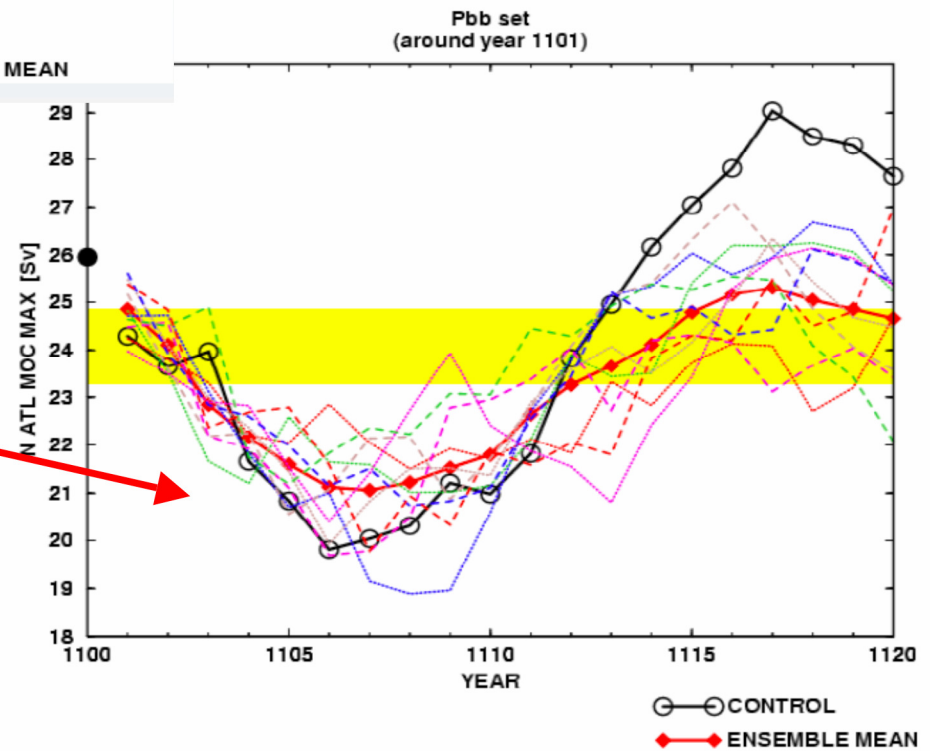
Quasi-Periodic MOC: Any Relation to SST?

The N. Atl. MOC in the 1860 Control





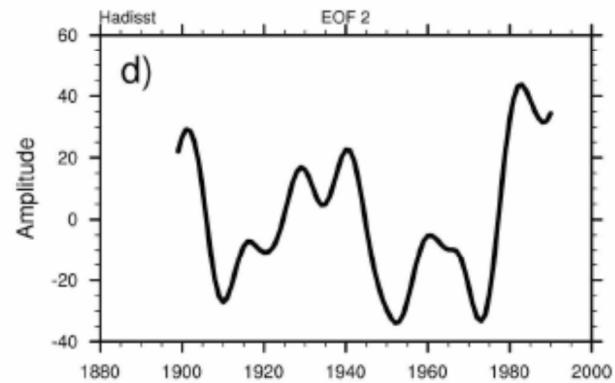
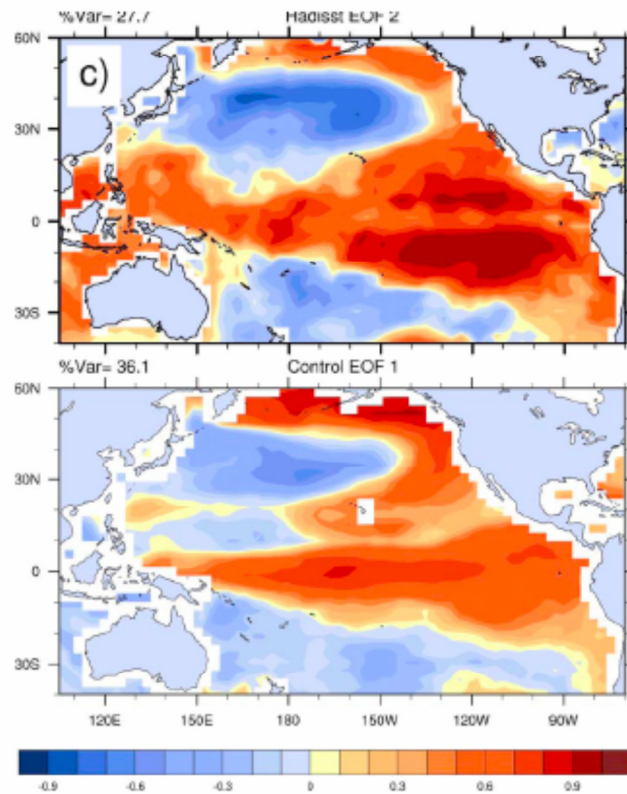
“Unpredictable Case”



“Predictable Case”

Source of Predictability?

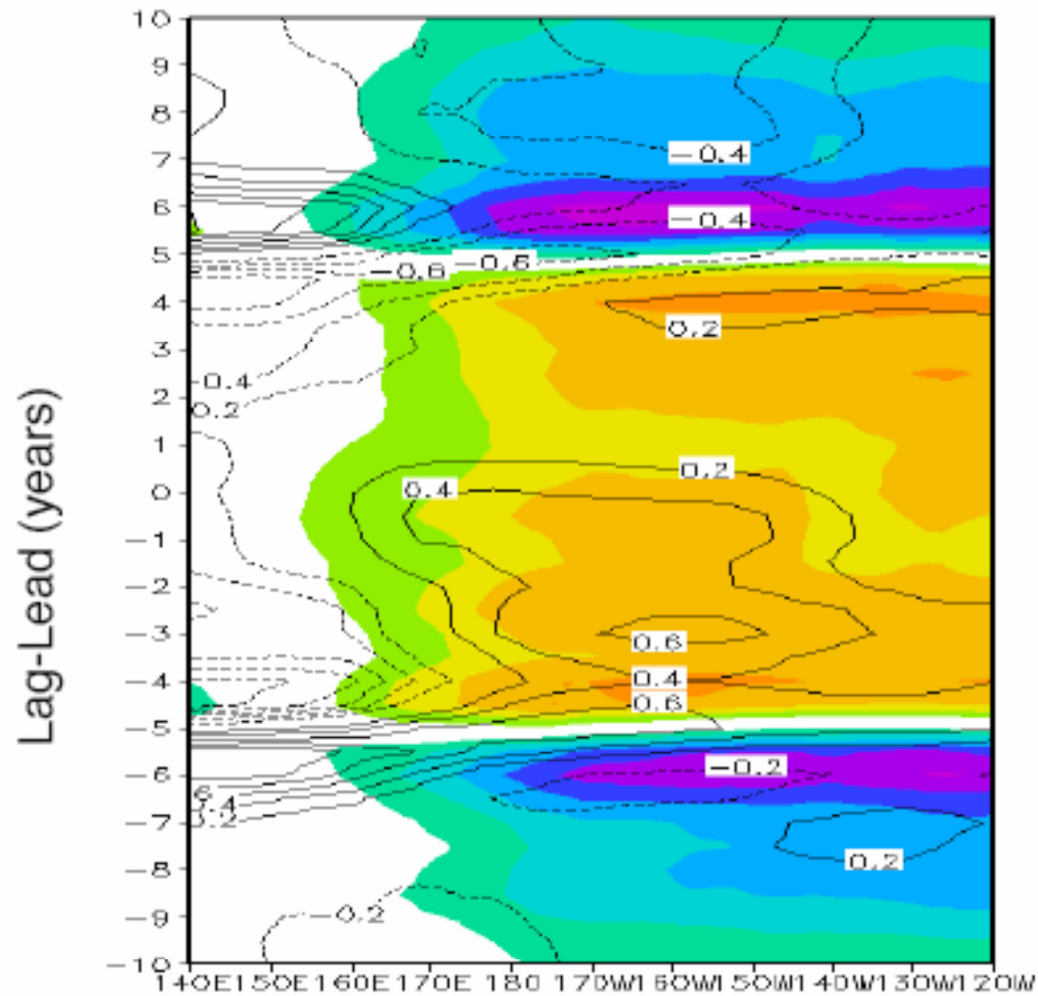
If there is a deterministic mechanism that produces the IPO pattern, it may be possible to predict if initialized properly in a coupled climate model



IPO from observations

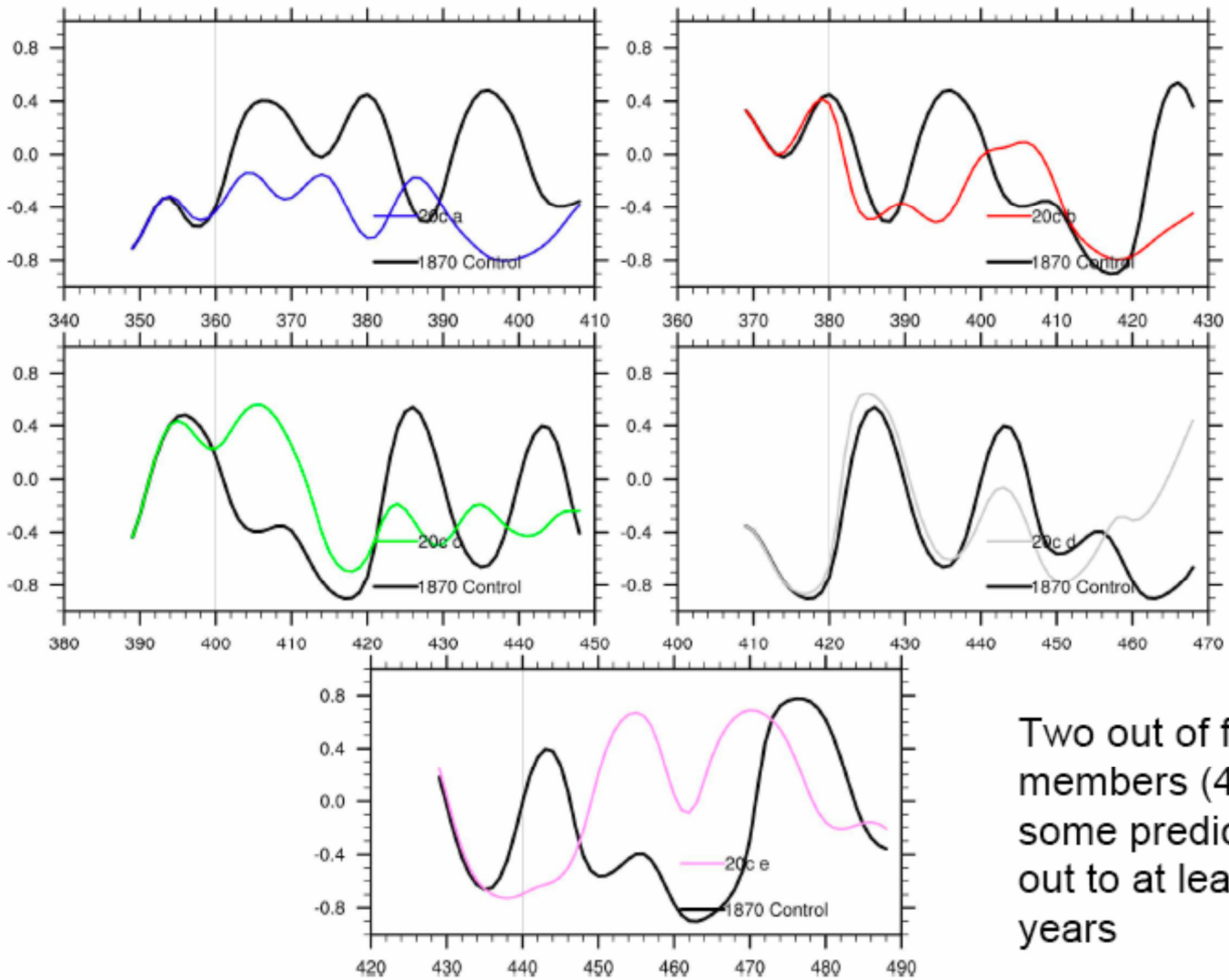
IPO from model control run

PDO Index Regression: Heat Content And SST Along EQ



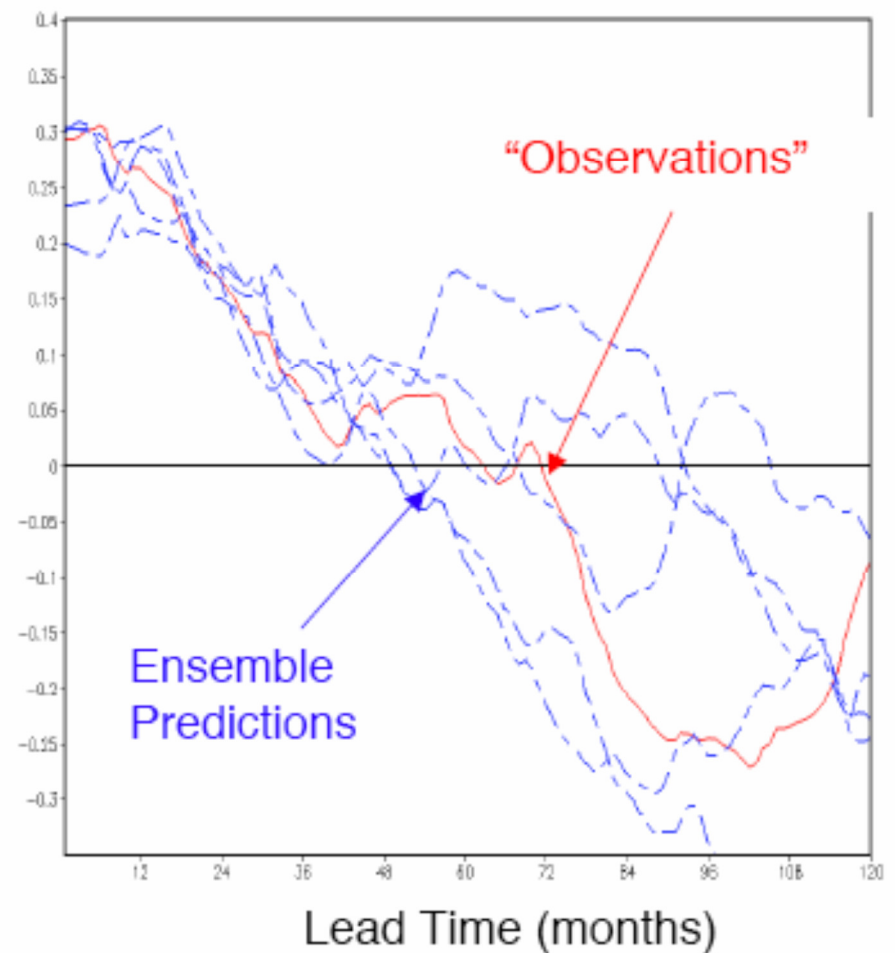
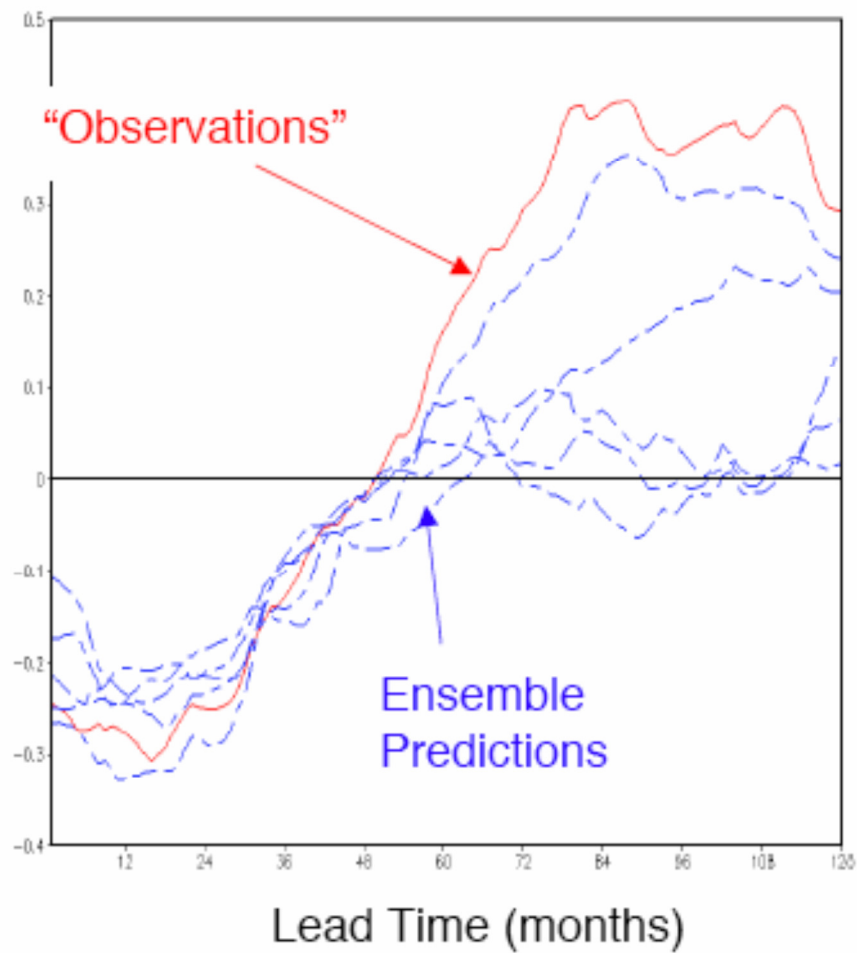
PDO Index = SST Averaged from 170E-130W and 5S-5N

Pattern correlation EOF1



Two out of five members (40%) show some predictive skill out to at least 10 years

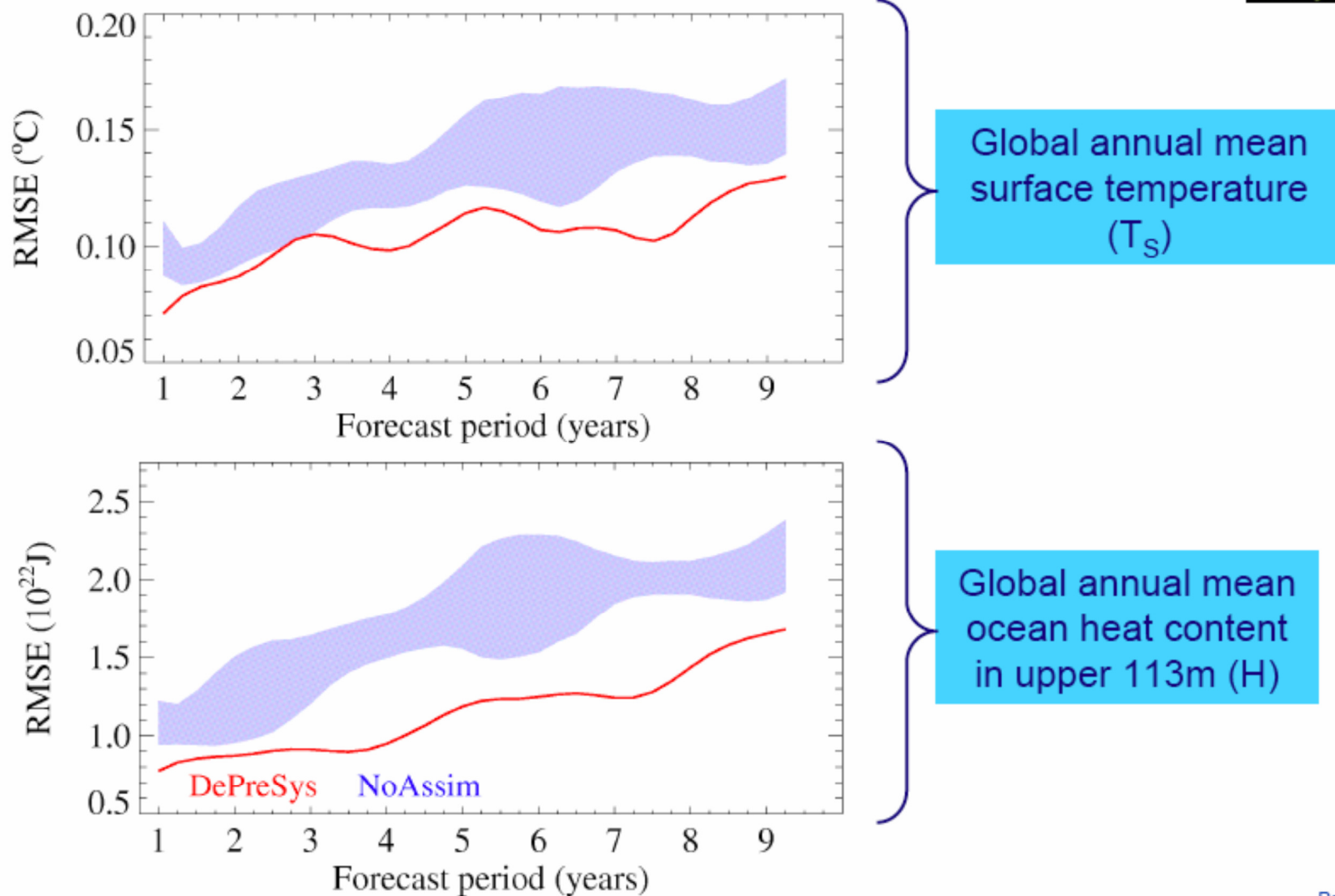
North Pacific Index Idealized Prediction Experiments



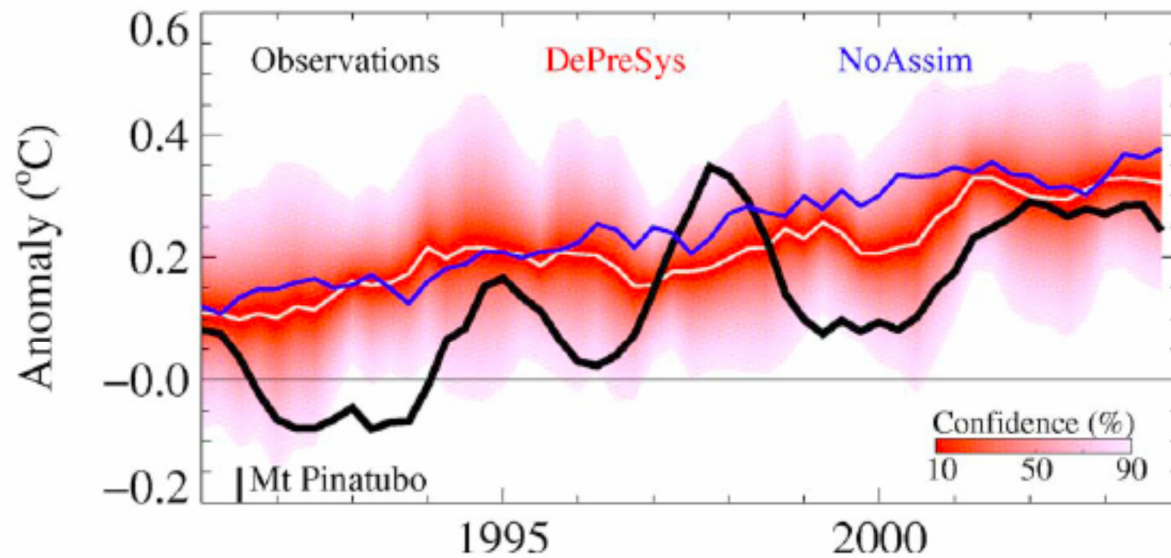
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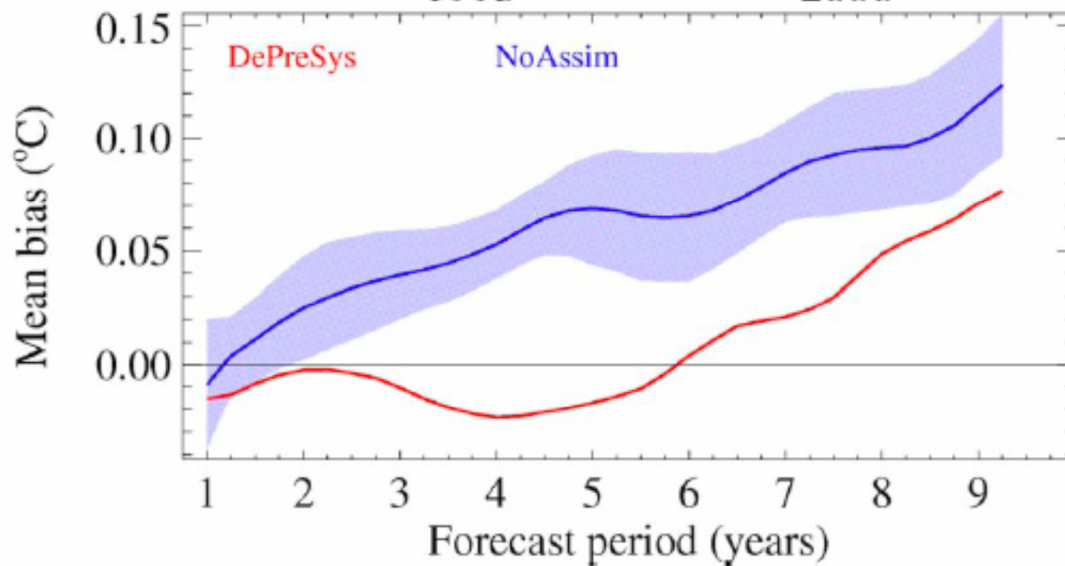
Improved skill is found in hindcasts of global mean surface temperature, explained mainly by ENSO in first year, and by better predictions of upper ocean heat content at longer lead times



Skill at longer lead times due to bias removal

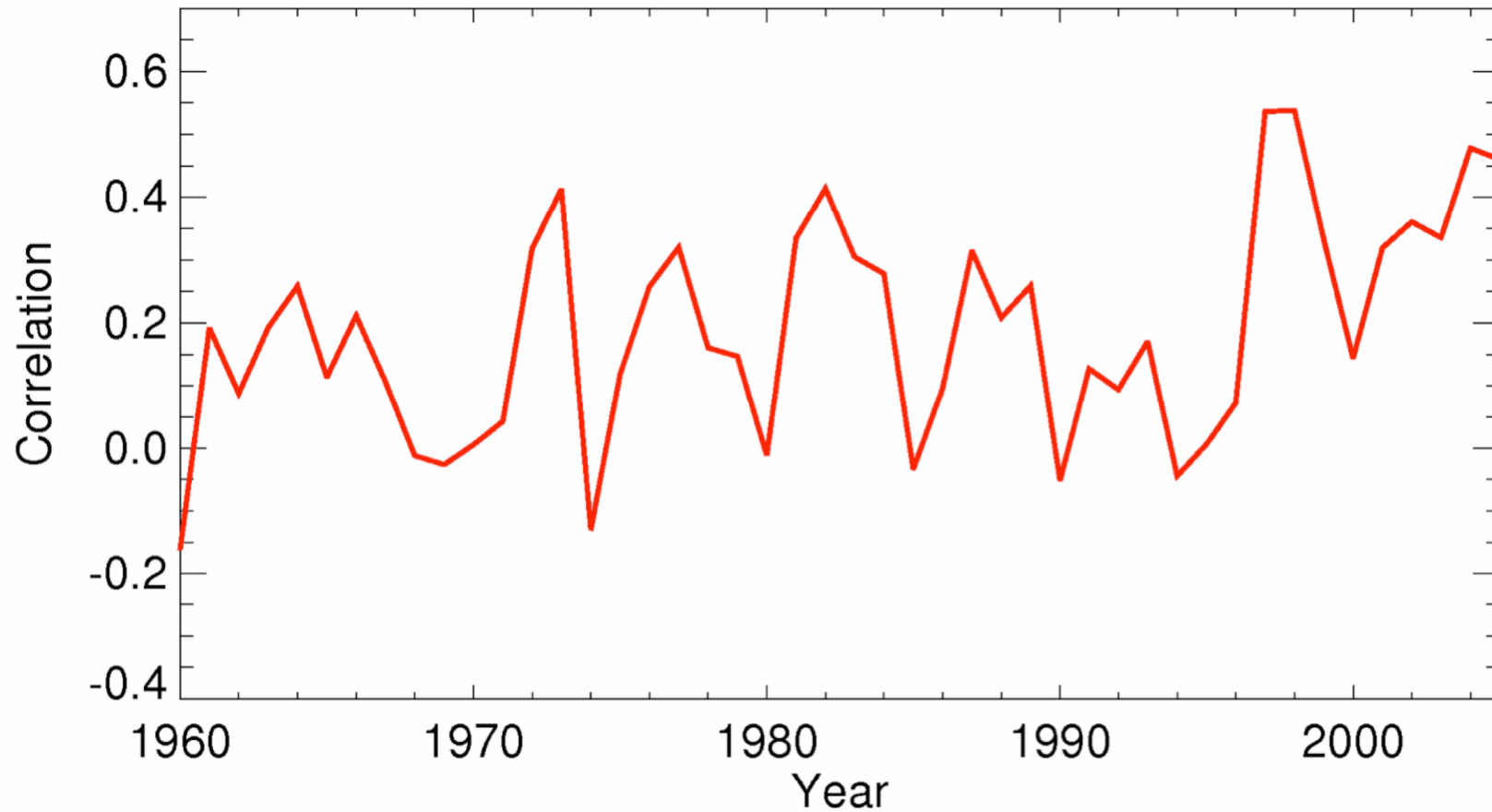


Time series of year 9 hindcast T_S



Mean bias of hindcast T_S

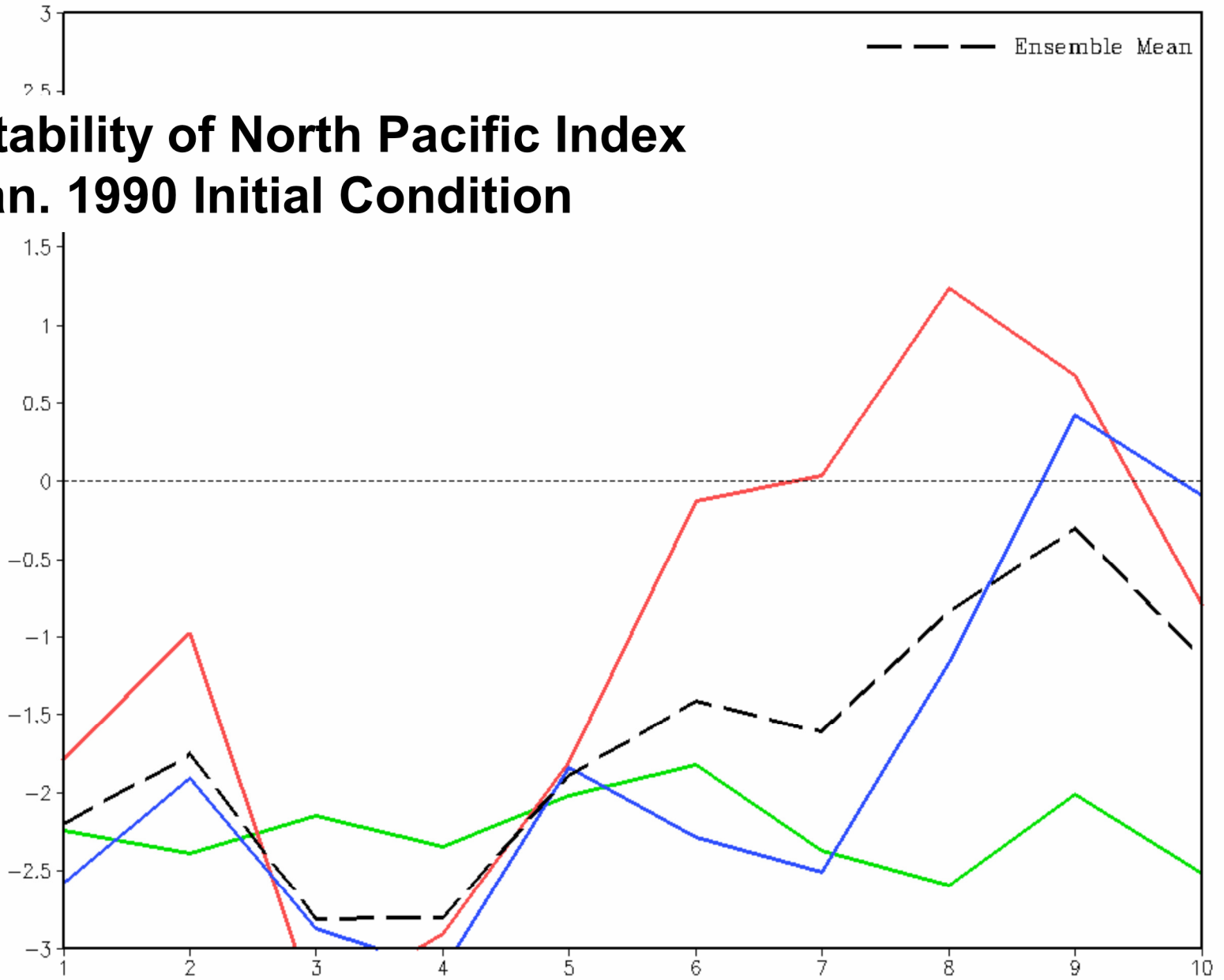
Correlation Between Observed (HadCRUT3) and Predicted (DePreSys) 3-year Mean Surface Temperature Anomalies (Relative 1958-2001)



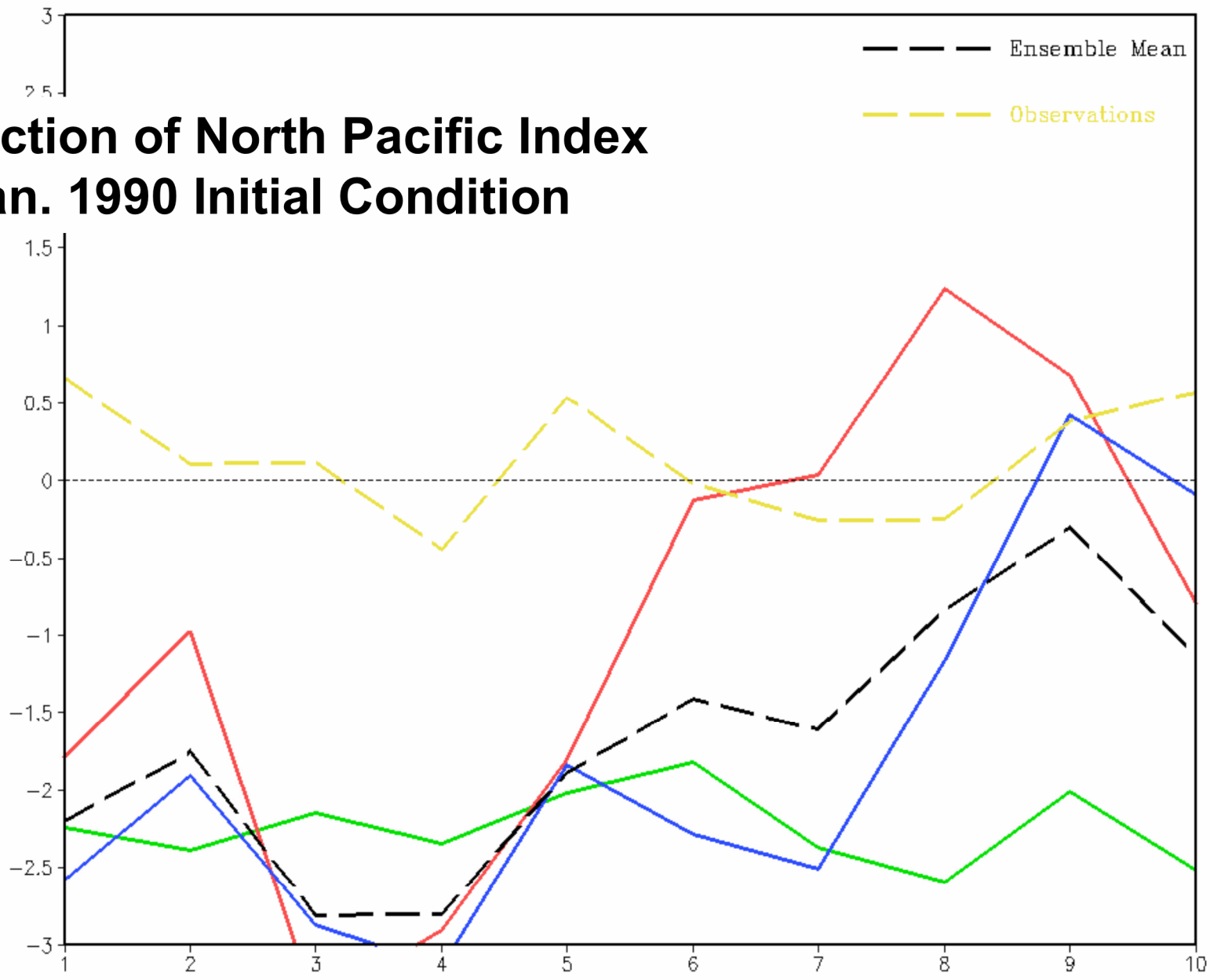
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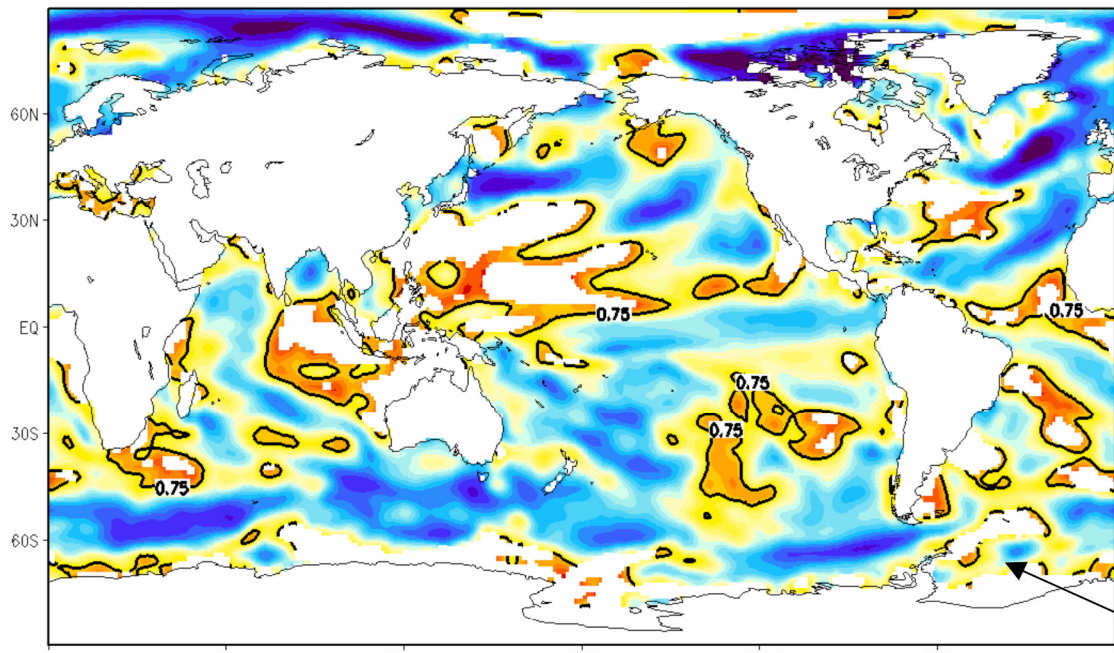
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Predictability of North Pacific Index Jan. 1990 Initial Condition



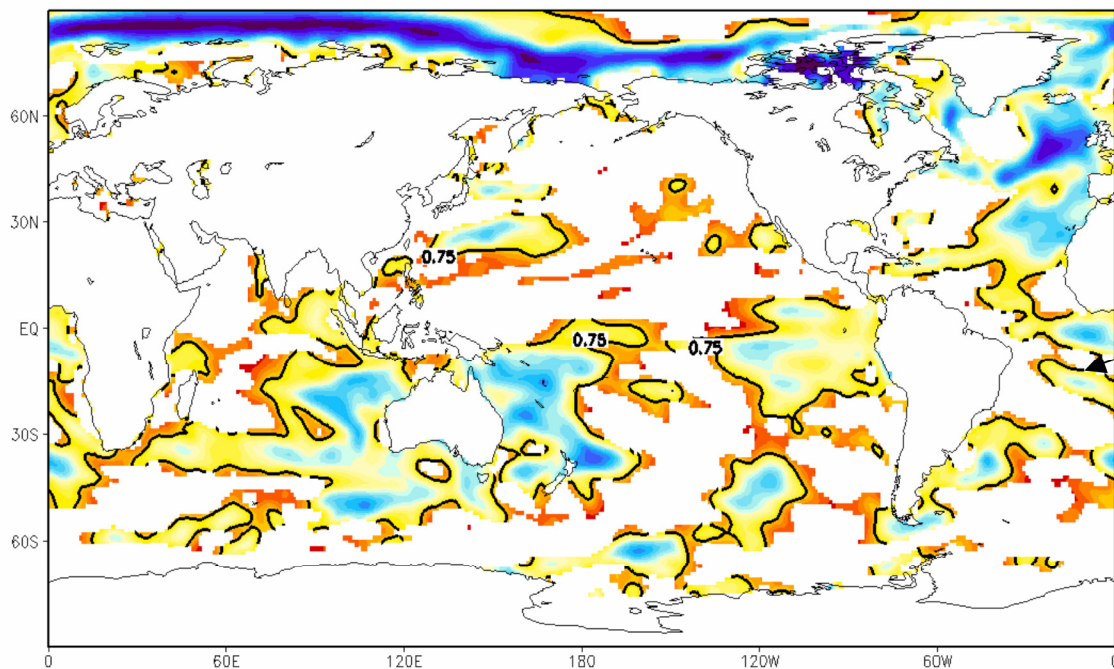
Prediction of North Pacific Index Jan. 1990 Initial Condition



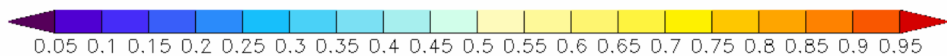


**Predictability Estimate:
Forecast Spread as a
Fraction of Saturation**
Blue → **High Predictability**
Red → **Low Predictability**

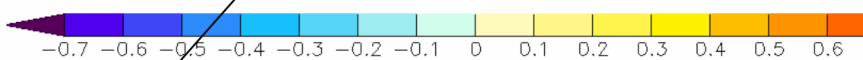
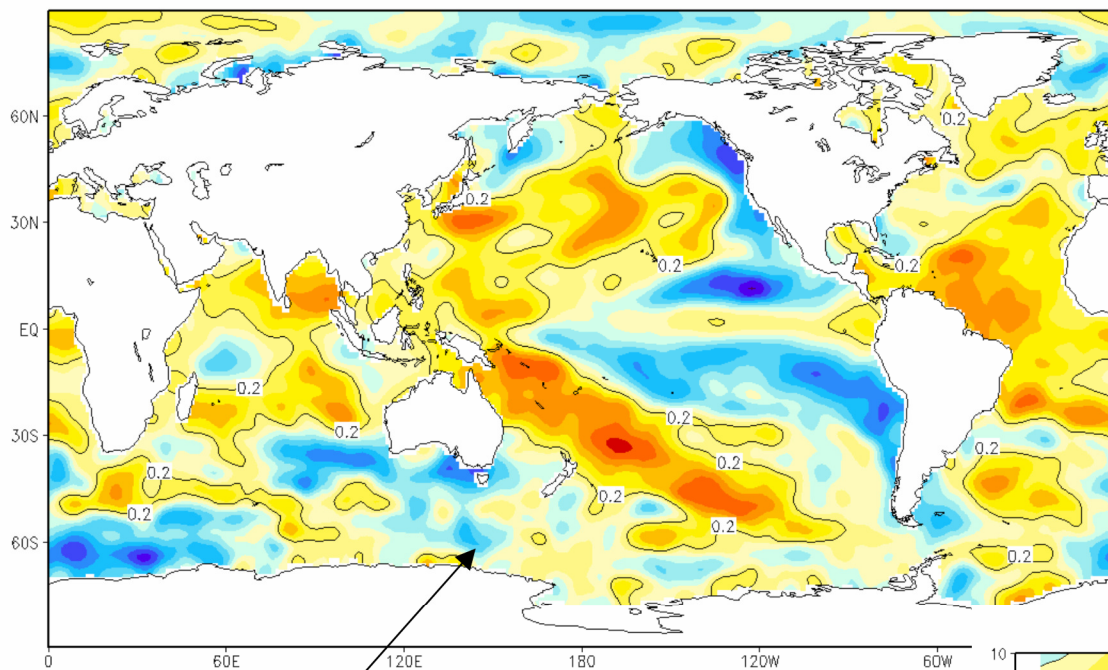
One-year Lead



Four-year Lead

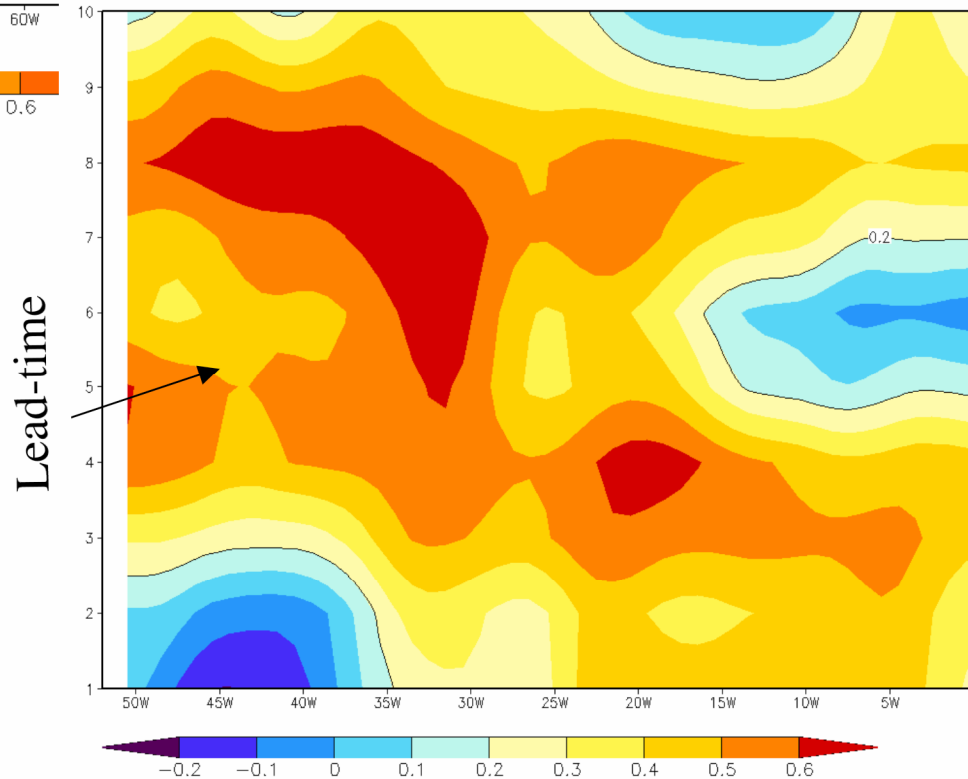


Hindcast Annual Mean SSTA Correlation Coefficient



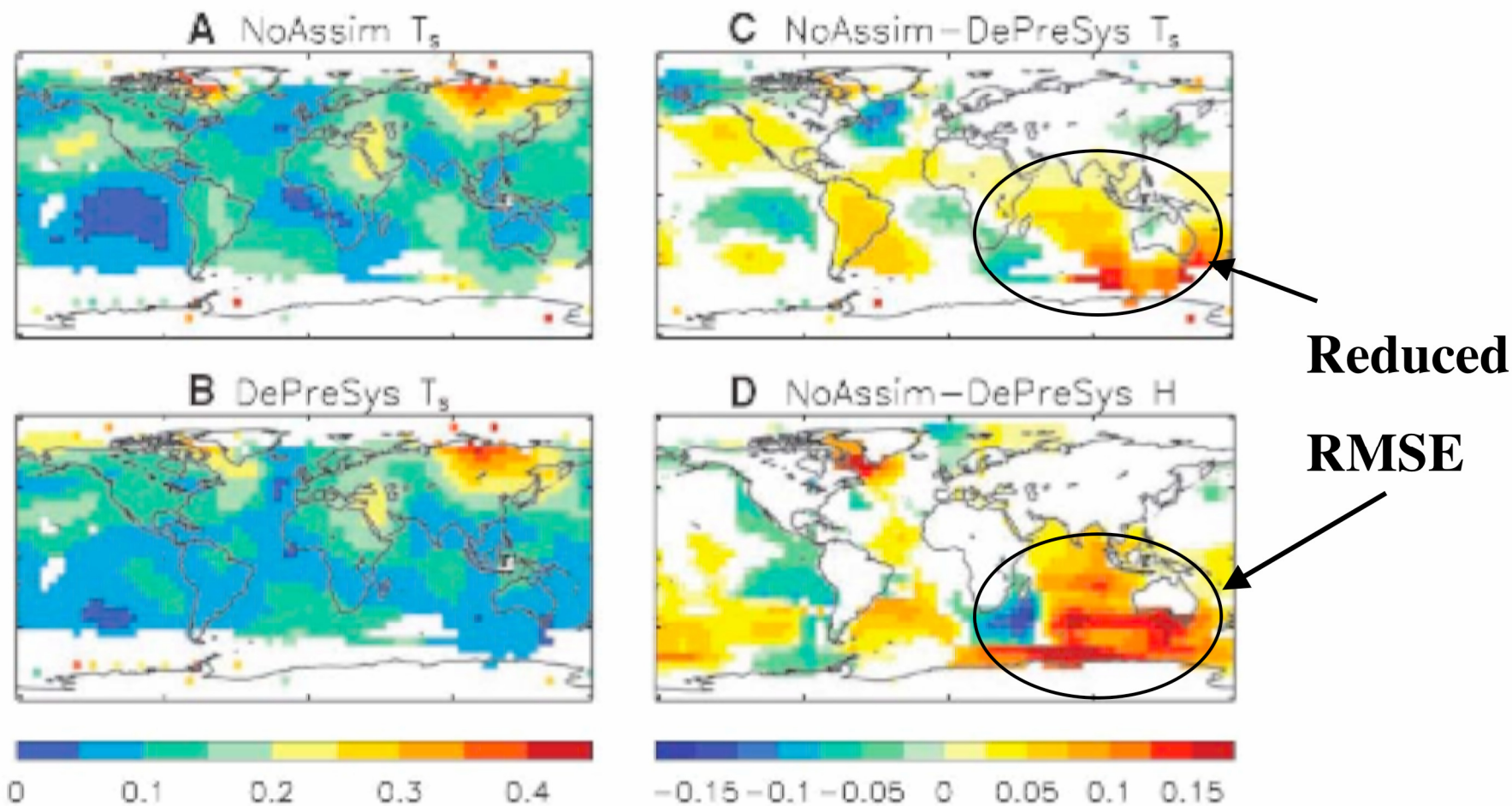
Lead-Time 8-years

**Equatorial Atlantic
Lead-Times 1-10 years**

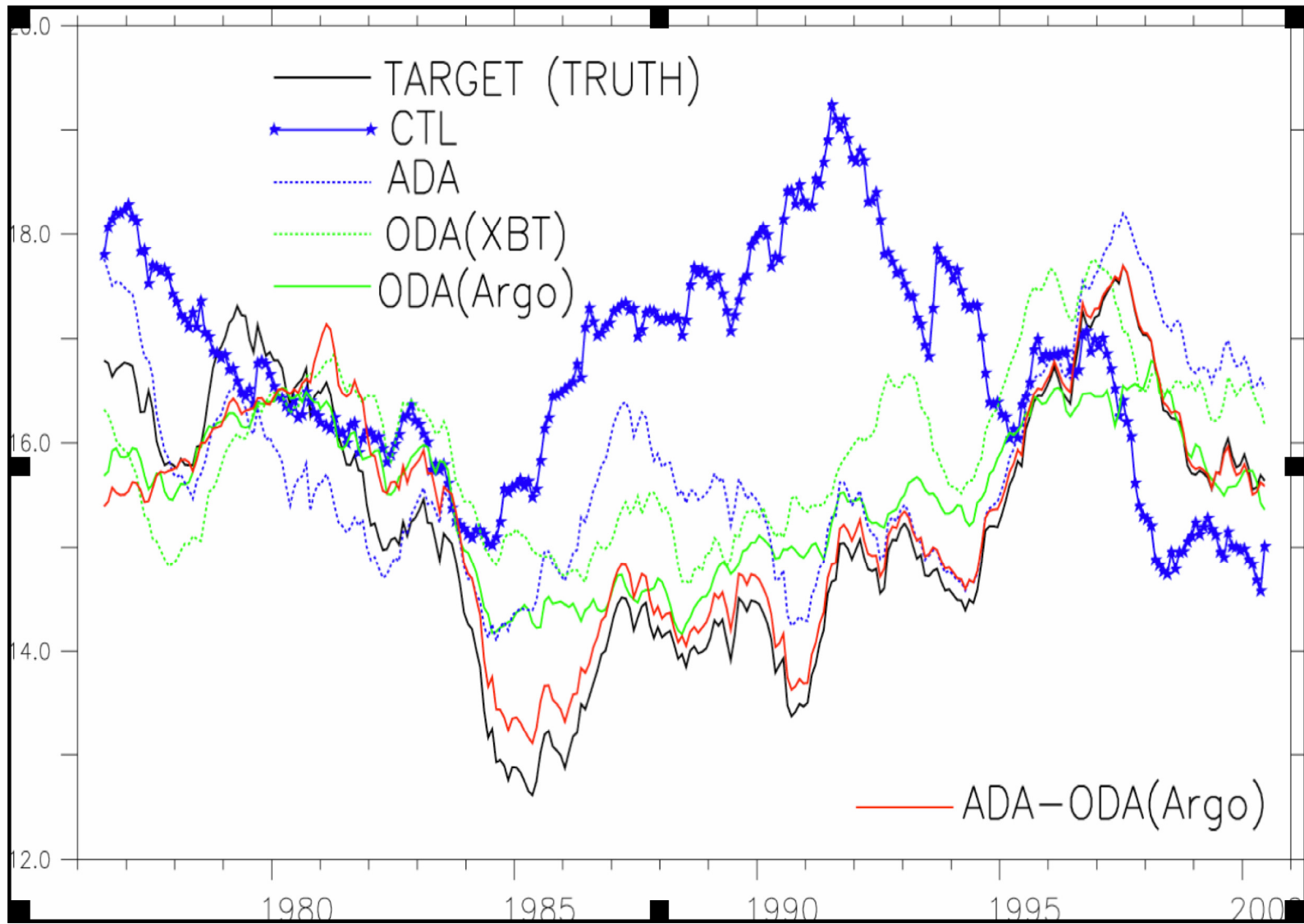


Challenges and Opportunities

- Identifying Sources and Limits of Predictability and Prediction Skill
 - Regional Predictability
 - “Higher Moments”
- Initializing the Total Climate System
 - Observing Systems
- Climate Drift/Model Errors
- Earth System Interactions
- Weather and Climate Link
- Unified/Multi-Scale Modeling
- Separating Forced vs. Natural Variability
 - Unpredictable Events (volcanoes)
 - Estimating the Climate Change Commitment
- Model Requirements
 - Resolution, Complexity, Ensemble Sizes
- Institutional and Infrastructure Issues
 - Computational Requirements
 - Data Requirements



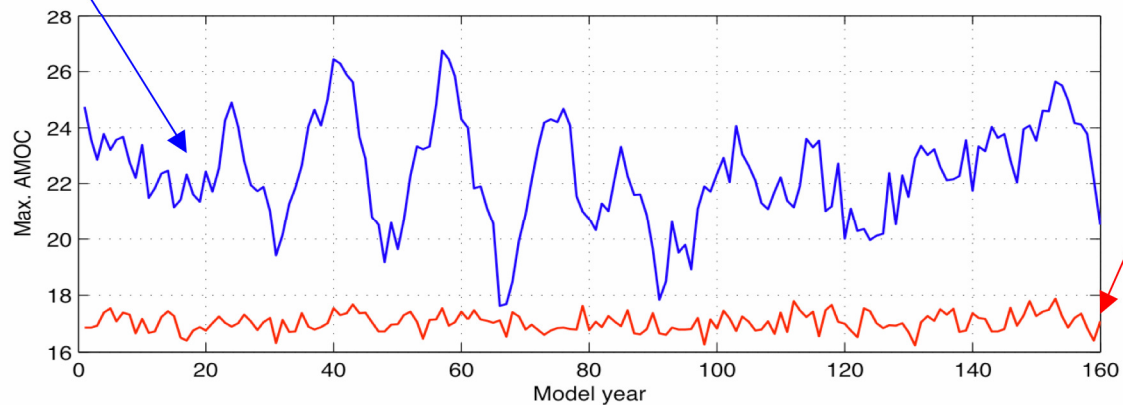
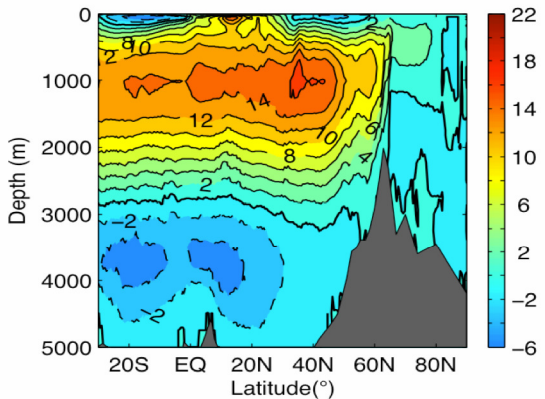
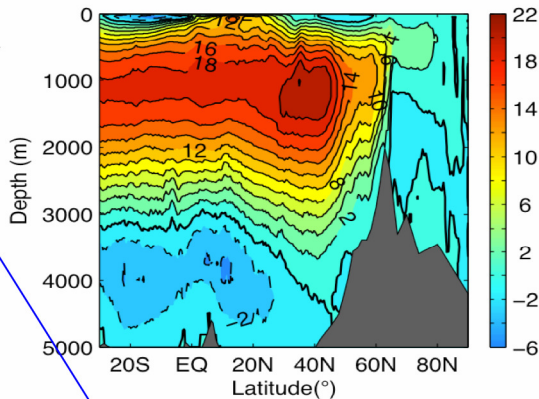
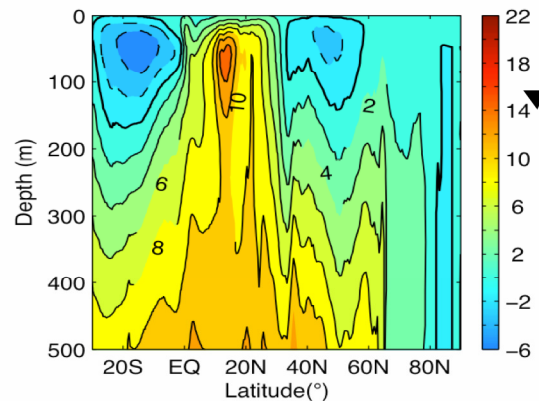
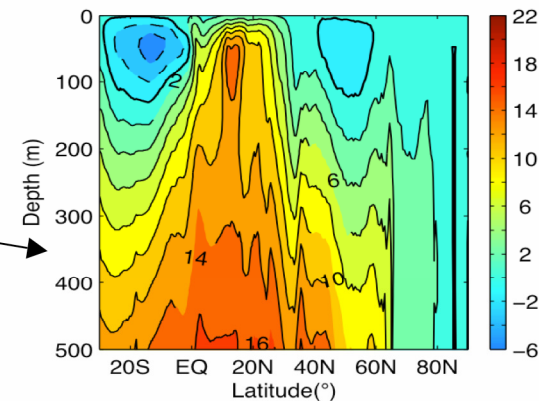
**RMSE of 9-year Mean
Temperature and Heat Content:
Impact of Initialization**



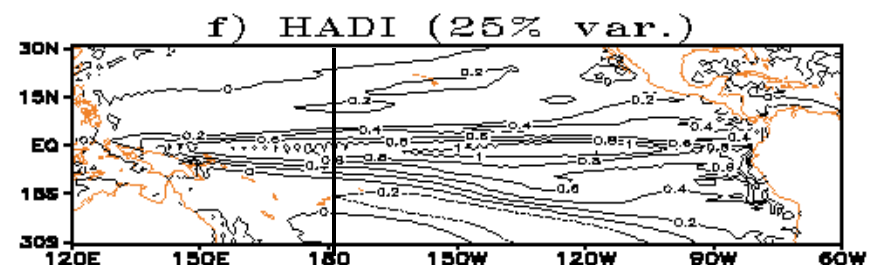
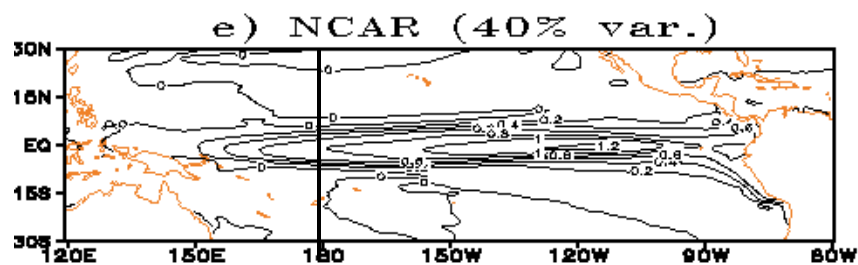
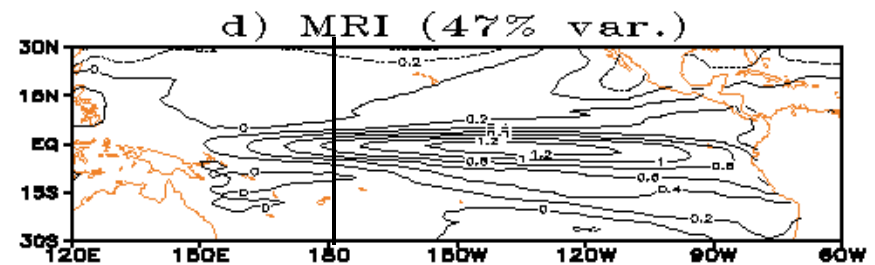
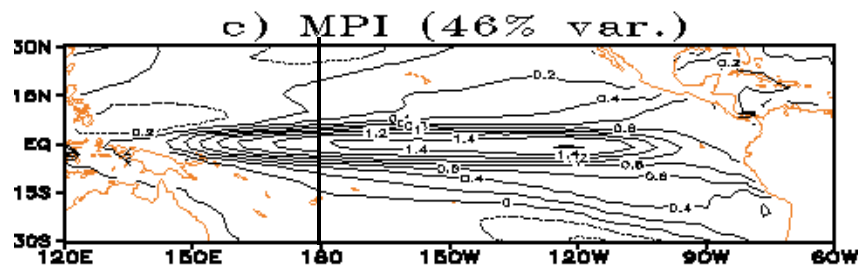
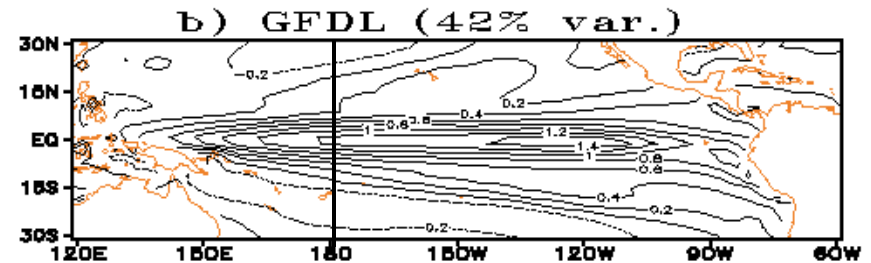
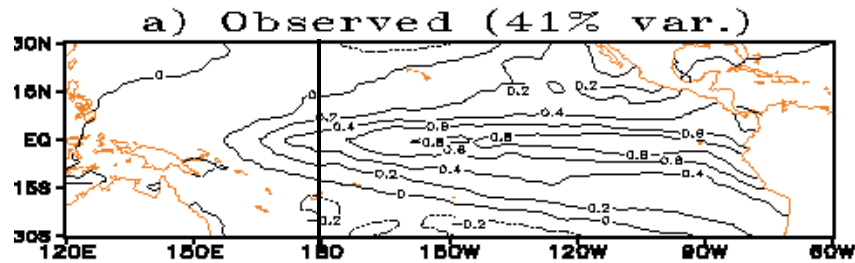
North/South Atlantic Meridional Stream Function

CCSM3.0

**Interactive
Ensemble
CCSM3.0**

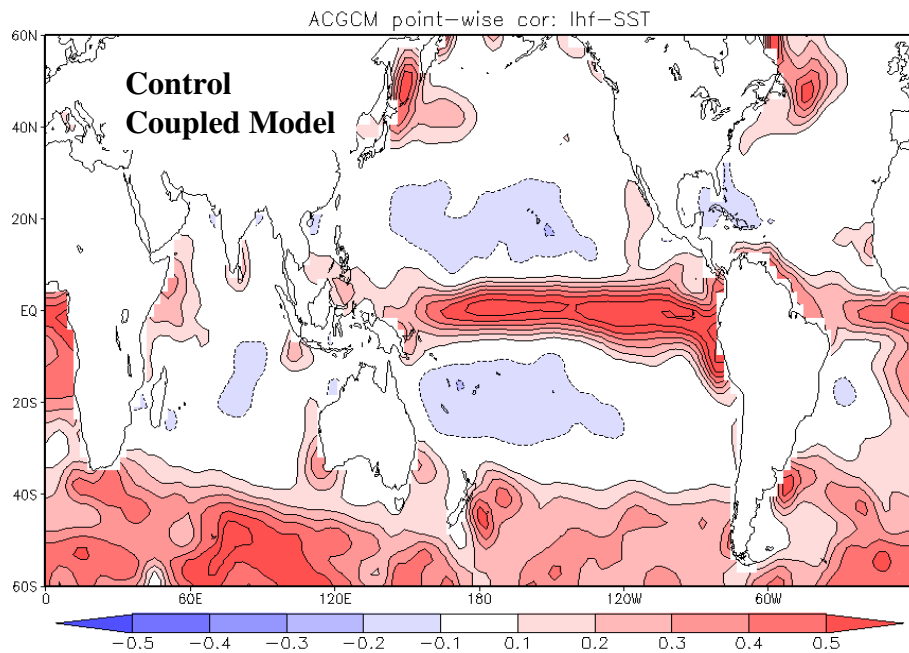
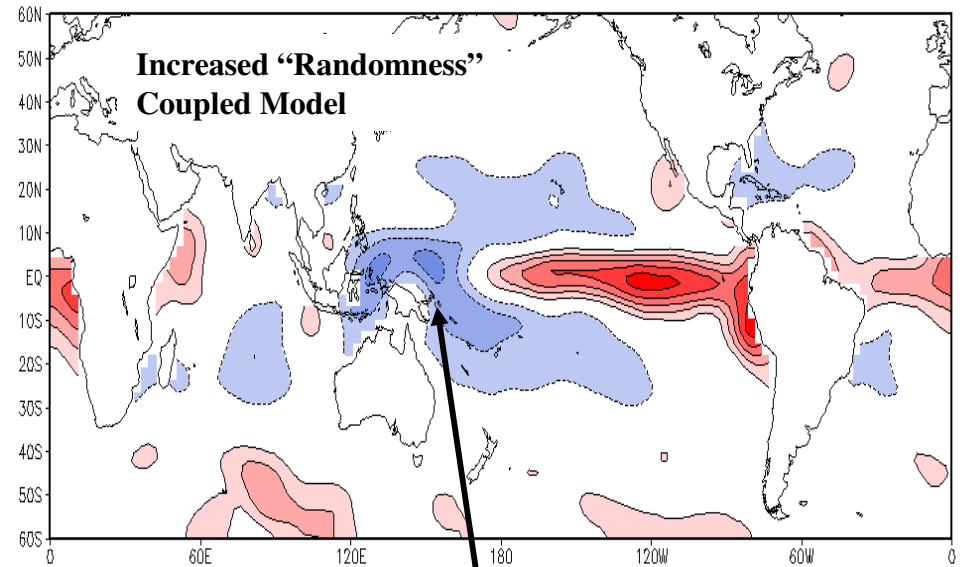
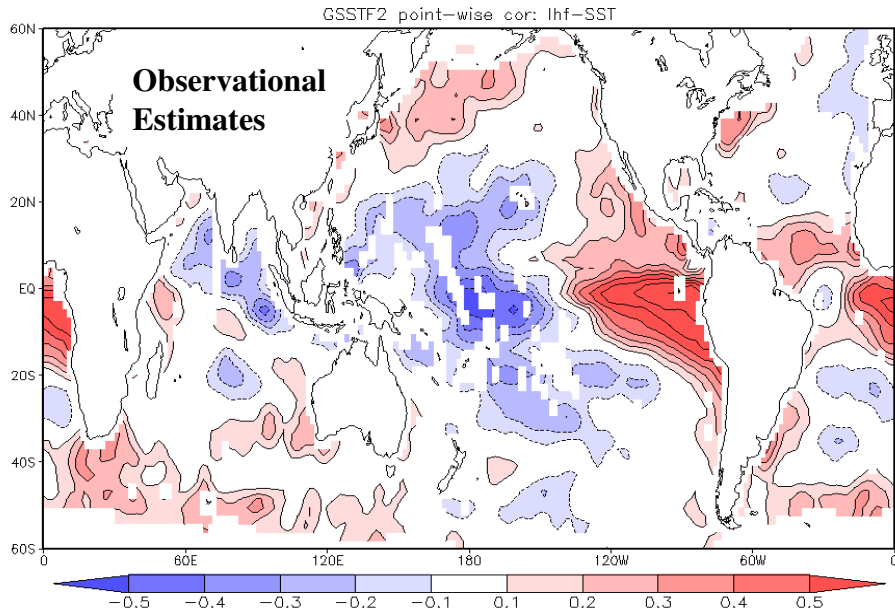


The 1st EOF mode of SSTA



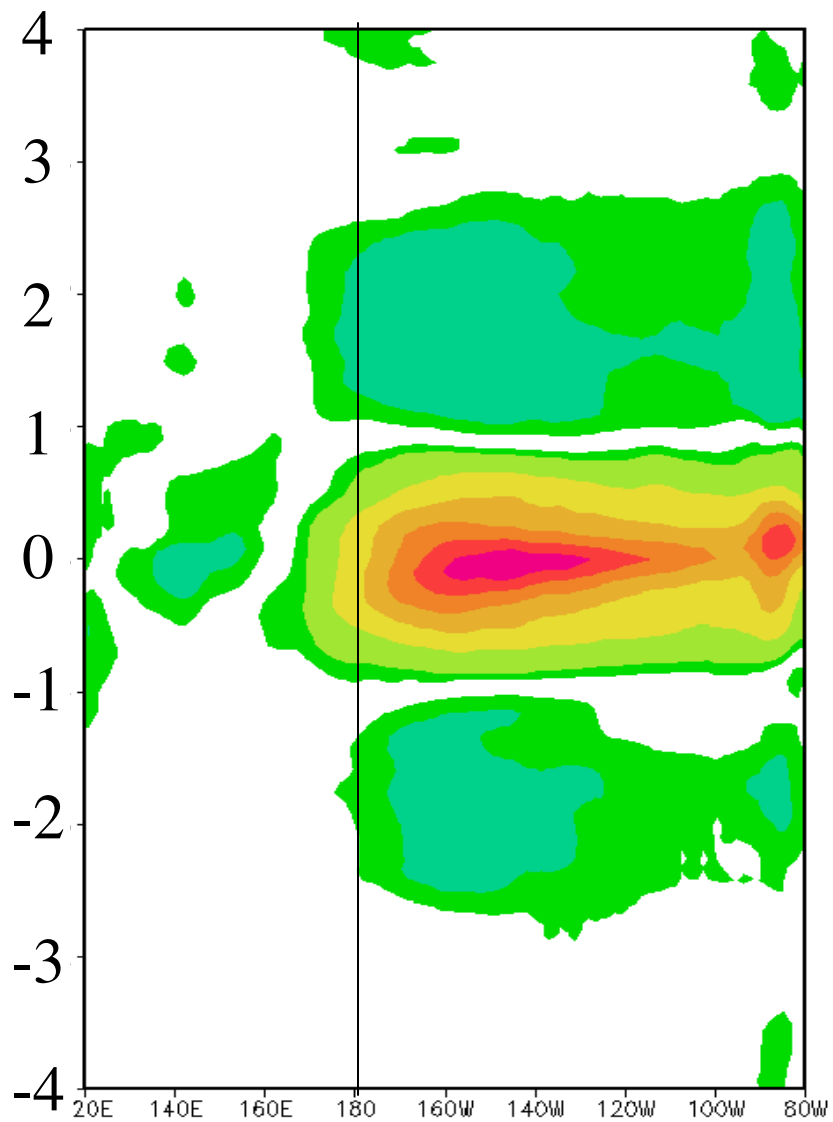
**Why Does ENSO Extend Too Far To The West?
The Weather and Climate Link?**

Contemporaneous Latent Heat Flux - SST Correlation

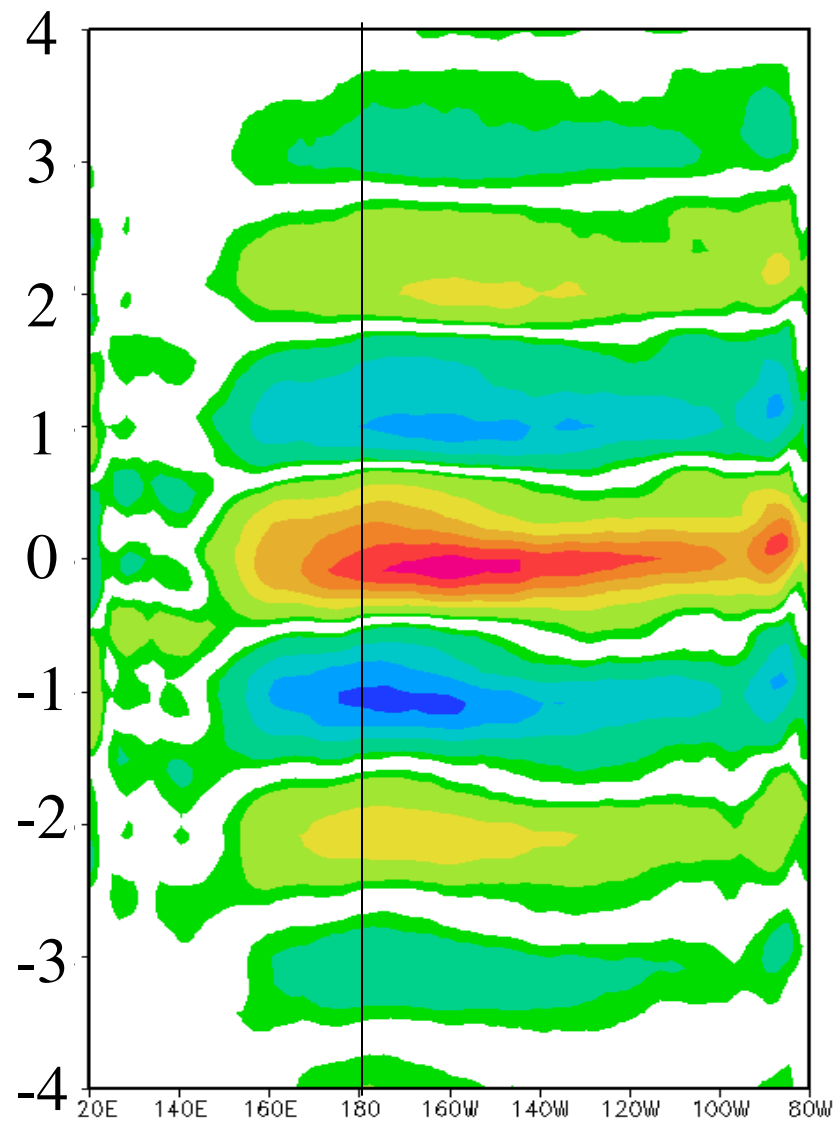


**Add White Noise Forcing
In Fluxes From Atmosphere
To The Ocean**

Noise Forced



Control



Nino34 Regression on Equatorial Pacific SSTA