ENSO Predictability and Prediction

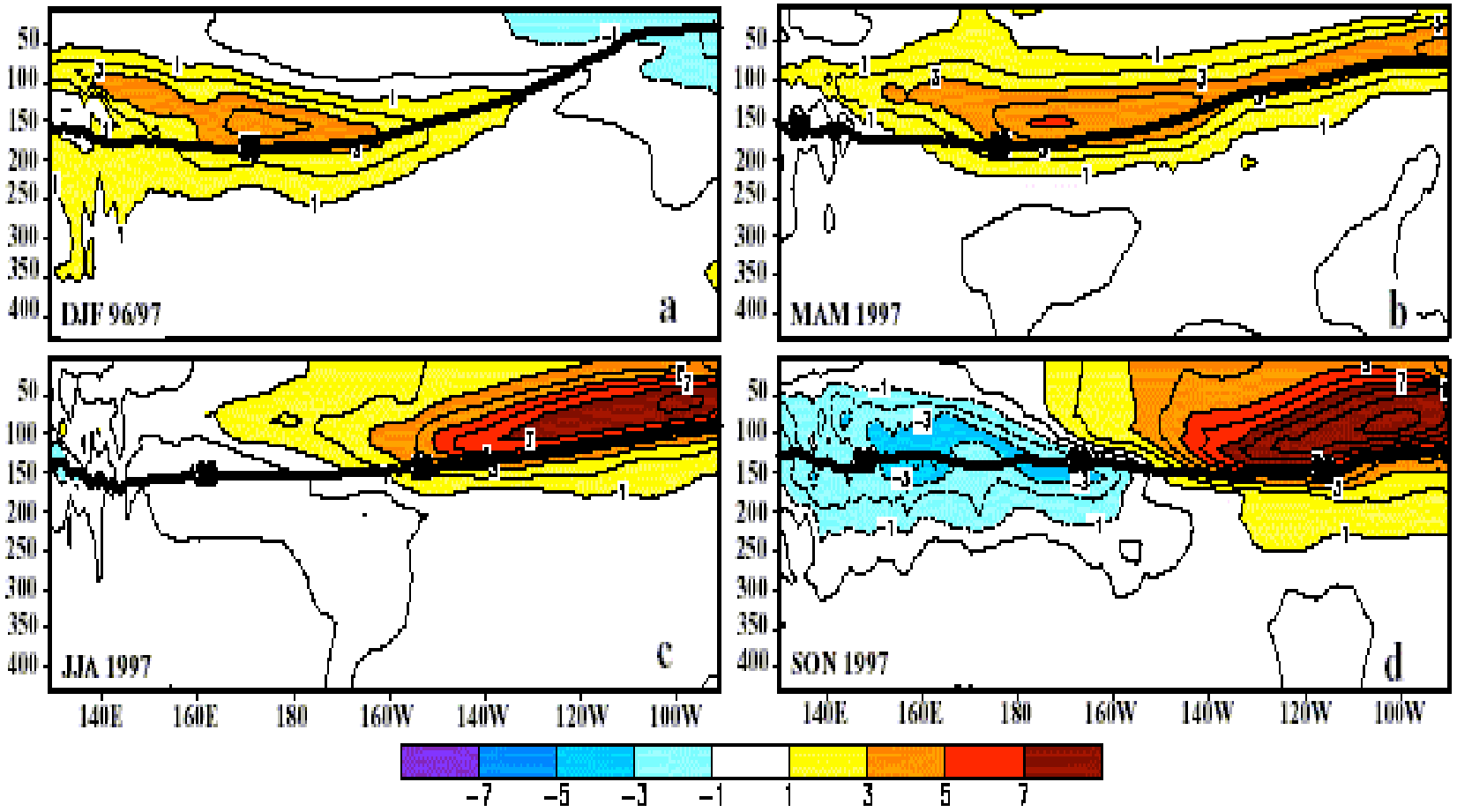
Predictability:

1. Why we can predict
2. How far into the future can we (theoretically) predict
   What is limiting the predictability?
   Model Error, Initial Condition Error, Intrinsic Limits

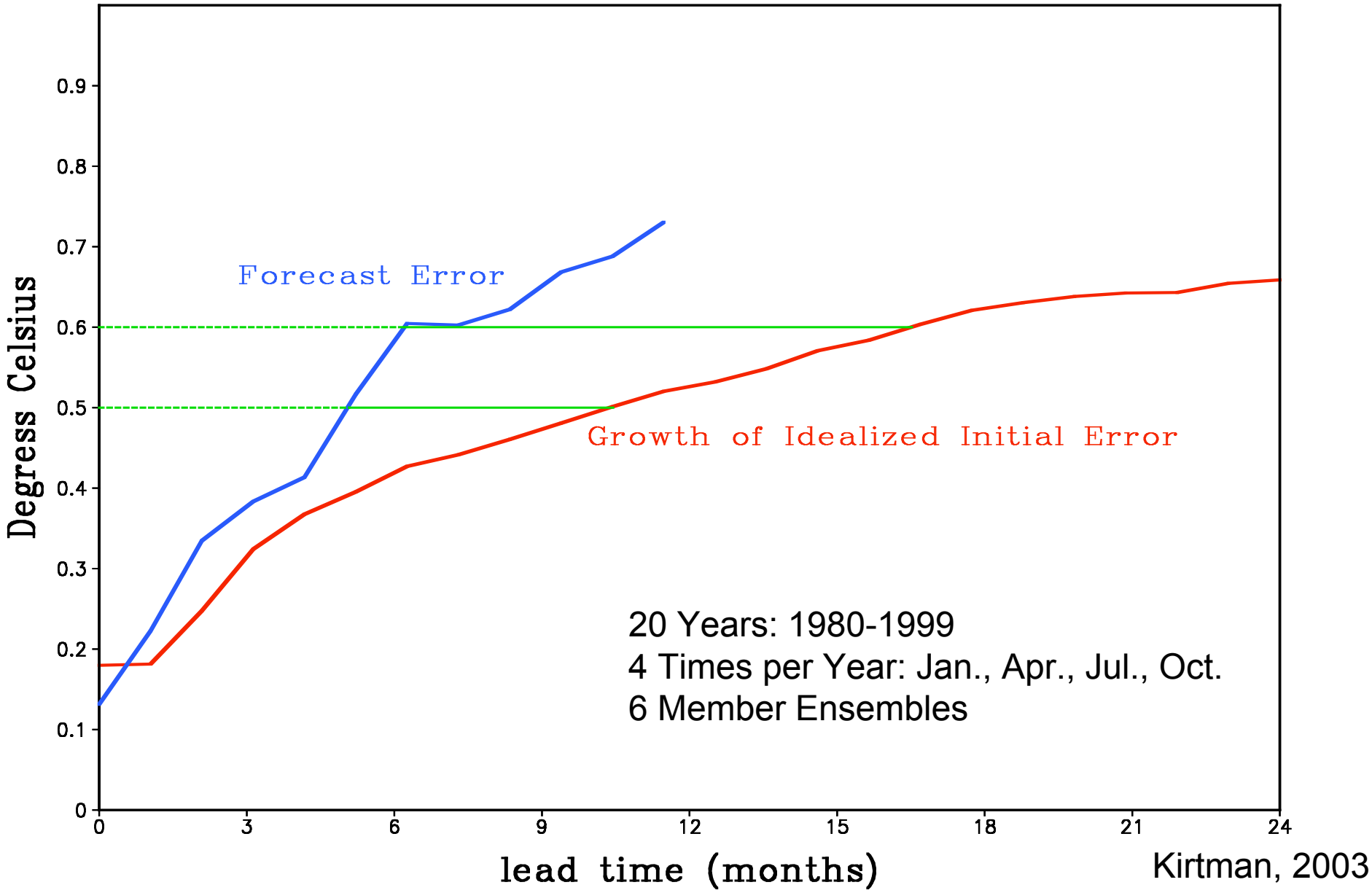
Prediction:

1. Historical Forecasting (no cheating)
   Also predictability!
   Need to Assess Forecast Quality
2. Forecasting the Future
   No Substitute for Real Prediction

(I) Predictability: Why We Can Predict (Precursors)

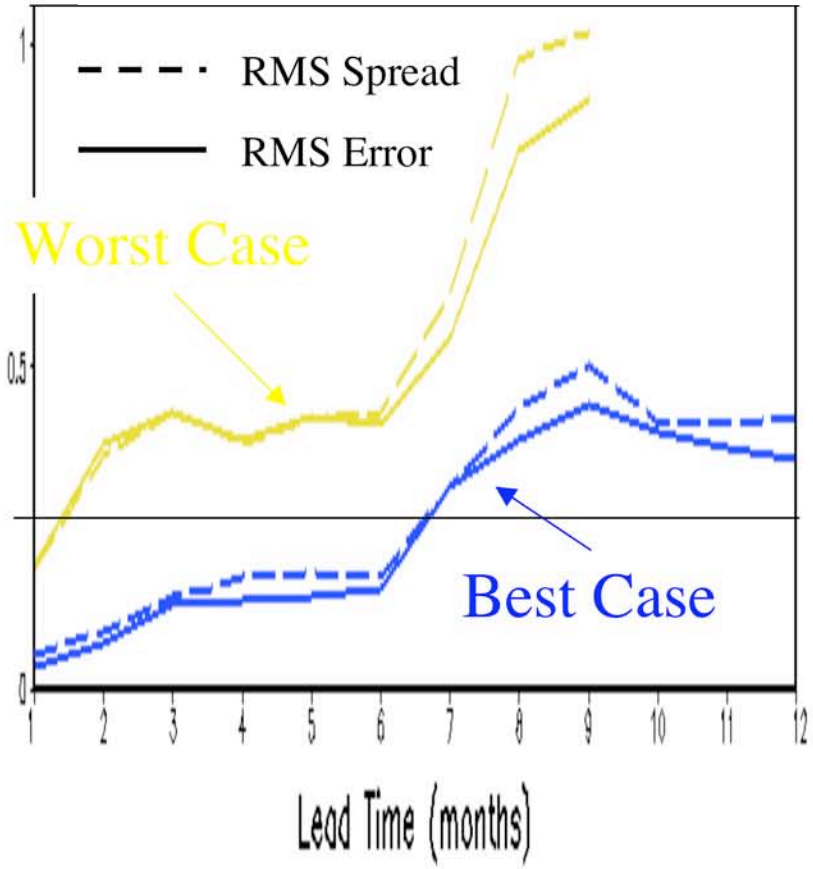


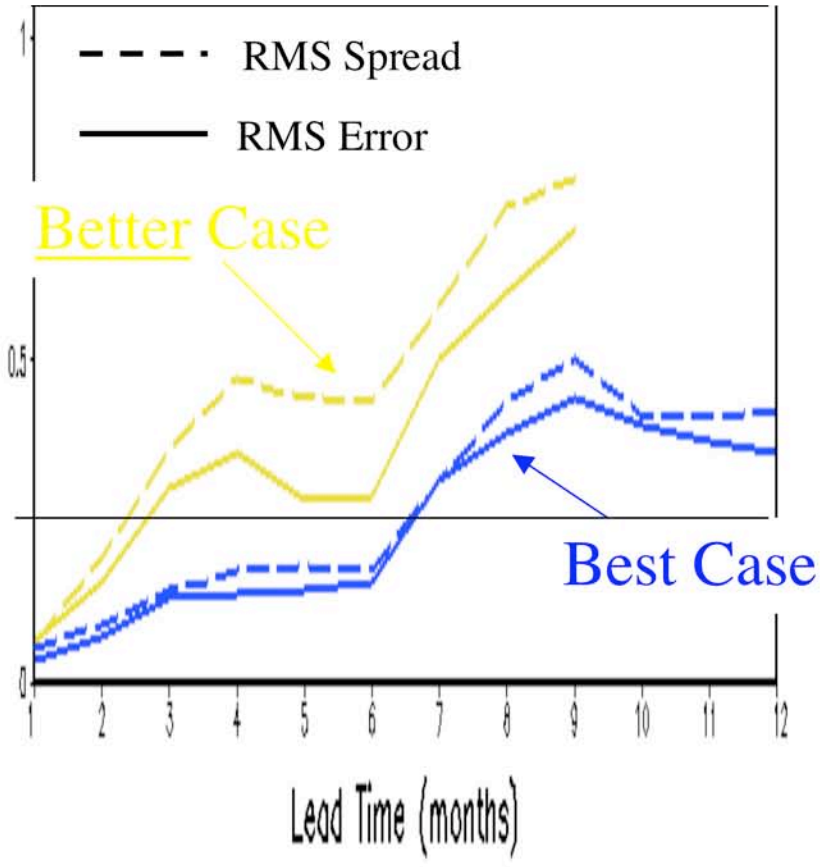
Current Limit of Predictability of ENSO (Nino3.4)
Potential Limit of Predictability of ENSO



Kirtman, 2003

(II) Predictability: How Far Into The Future Can We Predict What Limits Predictability





Worst Case: Initial Condition Error (Atmos+**Ocean**) + Model Error

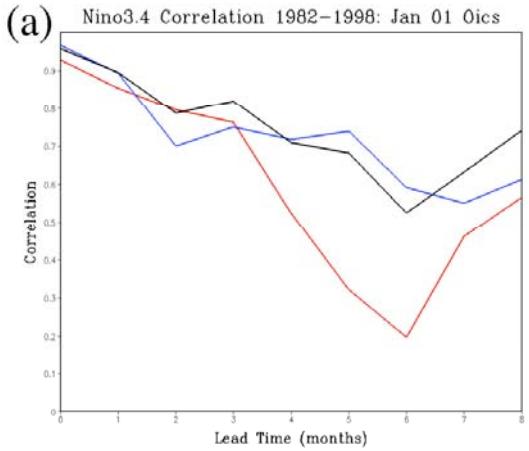
Better Case: Initial Condition Error (Atmos Only) + Model Error

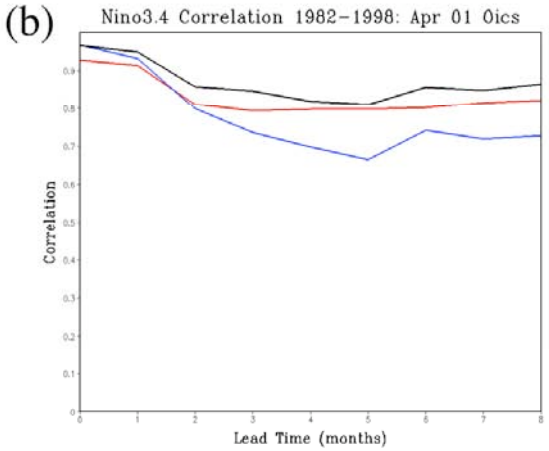
Best Case: Initial Condition Error (Atmos Only) + No Model Error

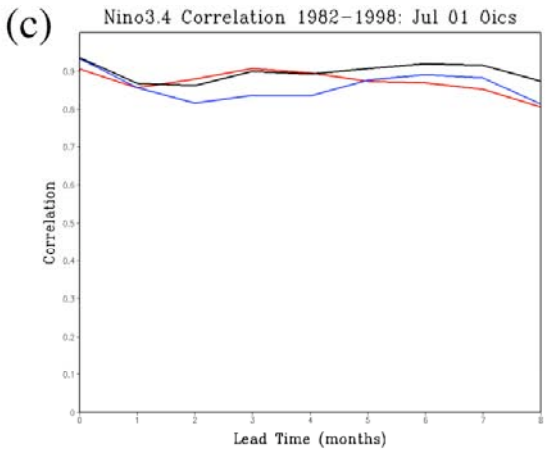
Historical Forecasting

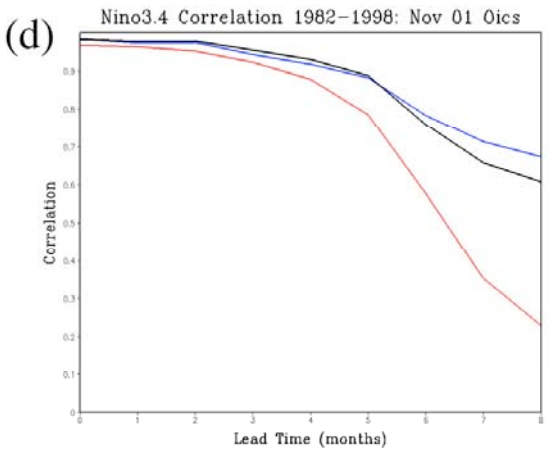
- CCSM3.0 vs. CCSM3.5
  - Initialization
    - Don't Necessarily Need to Have Your Own Data Assimilation System
    - But Much Better Balanced Initialization Possible
  - Impact of Reducing Systematic Error on Prediction Quality
    - Initialization shock
- Multi-Model
  - Mechanism for Quantifying Uncertainty
- Statistical Forecasting
  - Needed

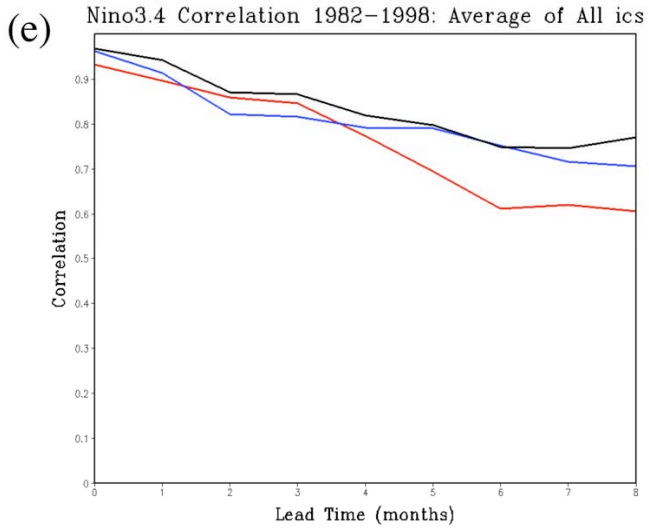
Nino3.4 Correlation Coefficient









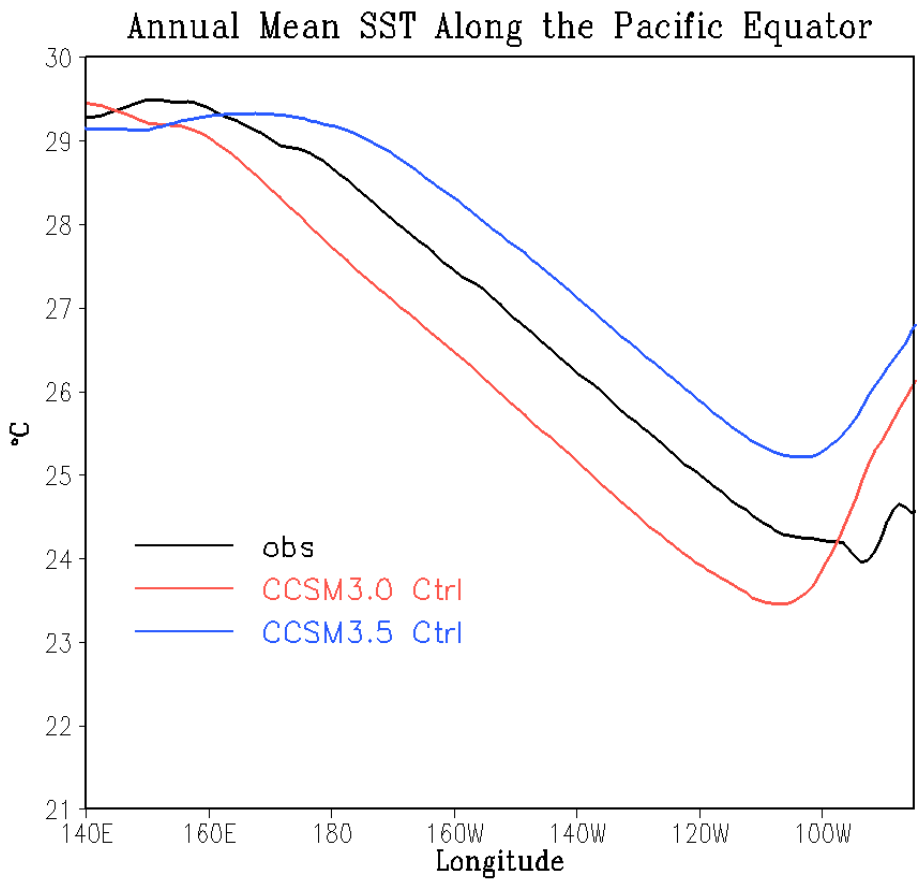


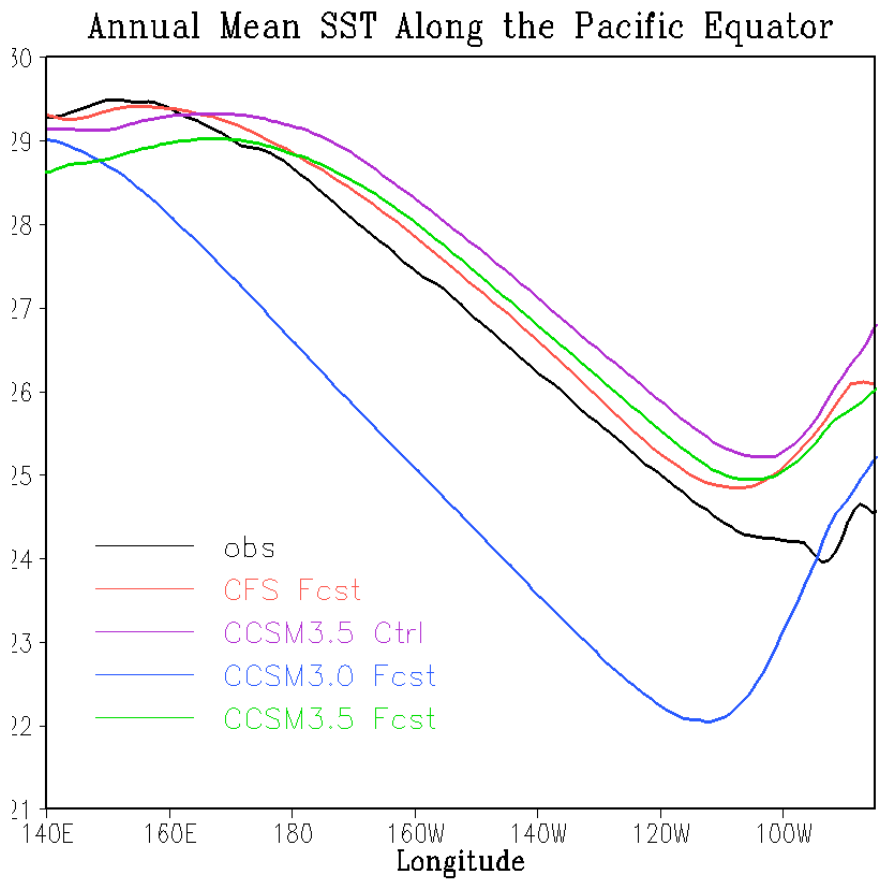
CFS

CCSM

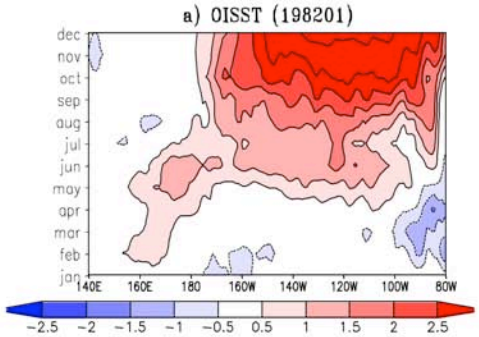
Multi-Model

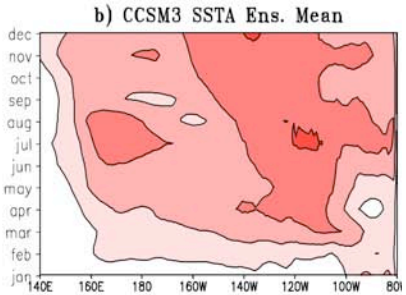
Impact of Reducing Systematic Error

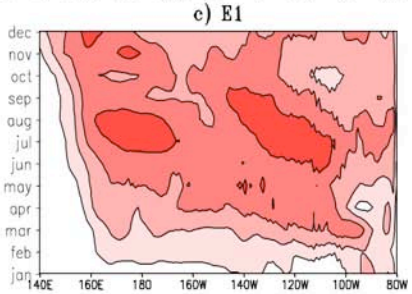


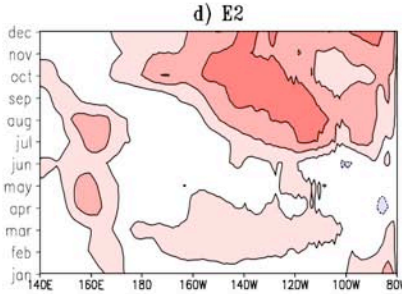


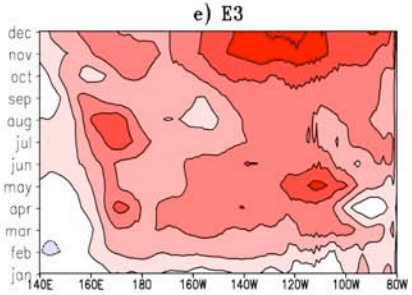
CCSM3.0 Jan 1982 IC

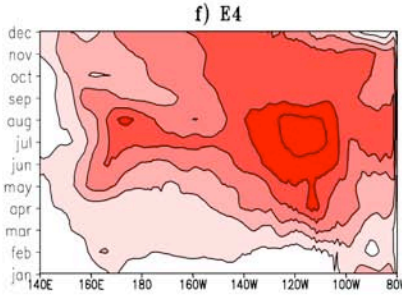


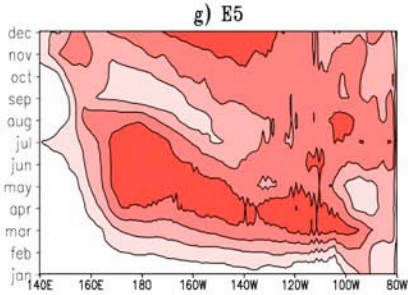


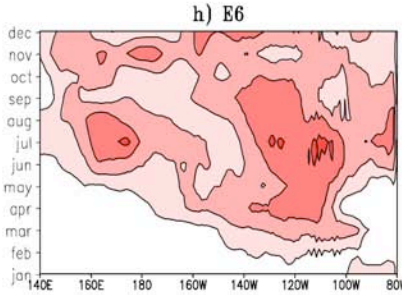




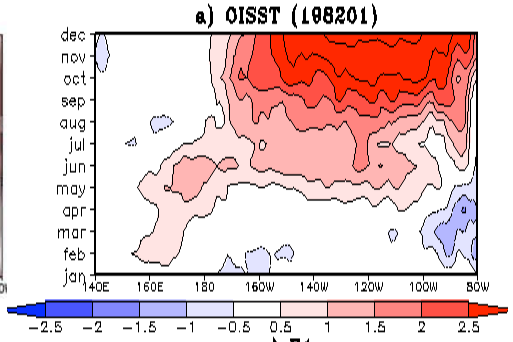


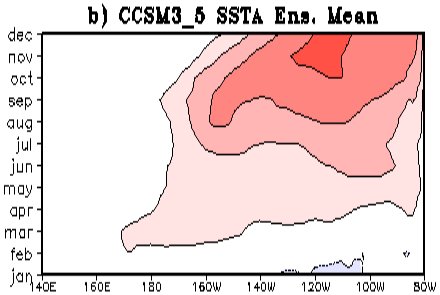


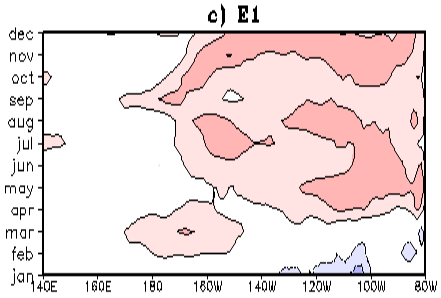


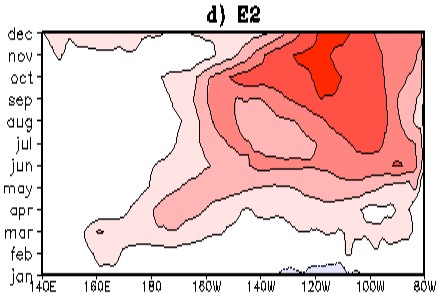


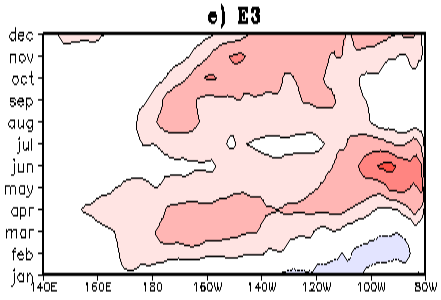
CCSM3.5 Jan 1982 IC

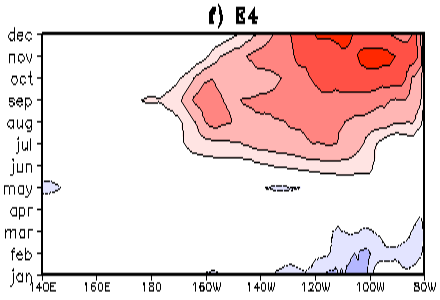


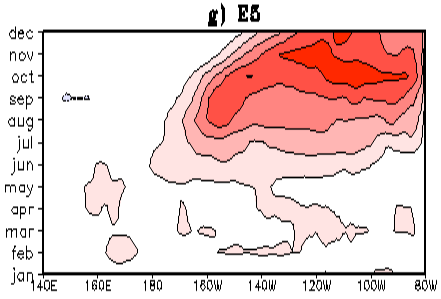


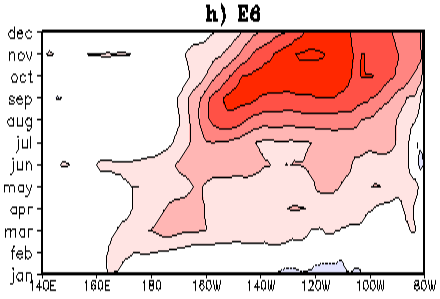






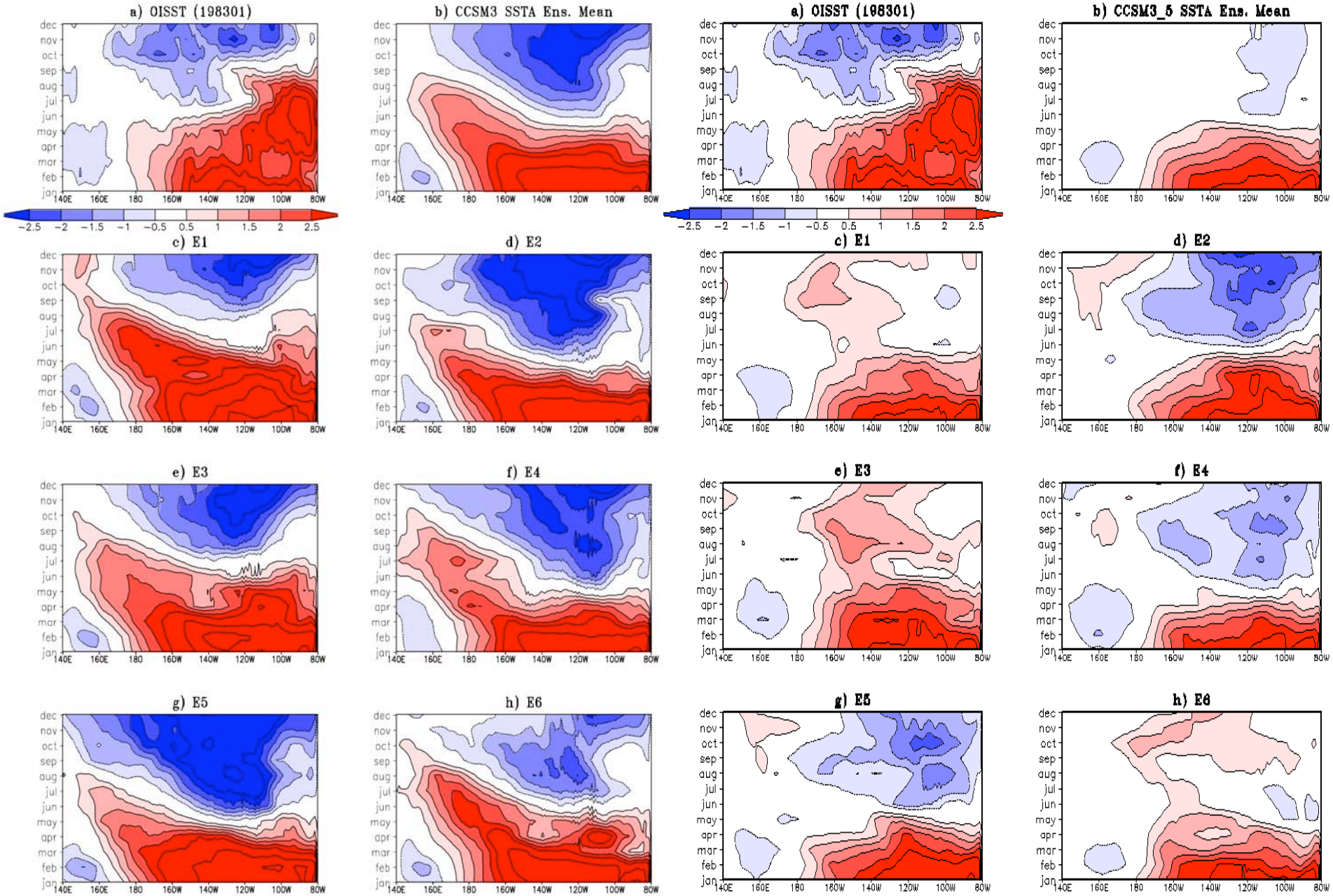


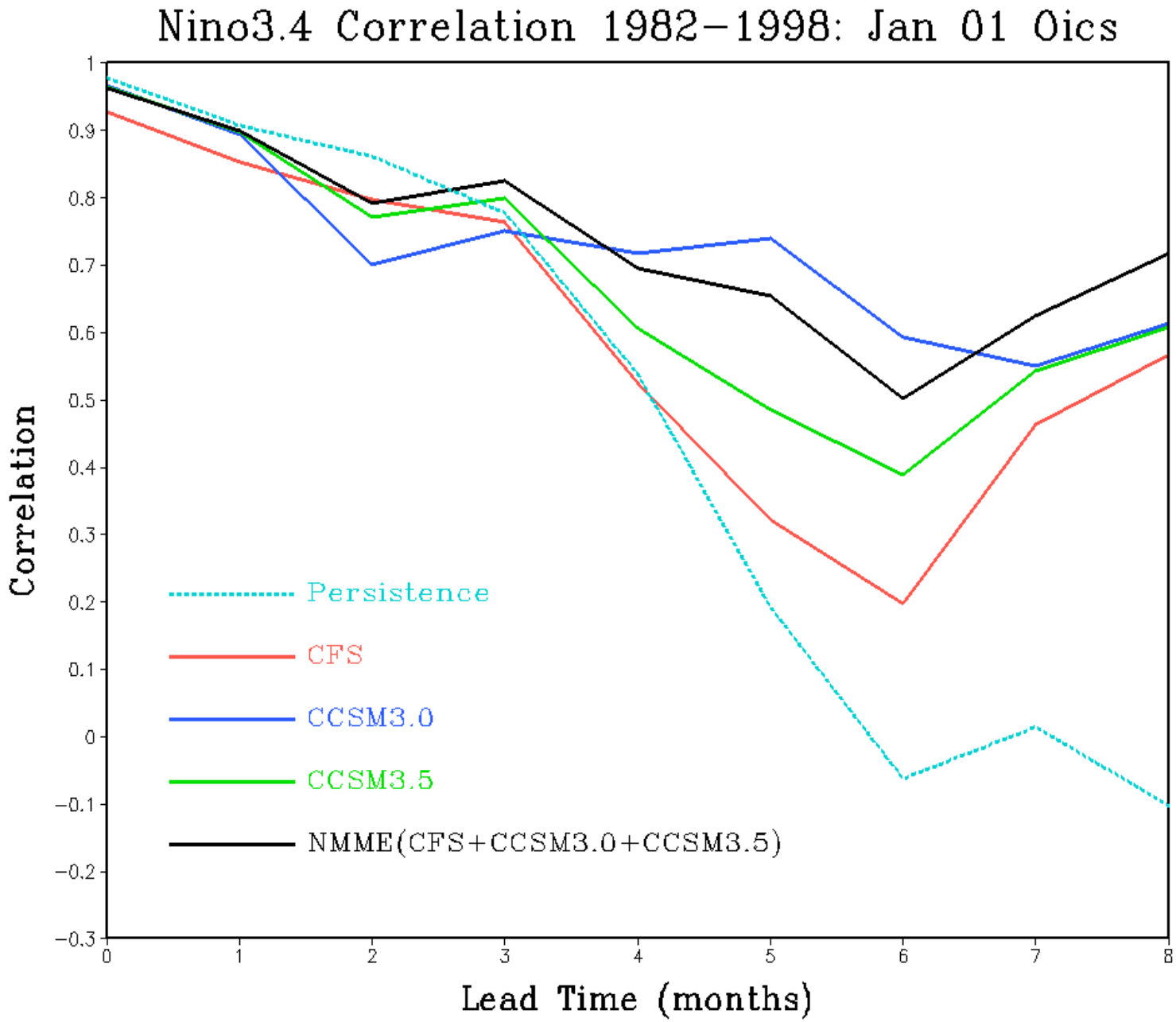


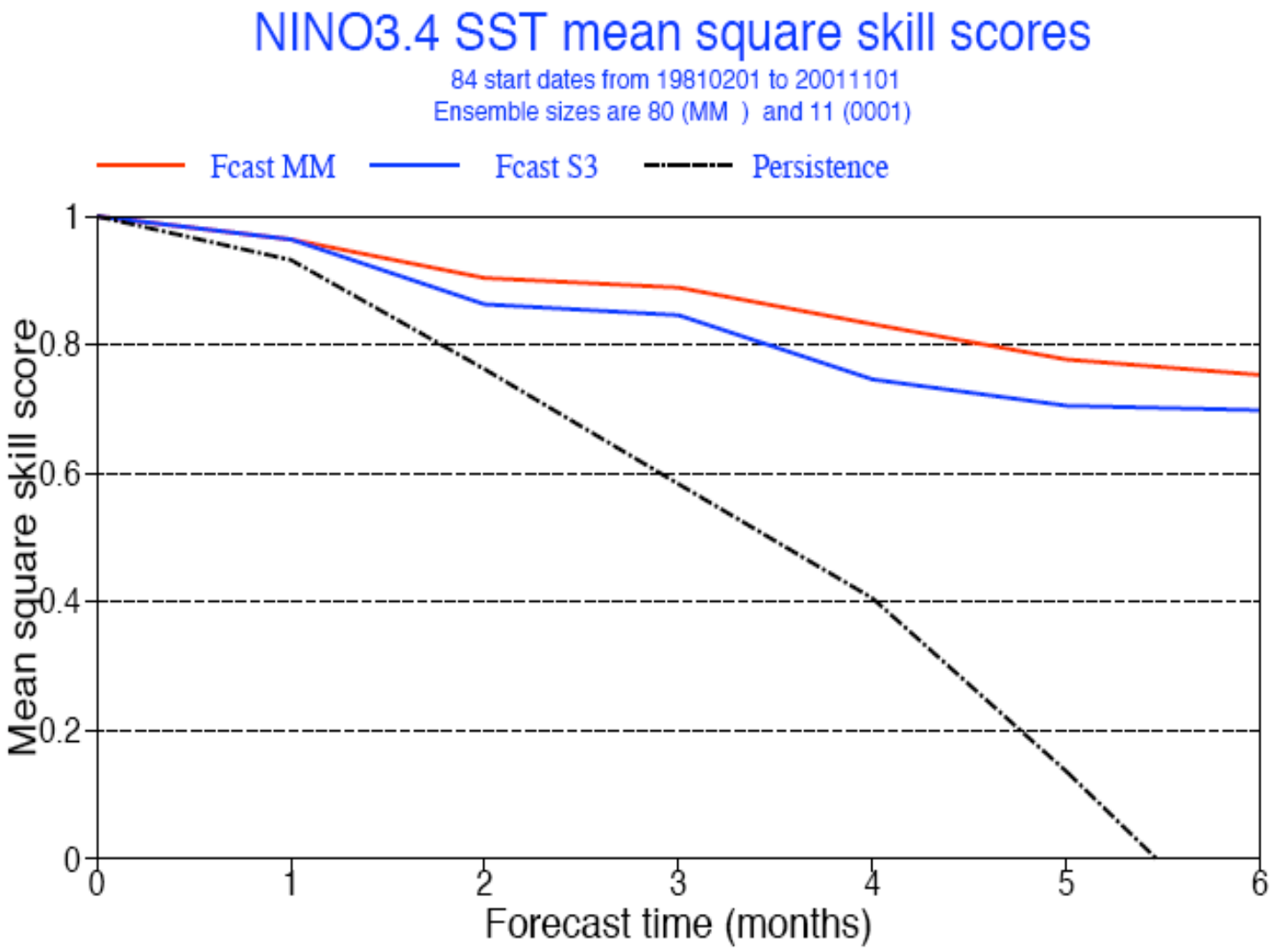


CCSM3.0 Jan 1983 IC

CCSM3.5 Jan 1983 IC

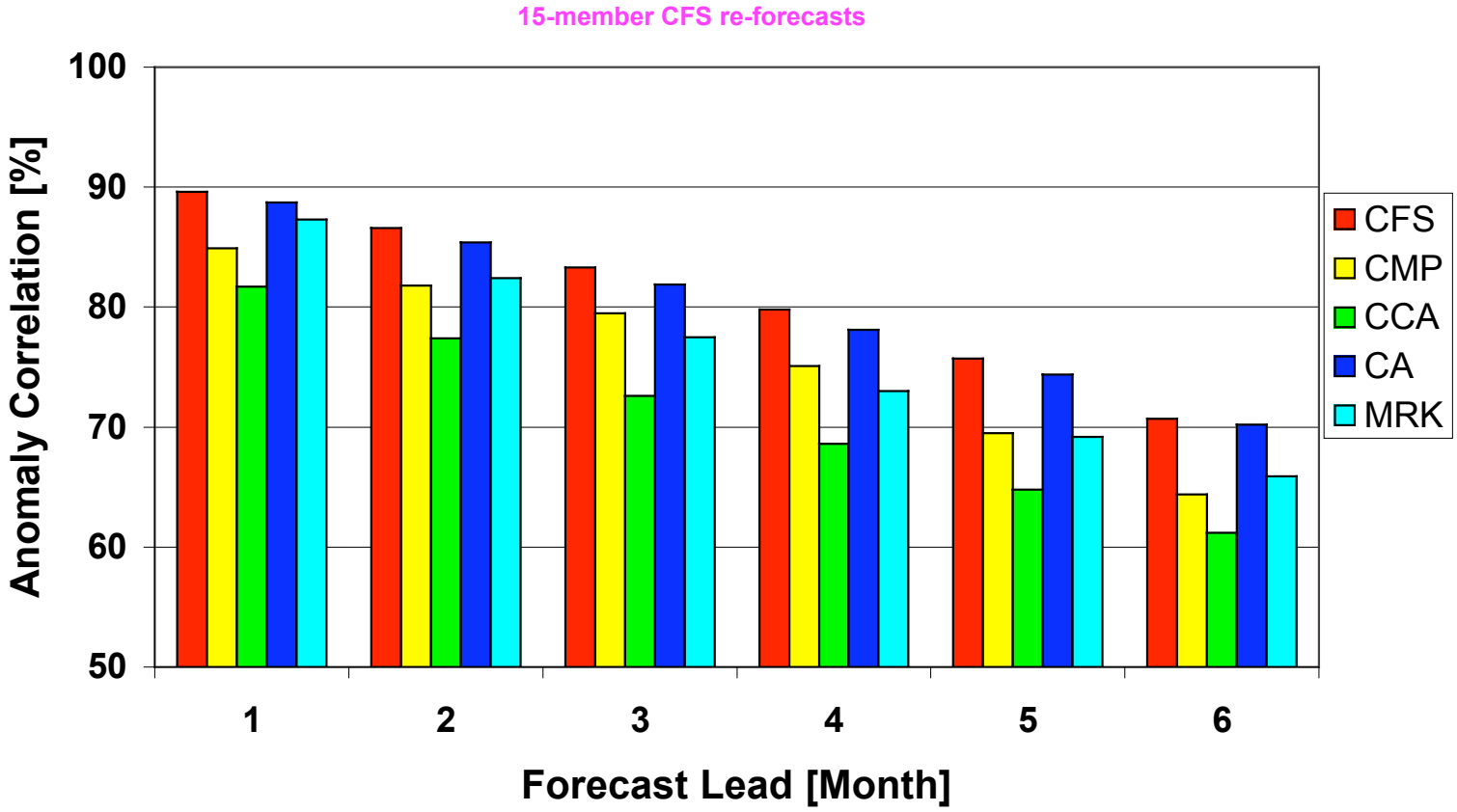



Nino3.4 Correlation 1982−1998: Jan 01 Oics
Correlation
Lead Time (months)
Persistence
CFS
CCSM3.0
CCSM3.5
NMME(CFS+CCSM3.0+CCSM3.5)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
0
1
2
3
4
5
6
7
8


NINO3.4 SST mean square skill scores
84 start dates from 19810201 to 20011101
Ensemble sizes are 80 (MM) and 11 (0001)
Fcast MM
Fcast S3
Persistence
Mean square skill score
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Forecast time (months)

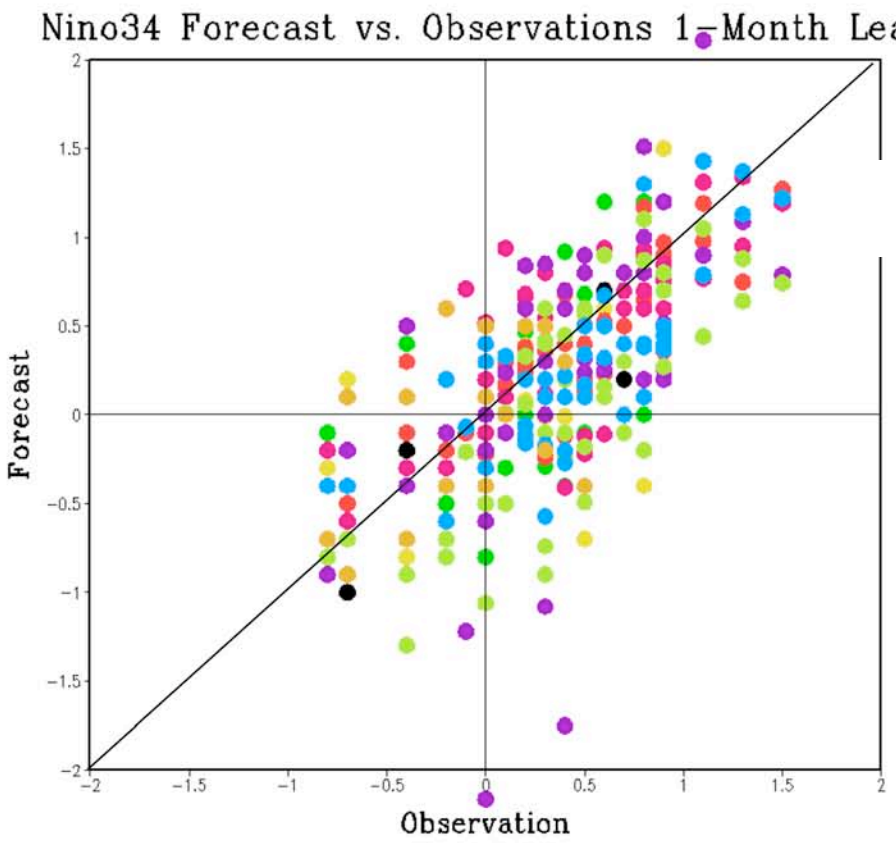
Dynamic Models Improving and Competitive with Statistical Models

Skill in SST Anomaly Prediction for Nino-3.4
[DJF 81/82 to AMJ 04]

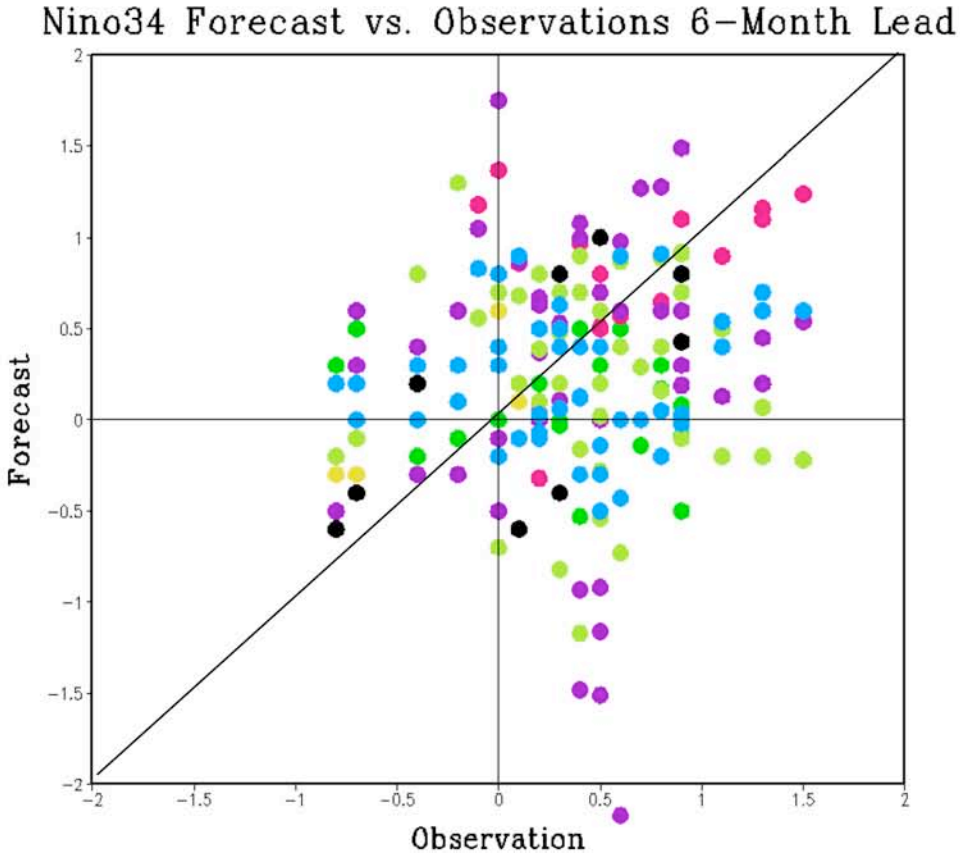


Saha et al. (2006; NCEP CFS)

No Substitute for Real Prediction

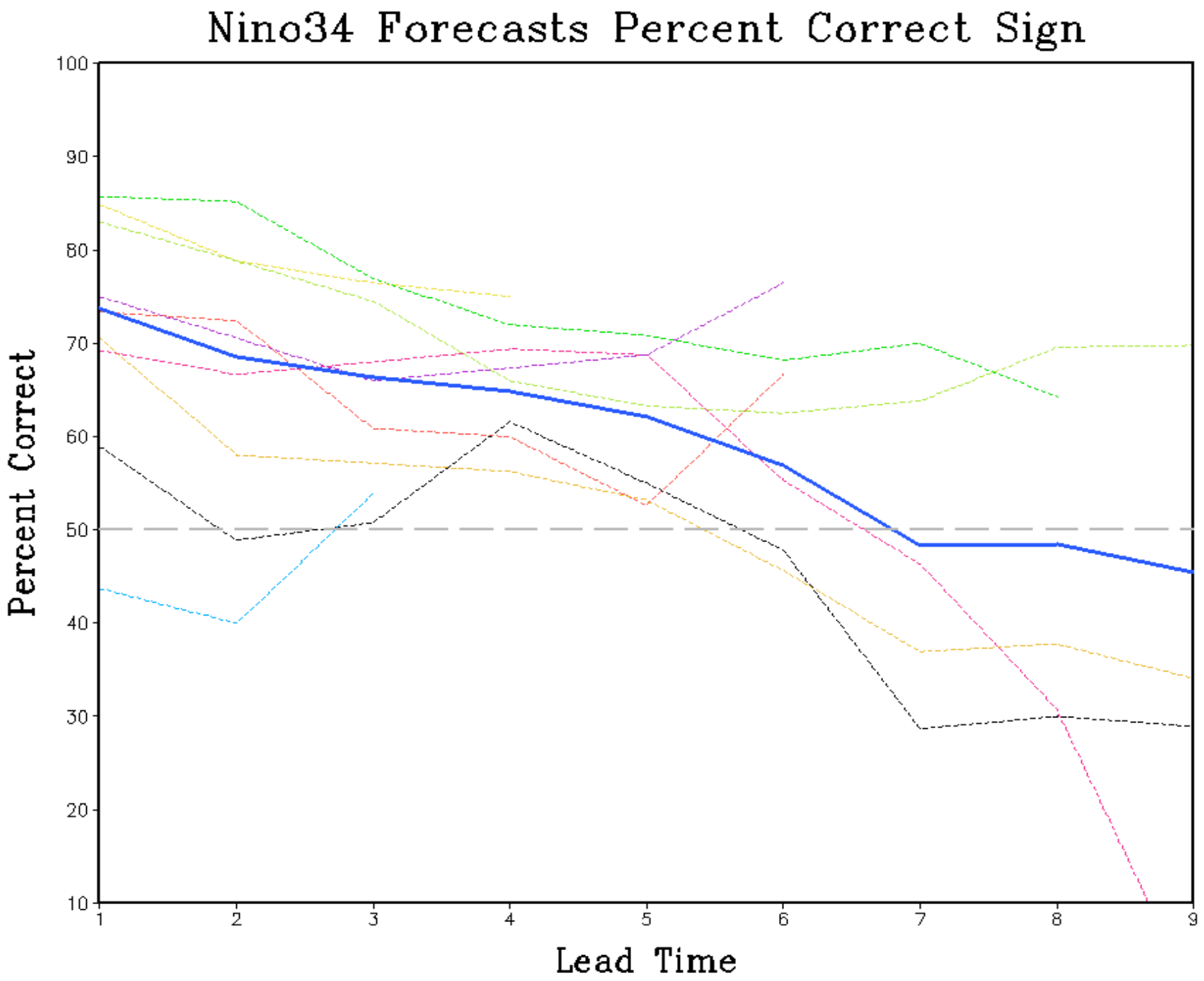


No Substitute for Real Forecasting



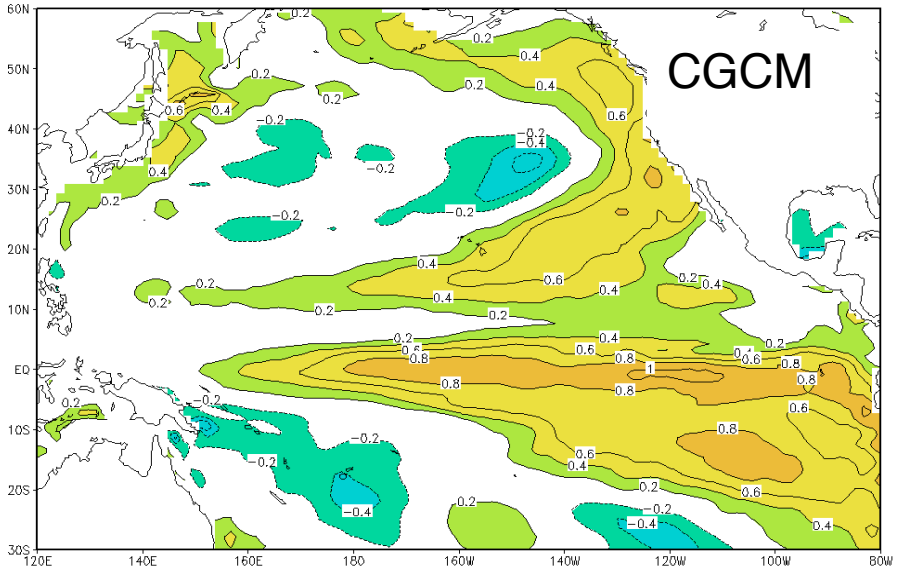
IRI Nino34 Forecast Archive
February 2002-September 2006

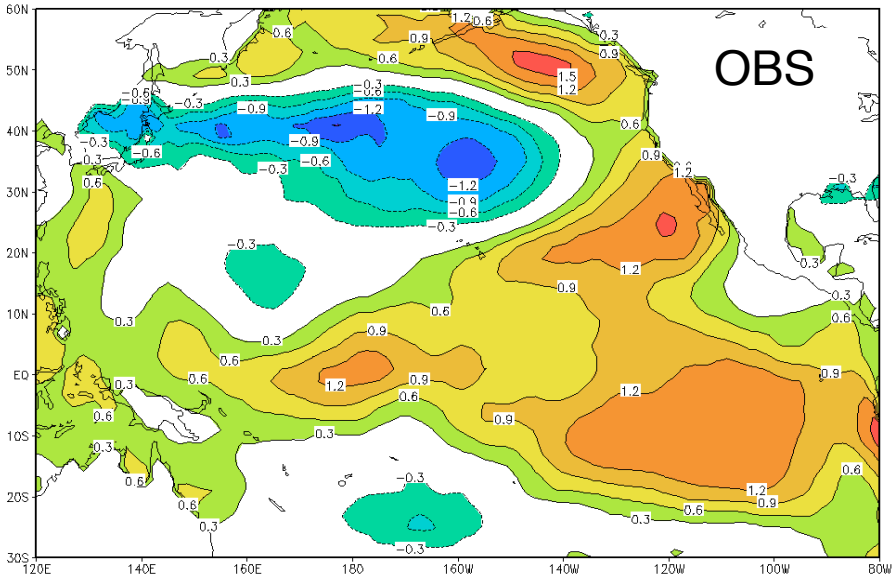
Running Seasonal Means


Nino34 Forecasts Percent Correct Sign
Percent Correct
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
Lead Time

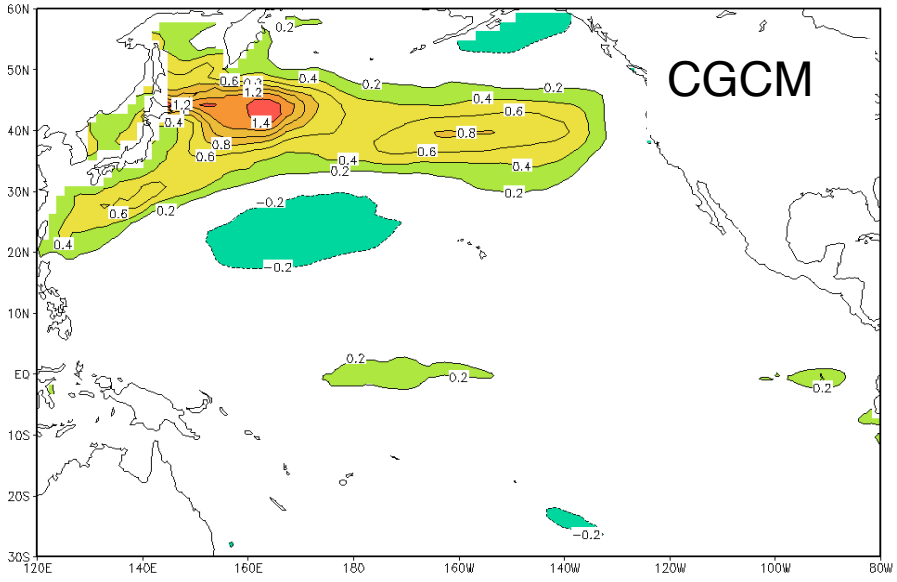
Decadal Predictability (Prediction)

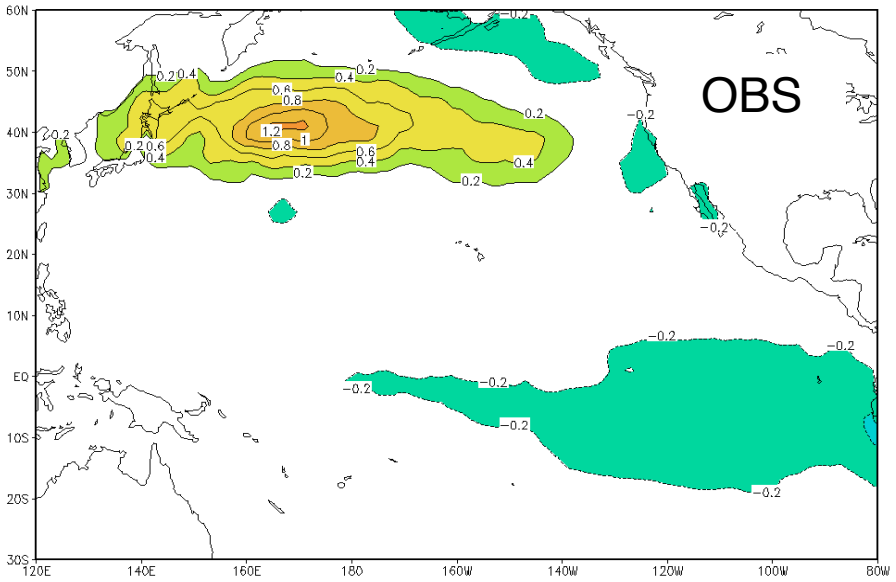
Estimated PDO



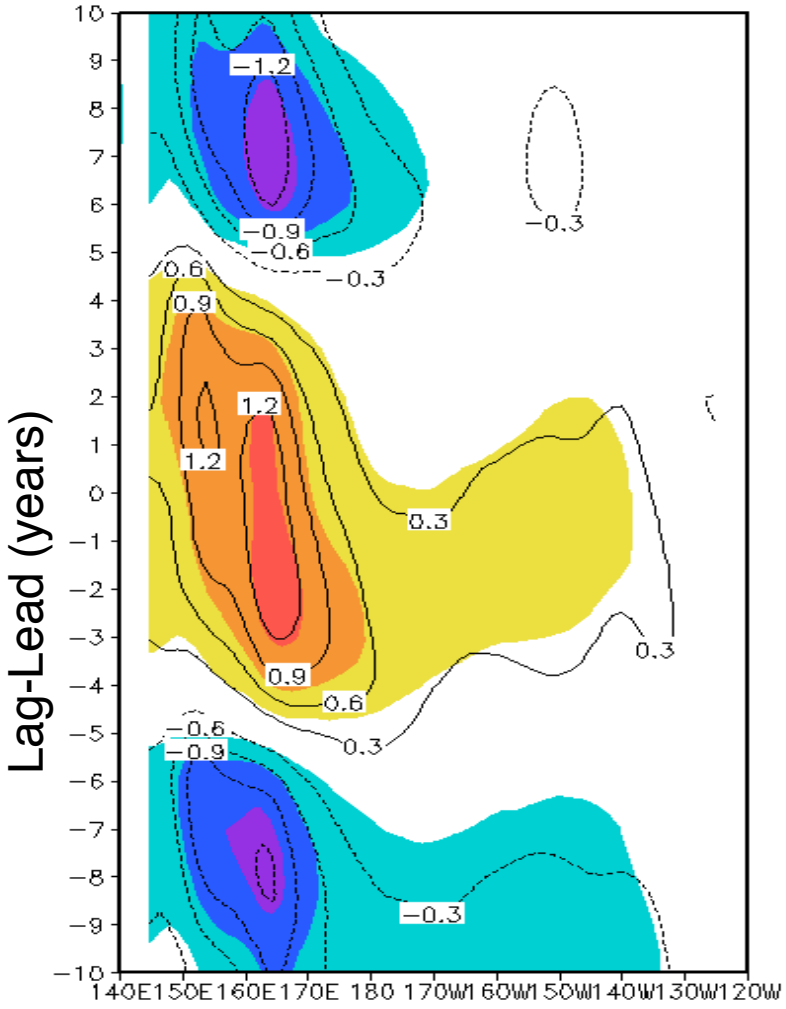


Estimated NPO

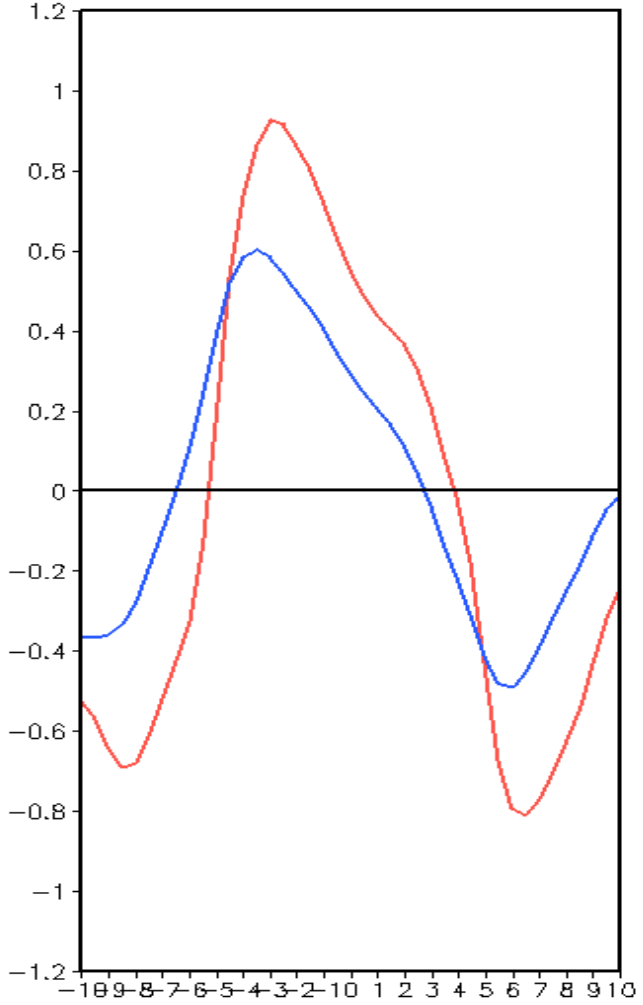




NP Index Regression: Heat Content And SST Along 42N

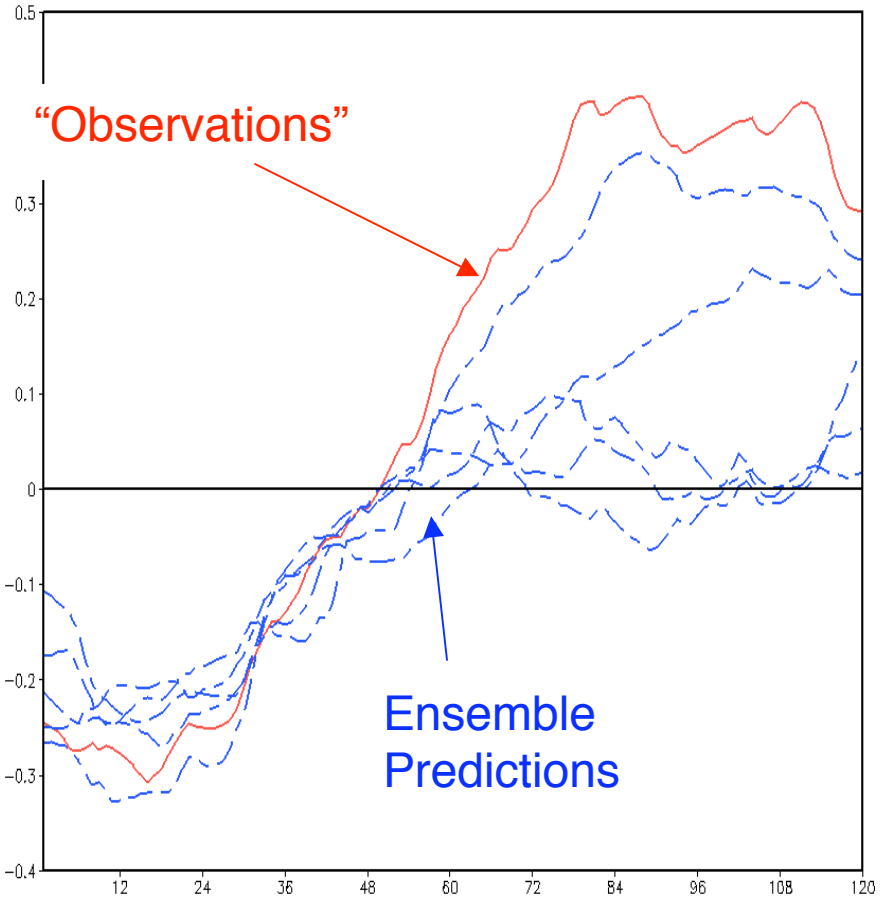


Heat Content And SST Along 42N and 180

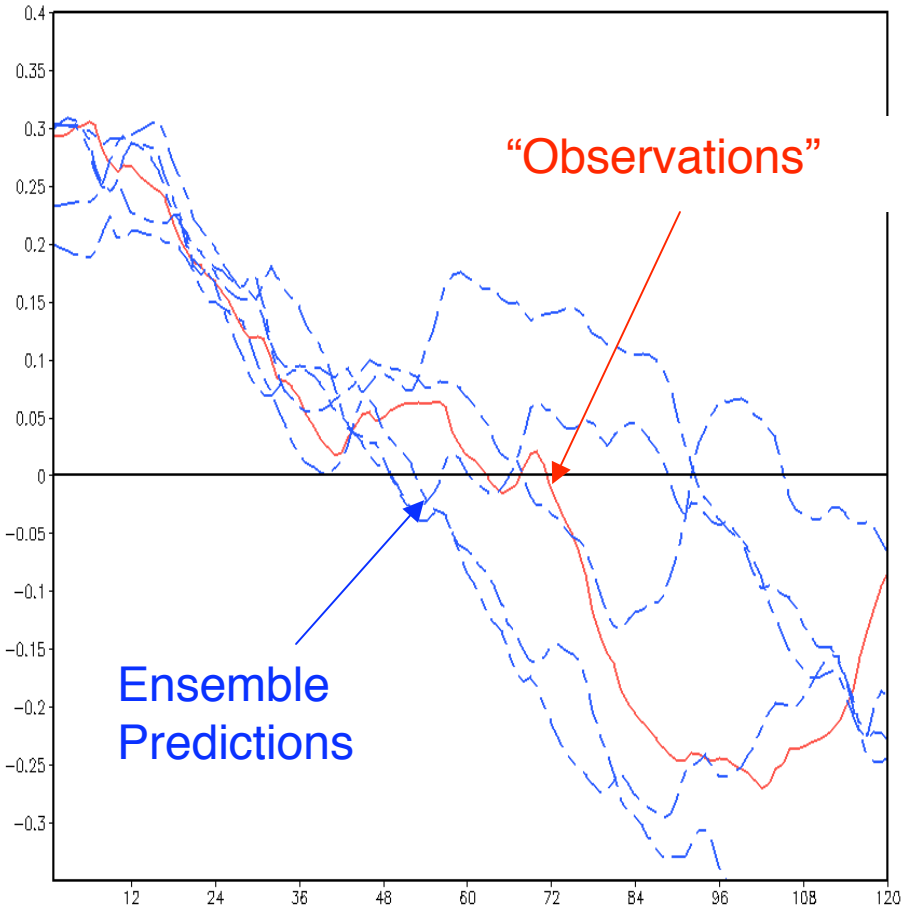


North Pacific Index = SST Averaged from 150-170 and 40-45N

North Pacific Index Idealized Prediction Experiments

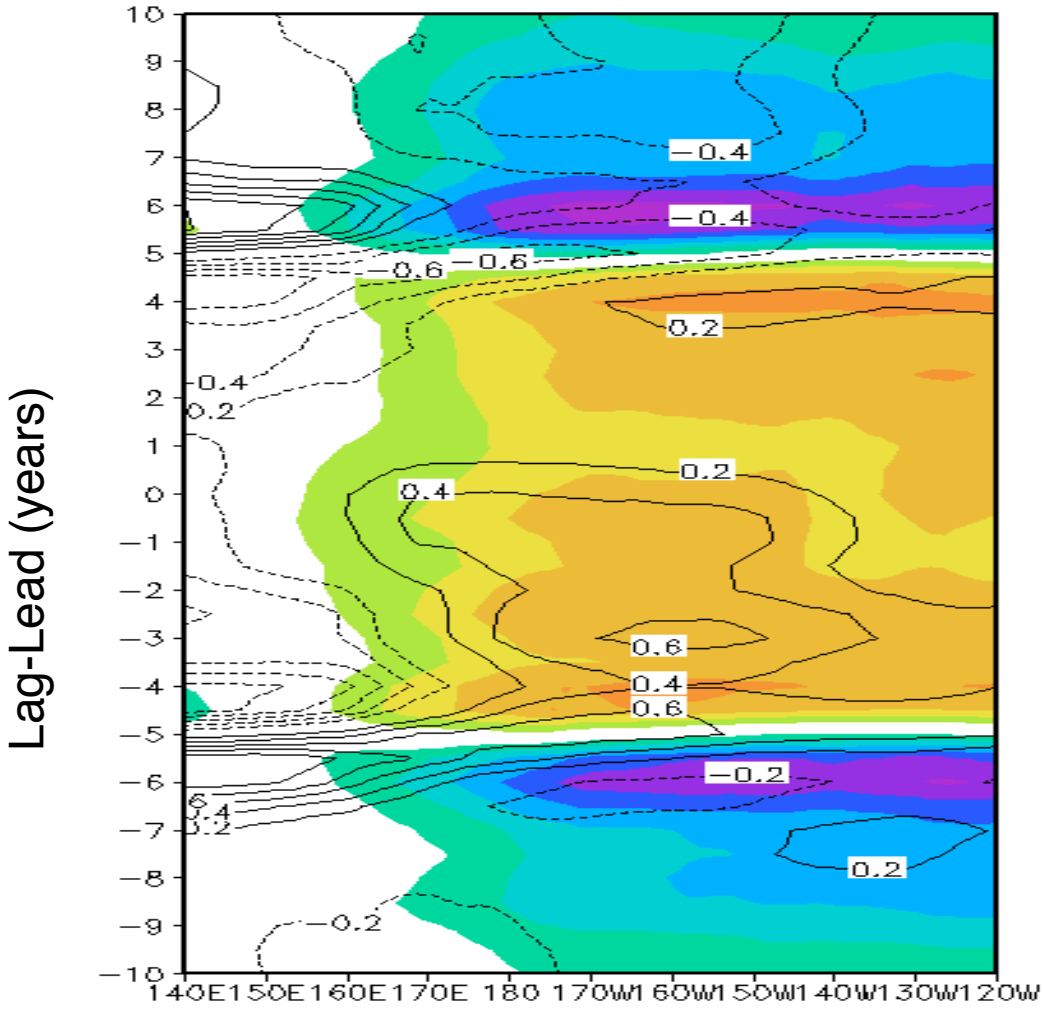


Lead Time (months)

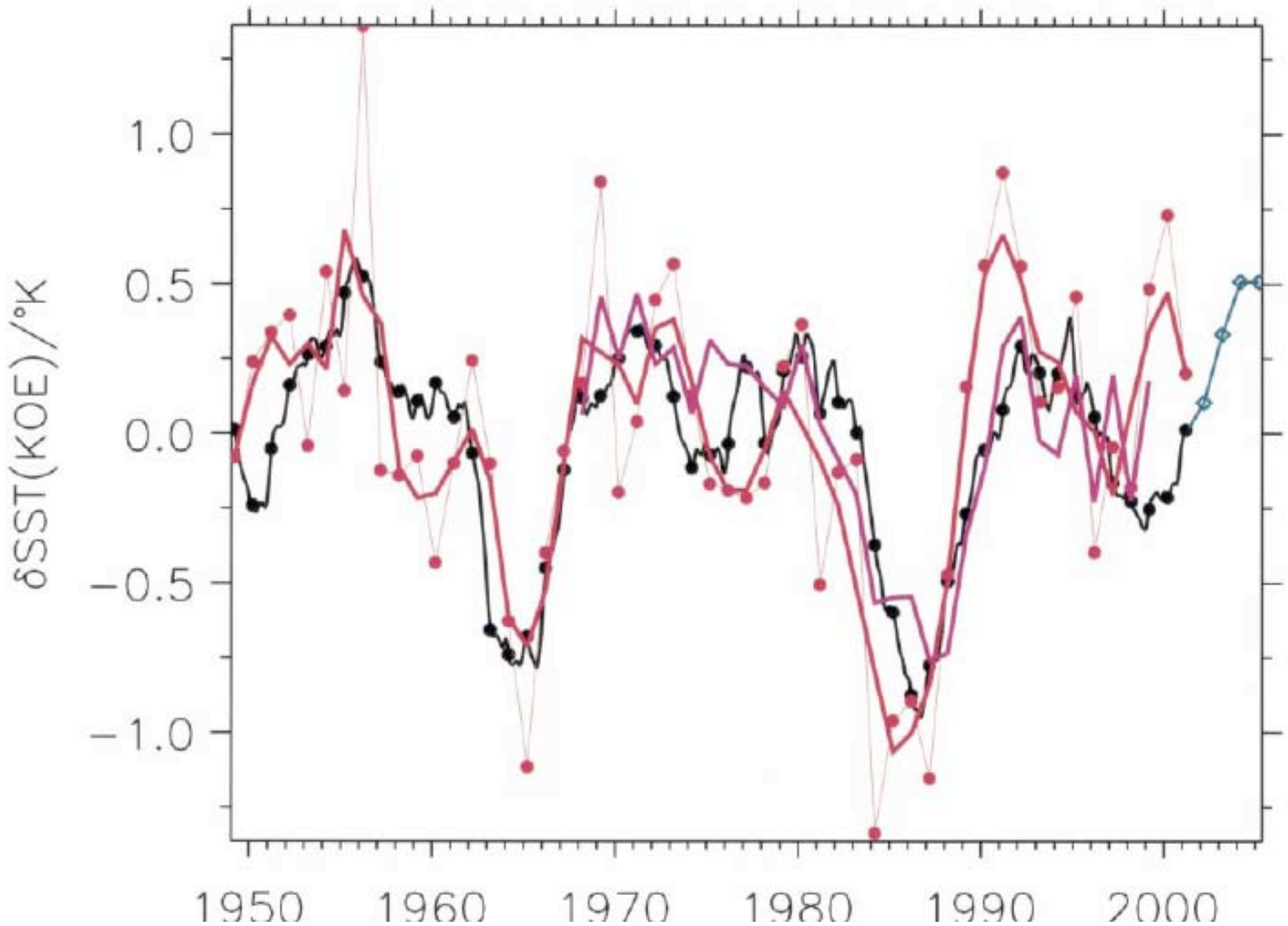


Lead Time (months)

PDO Index Regression: Heat Content And SST Along EQ

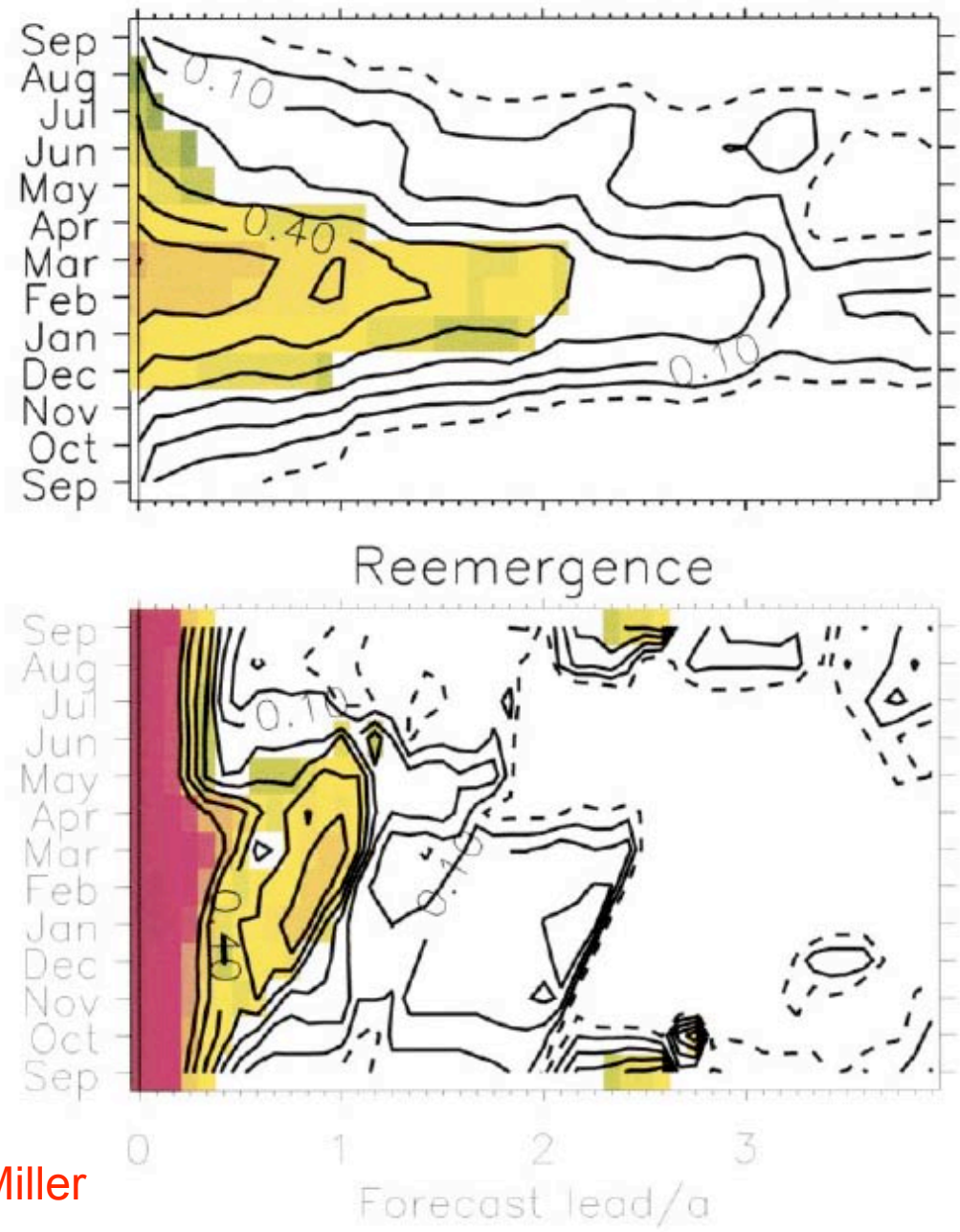


PDO Index = SST Averaged from 170E-130W and 5S-5N



Schneider and Miller

Correlation Coefficient



Schneider and Miller

Conclusions

- S-I “Predictability and Prediction” Model Easily Extends to Decadal Time Scales
  - External Forcing
- Model Error Significantly Contributes to Forecast Error
- Initial Condition Error Significantly Contributes to Forecast Error
  - Model Error is an Important Part of Initial Condition Error
- Initialization
  - Some Success In Using “Unbalanced” Initial States
  - Need for Balanced Initial States
  - May Not Require Your Own Data Assimilation System