Representation Error in Ocean Data Assimilation

Robert N. Miller

James G. Richman

College of Oceanic and Atmospheric Sciences

Oregon State University

Corvallis, OR 97330

Outline

1. Results from a model of the Pacific

    (a) Assimilation of SST and SSH

    (b) Tests of hypotheses on representation errors

2. Results from global MOM4

Pacific Circulation Model

- Parallel Ocean Program (POP)

- Domain:
    - $105^o E$ to $85^o W$
    - $30^o S$ to $64^o N$

- Resolution
    - 1° at the Equator, Mercator projection
    - 0.5^o average resolution
    - 50 vertical levels, 25 in top $500m$

- 25 years (1978-2002), forced by NCEP/NCAR reanalysis

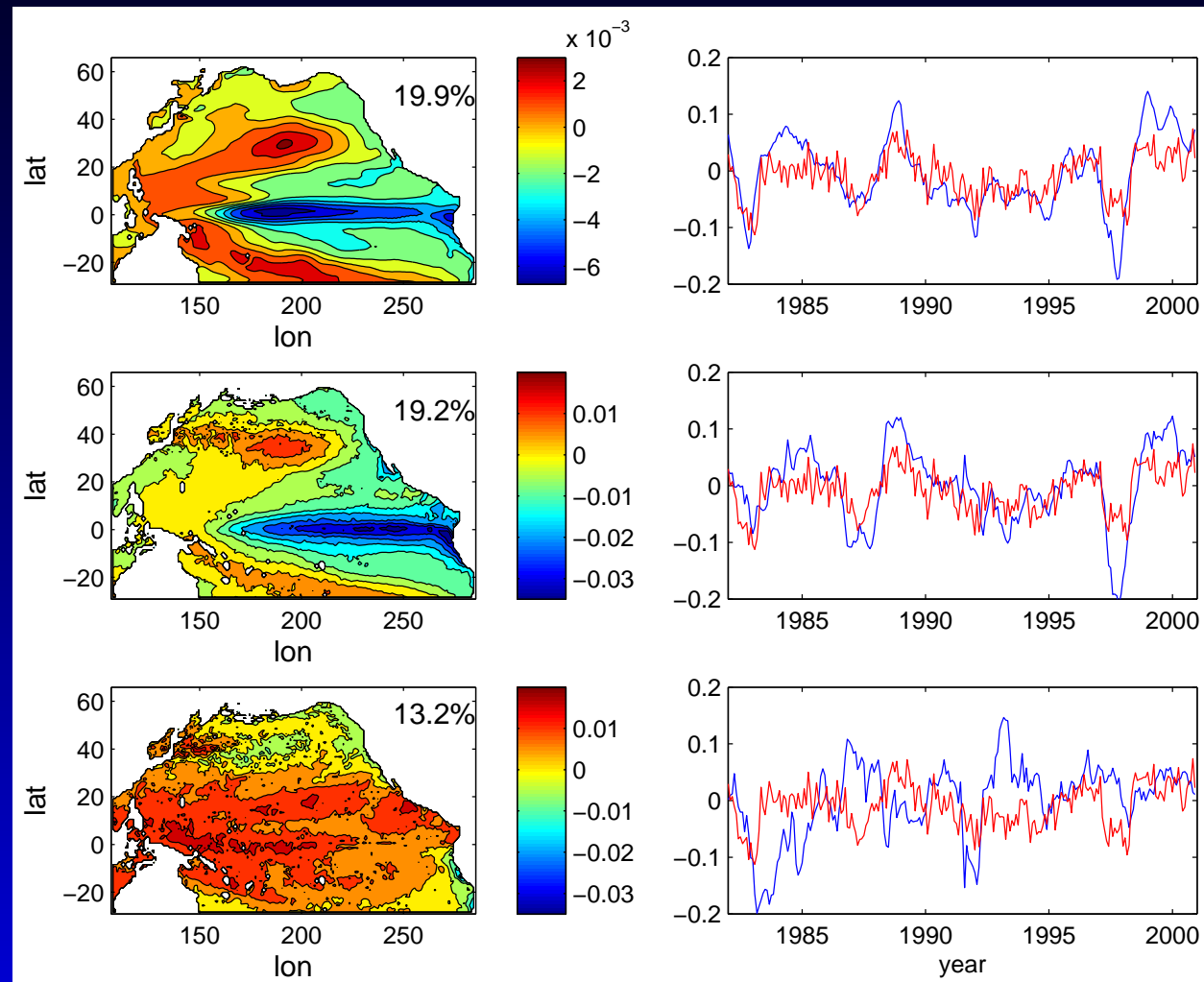- Initialized from Levitus, 30 year spinup

Model and AVHRR Anomalies
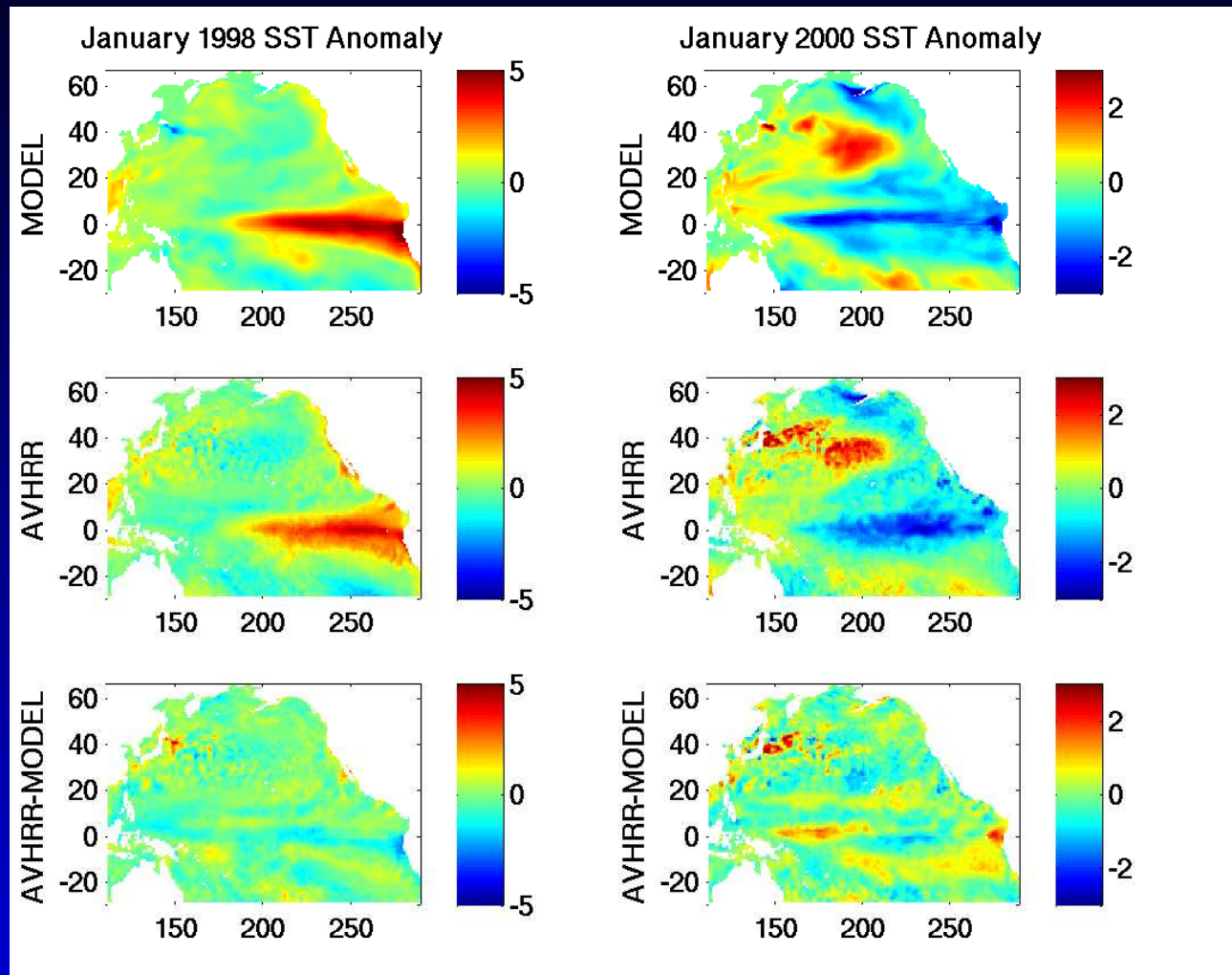
Model SST anomalies (top), AVHRR SST (middle) and data-model misfit (bottom) for 2 different years
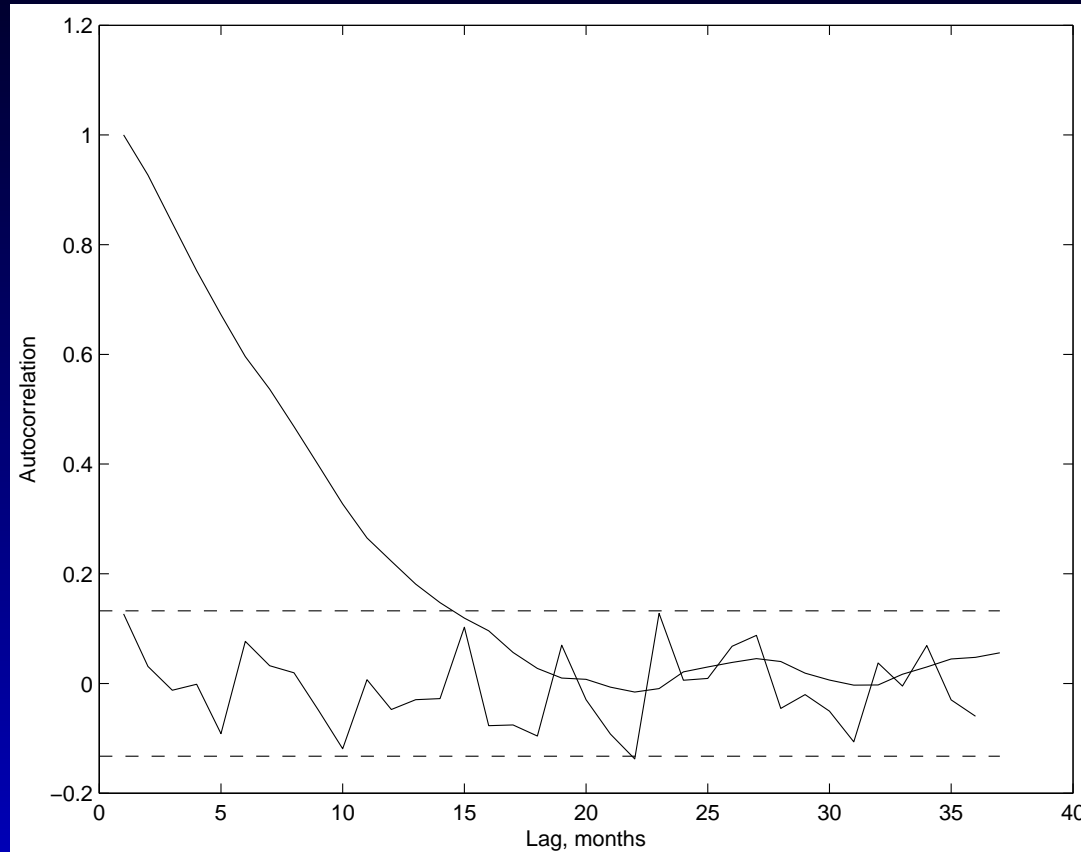
Model and SSH Anomalies
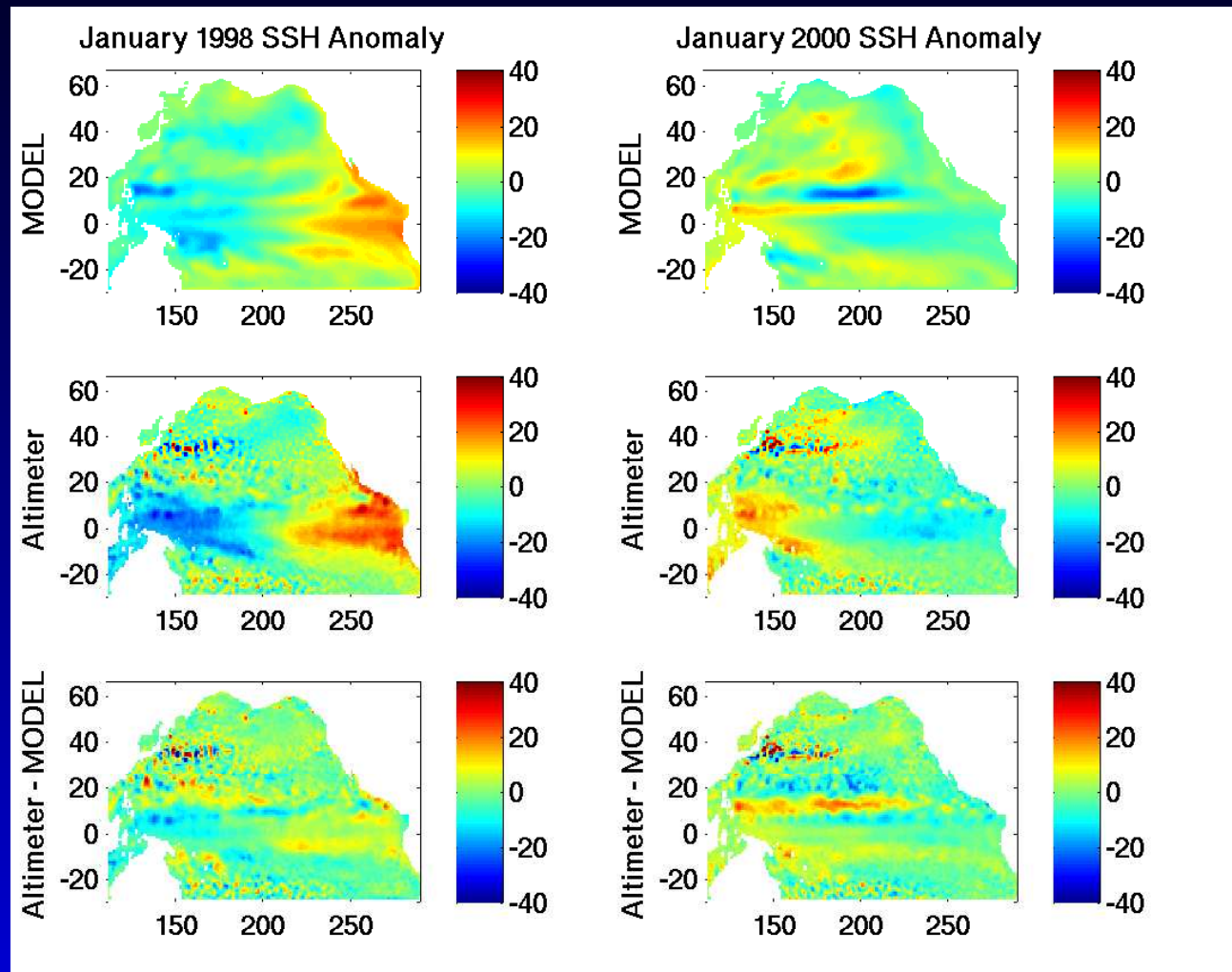
Model SSH anomaly (top) AVISO SSH (middle) and
data-model misfit (bottom) for 2 different years
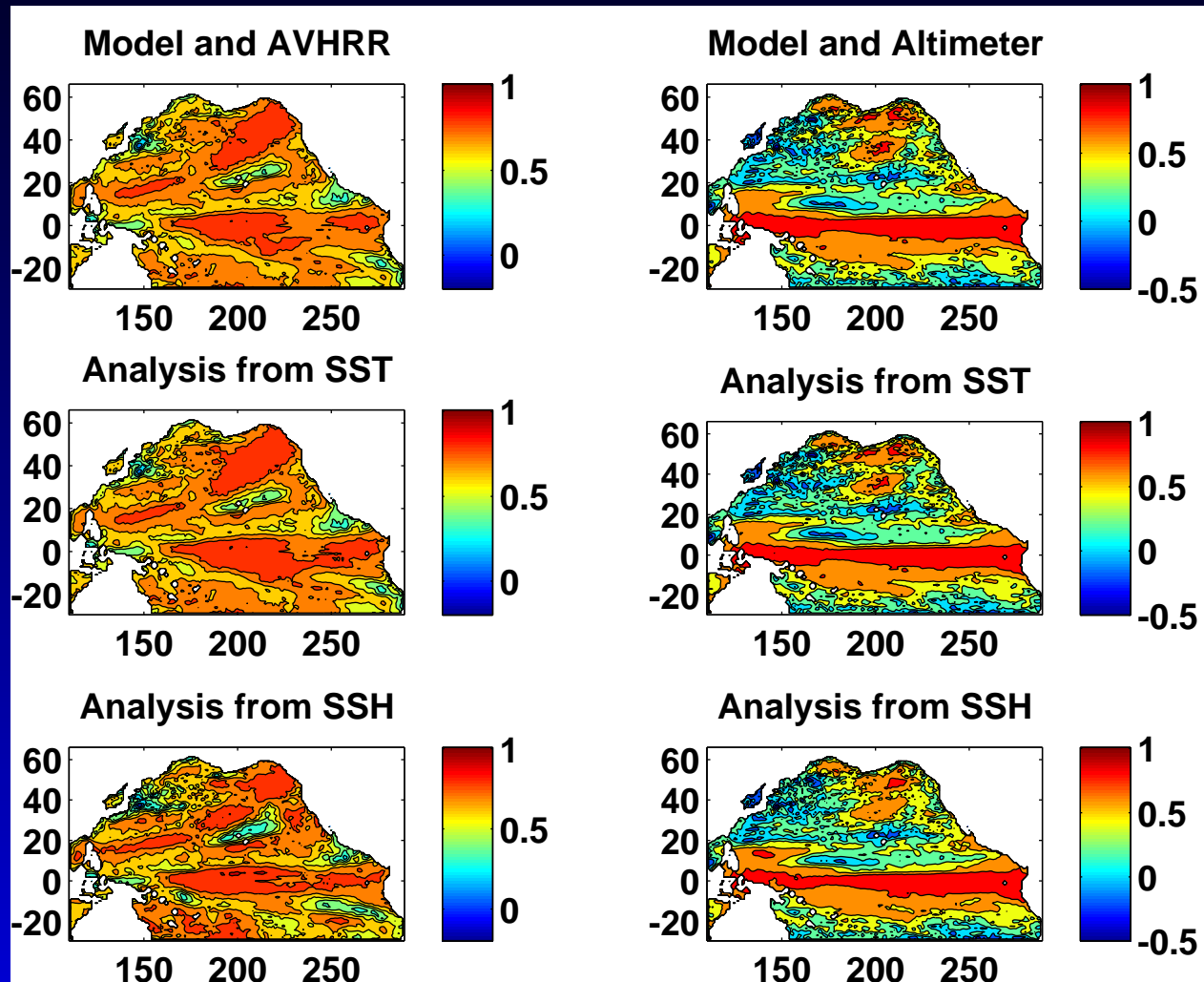
Leading EOFs

Leading EOFs and PCs for (top to bottom) Multivariate model SST; AVHRR SST; Misfit. Red = SOI.

Misfit EOF Time Series

Autocorrelations of time series of SST misfit PCs. Upper curve: lead PC; Lower curve: residuals from a fitted AR(1) process
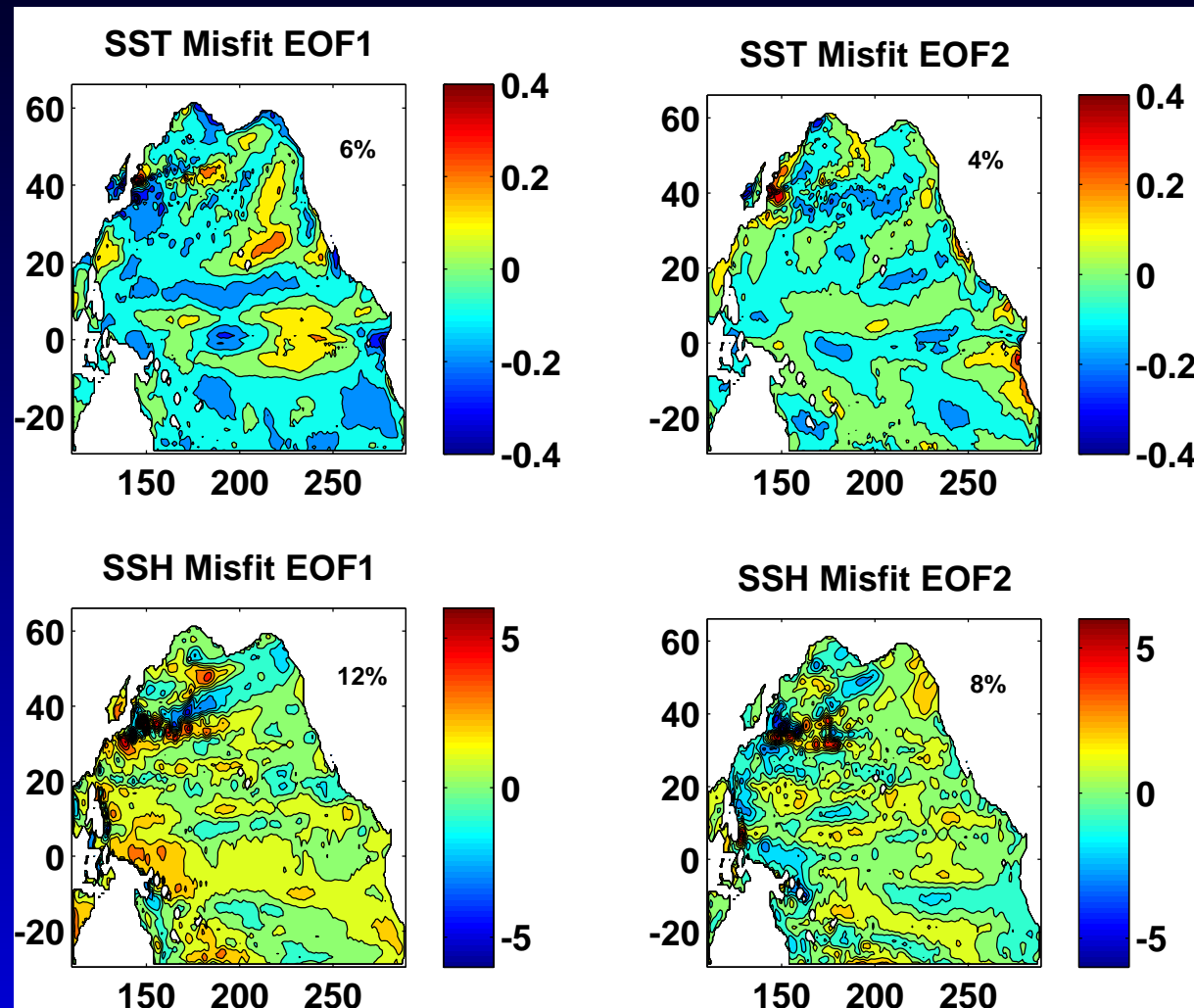
Data Assimilation Results

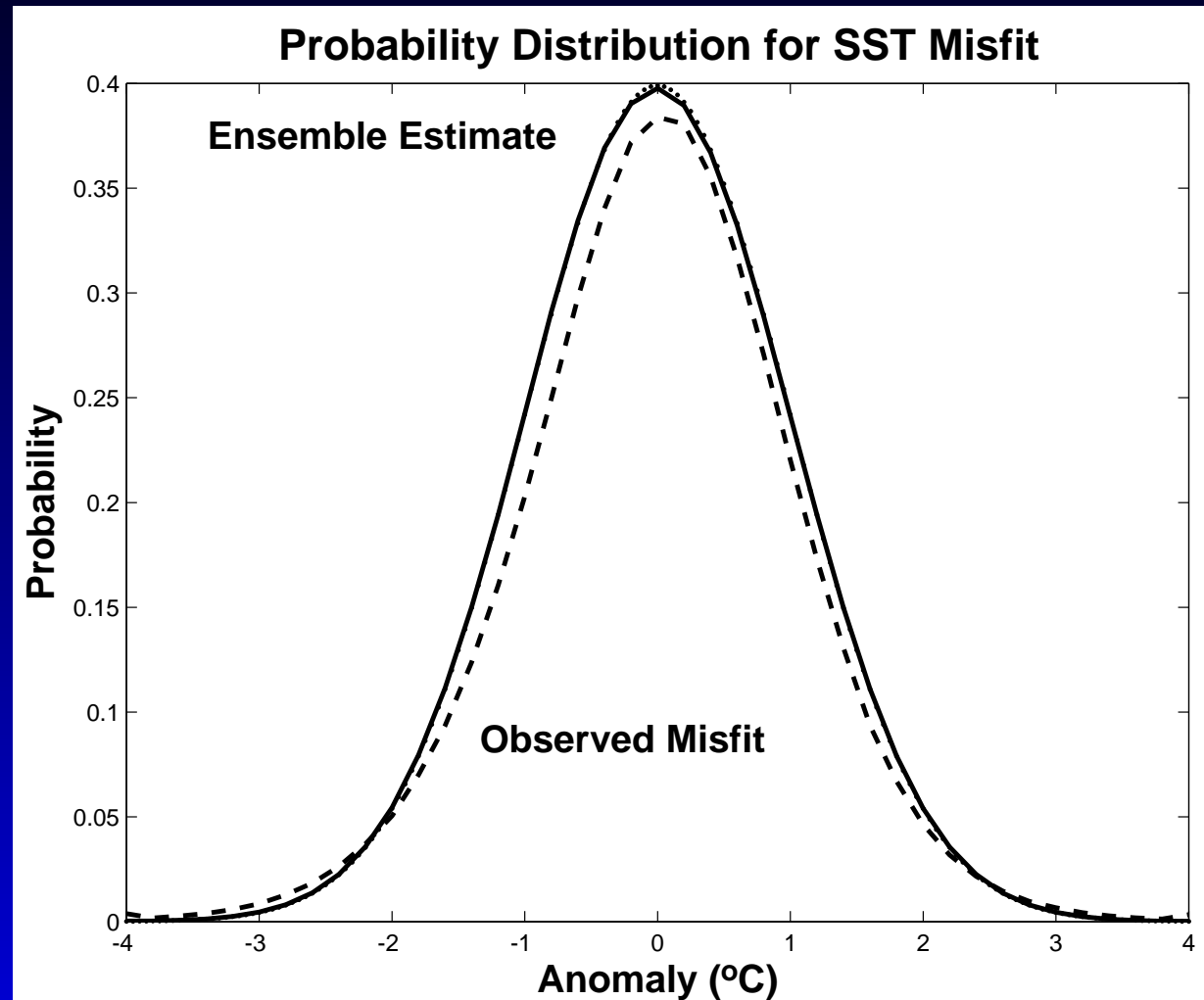
Correlation with observed SST (left) and SSH (right)

Top to bottom: No assim; assim of SST: SSH

Representation Error EOFs

EOFs of the SST and SSH representation error. Percentages of total orthogonal space variance are shown.

Distribution of SST Misfit

Probability Distribution for SST Misfit

Ensemble Estimate

Observed Misfit

Histograms of actual and simulated SST misfits. Values normalized by point-by-point RMS amplitudes.

Summary of 1° Pacific Model Results

- Lead EOFs of model and observed SST dominated by SOI

- Lead EOF of model-data misfit is well-modeled by an AR(1) process

- Estimates of representation error are as we expect

- Our estimates lead to ensembles with statistical properties of SST misfits
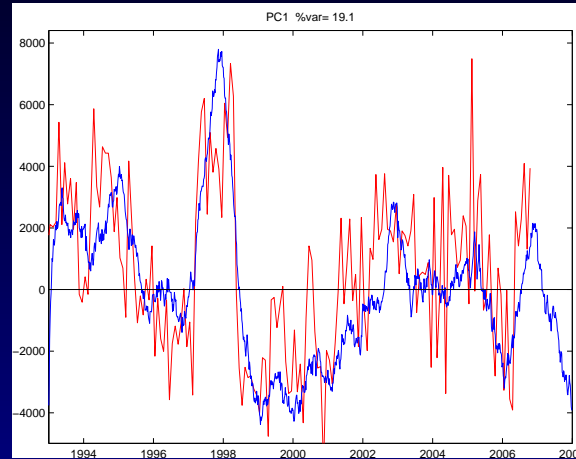
Error Estimates for NCEP CFS

- Analyze series of 5-day predictions and SST misfits

- Biases

- Misfits are dominated by seasonal cycle, despite being reinitialized every 5 days
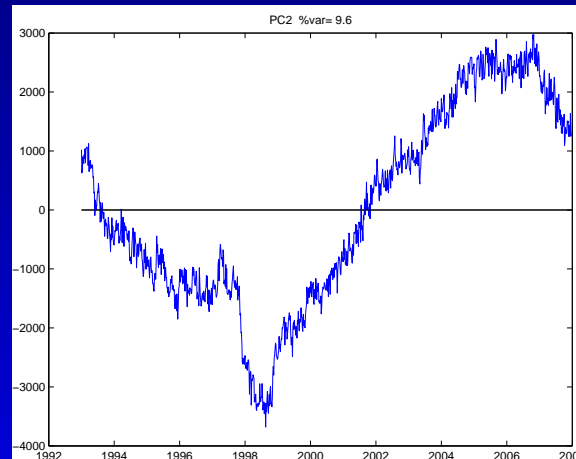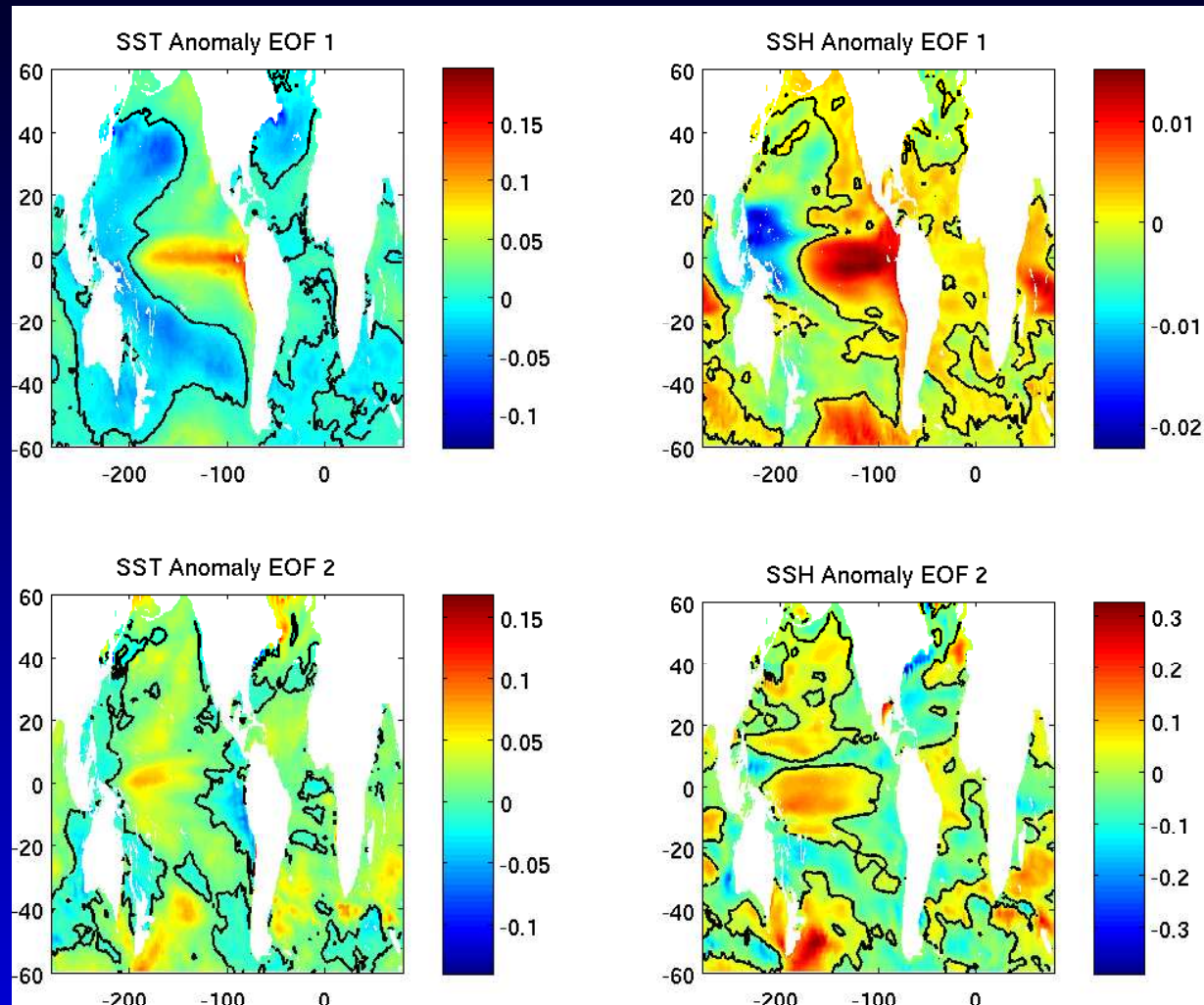
Bias

Mean SST Misfit, 2002-2008

Misfit Standard Deviation
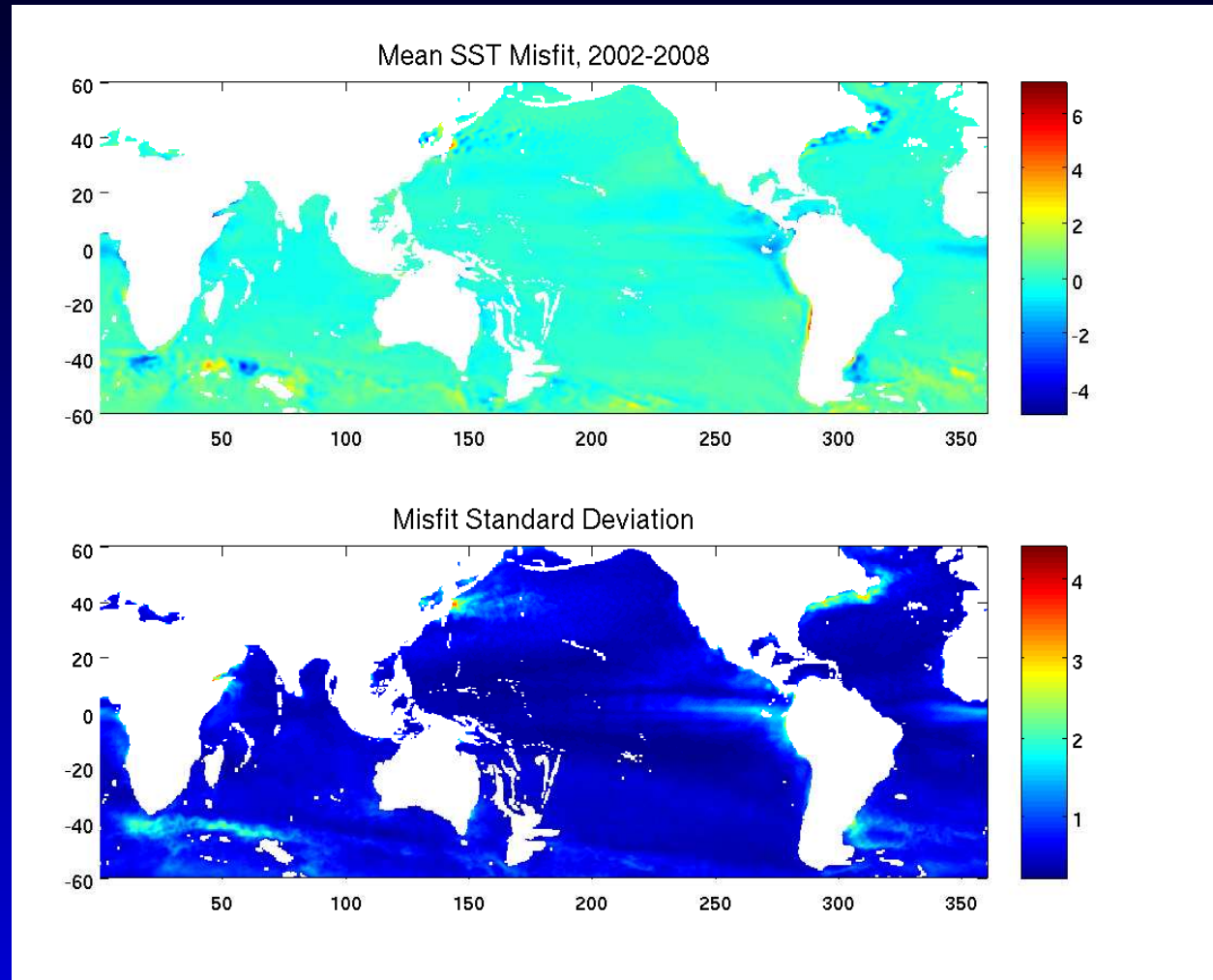
Seasonal Anomaly Model PCs

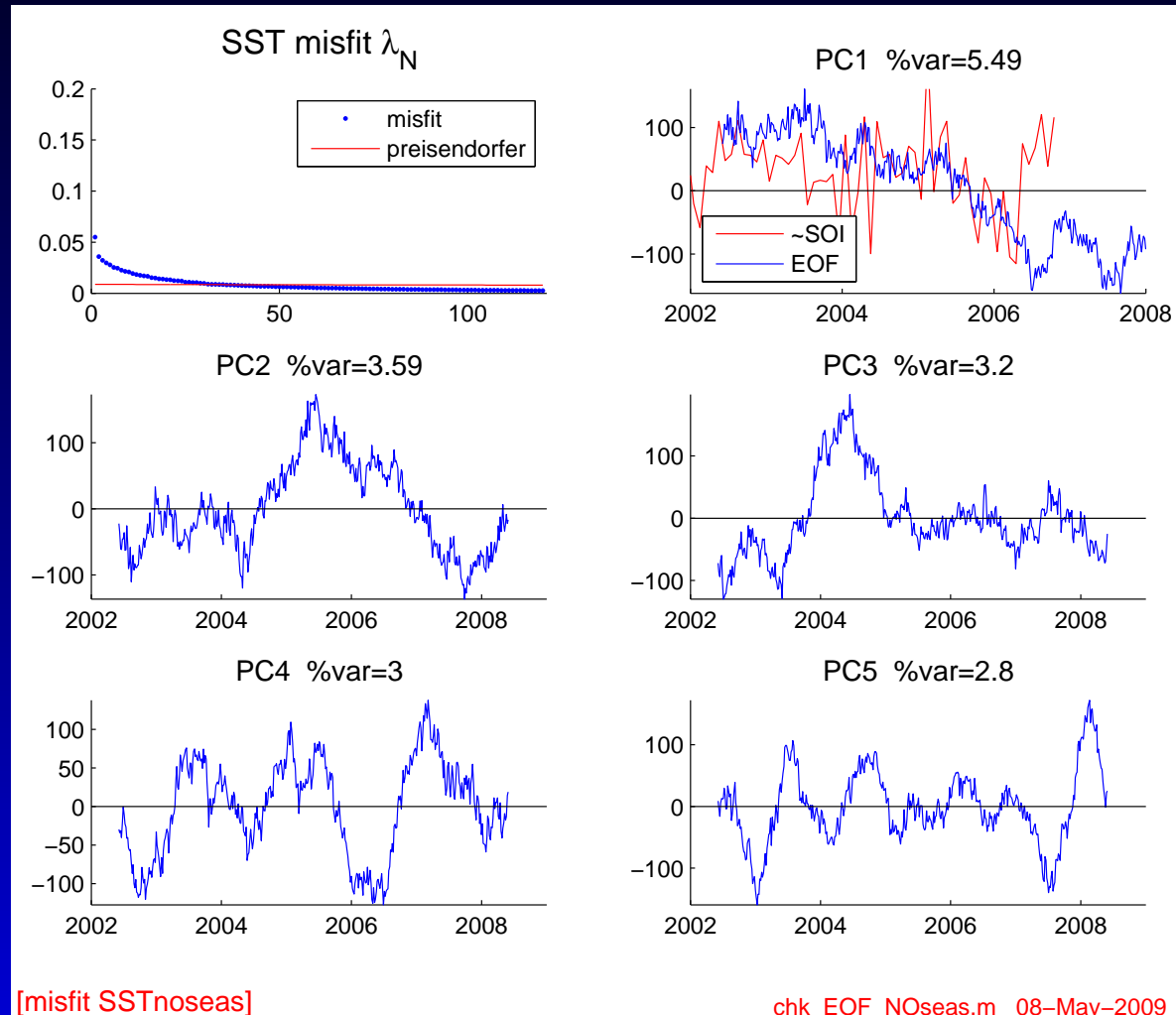Red curve depicts SOI; correlation coefficient = .74
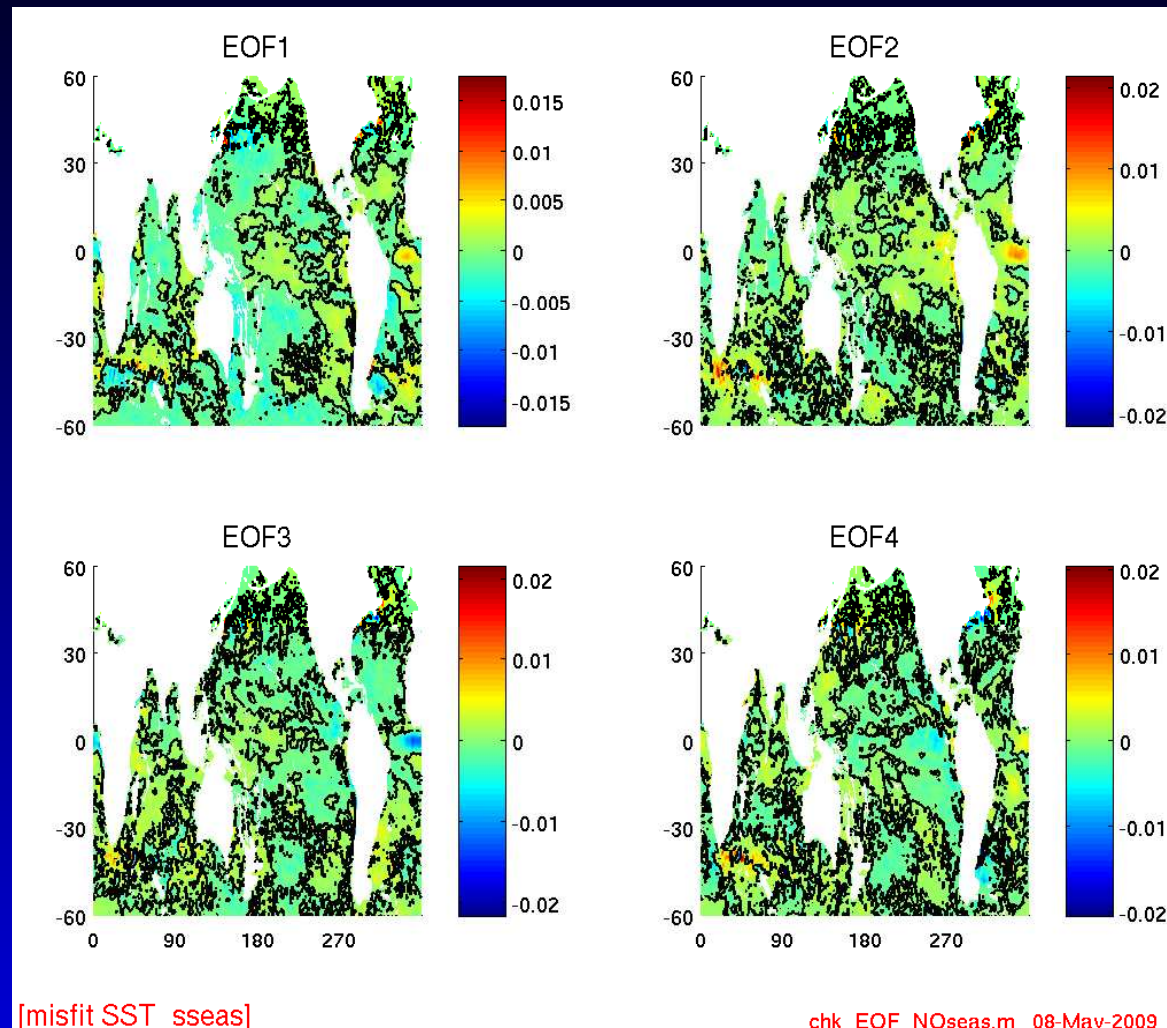
Seasonal Anomaly Model EOFs

Spectrum of Misfits

- spectrum pretty flat: about 30 significant EOFs

- lead PC, only about 5% of variance, little correlation with SOI

- PC shows strong trend, probably due to short time series

PCs of misfits

[misfit SSTnoseas]

chk_EOF_NOseas.m   08–May–2009

EOFs of misfits

[misfit SST sseas]

chk_EOF_NOseas.m   08-May-2009

Summary

- Contrary to expectations, residuals from 5 day forecasts are biased and show strong seasonal cycle

- Clearly small-scale adjustment processes are important

Current Work

- Analyze 15 year free run, no assimilation, to determine model space

- Perform 3D updates

- Generate ensembles