

Improved Historical Reconstructions of SST and Marine Precipitation Variations

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Introduction

- Historical Reconstructions:
 - Statistical analyses: satellite-based statistics and historical data
 - Satellite-based analyses for global statistics
- Improved reconstructions:
 - 1) SST: New data and methods
 - 2) Precip: For ocean-area reconstructions

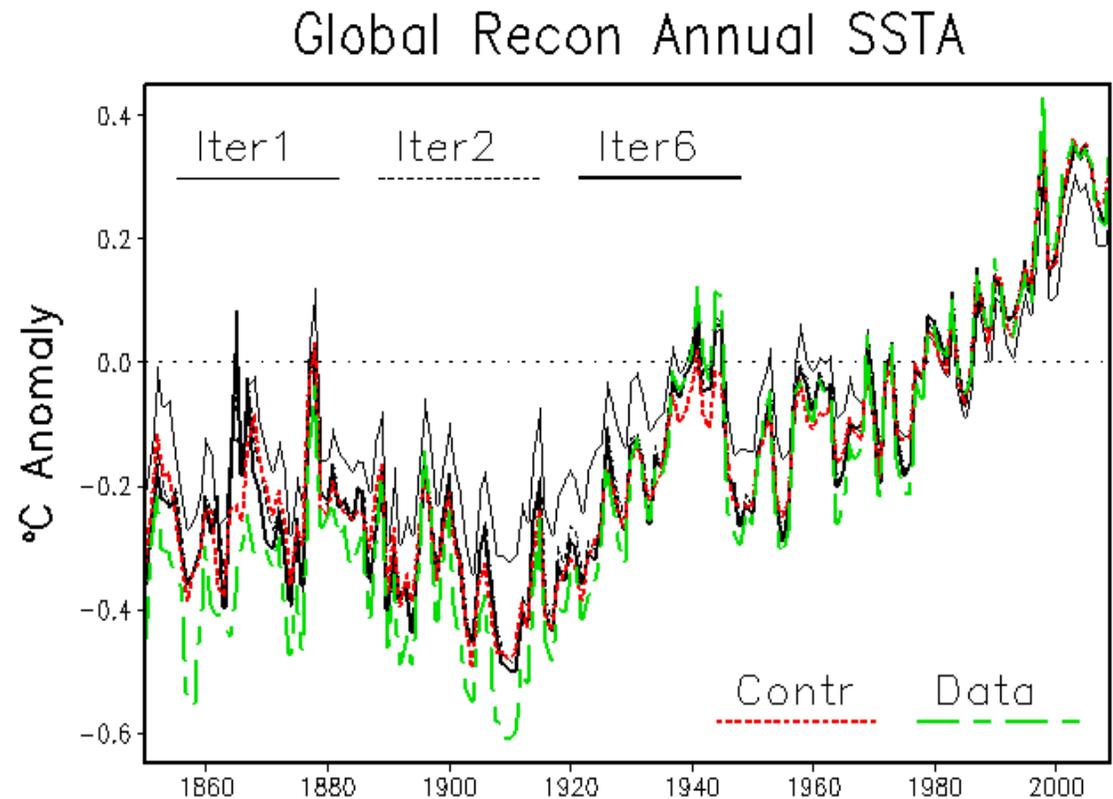


1) Improved Iterative SST Annual Average Anomaly Recon

- Satellite-based OI analysis of IR and in situ data for base statistics
- Iterative method suggested by Hadley Centre
 - Compared to simplified ERSST-like “control” method using the same data
 - Data: HadSST2 anoms w.r.t. 1961-1990, and bias adjusted (1850-2009)
- 1st Iteration:
 - 10 EOFs of satellite-based SSTs (1982-2009); reconstruct annual 1850-2009
- More Iterations:
 - OI to re-inject annual HadSST2 into historical reconstruction
 - New set of 10 EOFs from adjusted full 160-year period; use for new recon
 - Repeat until reconstructions stabilize (check mean spatial variance change)
- Use iterative method for annual-average 1st guess, use fixed monthly increment modes for monthly analysis

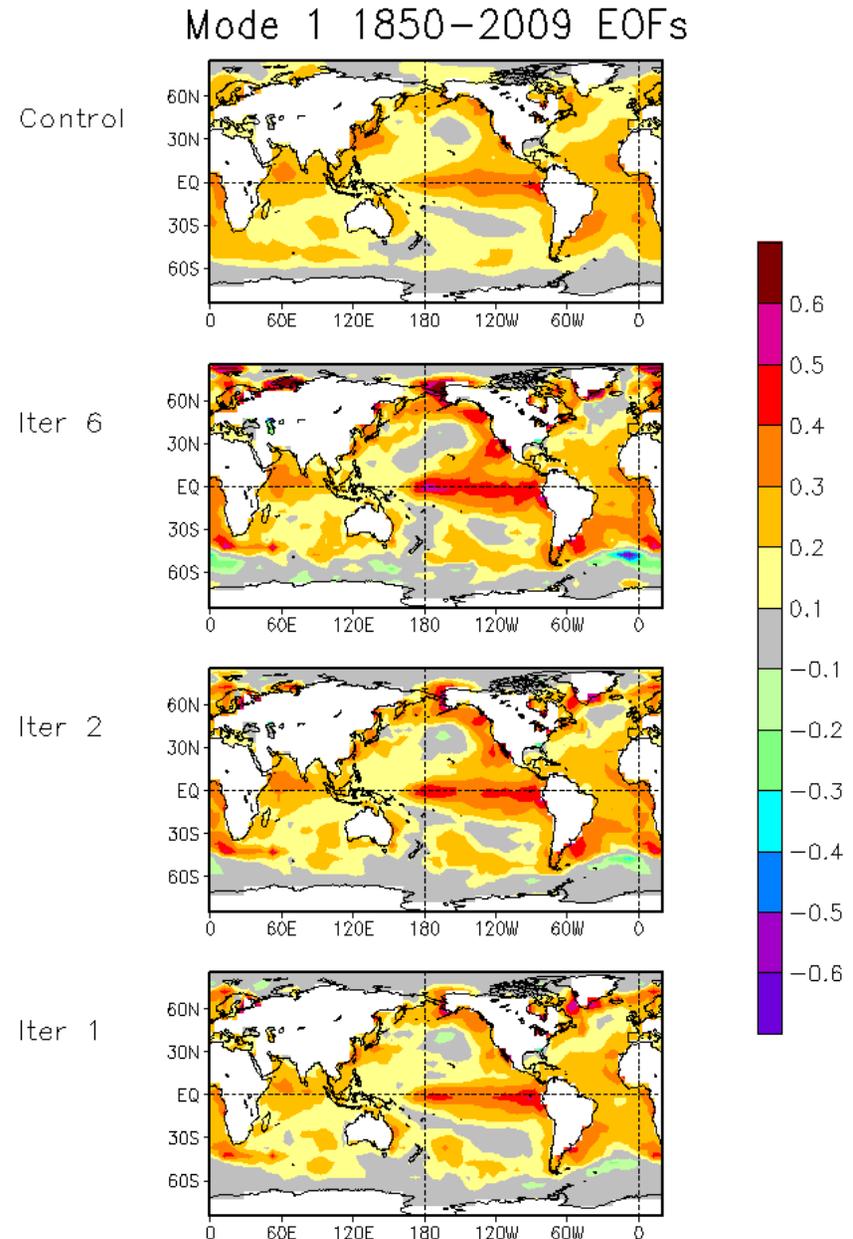
Changes With Iterations

- Global averages
- 1st Iteration anomalies weak
 - Satellite period EOFs don't resolve all multi-decadal variations
- More iterations average approaches control
 - Note: large change in 1865 evaluated, method then tuned



Spatial Changes With Iterations

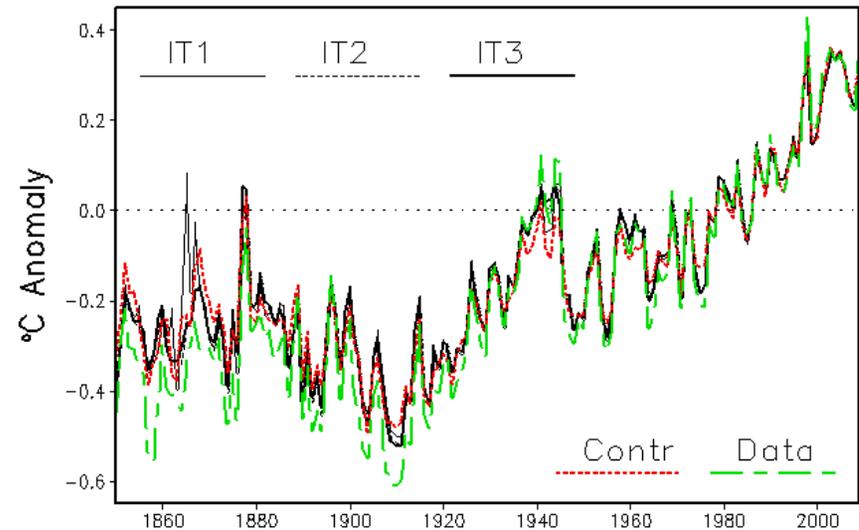
- Comparison of EOF mode 1 from control and iterations
- 1st iteration: weaker variations
- Variations strengthen with iterations



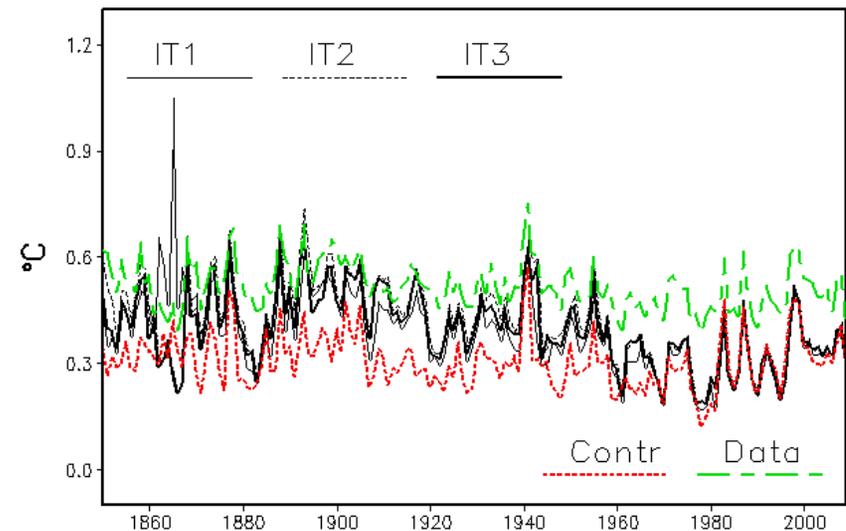
Improved Tuning of Iterative REOF

- Iterative test 1 (IT1):
 - 5% sampling, constant noise/signal ratio for OI data re-injection
 - Over fitting in 1865 causes large anomaly
 - 6 iterations to stabilize
- Iterative test 2 (IT2):
 - 10% sampling, constant noise/signal
 - Eliminates 1865 problem in IT1
 - 10 + iterations to stabilize
- Iterative test 3 (IT3):
 - 10% sampling, noise/signal varies with data sampling
 - 7 iterations to stabilize

Global Recon Annual SSTA



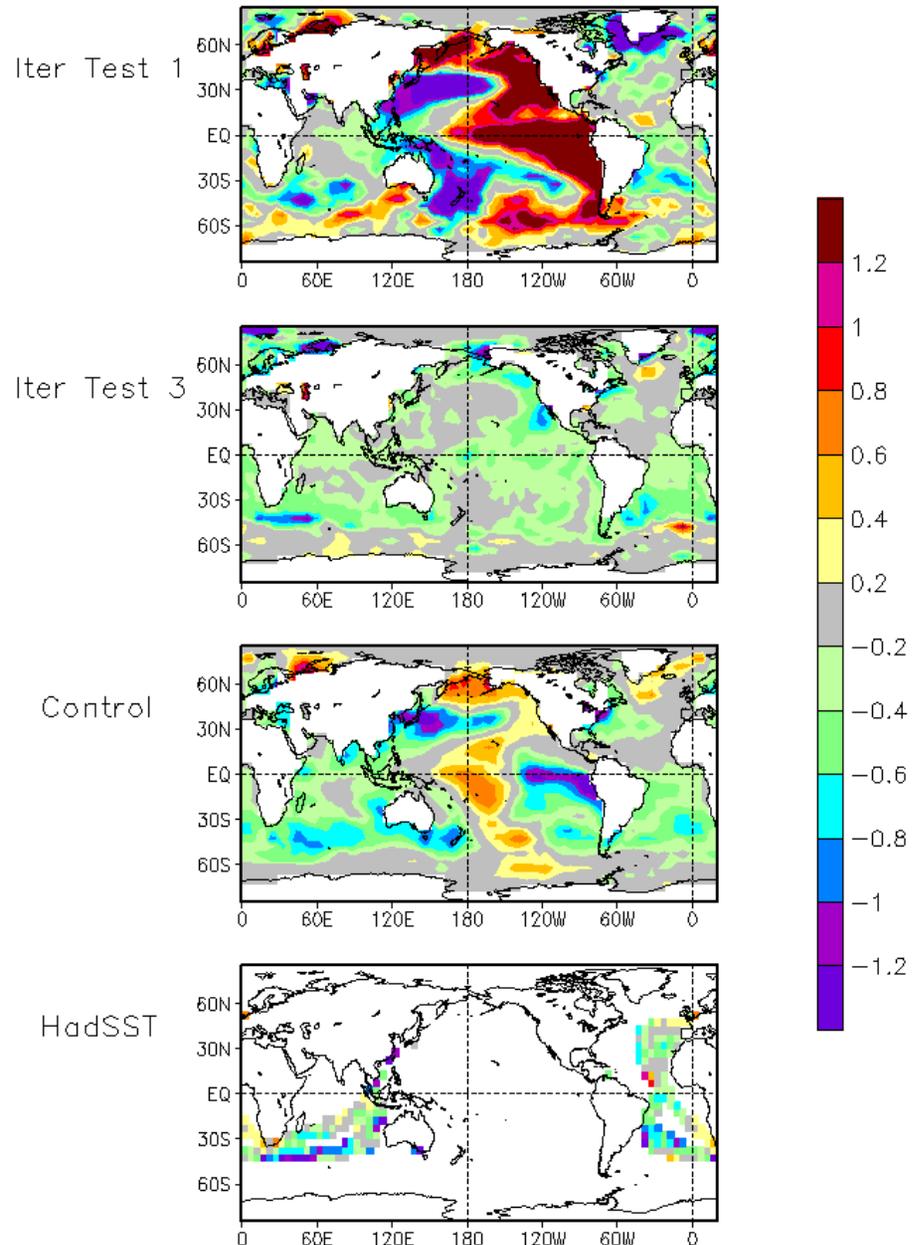
Global Spatial S.D.



The 1865 Problem

- Iterative test 1 creates an unsupported warm ENSO
- HadSST: almost no Pacific sampling
- Iterative test 3 filters out the ENSO
- Control 15-year filtering fills in with stronger anomalies from other years

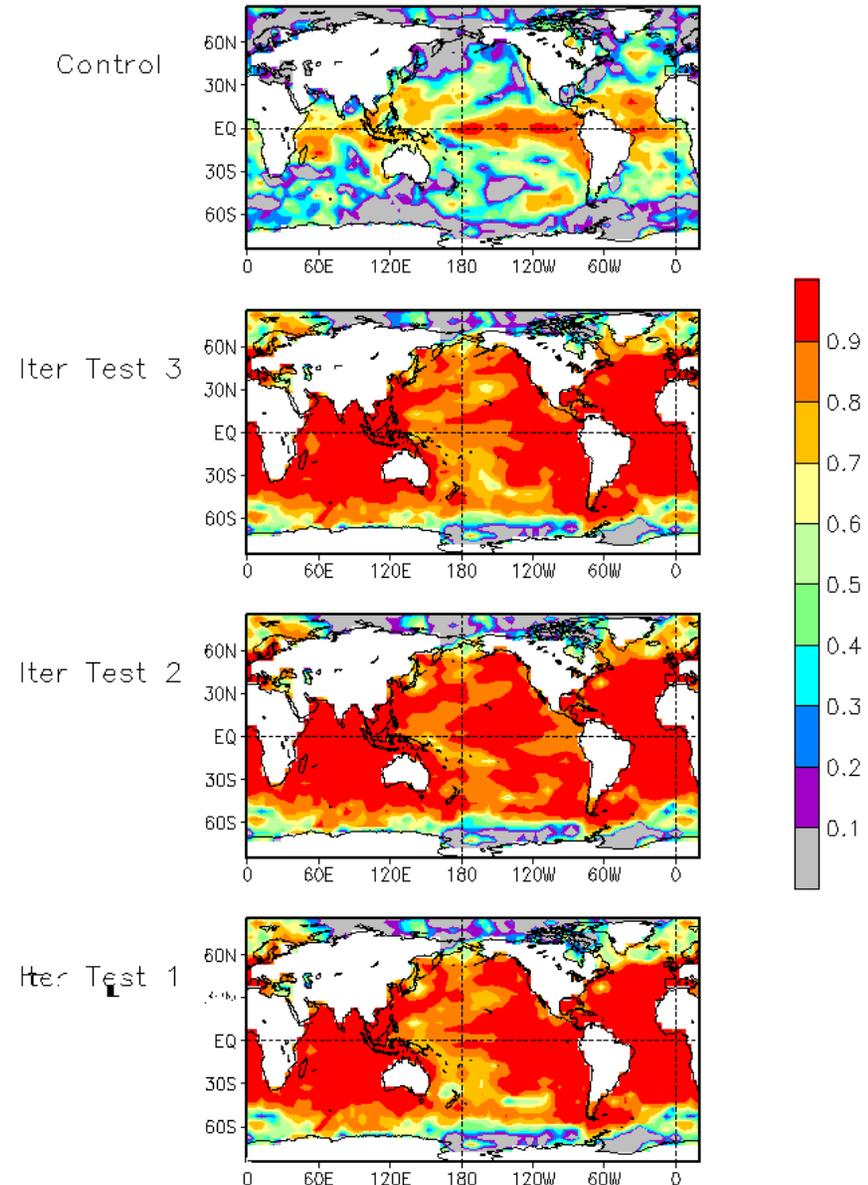
1865 SST Anomalies



Cross-Validation Correlations (1850-1899)

- Initial modes: 1990-2009
 - X-validation control uses these modes
- Data: 1982-1989
 - Repeat 8 years over historical period with historical sampling
 - Add noise proportional to sampling in each 5° area
 - Analyze & compare to full data
- Control: best in tropics
- Iterative REOFs all resolve variations better, IT3 is best

X-Val Corrs, 1850-1899



SST Reconstruction Conclusions

- Iterative SST reconstructions improve the historical variations for annual average 1st guess
 - Data re-injection makes reconstruction modes more dependent on historical period for better fits
 - Tuning of re-injection and limiting the number of modes filters out noise
- Test analysis produced using this 1st guess and monthly increment modes to analyze monthly SSTs
- Improved method may be used in improved ERSST

2) Precipitation Anomaly Reconstructions (1900-2008)

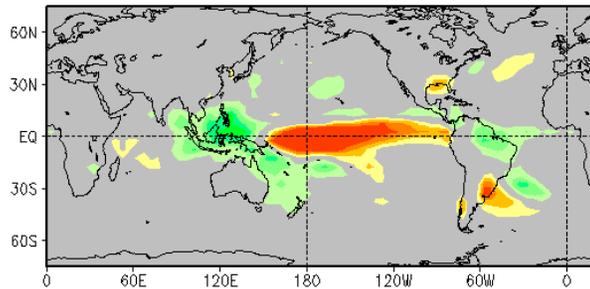
- Satellite analyses beginning 1979 (GPCP and others)
- A range of reconstructions tested on a 5° grid:
 - Direct monthly recons using historical gauge analyses
 - Indirect annual recons using CCA and historical SST and SLP analyses
 - Merged annual indirect with monthly direct
 - Latest experiments:
 - Annual-global direct reconstruction for 1st guess and monthly-global increment corrections, all based on gauge data
 - Annual 1st guess using gauges + oceanic CCA estimates as inputs, gauges for monthly-global increment corrections
 - Statistical re-injection of gauge data to adjust where sampling is available
- A brief summary of methods and results is presented



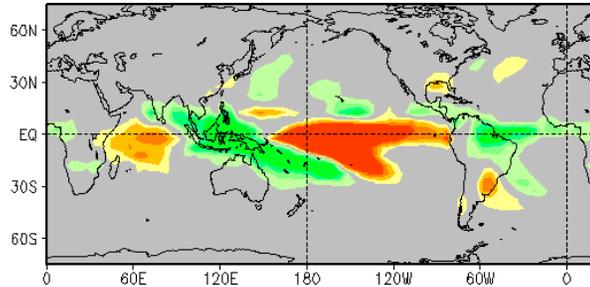
Climate-Mode Regressions with Monthly Direct Recon: Consistent Interannual Variations with Different Gauge Data

Against SOI

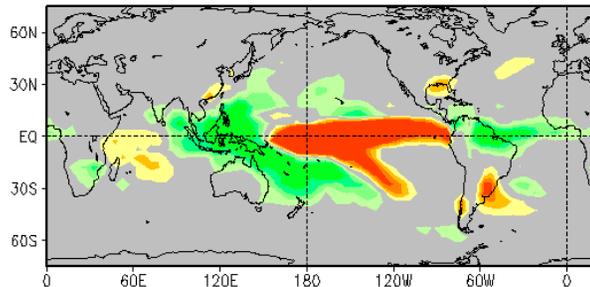
REOF(GHCN) SOI



REOF(GPCC) SOI



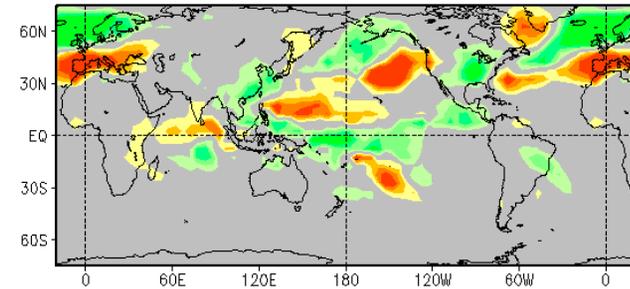
REOF(CRU) SOI



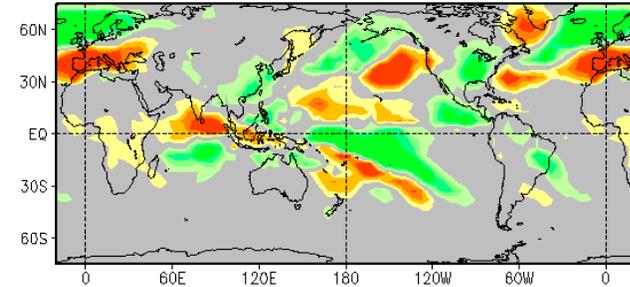
Annual Regressions (1901-1998)

Against NAO (Dec-Mar)

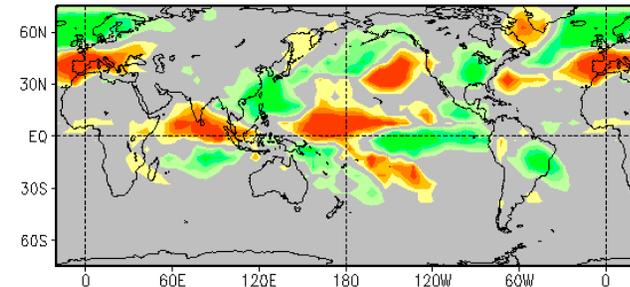
REOF(GHCN) NAO



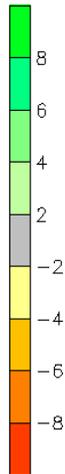
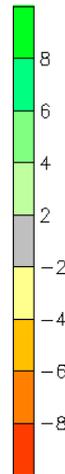
REOF(GPCC) NAO



REOF(CRU) NAO



Dec-Mar Regressions (1901-1998)



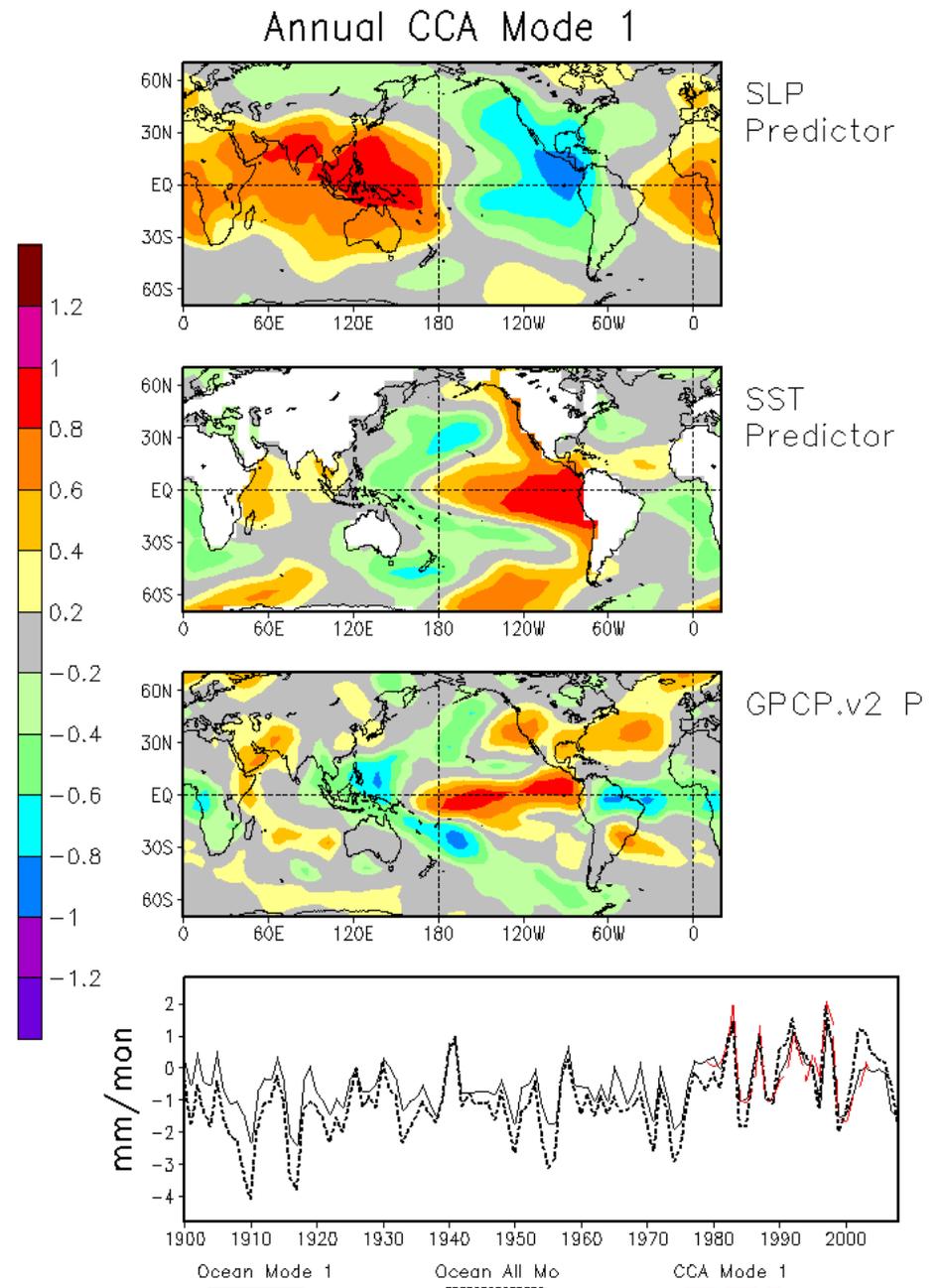


Problems

- Theory & most models say precipitation should increase with warming global temperatures
 - Monthly Recon EOF shows global decrease in 1st half of 20th century, increase in 2nd half
 - Sampling changes could be influencing multi-decadal signal
- Recon using CCA developed to use additional marine data
 - Correlation between precip and combined SST & SLP
 - Annual averages to concentrate on multi-decadal signal
 - Train in satellite period, use SST & SLP analyses since 1900

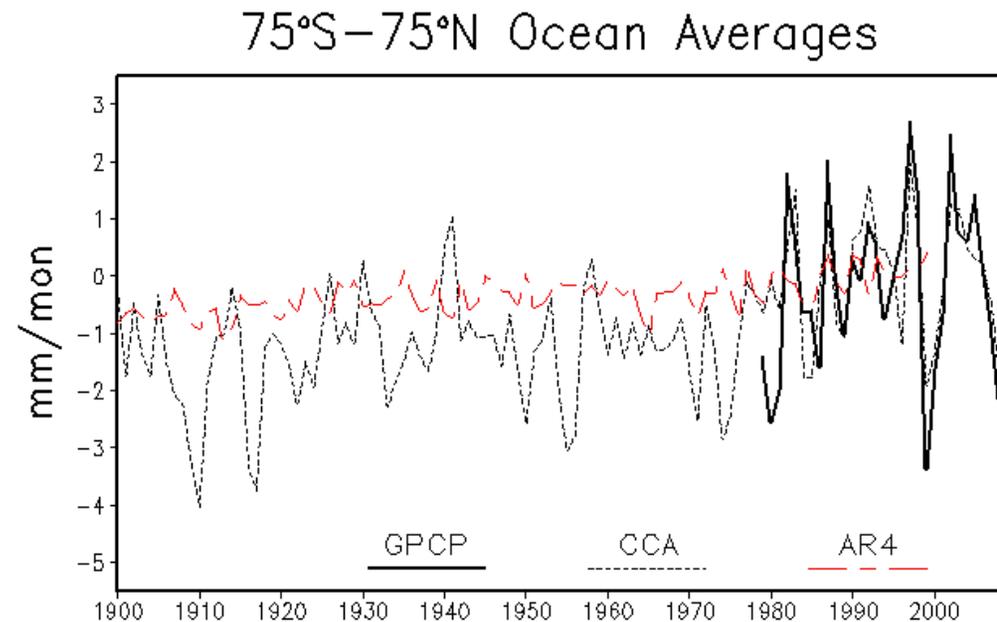
1st CCA Mode

- 2 Predictors (upper)
- Predictand (3rd panel)
- Time series for
 - CCA mode 1 (red, 1979-2004)
 - Ocean-area recon (1900-2008)
 - Solid black (associated with mode 1)
 - Dashed black (from all 8 modes)
- Most oceanic variations from 1st mode: ENSO-like



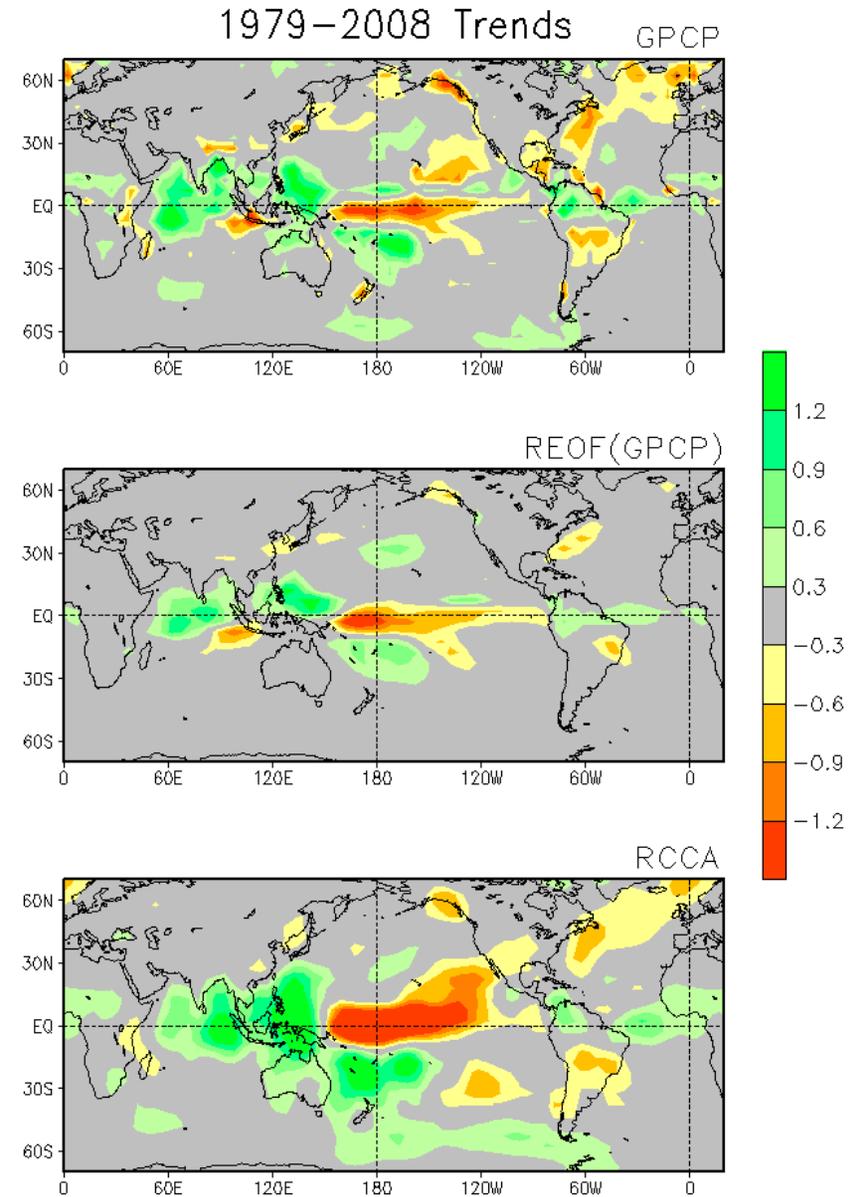
Near-Global Annual Recon CCA Comparisons Over Oceans

- Ocean-Area Averages
 - Consistent with GPCP base data
 - CCA Trend larger than ensemble AR4 model trend
 - CCA sensitive to 1970s SST climate shift



GPCP-Period Trends

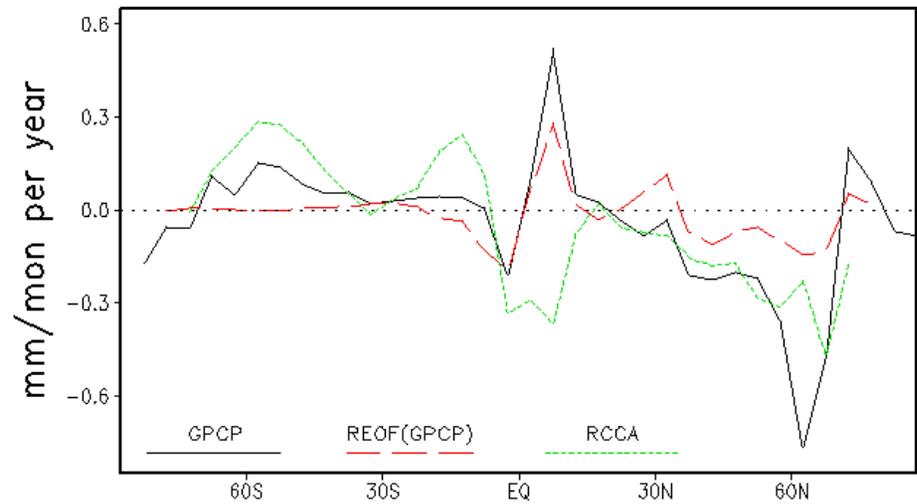
- GPCP trends
 - Full (upper)
 - Filtered using recon EOF modes (middle)
- CCA trend (lower)
 - Trend over same period
 - Similar to GPCP trends, but with larger spatial scales and stronger trends
- Apparent problem with the scales of CCA trends



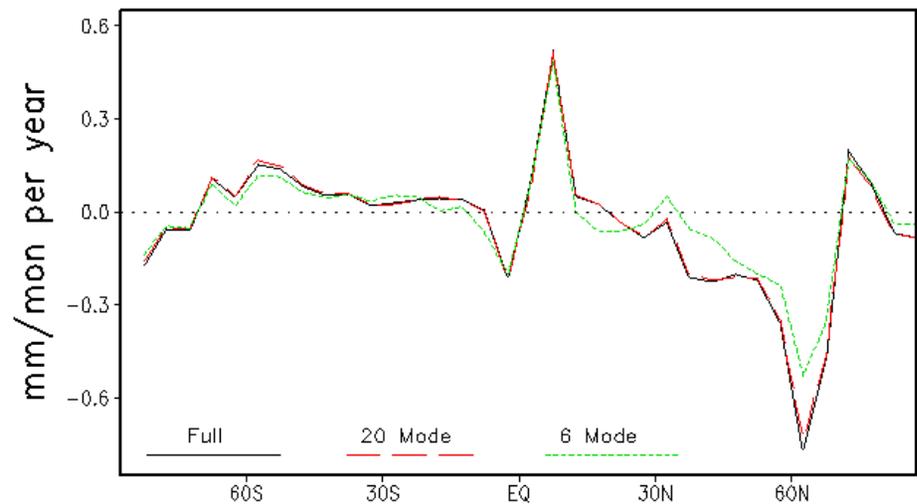
How Many EOFs are Needed to Resolve GPCP Trends?

- Zonal trends over oceans in GPCP period (1979-2008)
- CCA resolution a problem in zonal averages (upper)
- Global-Annual EOF smoothing (lower)
 - 6 modes gets most of trend
 - 20 modes get nearly all
- Can annual average be reconstructed using global-annual EOF modes?

Ocean Trends

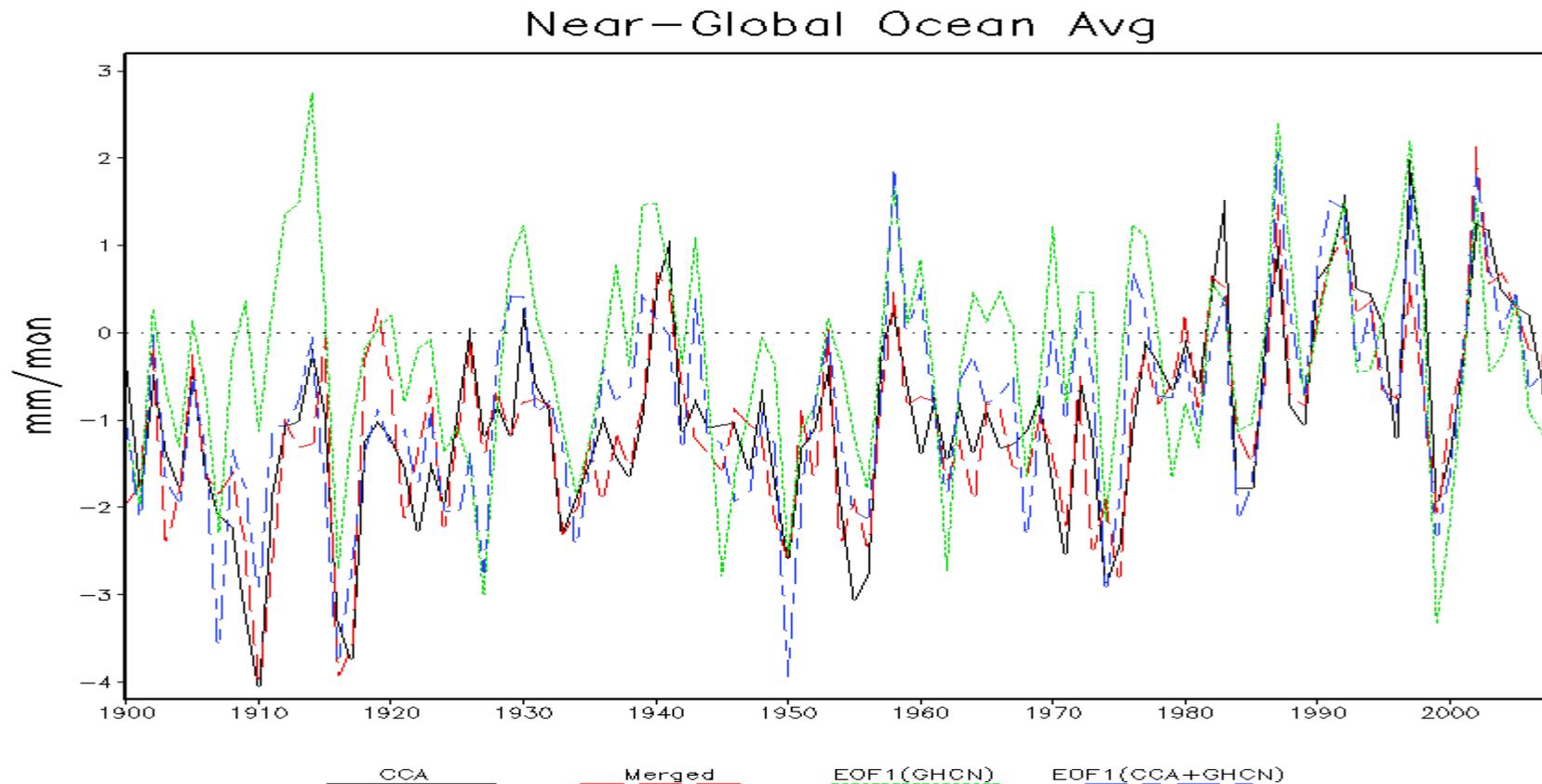


Ocean GPCP Trends



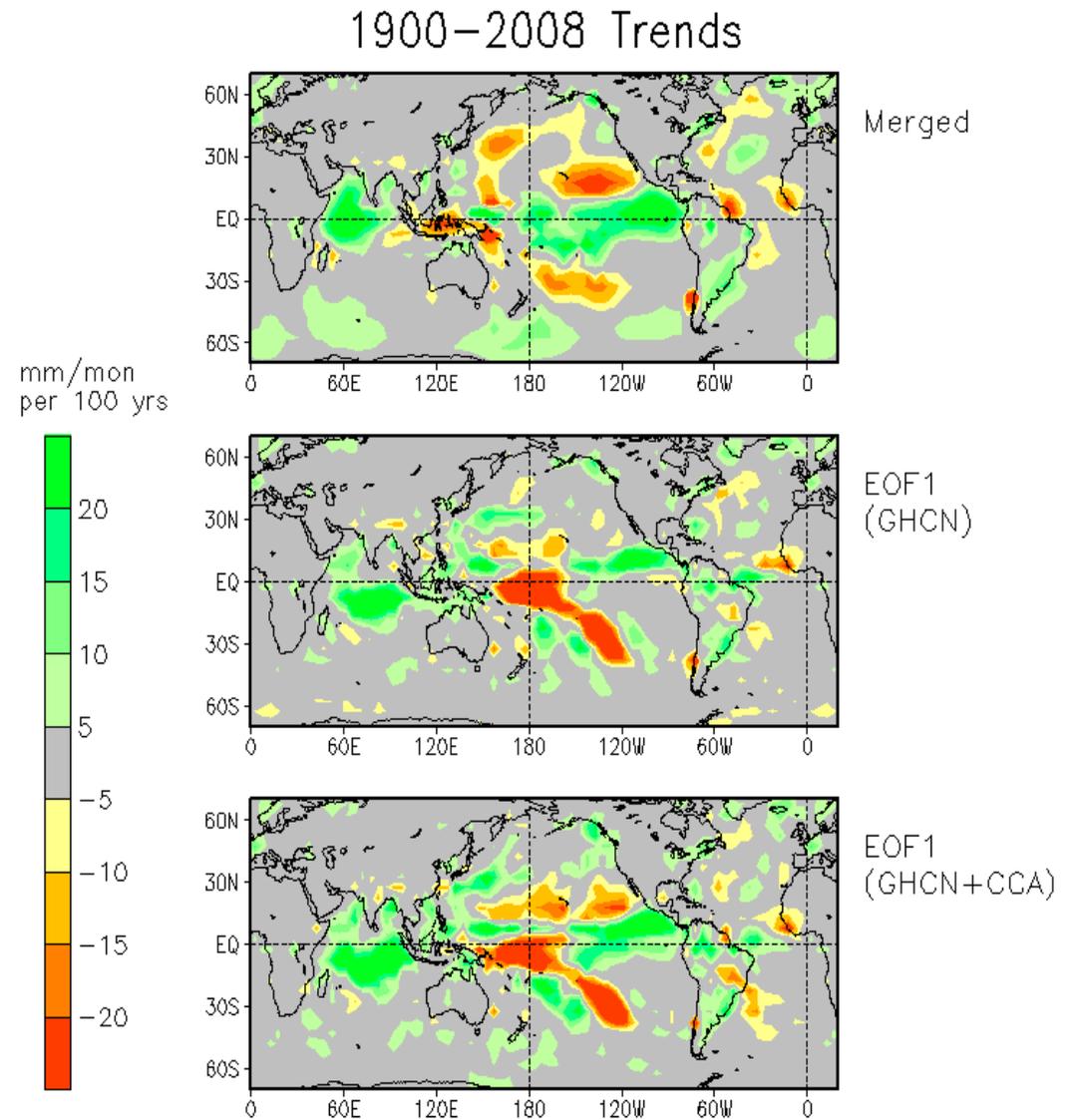
Ocean-Area Average Comparisons

- Merged uses CCA for oceanic multi-decadal
- EOF1(GHCN) uses only gauges: weaker increase over 20th century
- EOF1(CCA+GHCN) uses ocean-area CCA P & gauges: increase similar to CCA



Trend Maps: 1900-2008

- Merged (CCA over oceans):
large spatial scales
- EOF1(GHCN):
 - Smaller scales & weaker trends
 - Shifted trend patterns
- EOF1(GHCN+CCA):
 - Strength of trends similar to Merged—uses ocean information from CCA
 - Shape of pattern similar to EOF1(GHCN)—global mode filtering adjusts shape





Conclusions

- Monthly historical reconstructions possible beginning 1900
 - Satellite-based analyses critical for developing global recon statistics
 - Reconstructions are powerful tools for analysis of historical climate data
 - Estimating a first guess improves analyses
- Climate-scale variations reconstructed
 - Variations with scales roughly < 1000 km and sub monthly may not be resolvable with the available data
 - Uncertainties in reconstructions need to be estimated and considered
- Need to continue historical data development
 - Understanding and adjusting for historical biases is a major issue