Decadal Prediction at NCAR

Joe Tribbia
AND
G. Danabasoglu, P. Gent, J. Hurrell
J. Meehl, B. Large, F. Bryan, G. Branstator and …

NCAR Conclusions

- Abundant Decadal Variability in Ocean and Atmosphere and activity at NCAR
- Additional initial condition information should help ‘predict’ this variability
- Open questions

  a) mechanisms of variability

  b) practical utility of additional information

Without ODA
what will/can NCAR do?

- Plans and partners

  CCSM

  GFDL+MIT

  Italy (CMCC)

- Science questions

  Information=IC+ Signal (predictable?)

  Mechanisms of decadal variability

  Atmospheric manifestation

CCSM Plans

- IPCC Expectations
- 0.5 ° x 30-60L Atmosphere;
  1°x 40-60L Ocean
- Prescribed GHG Concentrations
- Ocean ICs? Experiment with

  Spin up to start date (see Gent's talk)

  'Balanced' Ocean Analyses from GFDL, INGV, U Md …

One initialization strategy

- Use Ocean Analysis product (GFDL, SODA-POP, INGV etc)
- Reinitialize (replace) barotropic mode (needed because of differing ocean topography)
- Successful for ENSO prediction
- Other strategies: ocean spin-up, use earlier forecast ocean states and analysis product
- Build an IC ensemble with representative uncertainty

Successful prediction of ’97-’98 ENSO – one year in advance

Forecast
Anomalies

Analyzed
Anomalies

Two year prediction---not successful

Forecast
Anomalies

Analyzed
Anomalies

With GFDL-MIT

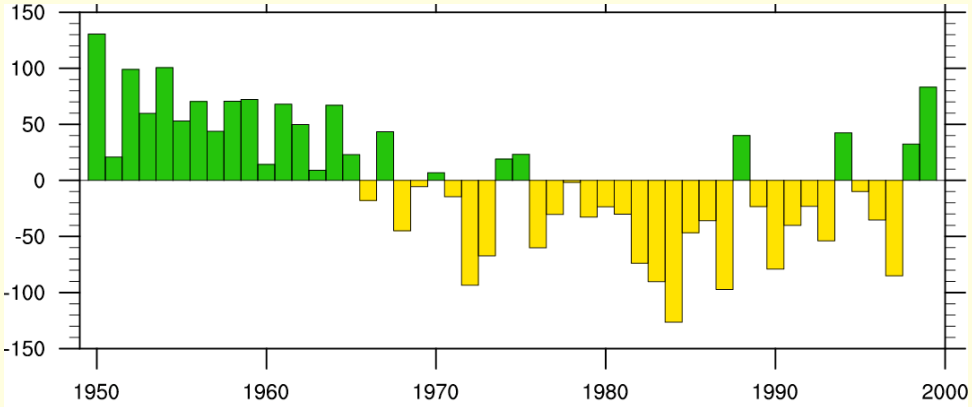
- Focused on predictability of Atlantic
- Decadal oscillations in AMOC
- Predictable?
- Realistic?
- Impact on Atmosphere

Motivation for Decadal Prediction

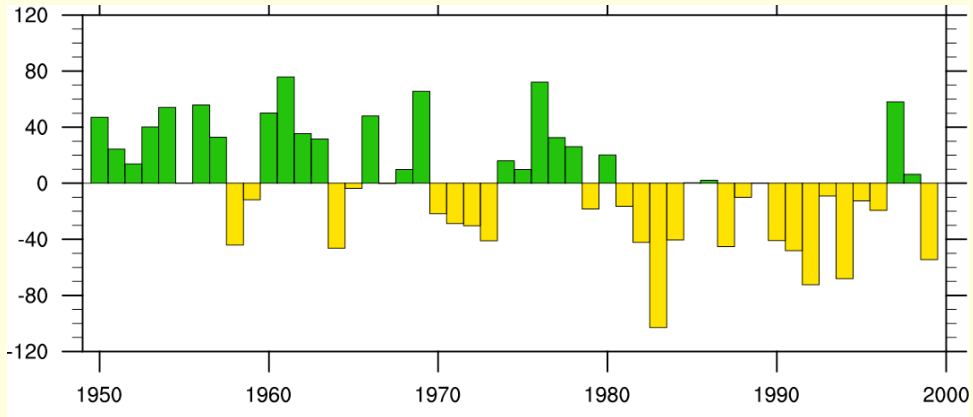
Examples of climate modes of variability on decadal timescales

Rainfall Anomalies (mm)

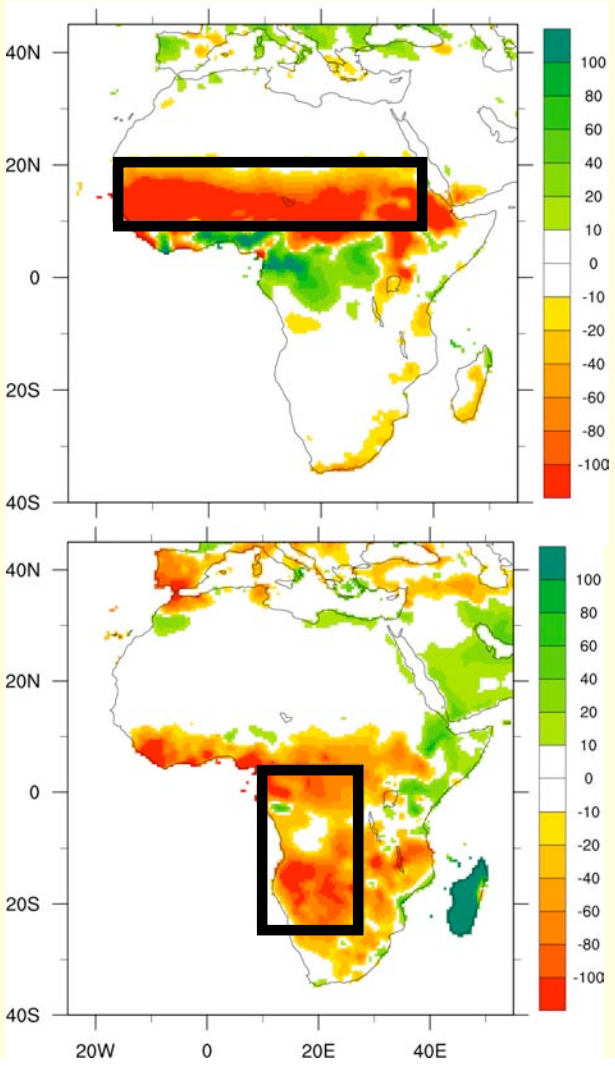
Sahel: JAS



Southern Africa: FMA



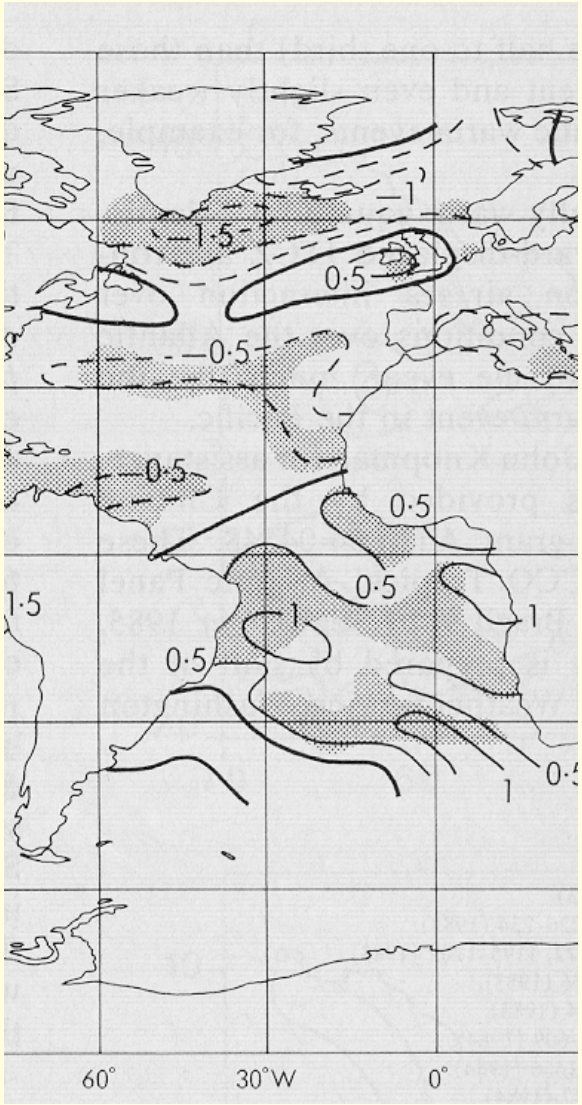
50-year Trend (mm)



Relationship to Atlantic SST

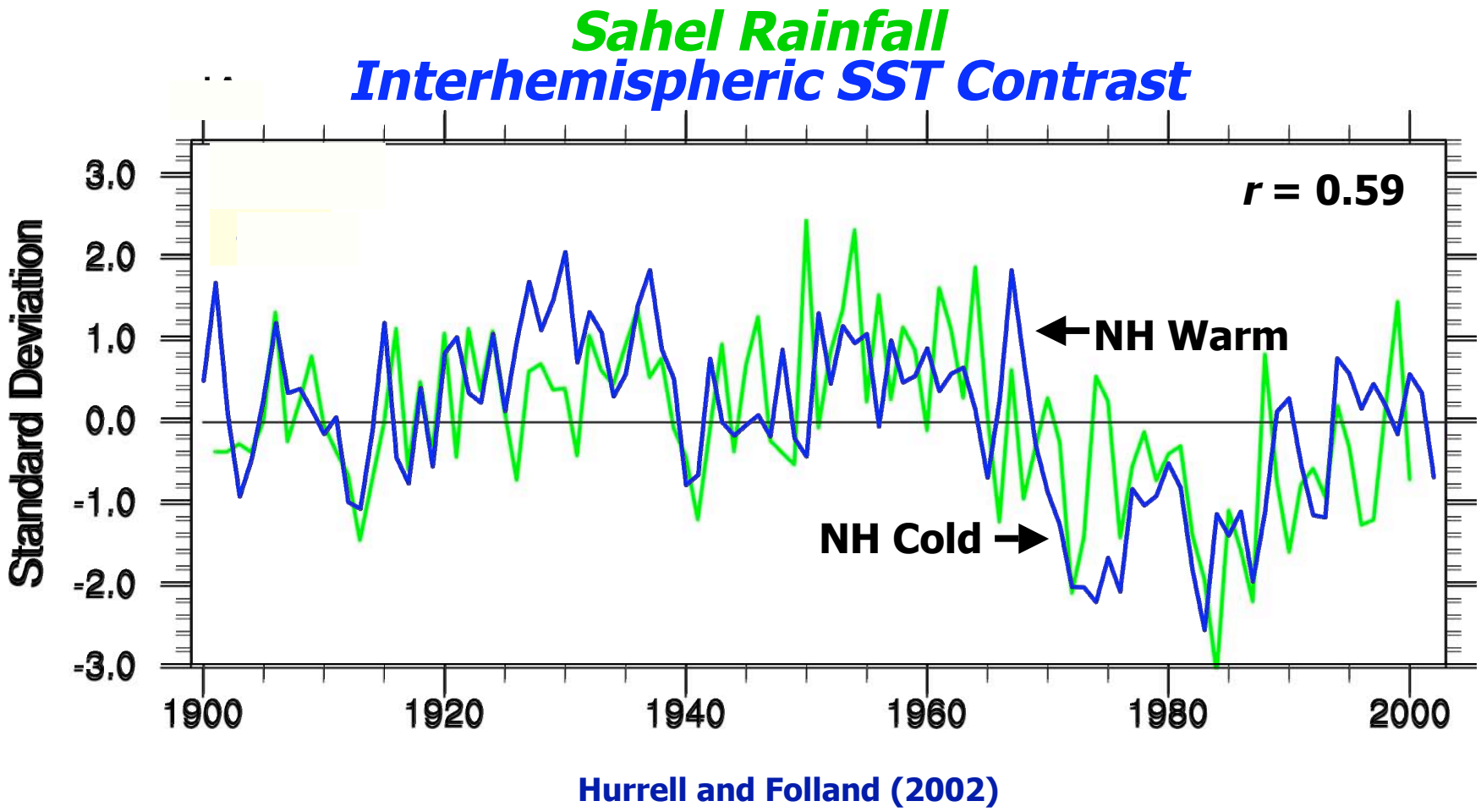
(Dry – Wet) Sahel Summers

Correlation of Atlantic SST Anomalies With Sahelian Rainfall Anomalies



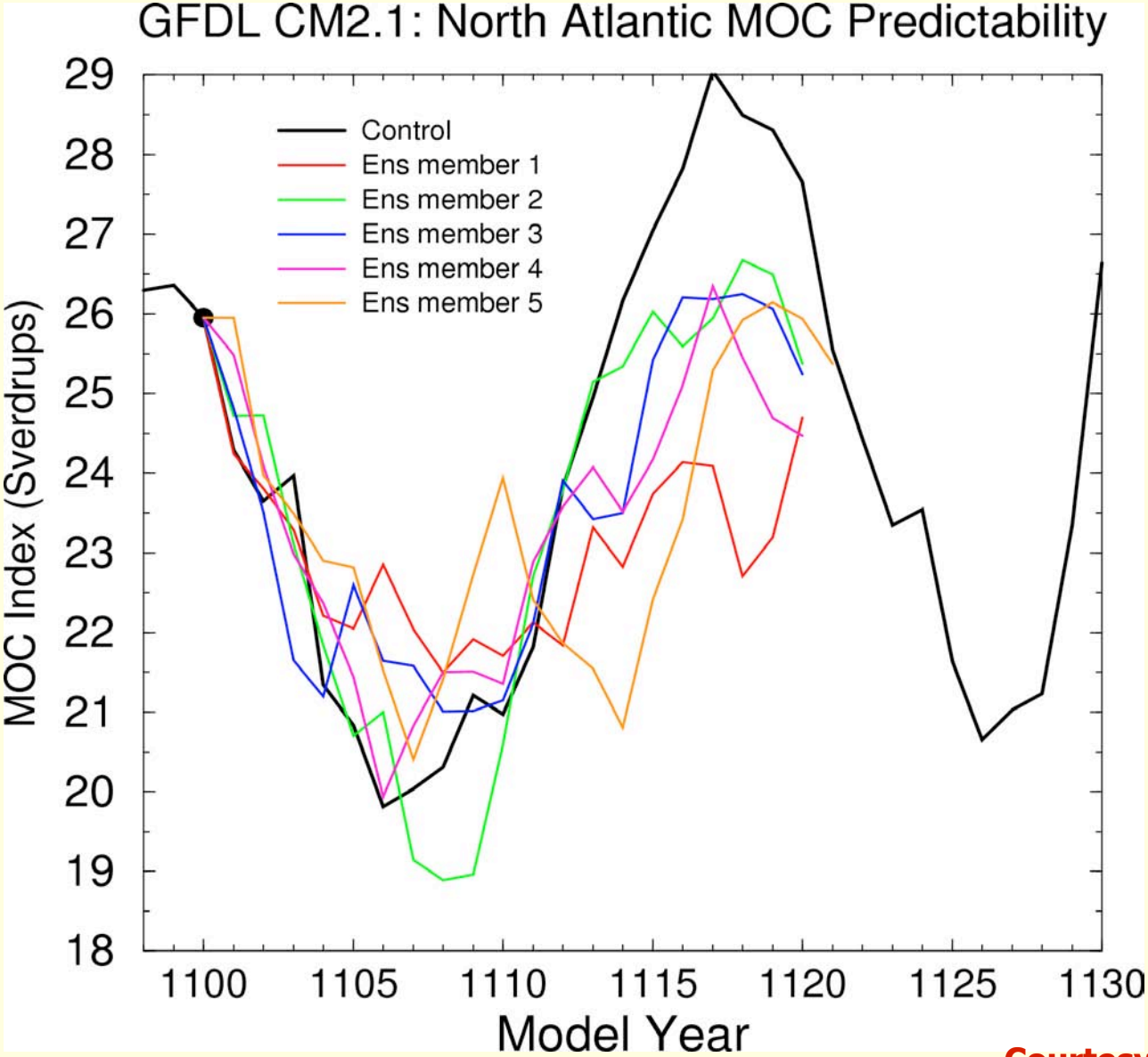
Lamb (1978);
Folland et al. (1986)

Relationship to Atlantic SST



Hurrell and Folland (2002)

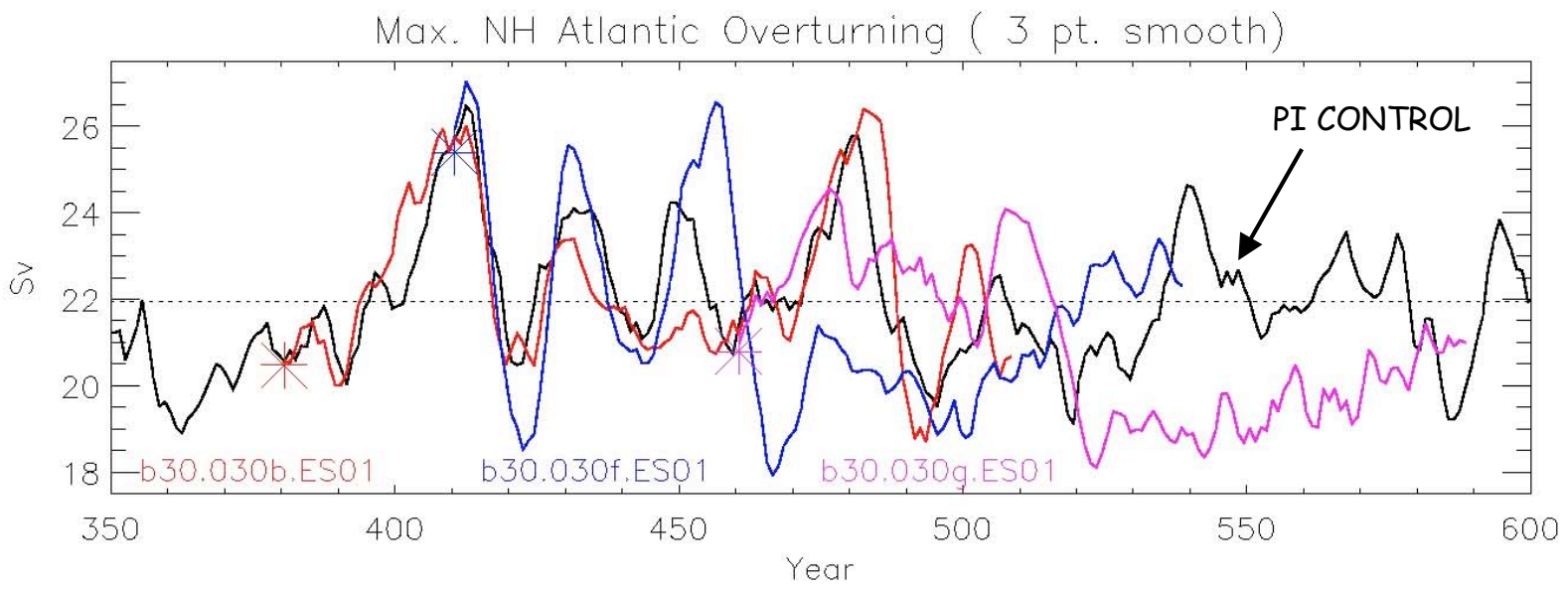
Scientific Basis for Decadal Prediction

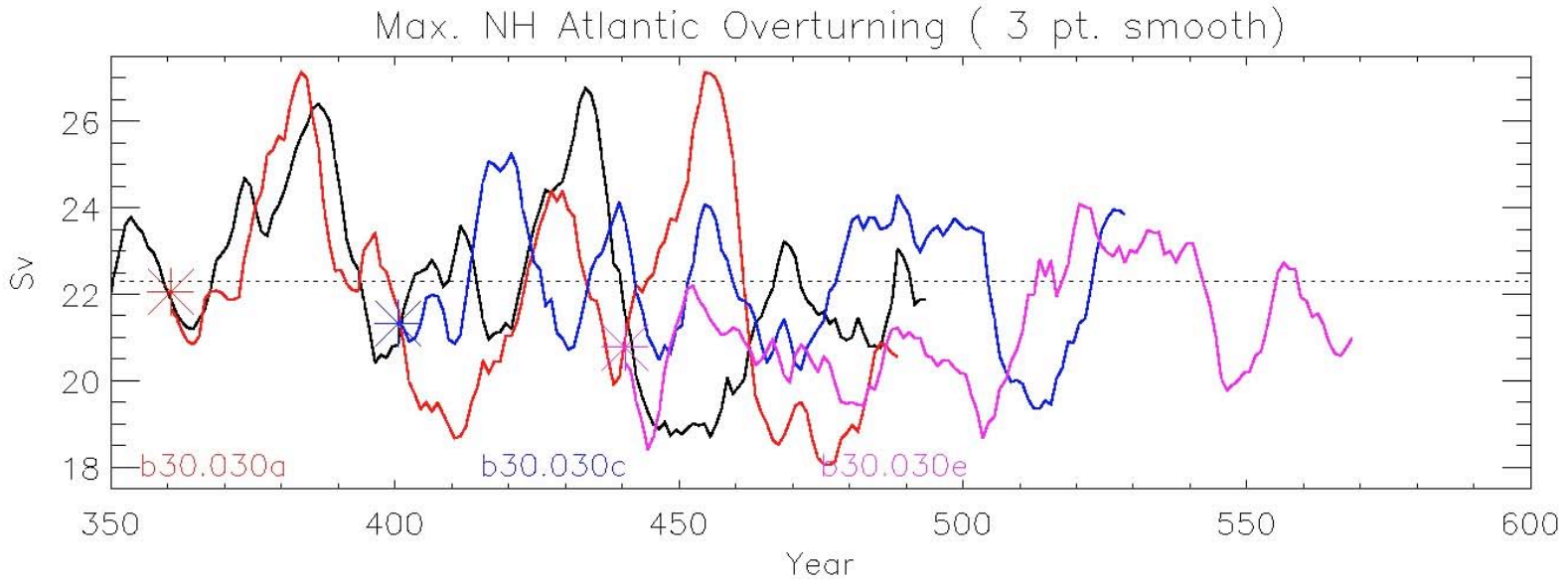


Perturbed ensemble members evolve coherently for two decades

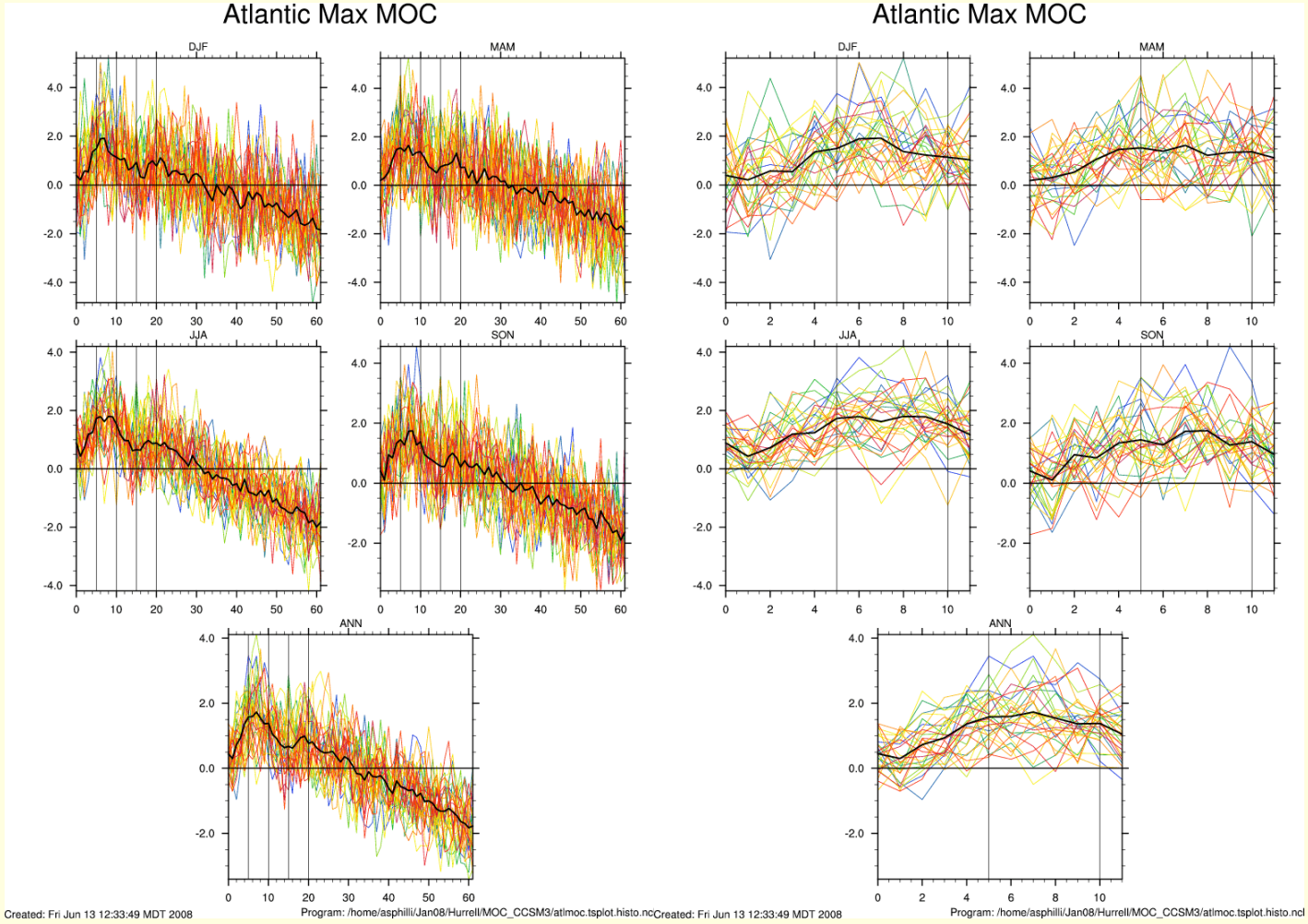
Courtesy of Tom Delworth

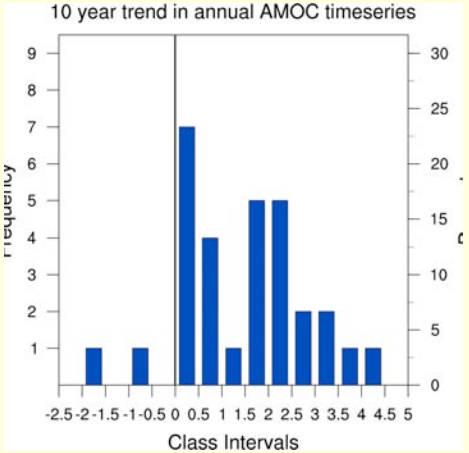
MOC in 20th Century Ensemble Integrations



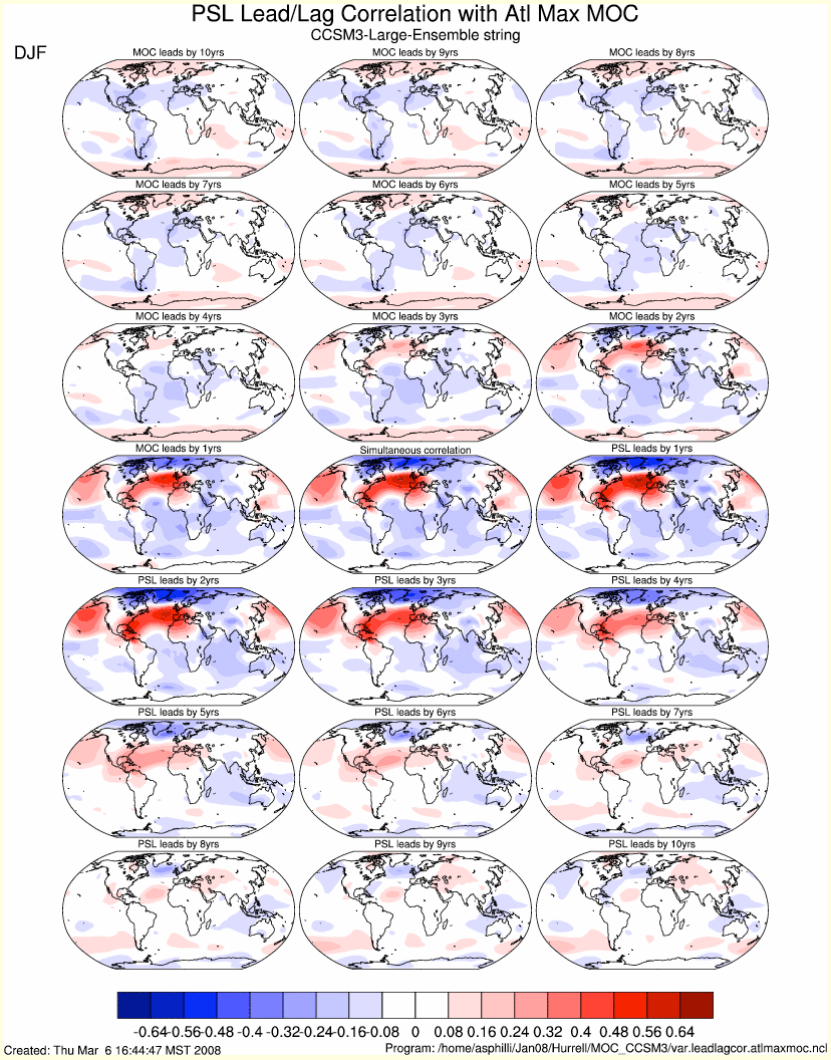


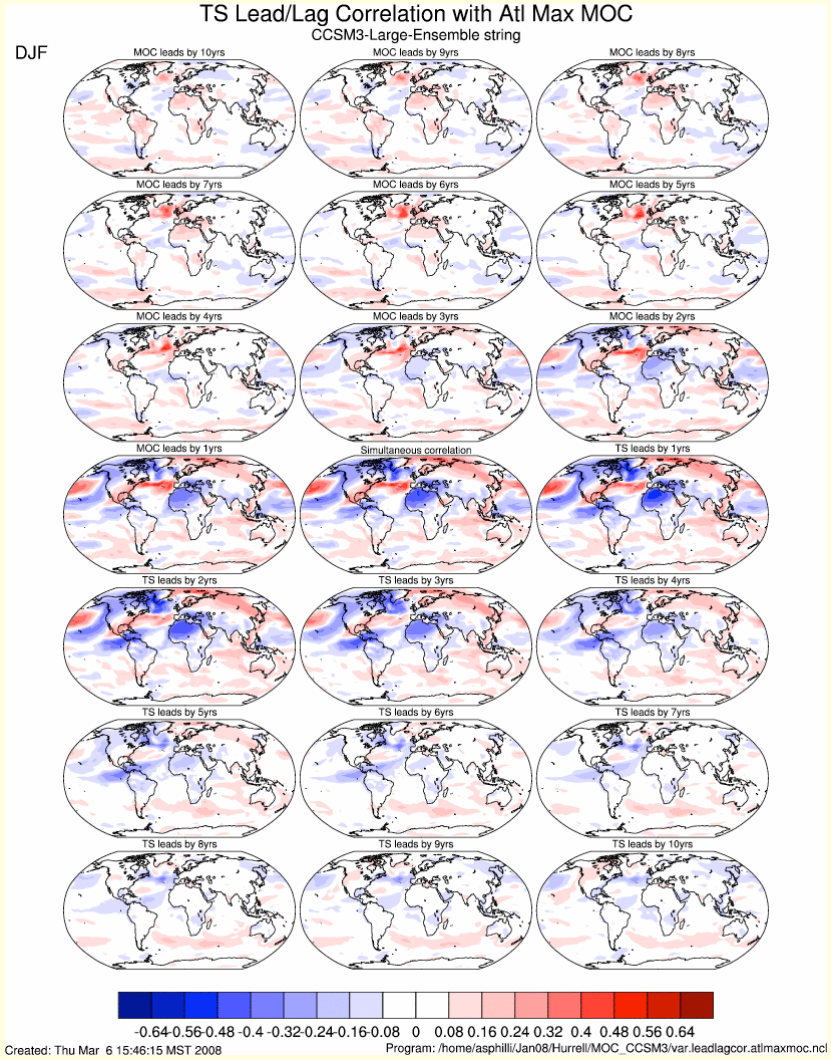
CCSM NVWG Ensemble (Model twin experiments-Pangloss' best of all possible worlds)





Atmospheric Correlations (30 member model twin experiments)





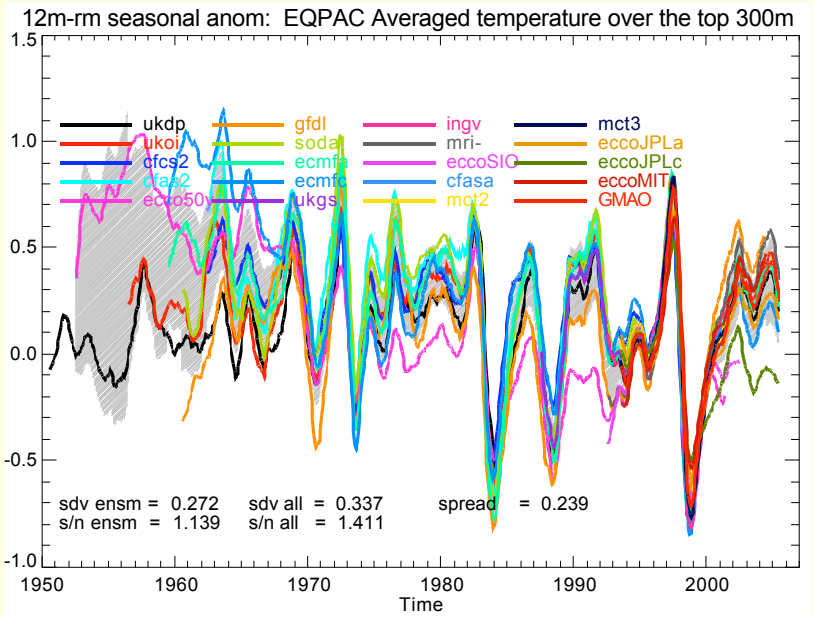
Decadal Prediction

Information 'challenges' …

- **Initialization**
  - o **Many different global reanalysis products, but significant differences exist**

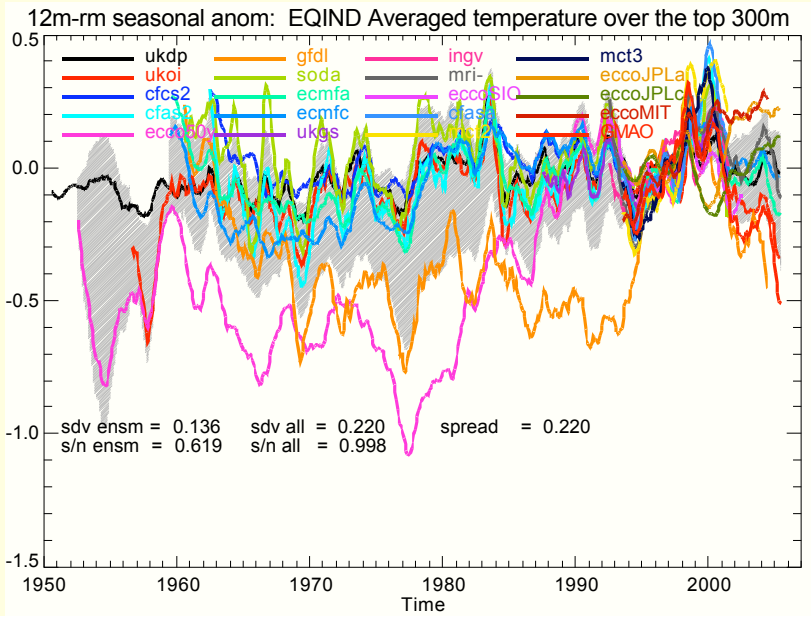
Ocean observing net not global or comprehensive

Tropical Upper Ocean T Anomalies (Upper 300 m)



Pacific ←

Indian →



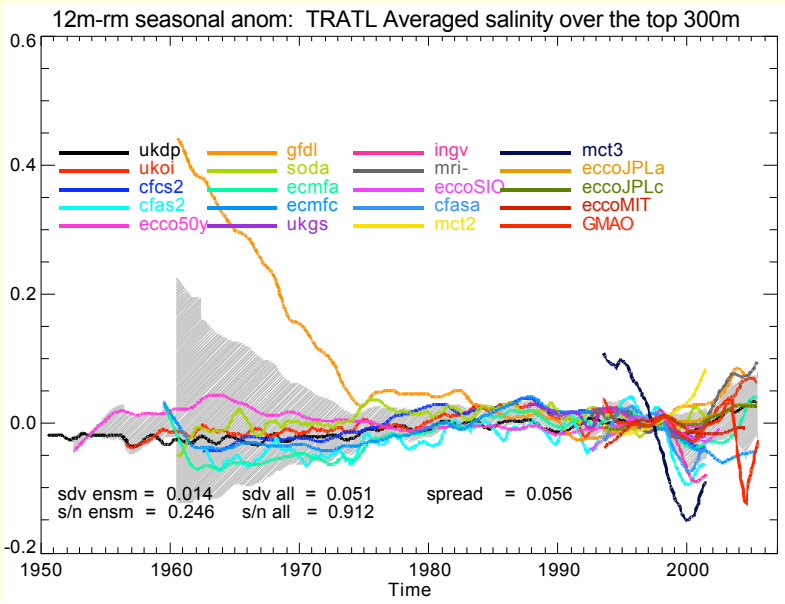
Decadal Prediction (hindcasts)

Information challenges …

- **Initialization**
  - o **Many different global reanalysis products, but significant differences exist**

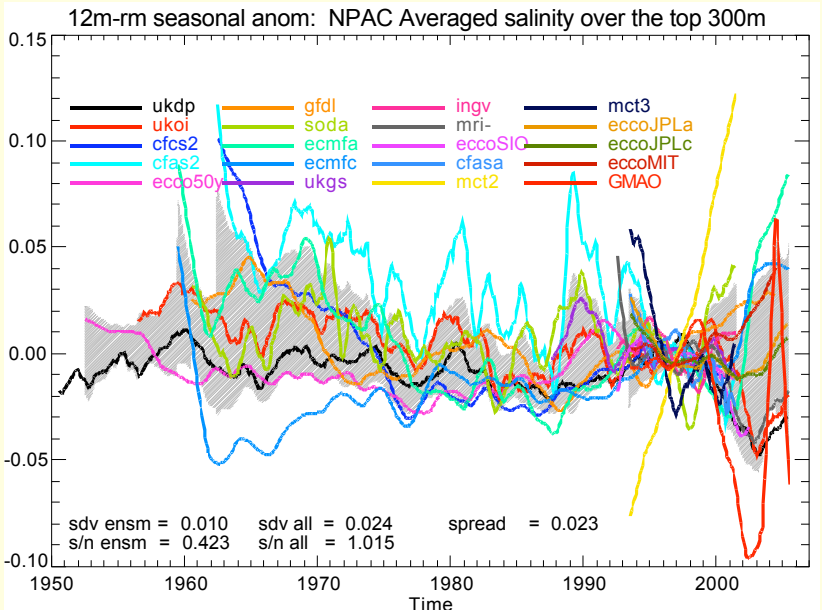
Large inherent uncertainty in driving of AMO

Atlantic Salinity Anomalies (upper 300 m)



Tropics ←

Mid-Lat →



Italy-US plans

- Participants: INGV/CCMC, NCAR,
  and possibly GFDL, COLA, IPRC
- Decadal integrations using initialized models, with and without updated GHG concentrations.
- Integrations will have an ensemble of 3 ocean initial states

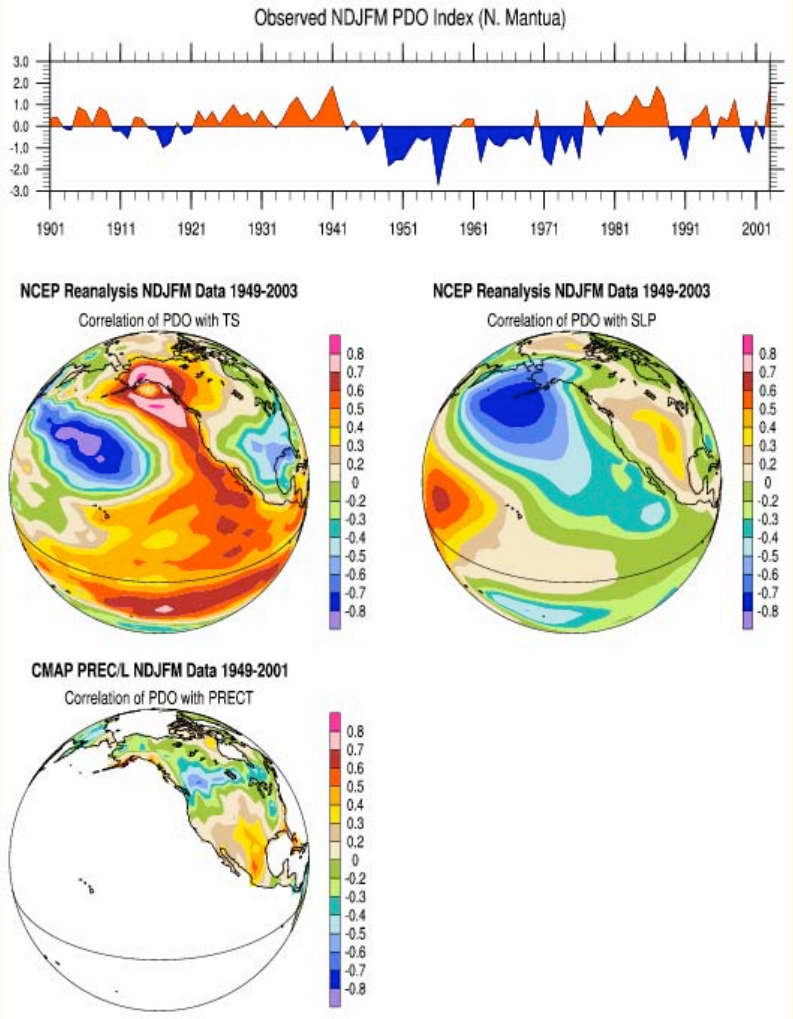
Italy-US plans

- Each ocean initialized state (1-3) will have 2 integrations associated with it.

  1) observed GHG and sulfate aerosols up to 2000 and A2 scenario GHG concentrations from 2000-2030.

  2) GHG and aerosol forcing held fixed at observed values from the start of the individual integration

Decadal Variability in Pacific



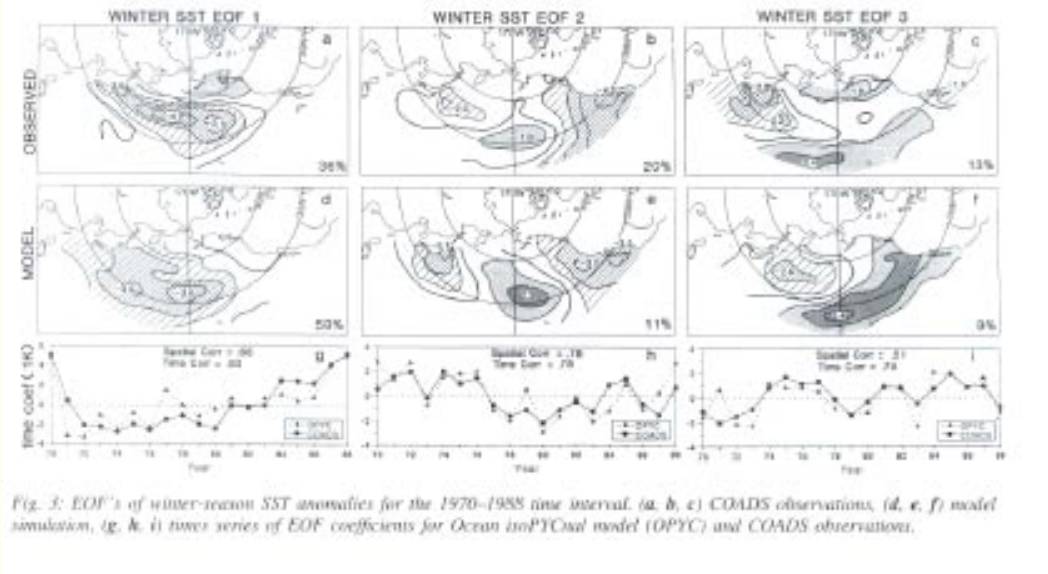
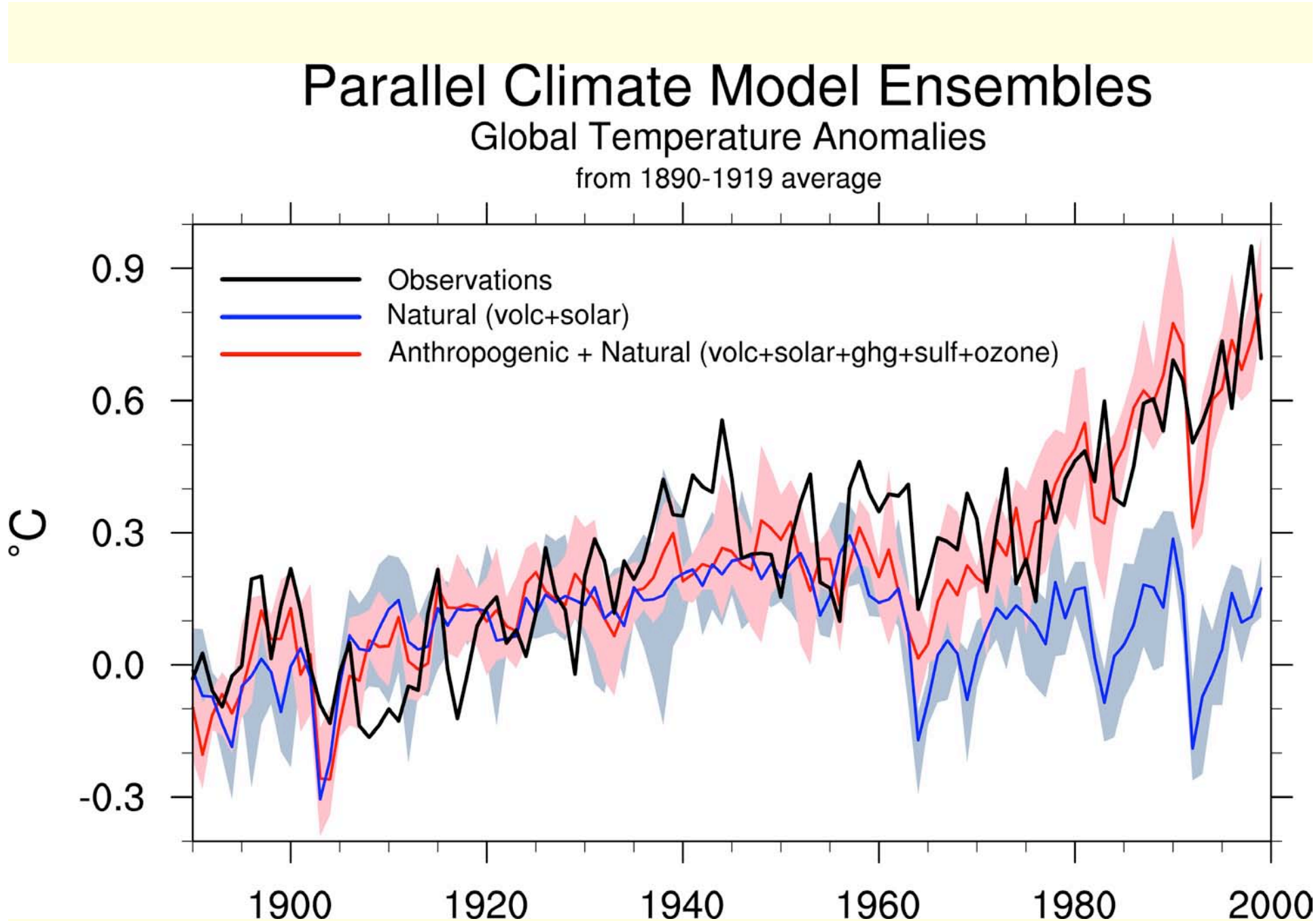


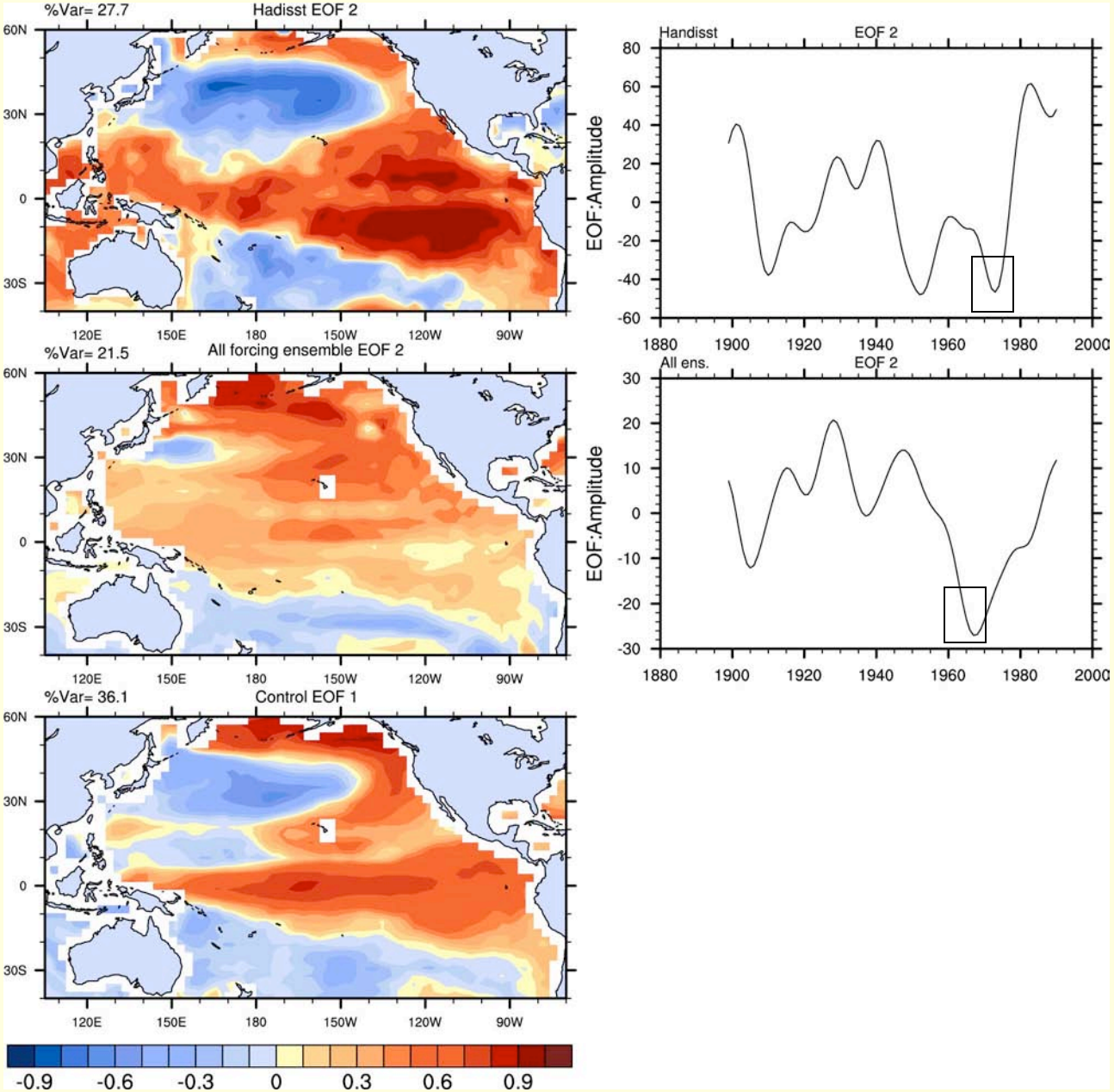
Fig. 5: EOF's of winter-season SST anomalies for the 1970–1988 time interval. (a, b, c) COADS observations, (d, e, f) model simulation, (g, h, i) times series of EOF coefficients for Ocean isoPYCnal model (OPYC) and COADS observations.


Parallel Climate Model Ensembles
Global Temperature Anomalies
from 1890-1919 average
Observations
Natural (volc+solar)
Anthropogenic + Natural (volc+solar+ghg+sulf+ozone)
°C
0.9
0.6
0.3
0.0
-0.3
1900
1920
1940
1960
1980
2000

Observed pattern of 1970s shift

Ensemble mean forced response pattern with 1960s shift (pattern correlation +0.45 with inherent decadal pattern below)

“Inherent” decadal variability pattern from long control run (pattern correlation +0.63 with observed at top)

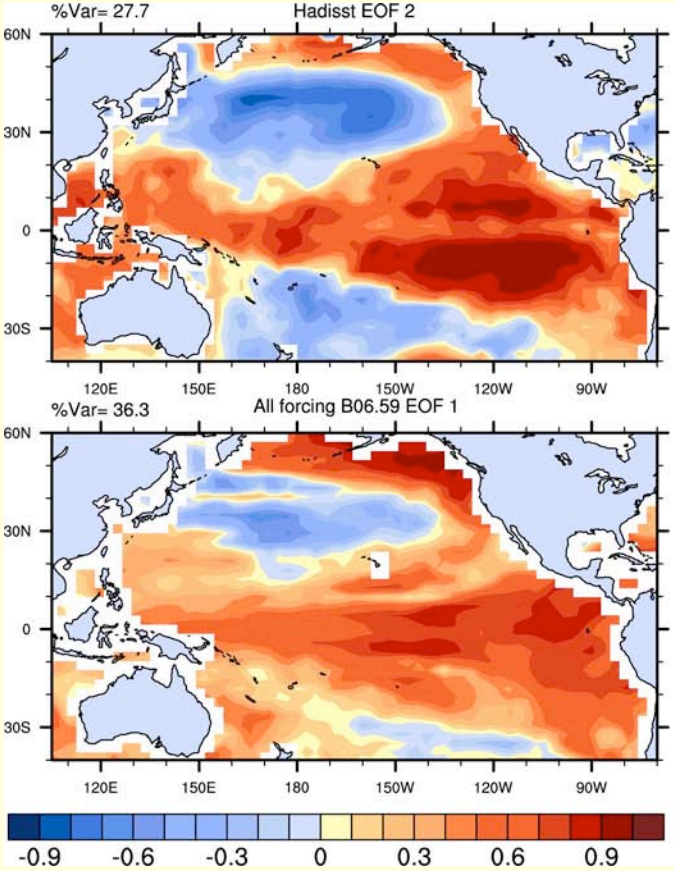


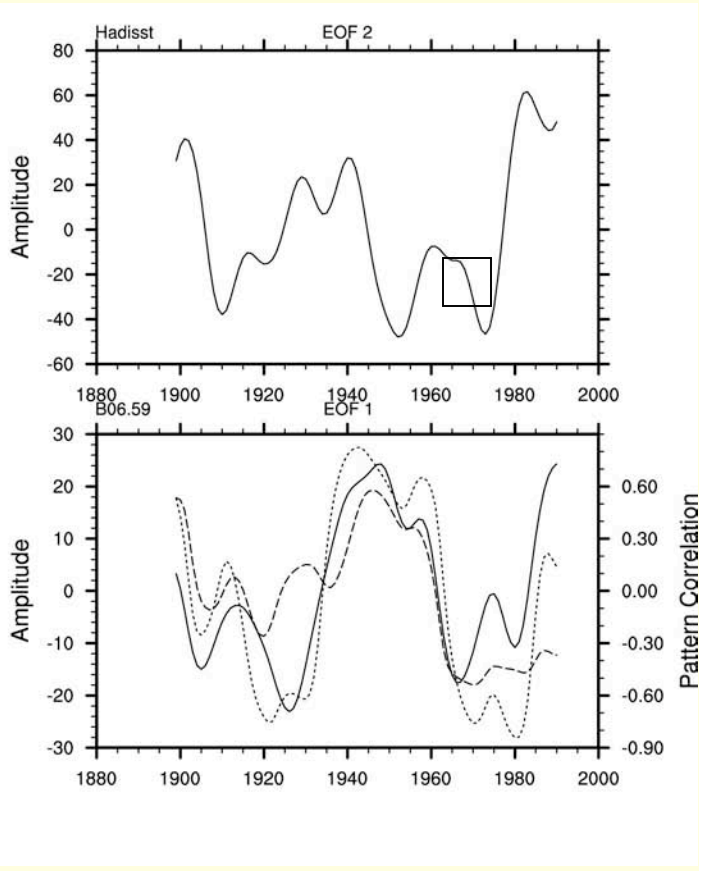
CCSM3 reproduces shifts

Observed 1970s shift

Single all-forcings member with early 1980s shift from inherent decadal variability (pattern correlation with observed: +0.70

Pattern correlation with control run EOF1: +0.77)





Dotted: pattern correlation with control decadal pattern

Dashed: pattern correlation with ensemble mean forced pattern

Pacific Transition

1. Globally averaged surface air temperatures in observations show transition in 1970s, as does ensemble mean all-forcings response in model; how much is forced and how much is natural?
2. “Decadal” pattern in observations has 1970s climate shift in the Pacific
3. Ensemble mean all-forcings response has 1960s climate shift in the Pacific, but is also related to “inherent” decadal pattern from un-forced control run
4. Decadal and forced patterns are not independent, thus making attribution difficult
5. Model results from one of the ensemble members suggest inherent decadal variability probably delayed observed climate shift in the Pacific from the 1960s to the 1970s