Current Activities Related to Decadal Prediction from COLA

Edwin K. Schneider

George Mason University and COLA

Topics

- Statistical evaluation of decadal predictability from AR4 models (Tim DelSole)
- EEMD perspective on decadal prediction (Zhaohua Wu)
- Null hypothesis for decadal predictability (Ed Schneider)
- Results from a decadal hindcast/prediction (Ed Schneider)
- A better model (through flux correction)
  - makes better SI predictions (Julia Manganello and Bohua Huang)
  - produces a more realistic (PDO Christina Stan and Ben Kirtman)
- Future plans (Jim Kinter)

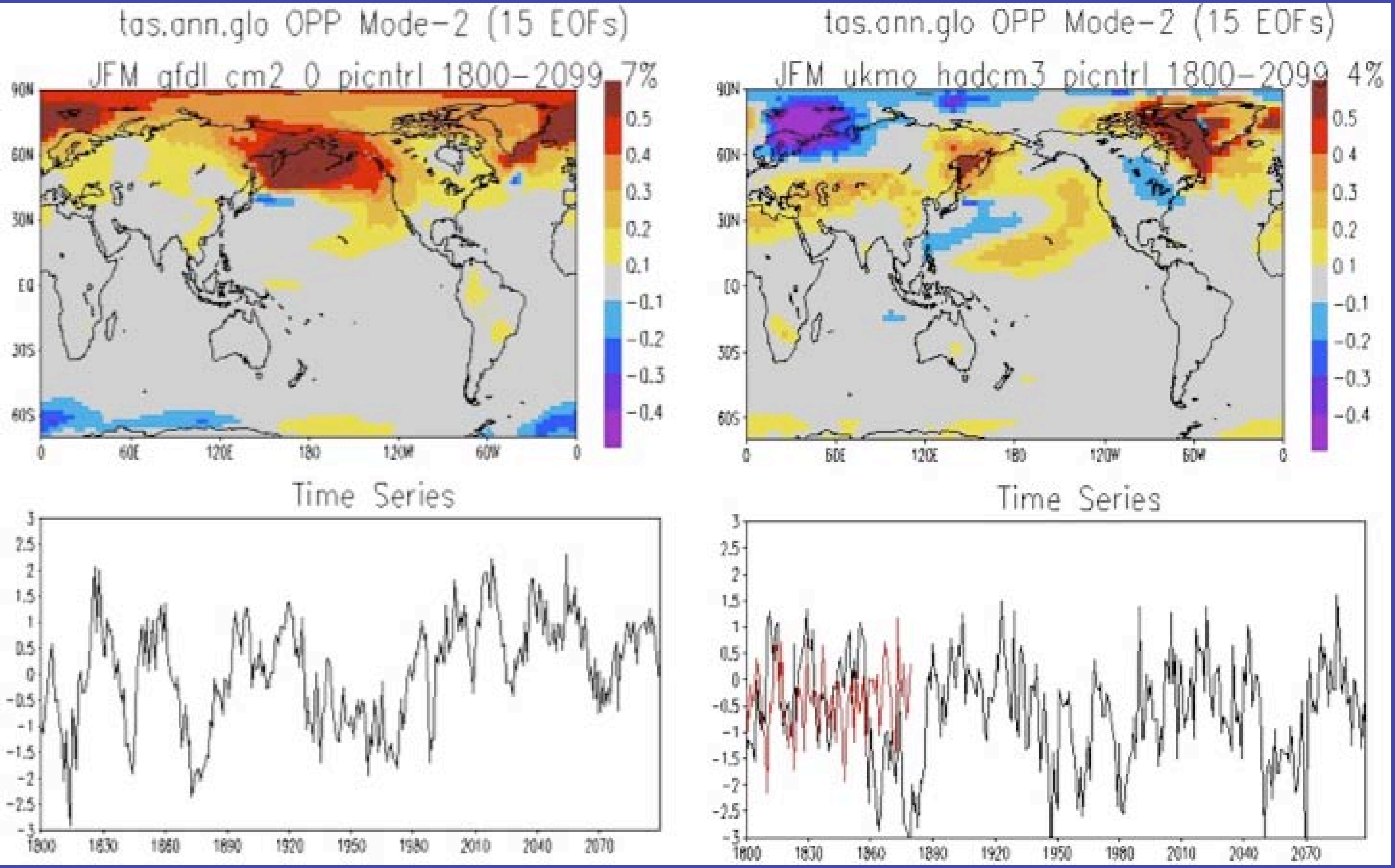
Optimal Persistence Analysis

- Multi-model comparison using Optimal Persistence Analysis to identify potentially predictable decadal patterns
- Comparison of COLA runs other CLIVAR decadal predictions, CMIP3 runs

  - DelSole, T., 2001: Optimally Persistent Patterns in Time-Varying Fields. J. Atmos. Sci., 58, 1341-1356.

  - DelSole, T., 2006: Low-Frequency Variations of Surface Temperature in Observations and Simulations. J. Climate, 19, 4487-4507.

Optimal Persistence Analysis



Optimal Persistence Analysis of pre-industrial surface air temperature records in two different CMIP3 models (left and right columns). The upper panels depict the spatial pattern of the second most persistent variation (first is trend), and the lower panels show the time series of the coefficients of these modes.

Ensemble Empirical Mode Decomposition

- Zhaohua Wu
- Example: Analysis of global mean land surface temperature record

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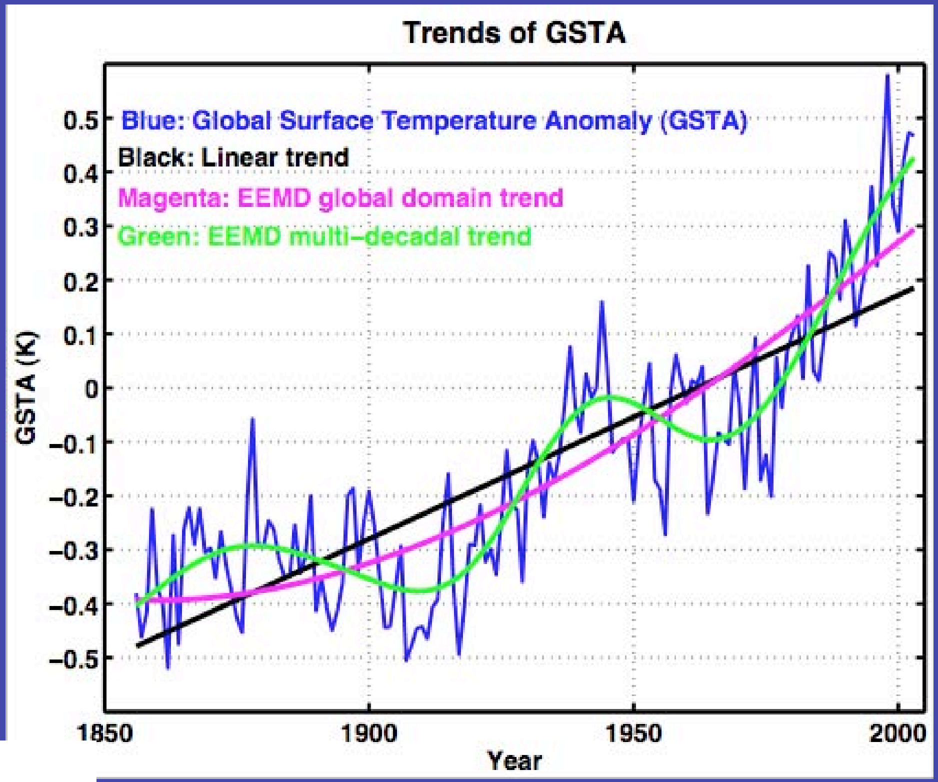
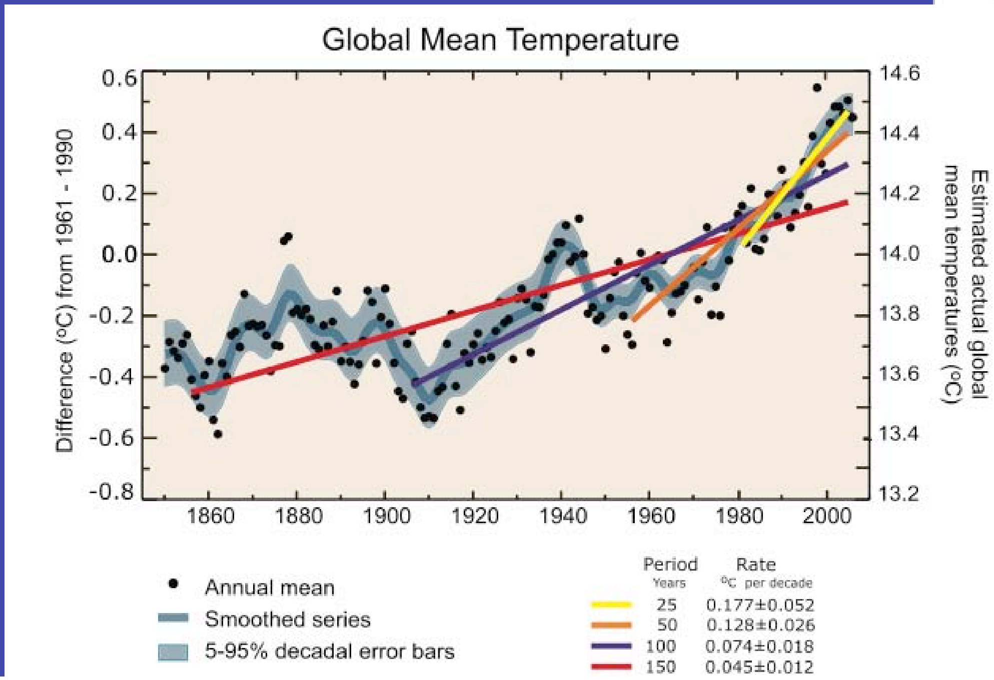
On the trend, detrending, and variability of nonlinear and nonstationary time series

Zhaohua Wu, Norden E. Huang, Steven R. Long, and Chung-Kang Peng



Trends of GSTA
Blue: Global Surface Temperature Anomaly (GSTA)
Black: Linear trend
Magenta: EEMD global domain trend
Green: EEMD multi-decadal trend
GSTA (K)
Year

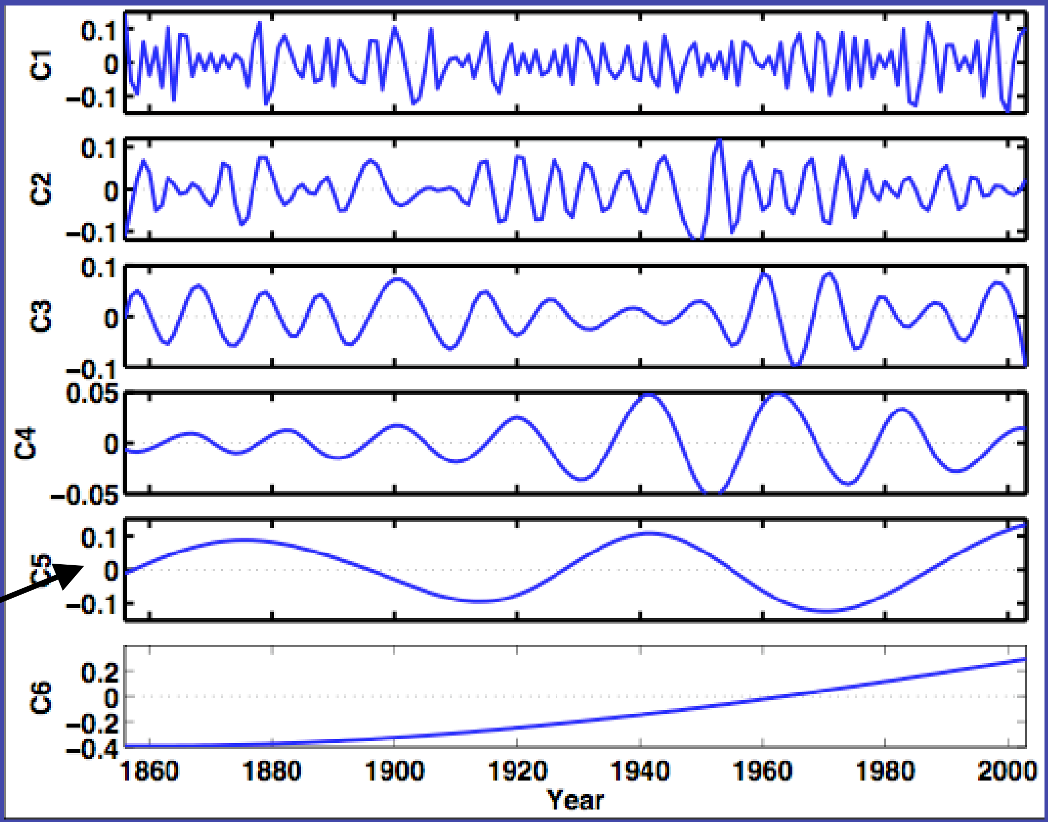
IPCC 3.1



Global Mean Temperature
Difference (°C) from 1961 - 1990
Estimated actual global mean temperatures (°C)
Annual mean
Smoothed series
5-95% decadal error bars
Period Years
Rate °C per decade
25 0.177±0.052
50 0.128±0.026
100 0.074±0.018
150 0.045±0.012

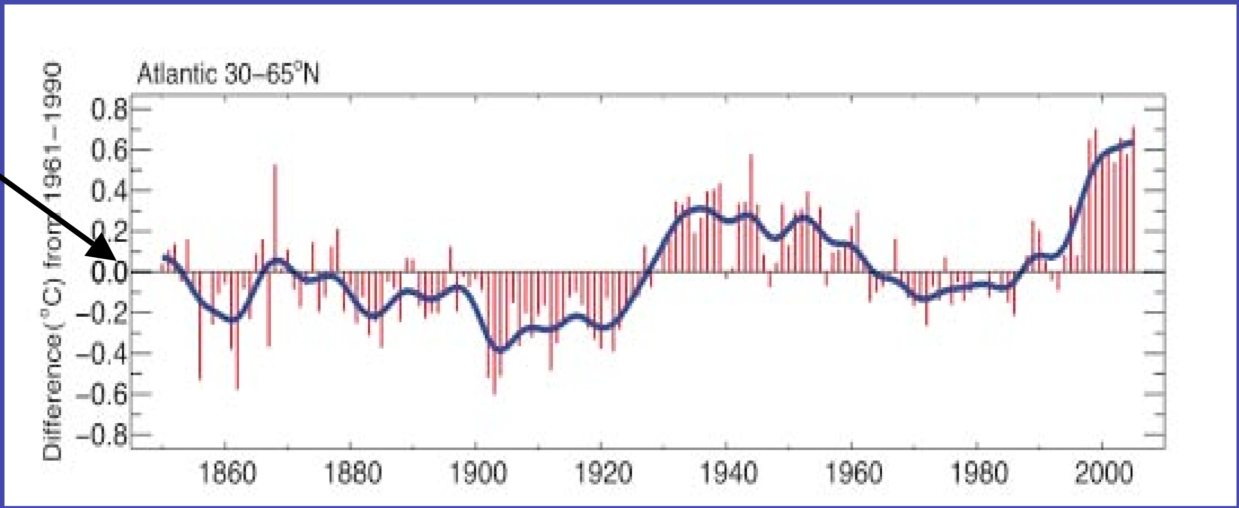
EEMD

EEMD



AMO

(IPCC 3.33)



Dynamics of Low Frequency Variability

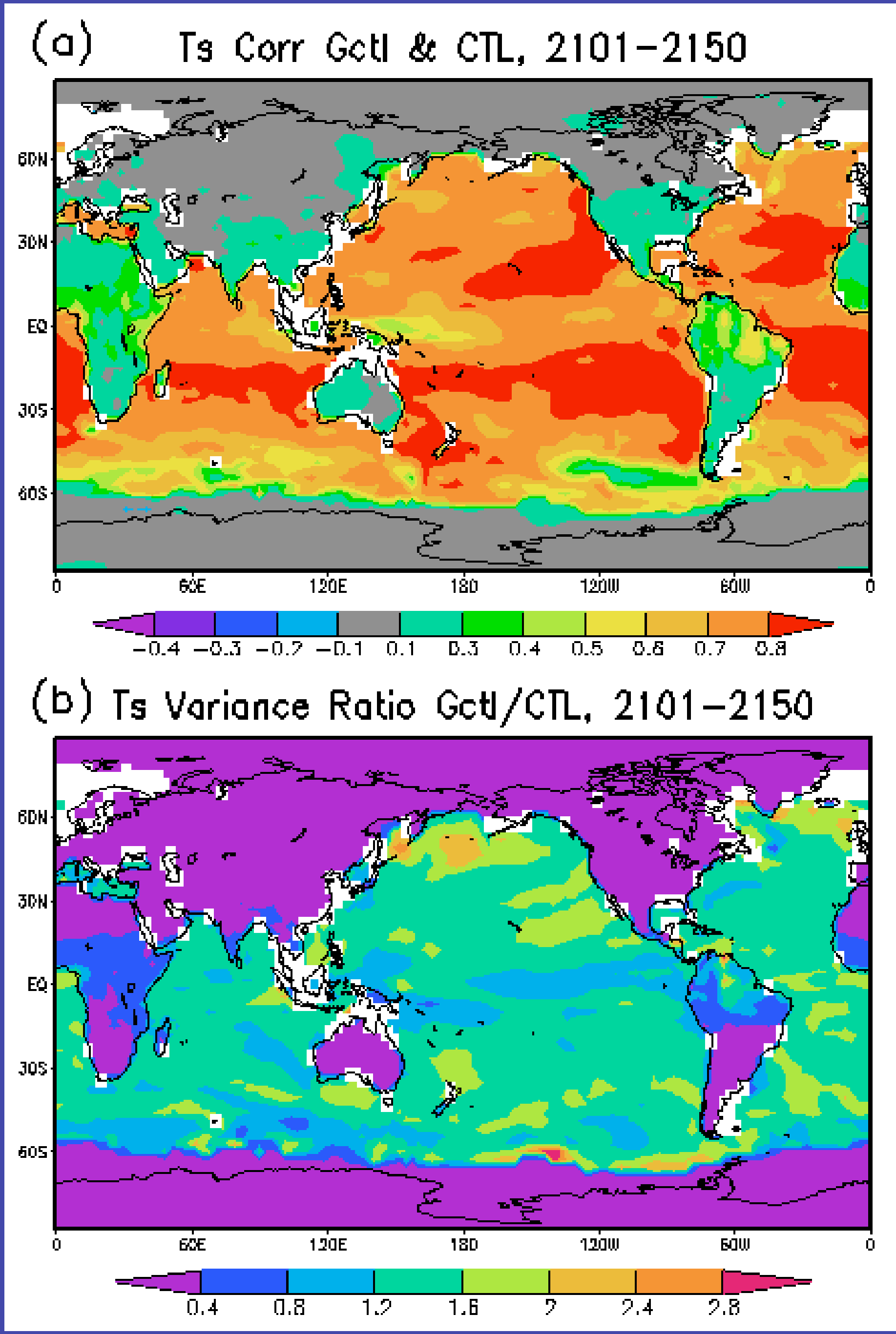
- EK Schneider and M Fan, JAS 2007.
- Evaluate the null hypothesis that all climate variability is the response to forcing by "weather noise."
  - Perfect model (COLA CGCM)
  - Observed

Procedure

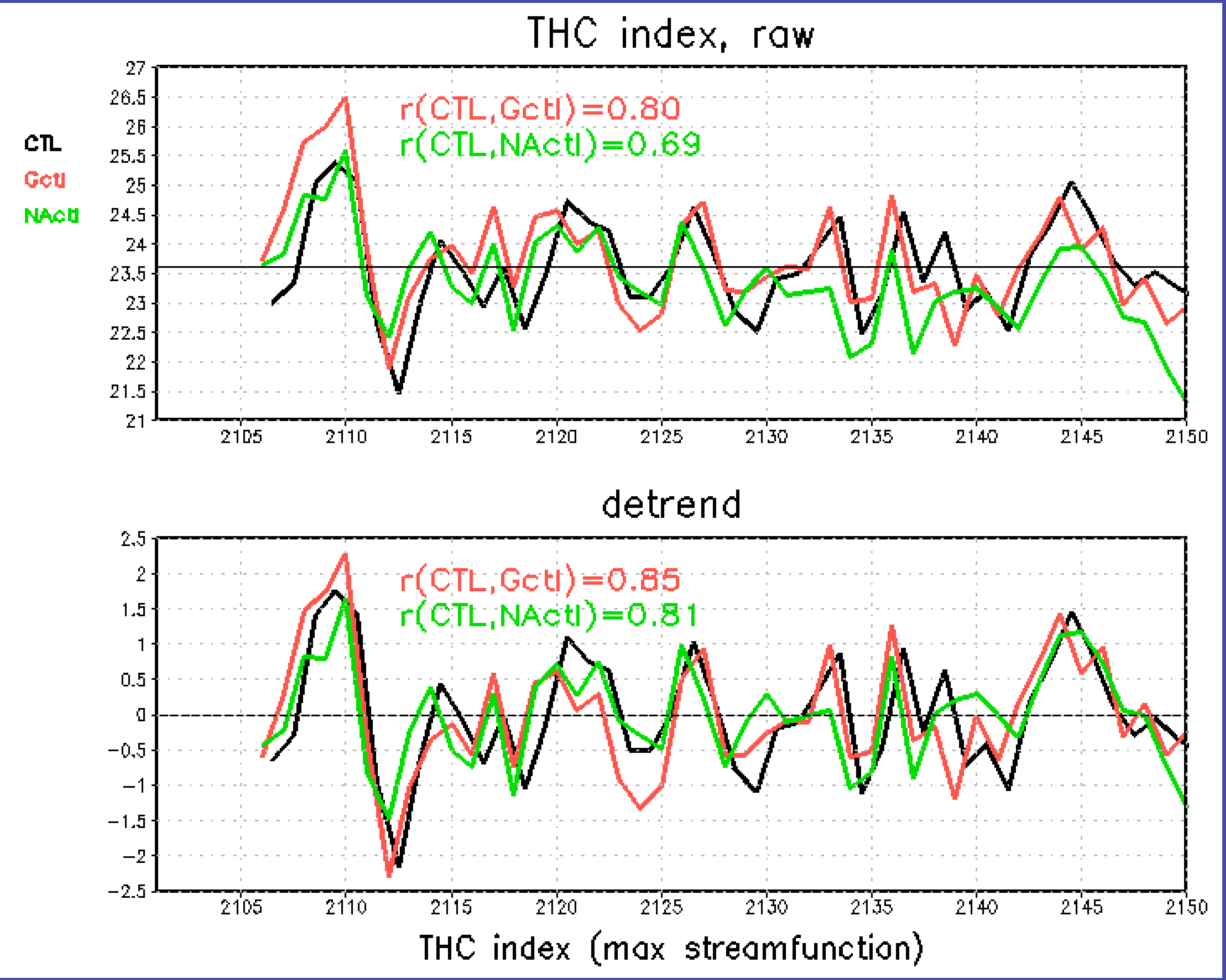
1. Evaluate weather noise surface fluxes from a model run or observations using an AMIP-like ensemble.
2. Force Interactive Ensemble CGCM (AGCM ensemble coupled to OGCM) with weather noise surface fluxes.
3. If observed low frequency surface variability (e.g. SST) is reproduced, the null hypothesis is satisfied and the variability is weather noise forced.

Correlation

Variance Ratio



NA Thermohaline Circulation Index



Predictability of MOC

- In COLA CGCM, MOC decadal variability is forced by weather noise.
  - **If this conclusion is general, the only paths towards improving prediction of MOC and related surface climate variability are:**
    - ***More accurate ocean initial conditions***
    - ***Improved models on climate time scales***
      - ***Reduced biases in climate statistics***
      - ***More realistic coupled feedbacks***

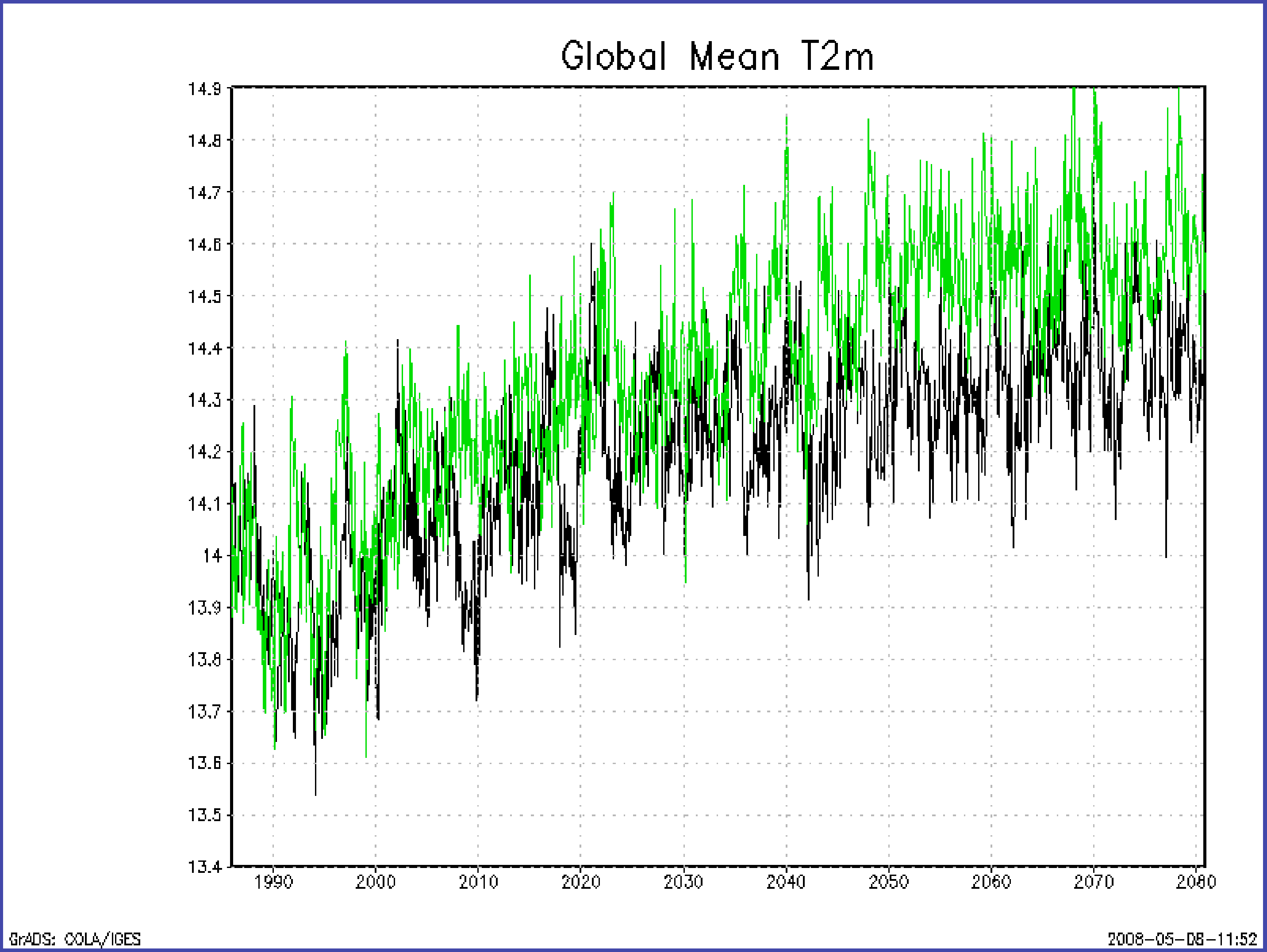
COLA Decadal Hindcast

- One case, 2 member ensemble
  - CFS, no external forcing, ODA+reanalysis initial state Jan 1 1985.
  - Unperturbed
  - Perturbed simulation (bdry conditions): Amazon deforested

CFS Global Mean 2m Air Temperature

Black: Control

Green: Deforest



Ocean Internal Variability

- Ocean internal variability with climatological atmospheric bc’s implies potential predictability of ocean independent of atmospheric coupling (Wu et al. 2004)

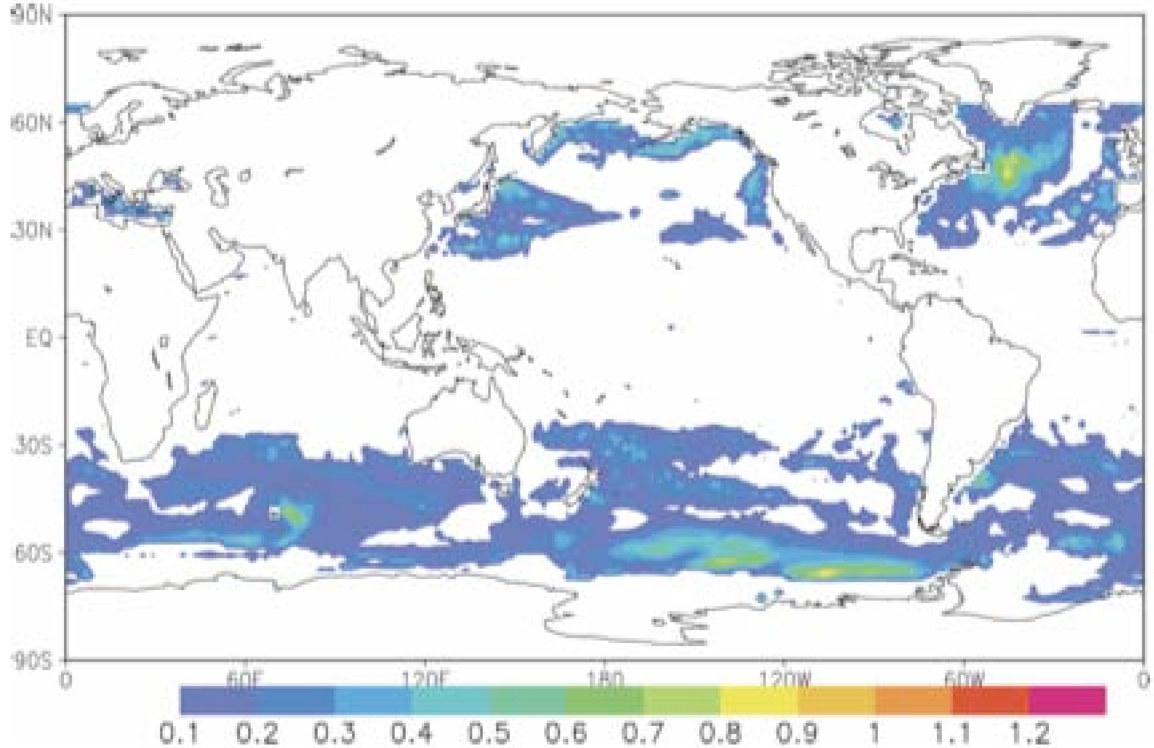


FIG. 7. A measure of "weather noise" internal to the OGCM: standard deviation of monthly SST anomalies from 46 year of an OGCM-only simulation forced by climatological wind stress.

COLA Plans for Decadal Prediction Research

Jim Kinter

COLA Director

Questions (1 of 2)

- The skill of statistical CPC seasonal predictions is enhanced by taking into account the observed trend … what is the origin of this skill?
- The climate undergoes regime transitions (e.g. 1976) … are these predictable?
- There are variations on decadal and longer time scales (AMO, PDO, ENSO modulations, monsoons) … are these predictable?
- Some groups are issuing decadal forecasts (Smith et al. 2007, Keenlyside et al. 2008) … what is the origin of this skill?

Questions (2 of 2)

- What is the relative importance of the initial state, initialization, and anthropogenic forcing?
- How are physical mechanisms in the Pacific and Atlantic altered by anthropogenic forcing?
- What is the origin and impact of the large trend in SST in the **Indian Ocean**?

COLA Experience

- COLA scientists have considerable experience in studies of climate predictability on seasonal to interannual time scales
  - COLA (Schneider CGCM, Kirtman anomaly coupled CGCM) produces and COLA has supported community real-time seasonal forecasts (ELLFB). COLA scientists have extensively examined several prediction/hindcasts products (CFS, Demeter, APCC, etc.)
- COLA scientists have studied decadal predictability **in the Atlantic** (Huang et al. 2004; Wu, Schneider and Kirtman 2004; Huang and Shukla 2005), **in the Pacific** (Yeh and Kirtman 2007; Yeh and Kirtman 2004; Klinger et al. 2004; Vikhliaev et al. 2007), and **globally** (Schneider and Fan 2007).

  Proceedings of the Workshop on Dynamics and Statistics of Secular Climate Variations, Miramare, Trieste, Italy; 4-8 December 1995, Editors: *J.L. Kinter III and E. Schneider*, April 1996.

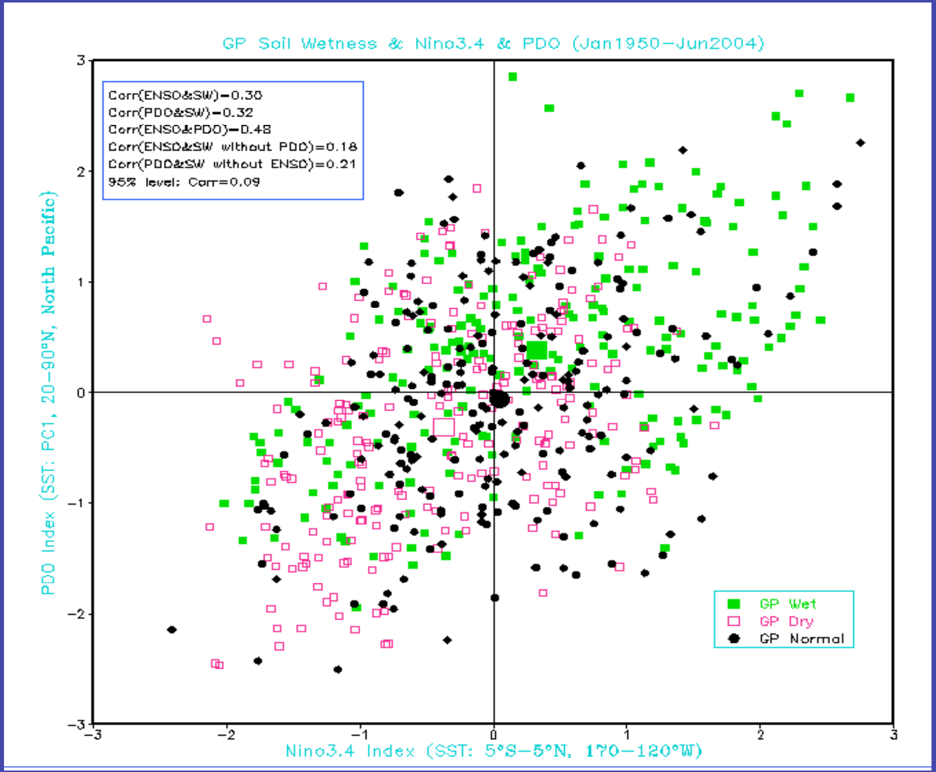
COLA Planned Experiments

- 20-year integrations with CFS and CFS-next
  - Close coordination with runs being made by other groups/ other models (CLIVAR plan)
  - Extensions of seasonal prediction runs made by NCEP (Vintzileos is point of contact)
  - Control ensemble with fixed external forcing (GHG and aerosols) and experimental ensemble with time-varying forcing
  - CFSRR for initial states

- Attribution of decadal variability (Klinger)
  - Using IPCC/CMIP3 control runs (PICNTRL) and IPCC 20th century runs as controls, perform CCSM runs with perturbed air-sea flux, such as adding the observed zonal wind stress trend to force the OGCM over the **Southern Ocean** or removing the heat and freshwater flux trends associated with global warming

One Area of Focus: PDO

- Test existing hypotheses e.g. by regional coupling
- PDO-ENSO interaction and influence on North American climate
- PDO predictability related to ability to determine its phase



Scatter diagram of PDO index against NINO3.4: Points colored in green (red, black) are above (below, within) the normal tercile of precipitation in the Great Plains (Hu and Huang, 2007).