Decadal Prediction at NCAR

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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
- $0.5^\circ \times 30-60L$ Atmosphere;
  $1^\circ \times 40-60L$ 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)**

**50-year Trend (mm)**

**Sahel: JAS**

**Southern Africa: FMA**
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**

**Sahel Rainfall**  
**Interhemispheric SST Contrast**

$r = 0.59$

Hurrell and Folland (2002)
Scientific Basis for Decadal Prediction

Perturbed ensemble members evolve coherently for two decades

GFDL CM2.1: North Atlantic MOC Predictability

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

  - Many different global reanalysis products, but significant differences exist

Ocean observing net not global or comprehensive

Tropical Upper Ocean T Anomalies (Upper 300 m)

12m-rm seasonal anom: EQPAC Averaged temperature over the top 300m

12m-rm seasonal anom: EQIND Averaged temperature over the top 300m

Pacific ↔

Indian →

sdv ensm = 0.272
s/n ensm = 1.139
spread = 0.239

sdv all = 0.337
s/n all = 1.411

spread = 0.220
Decadal Prediction (hindcasts)

Information challenges ...

- Initialization
  - Many different global reanalysis products, but significant differences exist.
  - Large inherent uncertainty in driving of AMO

Atlantic Salinity Anomalies (upper 300 m)

![Graph showing Atlantic Salinity Anomalies](image1)

Tropics ←

Mid-Lat →

![Graph showing Mid-Lat Salinity Anomalies](image2)
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
Parallel Climate Model Ensembles
Global Temperature Anomalies
from 1890-1919 average

- Observations
- Natural (volc+solar)
- Anthropogenic + Natural (volc+solar+ghg+sulf+ozone)
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-forcing 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-forcing response has 1960s climate shift in the Pacific, but is also related to “inherent” decadal pattern from unforced 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