Generation and Evaluation of Long-Term Forecasts with NCEP CFS: A Progress Report

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Outline

- Background and Objectives
- Experiments and findings
- Other Relevant Progress
Motivation

- An outstanding problem in climate prediction is the lack of long enough experiments of retrospective forecasts to assess model skill, to identify model deficiencies and, more generally, to study climate variability and predictability on various timescales.

- Most of existing experiments of this sort only cover the last 10-30 years, with degrees of freedom too few even for interannual fluctuations such as ENSO.

- Thus it is desirable to extend such experiments all the way to the mid-19th century, when instrumental in-situ observations first became available.
(1) Main obstacle: limitation of historical data for model initialization.

(2) Nevertheless, it has been demonstrated with an intermediate ENSO forecast system that, with a coupled initialization strategy using SST and SLP, skillful long-term retrospective forecasts are feasible using the available datasets.

(3) The procedure for the intermediate coupled model should be applicable to advanced CGCM systems such as CFS.
Feasibility (2)

Observed and Predicted NINO3.4 SSTA

Chen et al., Nature, 2004
Hypothesis

(1) The CFS can be well initialized in a coupled manner by assimilating only SST data over the past one and a half centuries.

(2) The coupled initialization run and the subsequent retrospective forecasts are realistic enough (at least) for ENSO and drought studies.
Coupled data assimilation (CDA): A/O Consistent with SST; Smoother forecast starts; Same model for initialization and prediction.

CFS v1: Realistic initial states (GODAS and R2); not necessarily the optimal; “initialization shock”
Wang et al., *Mon. Wea. Rev.*, 2005
Objectives

- Develop coupled data assimilation and model initialization procedure for the CFS;
- Generate retrospective forecasts for the past one and a half centuries with the CFS;
- Evaluate the predictability of ENSO and drought using the resulting datasets.
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Testing CDA procedure for the CFS

Equatorial anomalous heat content (0-300m)
Constructing 150-year CFS control run with CDA

Global mean T2m

Global mean precipitation

T2m standard deviation

Precipitation standard deviation

Comparison of CFS CDA with AVISO product: 1993-2007
Comparison of CFS CDA run with NCEP R1: 1949-2008

10m Zonal Wind, m/s

CFS Zonal Wind anomaly

NCEP-NCAR RA Zonal Wind anomaly
150-year CFS retrospective forecasts: Large El Nino events

**OBSERVED**

**FORECAST 1 year lead**

**DJF 1877-78**

**DJF 1982-83**
150-year CFS retrospective forecasts:
SW US precipitation and surface temperature
Findings

- Historic ENSO events are properly represented in the 150-year “coupled reanalysis”;
- The CFS is able to capture some of the variations in precipitation and temperature over the southwestern US by assimilating only SST;
- Forecast runs are able to predict large El Niño events, including those in the 19th century;
- There are systematic model biases, especially at high latitudes, which may not be overly prohibitive for our purpose but need to be corrected for further improvement.
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Linear multi-model ensemble predictions of the tropical Indo-Pacific SST

Wu and Chen, GRL, 2010
Methodologies of ensemble construction for probabilistic ENSO prediction

SV1 SST: SST perturbations
UV Realistic: Observed H-F winds
SO: Stochastic optimal H-F winds
SO+SV: SO+SV

LDEO5 model
Brier Score
Cheng et al., JC, 2010
The effects of the surface heat and freshwater flux anomalies on tropical ocean simulation

Shadings: Temperature; Contours: Salinity

Chen and Cane, JCP, 2008
Indo-Pacific Tripole: an intrinsic mode of Tropical climate variability

EOF1 (SST, SSH, winds)
SODA 1950-2001

Zonal mass flux and wind vector (5S-5N)

Chen, AG, 2011; Chen and Cane, JCP, 2008
Thank You