Seasonal-to-interannual climate prediction using a fully coupled OAGCM
– ENSO & IOD predictions –

Jing-Jia Luo, Sebastien Masson
Swadhin Behera, Horifumi Sakuma, Toshio Yamagata

Climate Variations Research Program
Frontier Research Center for Global Change, JAMSTEC
Japan
The SINTEX-F Coupled GCM

1. Model components:
   AGCM (MPI, Germany): ECHAM4 (T106L19)
   OGCM (LODYC, France): OPA8 (2° x 0.5°~2°, L31)
   Coupler (CERFACS, France): OASIS2

   * No flux correction, no sea ice model

2. International collaborators:
   LODYC: OPA model group
   INGV (Italy): Antonio Navarra’s group
   MPI-Met: ECHAM model group
   CERFACE: OASIS coupler group
   PRISM project group

Running on the Earth Simulator
9-member seasonal hindcast experiments

1. Three models with different coupling physics:
   (with realistic ENSO & IOD simulations, Luo et al. J. Climate 2005a)
   
   **sfe1**: Ocean surface is solid to atmosphere.
   (\(|u_a| u_a\) for Tau & heat flux)

   **sfe2**: Ocean surface current momentum is passed to atmosphere.
   (\(|u_a-u_o| (u_a-u_o)\) for Tau & heat flux)

   **sfe3**: Ocean surface is solid to atmosphere, but
   (\(|u_a-u_o| (u_a-u_o)\) for Tau)

2. Initial condition:
   
   • 1971-1981: Model spin-up
   • 1982-2004: A simple coupled SST-nudging scheme

3. Three different restoring timescales for SST-nudging:
   
   • 1 day, 2 days, 3 days (weekly NCEP Reynolds data)

**Forecast**: 12 months from 1st day of each month during 1982-2004.
ACC scores of SSTA 1982-2004

3 month lead

6 month lead

9 month lead

12 month lead

Shaded:

>0.6

CI: 0.1

Luo et al.,
J. Climate,
2005b.
El Niño:
1986/87
1991/92
1997/98
2002/03

La Niña:
1984/85
1988/89
1995/96
1999/2000

CI: 0.3°C

NCEP obs.
3-month lead
6-month lead
9-month lead
Extended ENSO prediction:

SSTA & 2-m air temperature anomaly

CI: 0.3°C
SSTA & 2-m air temperature anomaly

(a) Dec 2002–Feb 2003; observed

(b) 18-month lead predicted

(c) 24-month lead predicted

CI: 0.3°C
Difficulties in predicting Indian Ocean Dipole (IOD): 
(compared to ENSO predictions)

- Signal is not as strong/regular as ENSO
- Chaotic and active ISOs (initial conditions & predictions)
- Strong monsoon influence (seasonal & interannual)
- ENSO influence (interactive?)
- Sparse subsurface observations in the Indian Ocean
- Large deficiencies of coupled GCMs in simulating Indian Ocean climate
Indian Ocean Dipole

9-member ensemble hindcasts (1982-2004)

Luo et al., J. Climate, 2006, in press.
Prediction plumes:

EIO SSTA (90°–100°E, 10°S–0°)

NCEP SST
1 Sep. (-1)
1 Nov. (-1)
1 Jan. (+0)
1 May (+0)
1 Sep. (+0)
Real time forecast:

Predicted SST anomaly in 2006 (18-member mean)

Consensus forecasts based on those initiated from 1/12/2005, 1/01/2006, 1/02/2006, and 1/03/2006, respectively.

Similar to the situation in 1994
IOD forecasts in 2006 (18-member)

http://www.jamstec.go.jp/frcgc/research/d1/iod/
Initial conditions:

Possible preconditioning for long-range prediction of IOD
Obs. conditions in SON2006 (IOD impacts?)

Rainfall anomaly (mm/day)

2-m air temperature anomaly (°C)

Obs. precip. anomaly (SON2006)

Obs. temp. anomaly (SON2006)
Predicted conditions in SON2006 from 1 July 2006 (27-member mean)
Summary:

- ENSO can be predicted out to 1-year lead and even up to 2-years ahead in some cases.
- ISOs may limit ENSO predictability in certain cases.
- The results suggest a potential predictability for decadal ENSO-like process.

- IOD can be basically predicted at 1-2 seasons ahead.
- Long-range (up to 1-year lead) prediction is not impossible in certain instances.

**Preconditioning:** Tsub in the tropical southwestern Indian Ocean.

Real time forecasts at one month intervals:
http://www.jamstec.go.jp/frcgc/research/d1/iod/
Thank you!
a) Nino3.4 SSTA prediction (190°-240°E, 5°S-5°N)

- ensemble mean
- persistence

b) ACC

c) RMSE

Lead time (months)
NCEP SST
1 Sep. (-1)
1 Nov. (-1)
1 Jan. (+0)
1 May (+0)
1 Sep. (+0)
CI: 0.3°C