Two flavours of ENSO and its predictability.

JIN Kyung Emilia and SHUKLA Jagadish
Center For Ocean Land Atmosphere Studies (COLA/GMU)
Institute For Global Environment & Society (IGES)
4041 Powder Mill Road, Suite 302, 20705-3106 MD Calverton
U.S.A.

JIN Fei-Fei and KUG Jong-Seong
University of Hawaii at Manoa SOEST
Department of Meteorology Science of the Atmosphere
2525 Correa Road, HIG 350, HI 96822 Honolulu
U.S.A.
Two Flavors of ENSO
and Its Predictability

Emilia Jin
Center for Ocean-Land-Atmosphere studies (COLA)
George Mason University (GMU)

Jong-Seong Kug and Fei-Fei Jin
University of Hawaii
What is limiting the ENSO predictability?

✓ Model Flaws
→ mean error, phase shift, different amplitude, and wrong seasonal cycle, etc

✓ Flaws in the way the data is used
→ data assimilation and initialization, chaos within non-linear dynamics of the coupled system

✓ Inherent limits to predictability
→ some times are more predictable than others, amplitude of SST anomalies with respect to ENSO phase

✓ Gaps in the observing system
Background and Objective

- Conventional El Niño
  : “as a phenomenon in the equatorial Pacific Ocean characterized by a positive sea surface temperature departure from normal in the NINO 3.4 region greater than or equal in magnitude to 0.5°C averaged over three consecutive months” (NOAA)

- Different flavors of El Niño
  • Trans- Niño (Trenberth and Stepaniak, 2001), Dateline El Niño (Lakin and Harrison 2005), El Niño Modoki (Ashok et al. 2007), Non-canonical ENSO (Guan and Nigam, 2008), Warm pool El Niño (Kug et al. 2008), etc.
  : Even though there are differences, the distinctive interannual SST variation over the central Pacific which becomes more active in recent year and significantly different global impact form conventional El Niño are common features.

- The transition mechanisms and dynamical structure of two-types of El Nino are significantly different (Kug et al. 2008).

→ In this study, CGCM’s ability to predict the distinctive characteristics of two types of El Niño is investigated using two state-of-the-art CGCMs retrospective forecasts.
Observed Two Types of El Nino

Normalized NINO3 and NINO4 SST

Either NINO3 SST or NINO4 SST is greater than their standard deviation

Kug et al., 2008
Observed DJF SST Anomalies

- Warm-pool
- Cold-tongue
- Mixed

Maps showing temperature anomalies over time.
• Initial condition cases of 12 calendar months are analyzed.
• As observational counterparts, OISST, CMAP rainfall, and NCEP/NCAR reanalysis data are used.

<table>
<thead>
<tr>
<th>Model</th>
<th>Lead month</th>
<th>Ensemble Member</th>
<th>Period</th>
<th>AGCM</th>
<th>OGCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRCGC</td>
<td>12</td>
<td>9</td>
<td>1982-2006</td>
<td>ECHAM 4 T106 L19</td>
<td>OPA 8.2 2x2 L31</td>
</tr>
<tr>
<td>SINTEX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCEP</td>
<td>9</td>
<td>15</td>
<td>1981-2006</td>
<td>GFS T62 L64</td>
<td>MOM 3 1/3x5/8 L27</td>
</tr>
<tr>
<td>CFS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• In this study, forecast data is reconstructed with respect to lead time (monthly forecast composite).

Courtesy of J.-J. Luo, T. Yamagata, and NCEP EMC
Observed DJF SST Anomalies

- **Warm-pool**
- **Cold-tongue**
- **Mixed**
Simulated SODJFM SST Anomalies
Forecast lead month 1

Warm-pool  CFS  Cold-tongue  Warm-pool  SINTEX  Cold-tongue

Shading is for model, and contour is for observation

Warm-pool  Cold-tongue
Simulated DJF SST Anomalies
Forecast lead month 6

Shading is for model, and contour is for observation

Note: loss of predictability in the Warm Pool El Nino cases

Shading is for model, and contour is for observation
Composite of SST Anomalies along the Equator
Forecast lead month 7

Note: Positive anomaly and negative bias in the Warm Pool and Cold Tongue

Shading is for model bias, Contour is for observed composite

Warm-pool

Cold-tongue

Mixed
Interannual Variability of NINO3 and NINO4
Scatter Diagram of Normalized DJF NINO3 vs. NINO4

CFS

Lead month 1

NINO3 Index

NINO4 Index

Leads month 1

SINTEX

Lead month 1

Lead month 7

NINO3 Index

OBS

CFS

WP

CT
Relationship between NINO3 and NINO4

CFS

All-months

Correlation

1
0.9
0.8
0.7
0.6
COR=0.69

Forecast lead month

1 2 3 4 5 6 7 8 9

SINT

All-months

Correlation

1
0.9
0.8
0.7
0.6

Forecast lead month

1 2 3 4 5 6 7 8 9

OBS

Calendar month

DEC NOV OCT SEP AUG JUL JUN MAY APR MAR FEB JAN

Forecast lead month

1 2 3 4 5 6 7 8 9
Impact of Coupled Model Error on Predictability

1st mode SEOF of SST (Low frequency mode)

With increase of the lead month, the forecast ENSO mode progressively approaches to the model intrinsic mode in free coupled run and departs from the observed.

Jin and Kinter, 2008
Climate Dynamics
Free long run

- 202-year simulation
- Analyzing last **200 years** (200-yr climatology)

**PRCGC SINTEX**

**Model and Dataset**

forecast

- 1982-2004 period
- 9 members
- 12 calendar months ICs
- 12 months lead

Luo et al. 2005

**NCEP CFS**

- 52-year simulation
- Analyzing last **50 years** (50-yr climatology)

- 1981-2003 period
- 15 members
- 12 calendar months ICs
- 9 months lead

Saha et al. 2006

Courtesy of J.-J. Luo, T. Yamagata, and K. Pegion
Scatter Diagram of Normalized DJF NINO 3 vs. NINO 4
From free long run of two CGCMs

Obs. CFSCFS SINTEX

1950-2005 50 years 200 years

NINO3 Index

NINO4 Index

COR=(NINO3, NINO4) 0.69 0.82 0.86

Shading: Observed; models do not capture observed behavior

→ Model Flaw: One Flavor of El Nino
Observed Composite of Precipitation Anomalies

Warm-pool

Cold-tongue

Forecast lead month 6

SINTEX

CFS

Obs.
500 hPa GPH Anomalies

Warm-pool

Cold-tongue

Forecast lead month 6

Obs.

CFS

SINTEX
In two state-of-the-art CGCMs, the forecast skill of El Niño is investigated focusing on two flavors of El Niño: Warm-pool and cold-tongue.

As the lead month of forecast increases, the models fail to distinguish between two flavors of El Niño.

Both models have difficulties to reproduce the nonlinear relationship between NINO3 and NINO4 SST anomalies.

From the free long run, models tend to simulate the mixed mode of El Nino rather than warm-pool or cold-tongue El Niño.

Tropical precipitation and extratropical circulation anomalies associated with two flavors of El Niño are not captured by models.

Summary

Emilia K. Jin
kjin@cola.iges.org
Emilia K. Jin
kjin@cola.iges.org