Predictability of Tropical Intrasesonal variability (ISV) in the ISV Hindcast Experiment

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and Participating modeling groups
The ISVHE is a coordinated multi-institutional ISV hindcast experiment supported by APCC, NOAA CTB, CLIVAR/AAMP & MJO WG, and AMY.
Better understand the physical basis for ISV prediction and develop optimal strategies for multi-model ensemble ISV.

Identify model deficiencies in predicting ISV and find ways to improve models’ convective and other physical parameterization.

Determine the predictability of MJO in the multi-model framework.

Determine the predictability of EPAC ISV in the multi-model framework.

Numerical Designs and Objectives

- **Control Run**
  - Free coupled runs with AOGCMs or AGCM simulation with specified boundary forcing for at least 20 years
  - Daily or 6-hourly output

- **ISV Hindcast EXP**
  - ISV hindcast initiated every **10 days** on 1st, 11th, and 21st of each calendar month for at least **45 days** with more than 6 ensemble members from 1989 to 2008
  - Daily or 6-hourly output

- **YOTC EXP**
  - Additional ISO hindcast EXP from May 2008 to Sep 2009
  - 6-hourly output
## Description of Models and Experiments

### One-Tier System

<table>
<thead>
<tr>
<th>Model</th>
<th>Initial Condition</th>
<th>Period</th>
<th>Ens No</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABOM1</td>
<td>The first day of every month</td>
<td>1980-2006</td>
<td>10</td>
</tr>
<tr>
<td>ABOM2</td>
<td>The 1st and 11th day of every month</td>
<td>1989-2009</td>
<td>11</td>
</tr>
<tr>
<td>ECMWF</td>
<td>The first day of every month</td>
<td>1989-2008</td>
<td>5</td>
</tr>
<tr>
<td>CMCC</td>
<td>The 1st 11th and 21st day of every month</td>
<td>1989-2007</td>
<td>5</td>
</tr>
<tr>
<td>JMA</td>
<td>Every 15th day</td>
<td>1989-2008</td>
<td>5</td>
</tr>
<tr>
<td>NCEP/CPC</td>
<td>The 2nd 12th and 22nd day of every month</td>
<td>1981-2008</td>
<td>5</td>
</tr>
<tr>
<td>NCEP/CPC</td>
<td>The 1st 11th and 21st day of every month</td>
<td>1999-2010</td>
<td>5</td>
</tr>
<tr>
<td>SNU</td>
<td>The 1st 11th and 21st day of every month</td>
<td>1990-2008</td>
<td>4</td>
</tr>
</tbody>
</table>
Signal to Noise ratio estimate ISV predictability

Waliser et al. (2003)

Signal (L=25 days)

\[ \sigma_{Sij}^2 = \frac{1}{2L+1} \sum_{\tau=-L}^{L} (X_{i,j+\tau}^0)^2 \]

Noise: Predictability Error

\[ \sigma_{Eijk}^2 = (X_{ij}^k - X_{ij}^0)^2 \]
Predictability of winter MJO in the ISVHE multi-model framework
### MJO Predictability estimates based on the RMM indices

#### Bivariate estimates of Signal and noise

<table>
<thead>
<tr>
<th>Single member Predictability estimate</th>
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<tr>
<td><strong>Error</strong> -- Difference between hindcast RMM1 and RMM2 values for two ensemble members.</td>
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</table>

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<tr>
<th>Ensemble mean Predictability estimate</th>
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</thead>
<tbody>
<tr>
<td><strong>Error</strong> -- Difference between hindcast RMM1 and RMM2 values for an individual ensemble member and the ensemble mean of all other members.</td>
</tr>
</tbody>
</table>

#### Signal - Combined RMM1, RMM2 variance in a 51 sliding day window in individual ensemble member hindcasts.

$$E_{ij}^2 = (RMM1_{ij}^{k1} - RMM1_{ij}^{k2})^2 + (RMM2_{ij}^{k1} - RMM2_{ij}^{k2})^2$$

#### Ensemble mean Predictability estimate

$$S_{ijk}^2 = \frac{1}{51} \times \sum_{t=-L}^{L} (RMM1_{ik,j+t})^2 + (RMM2_{ik,j+t})^2$$

- **i** - initial condition
- **j** - hindcast lead
- **L** = 25

**L=25**
**MJO Predictability in the ISVHE models**

**Single member predictability estimates**

Min ---18 days (ABOM2)  
Max--- 27-28 days (ABOM1, ECMWF, CFS2)

**Average estimate from eight models  
---- 24 days (s.d. of 3.6 days)**

**Ensemble mean predictability estimates**

Min ---35 days (JMAC)  
Max--- 50 days (ABOM2)

**Average estimate from eight models  
---- 43 days (s.d. of 4.7 days)**

In most models the MJO is predictable for 20-30 days by individual ensemble member hindcasts and by using ensemble means the predictability of MJO can be extended up to 40-50 days.

*Neena et al, (submitted)*
Suitable ensemble prediction systems are crucial for MJO forecasting.

Ensemble mean prediction skill holds more promise — there is scope for improving further by at least 3 more weeks.

Present day prediction capabilities for the MJO can be extended by at least one more week in all the eight dynamic models.

**Prediction skill and Predictability**

Predictability estimates are shown as +/- 5 day range estimates.

Remarkable improvement for ensemble mean prediction skill ABOM1, ABOM2 and ECMWF.

Average single member prediction skill for MJO -- 2 weeks.

Suitable ensemble prediction systems are crucial for MJO forecasting.

**MJO prediction — Where do we stand?**

**Average single member prediction skill for MJO — 2 weeks.**

**Remarkable improvement for ensemble mean prediction skill for ABOM1, ABOM2 and ECMWF.**

**Neena et al.,**
In a statistically consistent ensemble, the RMS forecast error of the ensemble mean (dashed) should match the standard deviation of the ensemble members (ensemble spread) (solid).

Ensemble fidelity is defined as the average difference between the solid and dashed curves over the first 25 days hindcast.

Models with more statistically consistent ensembles for the MJO show better improvement in the ensemble mean prediction skill over the individual ensemble member hindcast skill!
Predictability of summer Eastern Pacific (EPAC) ISV in the ISVHE multimodel framework
The eastern Pacific warm pool represents a region of strong ISV during boreal summer.

The 30–50 days EPAC ISV mode is characterized by both eastward as well as northward propagation (e.g., Jiang and Waliser, 2008, Maloney et al, 2008).

A quasi biweekly mode was also identified over the EPAC. Jiang and Waliser (2009).

Here, the EPAC ISV mode is isolated using combined EOF analysis of 20-100 day filtered TRMM precipitation and U850 over 230-280E, 0-20N.

CEOF1---32% variance
CEOF2---9% variance

Regressed 20-100 day filtered precip(shaded) and u850(contour) anomalies wrt PC1
A 2-3 week predictability is observed for the EPAC ISV mode, the predictability may be higher for the ensemble means. PC2 exhibits a predictability around two weeks.
Average single member prediction skill for EPAC ISV
----9-10 days!

Ensemble averaging does not improve the EPAC ISV prediction skill by a large amount.

The ABOM1 and ABOM2 models which shows higher prediction skill for MJO performs poorly for EPAC ISV.

ECMWF and SNUC are the better performers over EPAC.

There is a large possibility for improving the EPAC ISV predictions in most models.

The notable feature is the lack of improvement in ensemble average forecasts.

An average 15-25 day predictability exists for the EPAC ISV mode across the eight models.
The predictability of winter MJO and summer EPAC ISV is investigated in the ISVHE hindcasts of eight coupled models.

- A 20-30 day predictability for individual ensemble member MJO hindcasts and a 40-50 day predictability for ensemble mean MJO hindcasts is observed.

- Present day MJO prediction capabilities can be extended further by at least one week for individual ensemble forecasts in most models. Ensemble mean prediction skill improvement holds more promise.

- In addition to improving the dynamic models, devising ensemble generation approaches tailored for the MJO would have a great impact on MJO prediction.

- For the EPAC ISV, a 15-25 day predictability is observed in individual ensemble member hindcasts.

- Ensemble average forecasts does not show much skill improvement over the EPAC.

THANK YOU !!!
Special case – Predictability dependence on MJO amplitude

**Weak MJO Vs Strong MJO**

**Single member predictability estimates**

Min --- 13 days  [18 days]
Max--- 27 days  [27 days]

**Average estimate from eight models**

---- 18 days [24 days]

**Ensemble mean predictability estimates**

Min --- 22 days [35 days]
Max--- 46 days [50 days]

**Average estimate from eight models**

---- 29 days [43 days]

Choosing only those hindcasts for which RMM amplitude is <1.0 S. D. during hindcast initiation

The single member (ensemble mean) estimate of MJO predictability is lower by one week (two weeks) for weak MJO, in all models except ABOM1
Only 3 models exhibit such phase dependence of predictability.

For these models, MJO predictability is higher for hindcasts initiated from MJO phases over Indian Ocean and Western Pacific.

Hindcasts initiated from secondary MJO events have longer predictability than those from primary events.