Representation of the Eastern Pacific Intraseasonal Variability and its Impacts on Hurricanes in Climate Models

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Acknowledgment: Duane Waliser (JPL/Caltech), Ming Zhao (GFDL/NOAA), Daehyun Kim (Columbia U.), US CLIVAR MJO Working Group, Modeling Centers

Funding: NOAA Climate Program Office - CPPA / MAPP Program
1. Introduction

Standard Deviation of Bandpass Filtered Rainfall

Northern Summer (May-Oct)

10-90 day filtered
Regional Impacts of ISV over the Eastern Pacific

Caribbean Precipitation (Martin et al. 2010)

Central America Mid-Summer Drought (Magana et al. 1999; Small et al. 2007)

North American Monsoon (Lorenz and Hartmann 2006)

Caribbean Sea LLJ (Serra et al. 2010)

Gap Winds (Maloney & Esbensen 2003)

El Nino Development (Vintzileos et al. 2003)

“Gulf Surge Moisture Events”

Tropical Cyclone Maloney and Hartmann (2000a,b) Higgins and Shi (2001)
Evolution of 40-day ISV Mode

Shading: Rainfall  
Vectors: QuikSCAT sfc wind

- Local expression of MJO (cf. Maloney et al; 2007);
- Signals from west;
- Enhanced convection corresponding to westerly wind anomalies;

Jiang and Waliser (2008)
40-day ISV mode

Hovmoller Diagram of Rainfall (130-90°W)

Jiang and Waliser (2008)

~0.65 deg/day
Evolution of the Quasi-Biweekly Mode (QBM)

Jiang & Waliser (2009)
Hovmoller Diagram of Rainfall (130-100°W)

Jiang & Waliser (2009)
## 2. Representation of the two ISV modes in GCMs

### Participating models

<table>
<thead>
<tr>
<th>Model (group)</th>
<th>Horizontal Resolution - AGCM</th>
<th>Vertical Resolution (top level) - AGCM</th>
<th>Cumulus parameterization</th>
<th>Integration</th>
<th>Reference</th>
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<tr>
<td>CAM3.5 (NCAR)</td>
<td>1.9° lat x 2.5° lon</td>
<td>26 (2.2hPa)</td>
<td>Mass flux (Zhang &amp; McFarlane 1995)</td>
<td>20 years 01JAN1986-31DEC2005</td>
<td>Neale et al. (2007)</td>
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<tr>
<td>CAM3z (SIO)</td>
<td>T42(2.8°)</td>
<td>26 (2.2hPa)</td>
<td>Mass flux (Zhang &amp; McFarlane 1995)</td>
<td>15 years 29JAN1980-23JUL1995</td>
<td>Zhang et al. (2005)</td>
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<tr>
<td>CFS (NCEP)</td>
<td>T62(1.8°)</td>
<td>64 (0.2hPa)</td>
<td>Mass flux (Hong &amp; Pan 1998)</td>
<td>20 years</td>
<td>Wang et al. (2005)</td>
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<tr>
<td>CM2.1 (GFDL)</td>
<td>2° lat x 2.5° lon</td>
<td>24 (4.5hPa)</td>
<td>Mass flux (RAS; Moorthi &amp; Suarez 1992)</td>
<td>20 years</td>
<td>Delworth et al. (2006)</td>
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<tr>
<td>ECHAM4/OPYC* (PCMDI)</td>
<td>T42(2.8°)</td>
<td>19 (10hPa)</td>
<td>Mass flux (Tiedtke 1989; Nordeng 1994)</td>
<td>20 years</td>
<td>Roeckner et al. (1996), Sperber et al. (2005)</td>
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<tr>
<td>GEOSS (NASA)</td>
<td>1° lat x 1.25° lon</td>
<td>72 (0.01hPa)</td>
<td>Mass flux (RAS; Moorthi &amp; Suarez 1992)</td>
<td>12 years 01DEC1993-30NOV2005</td>
<td>To be documented</td>
</tr>
<tr>
<td>SPCAM (CSU)</td>
<td>T42(2.8°)</td>
<td>26 (3.5hPa)</td>
<td>Superparameterization (Khairoutdinov &amp; Randall 2003)</td>
<td>19 years 01OCT1985-25SEP2005</td>
<td>Khairoutdinov et al. (2005)</td>
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<tr>
<td>HIRAM (GFDL)</td>
<td>0.5° lat x 0.6° lon</td>
<td>32 (4.5hPa)</td>
<td>Mass flux (Bretherton et al. 2004)</td>
<td>19 years 01JAN1990-31DEC2008</td>
<td>Zhao et al. (2009)</td>
</tr>
</tbody>
</table>

Courtesy of MJO Working Group

Kim et al. 2009
STDs of summer (JJAS) rainfall

10-90 day filtered

Jiang et al (2011)
Pattern correlations of the two ISV modes between observations and GCM simulations

Jiang et al (2011)
Evolution of Rainfall & 850mb wind associated with 40-day ISV mode

Jiang et al (2011)
Eastward propagation of the 40-day ISV mode

OBS

(a) TRMM

(5°N-15°N)

Blue line: 4 deg/day

Jiang et al (2011)
Eastward propagation of the 40-day mode

OBS

Blue line: 4 deg/day

Jiang et al (2011)
Northward propagation of the 40-day mode

(130°W-90°W)

Blue line: 0.6 deg/day
Evolution of Rainfall & 850mb wind associated with the QBM
Northward propagation of the QBM

\[ (130^\circ W-90^\circ W) \]

\( \text{Blue line: 1.2 deg/day} \)
3. Modulation of hurricanes by the ISV over the EPAC in GFDL HiRAM
HiRAM2.1 captures geographical distribution of hurricane tracks (1981-2005)

Zhao et al (2009)
HiRAM2.1 captures both the inter-annual variability and decadal trend over the N. Atlantic, the E. and W. Pacific

Red: Observations
Blue: HiRAM ensemble mean
Shading: Model spread

Model time-series are normalized to observed time-mean

Zhao et al. (2009)
ISV and TC genesis (1998-2008): OBS

Jiang et al. (2011b)
J. Climate

Shading: rainfall anomalies
ISV and TC genesis (1998-2008): HiRAM

Jiang et al. (2011b)
TC Genesis counts over the EPAC and ISV Phases

**OBS**

**HiRAM**

Phase 0 - Weak ISV
Modulation of TC movement by the ISV (1998-2008)

OBS

GFDL/HiRAM

Jiang et al. (2011b)
Genesis Potential Index (GPI)

Emanuel and Nolan (2004); Camargo et al. (2009)

\[
GPI = \left| 10^5 \eta \right|^{\frac{3}{2}} \left( \frac{\gamma}{50} \right)^3 \left( \frac{PI}{70} \right)^3 (1 + 0.1 \cdot V_{shear})^{-2}
\]

\(\eta\) 850mb absolute vorticity (s\(^{-1}\))

\(\gamma\) 600mb relative humidity (%)

\(PI\) Maximum potential intensity (MPI) – SST, q, T, Ps

\(V_{shear}\) Vertical wind shear, 200mb-850mb (ms\(^{-1}\))

ERA-Interim 1998-2008

Jiang et al. (2011b)
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ERA-Interim 1998-2008

Jiang et al. (2011b)
Contributing factors of total GPI’

Jiang et al. (2011b)

Shading: total GPI’

Phase 1+8

Phase 2+3

Phase 4+5

Phase 6+7

(a) 110°-95°W; 13°-18°N

(b) 140°-120°W; 10°-15°N

(c) 115°-95°W; 9°-13°N

ISV Phases
Summary

- Two dominant ISV modes over the EPAC, e.g., a 40-day ISV mode and a Quasi-Biweekly Mode (QBM) are identified based on rainfall observations.
- It remains challenging for GCMs in faithfully representing both of these two ISV modes including their amplitude, evolution patterns, and periodicities. In general, SPCAM and GFDL HiRAM exhibit relatively superior skills in representing both of the two ISV modes.
- The newly developed GFDL HiRAM GCM is able to well represent the observed modulations of TC activity over the EPAC by large-scale ISV.
- A budget analysis of the observed GPI anomalies during the ISV life cycle suggests that, relative roles of lower-level cyclonic vorticity, enhanced mid-level relative humidity, and reduced vertical wind shear in modulating TC formation over the EPAC are dependent on ISV phase and location. All of these factors can contribute to active TC genesis over the EPAC during particular ISV phases.
- The results presented in this study suggest great potential of intraseasonal TC forecasts based on high-resolution dynamical models with improved physics.

Ongoing project / Future Plan
- Characterize the role of QBM for regional climate
- Explore predictive skill and predictability of the two EPAC ISV modes;
- Use HiRAM to explore potential prediction skill and estimate predictability of TC-Activity on IS time scales.
References


