US CLIVAR MJO Working Group: Efforts to Establish and Improve Subseasonal Predictions


US CLIVAR Summit, 2008

http://www.usclivar.org/mjo.php
US CLIVAR MJO Working Group

Established Spring 2006
Additional Support from International CLIVAR

TERMS OF REFERENCE

• Develop a set of diagnostics to be used for assessing MJO simulation fidelity and forecast skill. ✔

• Develop and coordinate model simulation and prediction experiments, in conjunction with model-data comparisons, which are designed to better understand the MJO and improve our model representations and forecasts of the MJO. ✔

• Raise awareness of the potential utility of subseasonal and MJO forecasts in the context of the seamless suite of predictions. ✔

• Help to coordinate MJO-related activities between national and international agencies and associated programmatic activities. ✔

• Provide guidance to US CLIVAR and Interagency Group (IAG) on where additional modeling, analysis or observational resources are needed. ✔
MJO Simulation Diagnostics

Motivation

- Little Apparent Progress
- Little Model Stability
- Each used different metrics

Need a more formal / accepted process for model assessment.
**Description** - Level 2 Metrics

1) **FREQUENCY-WAVE SPECTRA**

   a) Using data averaged between 10°N-10°S, separate the data into individual calendar years, remove the time mean from each frequency-wavenumber for each year of data, and average the results. **Figures**

   b) Same as a), except stratifying by season. **Figures**

2) **COMBINED EOFs.**

   i) Average the 20-100 day filtered anomalies (all the data, not seasonally stratified) of OLR, u850, and u200 between 15°N-15°S.

   ii) Normalize each of three fields separately by the square-root of the zonal mean of their temporal variance at each longitudinal point.

   iii) Considering all three fields together, compute the combined EOF of the data. **Figures**

   iv) Compute the variance explained in the normalized data set by each of the EOF modes as well as the variance explained in the (i.e. filtered anomalies) by each of the EOF modes.

   v) Compute the variance explained by each of the three input fields for each EOF mode.

   vi) Calculate the lag correlation between PC-1 and PC-2 as in level 1 metrics 4a. **Figures**

   vii) Assess the statistical significance of the EOF's as described in General. **Figures**

   viii) Compute the mean coherence\(^2\) and phase of PC-1 and PC-2. **Figures**

3) **LIFE-CYCLE COMPOSITES.**

   i) Identify MJO events through plots of PC-1 vs. PC-2 from the combined EOFs. Specifically, select points exceeding a root-mean [i.e. \(\sqrt{PC-1^2 + PC-2^2} > 1\)].

   ii) Based on a two dimensional phase diagram of PC-1 and PC-2 (Figures), define eight different phases of the MJO and generate spatial composites of the selected points according to these phases. **Figures**
MJO Diagnostics

Standardized Diagnostics

Observational Uncertainty

Seasonal Stratification

Madden Julian Oscillation (MJO) Metrics

Observations - Level 2 metrics figure tables

1) FREQUENCY-WAVE SPECTRA (see Description)

a) Annual data

<table>
<thead>
<tr>
<th>OLR</th>
<th>PRCP</th>
<th>U200</th>
<th>U850</th>
<th>Usfc</th>
</tr>
</thead>
<tbody>
<tr>
<td>All season spectra (with annual cycle)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AVHRR</td>
<td>CMAP TRMM GPCP</td>
<td>NCEP1 NCEP2 ERA40</td>
<td>NCEP1 NCEP2 ERA40</td>
<td>NCEP1</td>
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</table>

b) Seasonally stratified data

<table>
<thead>
<tr>
<th>OLR</th>
<th>PRCP</th>
<th>U200</th>
<th>U850</th>
<th>Usfc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonally stratified spectra (Winter: November to April, without annual cycle)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVHRR</td>
<td>CMAP TRMM GPCP</td>
<td>NCEP1 NCEP2 ERA40</td>
<td>NCEP1 NCEP2 ERA40</td>
<td>NCEP1</td>
</tr>
</tbody>
</table>

| Seasonally stratified spectra (Summer: May to October, without annual cycle) |
| AVHRR | CMAP TRMM GPCP | NCEP1 NCEP2 ERA40 | NCEP1 NCEP2 ERA40 | NCEP1 |

2) COMBINED EOFs (see Description)

a) Combined EOFs
MJO Diagnostics

Equatorial Space-Time Spectra
U, Rain, OLR

NCEP1, NCEP2, & ERA40
**MJO Diagnostics**

**Time Series Spectra**

**U, Rain, OLR**

**Domains of Interest**

### Table 1. Domains for time series power spectra metrics

<table>
<thead>
<tr>
<th></th>
<th>OLR</th>
<th>Precipitation</th>
<th>$f_{max}$</th>
<th>$f_{min}$</th>
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</thead>
<tbody>
<tr>
<td>IO</td>
<td>10S-50N, 75-100E</td>
<td>10S-50N, 75-100E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
<td>3.75N-31.25N, 56.25S-78.75E</td>
</tr>
<tr>
<td>MC</td>
<td>2.5S-17.5S, 115-145E</td>
<td>2.5S-17.5S, 115-145E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
<td>3.75N-31.25N, 56.25S-78.75E</td>
</tr>
<tr>
<td>EP</td>
<td>10S-20N, 80-100E</td>
<td>10S-20N, 80-100E</td>
<td>3.75N-21.25N, 123.75S-151.25E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
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<tr>
<td></td>
<td>Boreal Summer (May to October)</td>
<td></td>
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</tr>
<tr>
<td>IO</td>
<td>10S-50N, 75-100E</td>
<td>10S-50N, 75-100E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
<td>3.75N-21.25N, 123.75S-151.25E</td>
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<tr>
<td>BB</td>
<td>10S-20N, 80-100E</td>
<td>10S-20N, 80-100E</td>
<td>3.75N-21.25N, 123.75S-151.25E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
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<tr>
<td>WP</td>
<td>10S-25N, 115-140E</td>
<td>10S-25N, 115-140E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
<td>3.75N-21.25N, 123.75S-151.25E</td>
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<tr>
<td>EP</td>
<td>6.25N-16.25N, 241.25E-266.25E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
<td>3.75N-21.25N, 123.75S-151.25E</td>
<td>1.2S-16.2PS, 68.79S-96.29E</td>
</tr>
</tbody>
</table>
MJO Diagnostics

Life-Cycle Composites
U, Rain, OLR, SLP, SF

Rainfall

U850

Satellite Rain/Cloud: AVHRR, GPCP, TRMM
Analysis Data: NCEP1, NCEP2
MJO Diagnostics

Paper #1 - Submitted

MJO Simulation Diagnostics

US CLIVAR Madden-Julian Oscillation Working Group:


*Co-Chairs

Please cite as:

Submitted to the Journal of Climate
June 2008
### MJO Simulation Diagnostics

**Application to Contemporary Models**

<table>
<thead>
<tr>
<th>Model</th>
<th>Horizontal Resolution</th>
<th>Vertical Resolution (top level)</th>
<th>Cumulus parameterization</th>
<th>Integration</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>CFS - NCEP</td>
<td>T62(1.8°)</td>
<td>64 (0.2hPa)</td>
<td>Mass flux (Hong and Pan 1998)</td>
<td>20 years</td>
<td>Wang et al. (2005)</td>
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<td>ECHAM4 /OPYC+ - PCMDI</td>
<td>T42(2.8°)</td>
<td>19 (10hPa)</td>
<td>Mass flux (Tiedtke 1989, adjustment closure Nordeng 1994)</td>
<td>20 years</td>
<td>Sperber 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 and Suarez 1992)</td>
<td>20 years</td>
<td>Delworth et al. (2006)</td>
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<td>SPCAM - CSU</td>
<td>T42(2.8°)</td>
<td>26 (3.5hPa)</td>
<td>Superparameterization (Khairoutdinov and Randall 2003)</td>
<td>19 years</td>
<td>Khairoutdinov et al. (2005)</td>
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<tr>
<td>GEOSS - NASA</td>
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<td>72 (0.01hPa)</td>
<td>Mass flux (RAS; Moorthi and Suarez 1992)</td>
<td>12 years</td>
<td>To be documented</td>
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<td>CAM3.5 - NCAR</td>
<td>1.9° lat x 2.5° lon</td>
<td>26 (2.2hPa)</td>
<td>Mass flux (Zhang and McFarlane 1995)</td>
<td>20 years</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 and McFarlane 1995)</td>
<td>15 years</td>
<td>Zhang et al. (2005)</td>
</tr>
<tr>
<td>SNUAGCM - SNU</td>
<td>T42(2.8°)</td>
<td>20 (10hPa)</td>
<td>Mass flux (Numaguti et al. 1995)</td>
<td>8 years</td>
<td>Lee et al. (2003)</td>
</tr>
</tbody>
</table>

Assess Current Capabilities for Simulating the MJO
MJO Simulation Diagnostics

Subseasonal Variance: Precip & U850

Contour Unit: [m² s⁻²]
Plot: 3m² s⁻² interval
Thick solid: 9m² s⁻²
MJO Simulation Diagnostics

Wavenumber-frequency: Precip & U850
MJO Simulation Diagnostics

Time-Longitude: OLR & Near Surface Convegence
Application of MJO Diagnostics

Paper #2 – In Preparation

1st draft text; 2nd draft figures

Application of MJO Simulation Diagnostics to Climate Models

US CLIVAR Madden-Julian Oscillation Working Group:

D. Kim et al.

Preparing for Submission to Journal of Climate
MJO Simulation Diagnostics & Their Application
Contributions & Acknowledgement
MJO Forecast Metric
Making Operational Predictions

Forecast centers derive benefit from simple forecast metrics. e.g. ENSO – “Nino 3.4 Index”
Weather – 500 mb heights
MJO - ?

In the case of the MJO, a common forecast metric allows for:
- quantitative forecast skill assessment.
- targeted model improvements.
- model improvements benchmarked against MJO
- even friendly competition to motivate further improvements.
- developing a multi-model ensemble forecast of the MJO.
Developing an MJO Forecast Metric

US CLIVAR MJO WG — Based on Wheeler & Hendon 2004

Fig. 1

Wheeler and Hendon (2004)
To: Operational Modelling Centres

From: The CAS/WCRP Working Group on Numerical Experimentation (WGNE) and US-CLIVAR Madden-Julian Oscillation Working Group

Date: January 2008

This letter seeks to gain the involvement of Operational Modelling Centres in an activity to monitor and compare numerical model forecasts of the Madden-Julian oscillation (MJO). The activity is a result of discussions and work of the U.S. Climate Variability and Predictability (CLIVAR) programme’s MJO Working Group. The group is co-sponsored by international CLIVAR, and the activity has the support of the Working Group on Numerical Experimentation (WGNE). The aim of the activity

Prepare and send — operationally — a select set of forecast fields (U850, U200, OLR) in order to join the fun and the Multi-Model Ensemble.
<table>
<thead>
<tr>
<th>Center</th>
<th>PID</th>
<th>Members</th>
<th>Forecasts Start Date</th>
<th>Days</th>
<th>Realtime</th>
<th>Model Clim</th>
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<td>UKME</td>
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<td>10/10/07</td>
<td>15</td>
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<td>ECMWF</td>
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<td>No</td>
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<td>ECMM</td>
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<td>6/9/08</td>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
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<td>ECMWF</td>
<td>EMON</td>
<td>51 (wkly)</td>
<td>6/12/08</td>
<td>32</td>
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<td>No</td>
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<tr>
<td>JMA</td>
<td>JMAM</td>
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<td>CPTC</td>
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<td></td>
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</tr>
</tbody>
</table>
Central Analysis and Presentation Site

US CLIVAR MJO Working Group

Forecast Metrics

- Forecasts
- Methodology
- Verification
- References

Forecasts

A key for the label headings in the figure box is provided below. Click on the headings for larger size images and specific model-related information.

Note: Move cursor over product name to display. Click for larger size and info.

Phase Plots of MJO Index Forecasts

<table>
<thead>
<tr>
<th>NCPE</th>
<th>NCPO</th>
<th>NCFS</th>
<th>CMET</th>
<th>UKME</th>
<th>UKMA</th>
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<tbody>
<tr>
<td>ECMF</td>
<td>BOME</td>
<td>BOMA</td>
<td>BOMC</td>
<td>JMAN</td>
<td>CPTC</td>
</tr>
</tbody>
</table>

Paper #3
BAMS Article in Prepration

Courtesy of
Jon Gottschalck
and CPC/NCEP/NOAA
&
Contributing Operational Centers
CLIVAR MJO Workshop

New Approaches to Understanding, Simulating, and Forecasting the Madden-Julian Oscillation

5-7 November 2007, Irvine, California
1) Where possible, develop scalar metrics of MJO model skill for use in multi-model comparisons and for tracking model fidelity.
2) Work with the observation, model-development, and theoretical communities to develop process-oriented diagnostics to improve our insight into the physical mechanisms for robust MJO simulation.
3) Continue to explore multi-scale interactions & convectively-coupled equatorial waves, both in observations and high resolution modeling frameworks, with particular emphasis on vertical structure and diabatic processes
4) Expand efforts to develop and implement MJO forecast metrics under operational conditions
5) Develop an experimental modeling framework to assess MJO predictability and forecast skill from contemporary/operational models.
3) Continue to explore multi-scale interactions … observations and high resolution modeling frameworks … vertical structure and diabatic processes -> CMMAP, YOTC

4) Expand efforts to develop and implement MJO operational forecast -> boreal summer focus -> ICTP Mtg, 4th WMO Monsoon Mtg, AAMP.

5) Hindcast to assess MJO (& impacts) predictability and forecast skill -> ICTP Mtg, 4th WMO Monsoon Mtg, AAMP, 2 Page Pre-Proposal via B. Wang, I.S. Kang, D. Waliser, etc.

Role of MJOWG – Informal continuation?? –
Note the above types of activities/events existed before but only so effective.