WCRP-WWRP/THORPEX
MJO Task Force

Follow-on from US CLIVAR
MJO Working Group
The MJO is the dominant form of intraseasonal variability in the Tropics.

The MJO impacts a wide range of weather & climate phenomena.
- Monsoon Onset & Breaks
- ENSO+IOD Interactions
- Tropical Cyclone Modulation
- Midlatitude Weather Impacts
- Organization of Chl, Aerosols, Ozone, etc variability.

Our weather & climate models have a poor representation of the MJO.

Great benefit could be derived from better predictions of the MJO - Helps to bridge the gap between weather and seasonal predictions.
US CLIVAR MJO Working Group
2006-08
Summary of Accomplishments

1) Develop MJO WG Web Site. [www.usclivar.org/mjo.php](http://www.usclivar.org/mjo.php)
   Diagnostics Link, Meeting & Telecon Updates, Theme Pages

2) Diagnostics for Assessing Model Simulations.
   On Website. J. Climate Article ~ In Press. Also adopted by NCAR/NCL.

3) Application of Diagnostics to Models.
   CAM3.5, CAM-3Z, spcam, ECHAM4/OPYC, CFS, SNU, GFDL, GEOS5
   J. Climate Article — In Press.

4) Operational MJO Forecasts & Metrics.
   Designed, Implemented at Several Operational Centers, w/ WGNE Help
   and NCEP/CPC leading, BAMS Article in Preparation

5) Workshop/Experimentation Planning
**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 coherence² 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-1² + PC-2²) > 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**

**Recipe for Calculating Diagnostics**

**Calculation Codes Available and now in NCAR NCL Latest Version**
### Observations - Level 2 metrics figure tables

1) FREQUENCY-WAVE SPECTRA (see Description)

a) Annual data

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All season spectra (with annual cycle)

b) Seasonally stratified data

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Seasonally stratified spectra (Winter: November to April, without annual cycle)

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Seasonally stratified spectra (Summer: May to October, without annual cycle)

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2) COMBINED EOFs (see Description)

a) Combined EOFs
MJO Diagnostics

Equatorial Space-Time Spectra
U, Rain, OLR

NCEP1, NCEP2, & ERA40
MJO Diagnostics

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

Satellite Rain/Cloud: AVHRR, GPCP, TRMM
Analysis Data: NCEP1, NCEP2
Figure 3: As in Figure 1, except for variance of 20-100 day band pass filtered precipitation and 850hPa zonal wind. Contours of 850hPa zonal wind variance are plotted every 3 m² s⁻², 9 m² s⁻² line is represented by thick solid line. The unit is mm² day⁻² for precipitation and m² s⁻² for zonal wind.
Figure 4: November-April wavenumber-frequency spectra of 10°N-10°S averaged precipitation (shaded) and 850hPa zonal wind (contoured). a) CMAP/NCEP1, b) CAM3.5, c) CAM3z, d) CFS, e) CM2.1, f) ECHAM4/OPYC, g) GEOS5 h) SNU and i) SPCAM. Individual November-April spectra were calculated for each year, and then averaged over all years of data. Only the climatological seasonal cycle and time mean for each November-April segment were removed before calculation of the spectra. Units for the precipitation (zonal wind) spectrum are mm² day⁻² (m² s⁻²) per frequency interval per wavenumber interval. The bandwidth is (180 d)-1.
MJO Simulation Diagnostics: Precip & LH Flux

Figure 10: Phase-longitude diagram of OLR (contour, interval-5, green-positive/purple-negative) and evaporation (shaded). Phases are from MJO life-cycle composite and values are 5S-5N averaged. The unit of OLR and evaporation is W m$^{-2}$.
Use of a common forecast metric allows for:

- quantitative forecast skill assessment.
- targeted model improvements.
- even friendly competition to motivate further improvements.
- developing a multi-model ensemble forecast of the MJO.

ENSO – “Nino 3.4 Index”
Weather – 500 mb heights
MJO - ?

http://www.usclivar.org/mjo.php
Developing an MJO Forecast Metric

US CLIVAR MJO WG — Based on Wheeler & Hendon 2004

Fig. 1

MODE 1

Mode 1

1.2 m s^{-1}

-3.4 m s^{-1} -10.3 W m^{-2}

MODE 2

Mode 2

11.5 W m^{-2} 1.3 m s^{-1}
INVITATION FROM WGNE & US CLIVAR MJO WG

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\(^1\). 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 participate and contribute to the possible development in the future of a multi-model ensemble.**

CPC/NCEP & J. Gottschalck have agreed to receive the forecast data and compute the metric from each center’s data, display it and help develop and carry out validation capabilities.
### Contributors, Contents and Status
**Courtesy of Jon Gottschalck and CPC/NCEP/NOAA**

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See web page for key to Product IDs

W: forecast sent only once per week
Examples – Display Format

Observational RMM1 / RMM2 values for the past 40 days

15-day model forecasts
- Green line: Ensemble mean week 1 (thick), week 2 (thin)
- Ensemble members
  - Light gray shading: 90% of forecasts
  - Dark gray shading: 50% of forecasts
A BAMS article, led by J. Gottschalck, is in preparation that will report on this activity to the community.

B. Wang and others are coordinating an activity/proposals to work towards a multi-model ensemble forecast.
CLIVAR MJO Workshop Recommendations

Objectives of WCRP/WWRP Task Force

- Further development of process-oriented diagnostics/metrics that improve our insight into the physical mechanisms for robust simulation of the MJO and that facilitate improvements in convective and other physical parameterizations relevant to the MJO. (e.g., YOTC, GEWEX/GCSS, WGNE)

- Continue to explore multi-scale interactions within the context of convectively-coupled equatorial waves, both in observations and by exploiting recent advances in high-resolution modeling frameworks, with particular emphasis on vertical structure and diabatic processes. (e.g., YOTC, CMMAP, CASCADE, AMY)

- Expand efforts to develop and implement MJO forecast metrics under operational conditions, with additional focus on boreal summer and ensemble development. Includes the development of a multi-model hindcast to assess MJO predictability & forecast skill and development of ensemble methods. (e.g., pan-Monsoon, Thorpex, WGNE, WGSIP, TFSIP, APCC, AMY).