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

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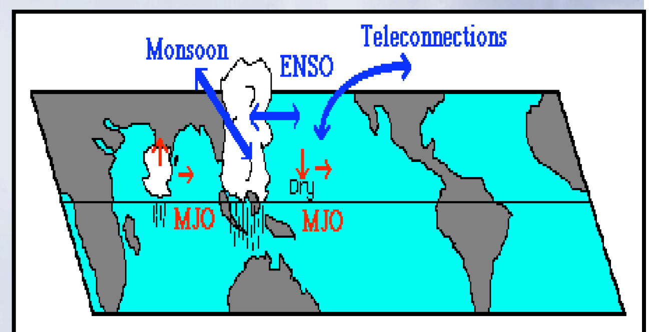

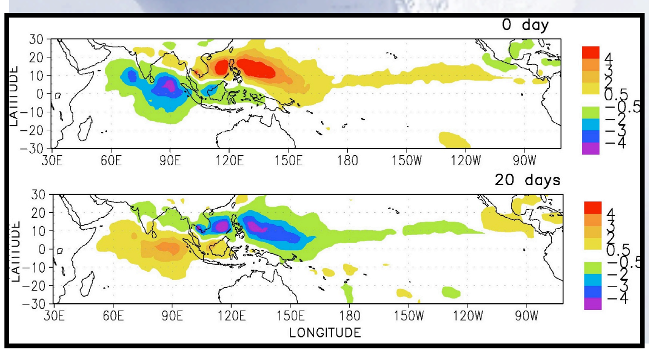

CMMAP, NYC, Jan 2009

With Support from International CLIVAR

US CLIVAR Established MJO Working Group : 2006-08

Goals/Progress: Summary

1) Develop MJO WG Web Site. www.usclivar.org/mjo.php
   - Diagnostics Link, Meeting & Telecon Updates, Theme Pages
2) Diagnostics for Asessing Model Simulations.
   - On Website. J. Climate Article ~ Accepted. 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 – submitted.
4) Operational MJO Forecasts & Metrics.
   - Designed, Implemented at Several Opertional Centers, w/ WGNE Help
   - BAMS Article Planned
5) Workshop/Experimentation Planning
   - November 2007, Irvine, CA. BAMS meeting summary in press.

I. MJO Working Group

2. Developing Model Simulation Diagnostics

Need standardized diagnostics to assess model performance with standardiced measures and track individual and community progress

MJO Diagnostics

Madden Julian Oscillation (MJO) Metrics

An activity led by US CLIVAR and supported by International CLIVAR

Introduction | Description | Observations | Simulations

DESCRIPTION
- LEVEL 1
- LEVEL 2
- OTHER

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 poin

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. $\mathrm{sqrt}(PC\text{-}1^2 + PC\text{-}2^2) > 1$].

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

Recipe for Calculating Diagnostics

Calculation Codes Available

Madden Julian Oscillation (MJO) Metrics

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Introduction | Description | Observations | Simulations

OBSERVATIONS
- Level 1
- Level 2
- Other

Observations - Level 2 metrics figure tables

1) FREQUENCY-WAVE SPECTRA (see Description)

a) Annual data

OLR	PRCP	U200	U850	Usfc
All season sptectra (with annual cycle)				
AVHRR	CMAP TRMM GPCP	NCEP1 NCEP2 ERA40	NCEP1 NCEP2 ERA40	NCEP1

b) Seasonally stratified data

OLR	PRCP	U200	U850	Usfc
Seasonally stratified spectra (Winter : November to April, without annual cycle)				
AVHRR	CMAP TRMM GPCP	NCEP1 NCEP2 ERA40	NCEP1 NCEP2 ERA40	NCEP1
Seasonally stratified spectra (Summer : May to October, without annual cycle)				
AVHRR	CMAP TRMM GPCP	NCEP1 NCEP2 ERA40	NCEP1 NCEP2 ERA40	NCEP1

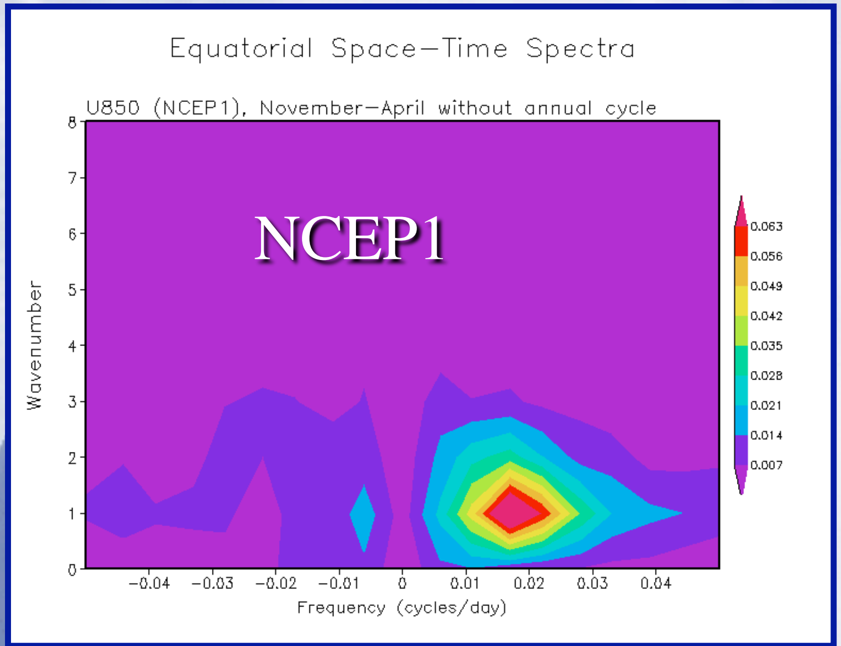
2) COMBINED EOFs (see Description)

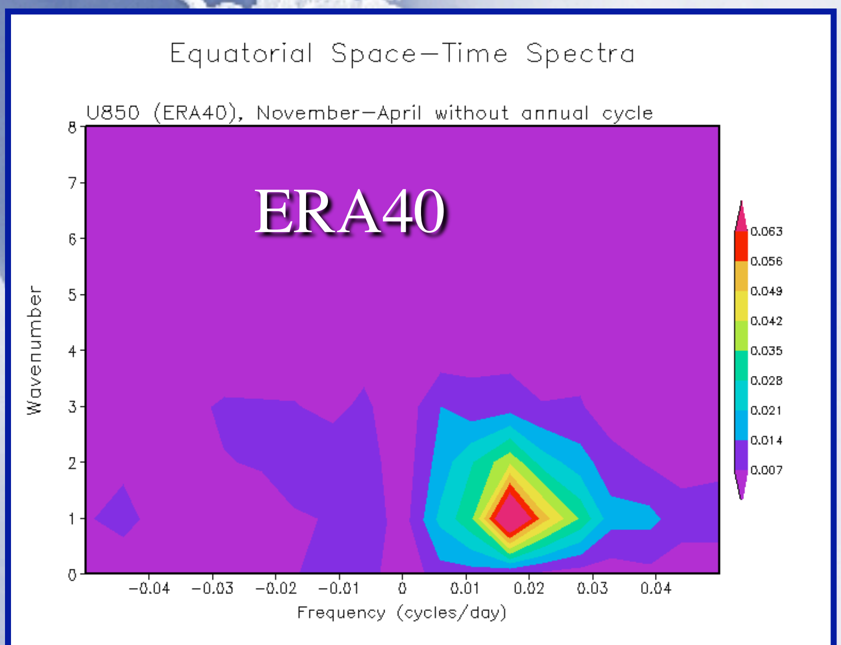
a) Combined EOFs

MJO Diagnostics

Plan To Make The Actual Map/Plot Data Available

Results Are Summarized in a Journal Of Climate Article (In Press)





MJO Diagnostics

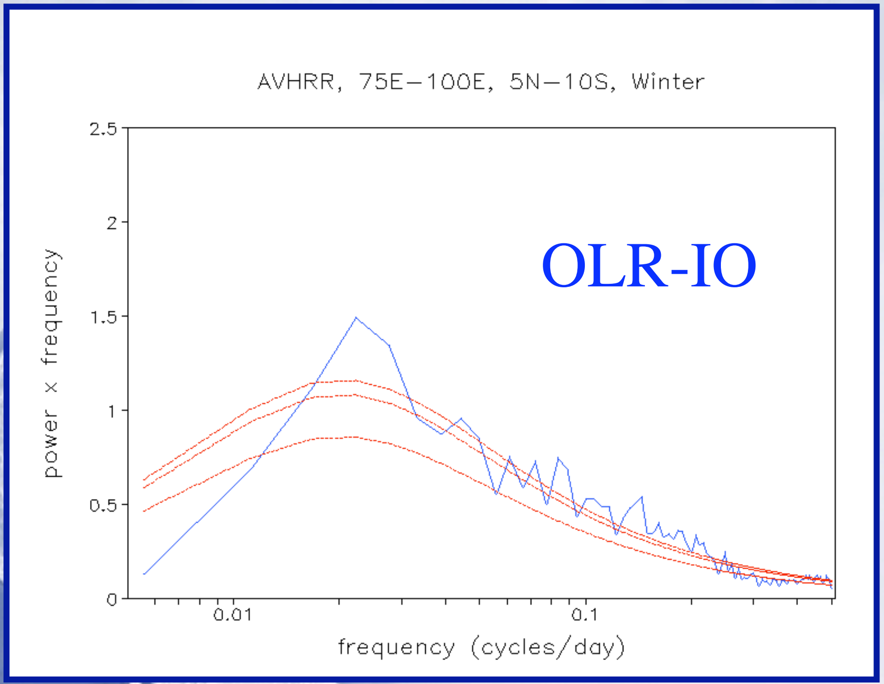
Equatorial Space-Time Spectra U, Rain, OLR

NCEP1, NCEP2, & ERA40

MJO Diagnostics

Time Series Spectra U, Rain, OLR

Domains of Interest



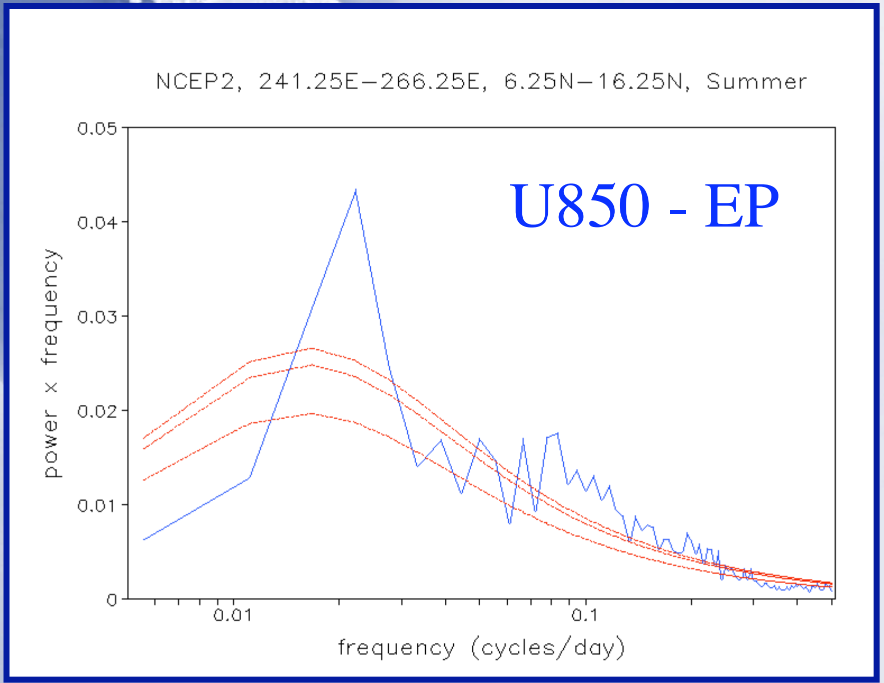
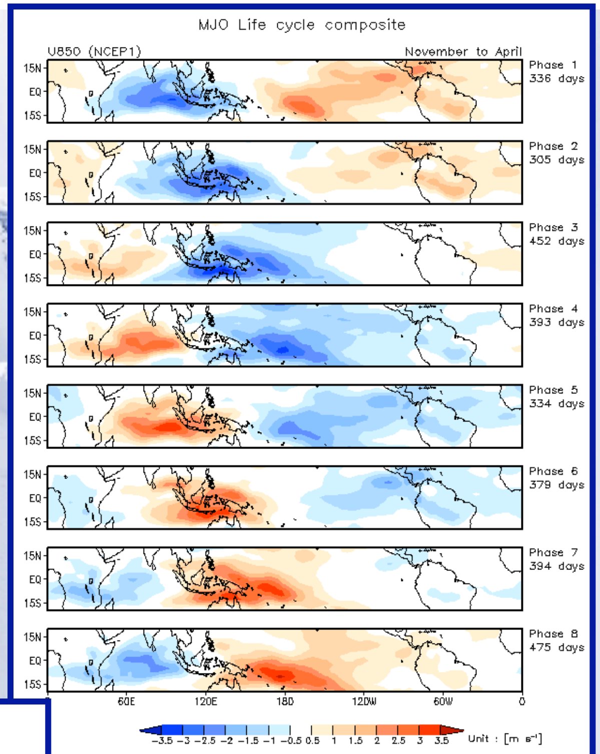


Table 1. Domains for time series power spectra metrics

	OLR	Precipitation	u_{850}	u_{200}
	Boreal Winter (November to April)			
IO	10S-5N, 75-100E	10S-5N, 75-100E	1.25°S-16.25°S, 68.75°E-96.25°E	3.75N-21.25N, 56.25E-78.75E
WP	20S-5S, 160E-185E	20S-5S, 160E-185E	1.25°N-13.75°S, 163.75°E-191.25°E	3.75N-21.25N, 123.75E-151.25E
MC	2.5S-17.5S, 115-145E	2.5S-17.5S; 115-145E		
EP				1.25N-16.25S, 256.25E-278.75E
	Boreal Summer (May to October)			
IO	10S-5N, 75-100E	10S-5N, 75-100E	21.25°N-3.75°N, 68.75°E-96.25°E	1.25°N-16.25°S, 43.75°E-71.25°E
BB	10-20N, 80-100E	10-20N, 80-100E		
WP	10-25N, 115-140E	10-25N, 115-140E	3.75°N-21.25°N, 118.75°E-146.25°E	3.75N-21.25N, 123.75E-151.25E
EP			6.25N-16.25N, 241.25E-266.25E	1.25°N-16.25°S, 238.75E-266.25E

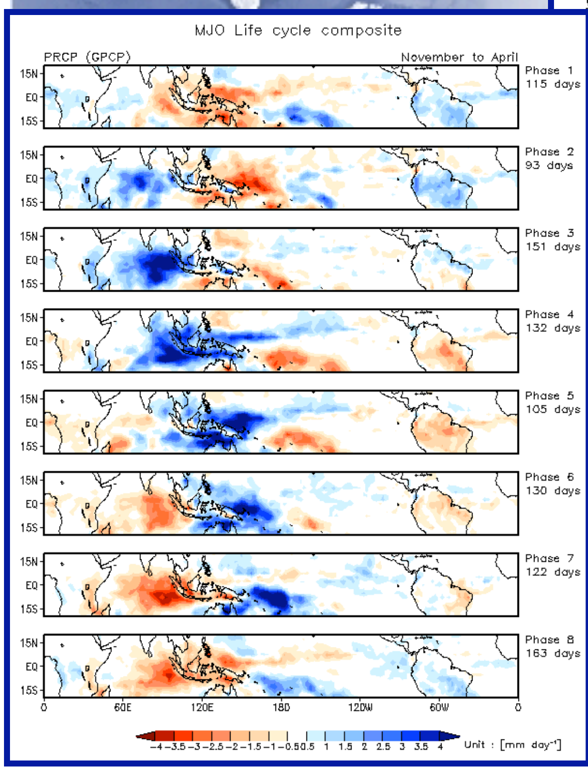
MJO Diagnostics

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



U850

Rainfall



Satellite Rain/Cloud: AVHRR, GPCP, TRMM

Analysis Data: NCEP1,NCEP2

I. MJO Working Group

3. Applying Diagnostics to Contemporary Climate Models

MJO Simulation Diagnostics

Application to Contemporary Models

Model (group)	Horizontal Resolution -AGCM	Vertical Resolution (top level) -AGCM	Cumulus parameterization	Integration	Reference
CAM3.5 (NCAR)	1.9° lat x 2.5° lon	26 (2.2hPa)	Mass flux (Zhang and McFarlane 1995)	20 years 01JAN1986-31DEC2005	Neale et al. (2007)
CAM3z (SIO)	T42(2.8°)	26 (2.2hPa)	Mass flux (Zhang and McFarlane 1995)	15 years 29JAN1980-23JUL1995	Zhang et al. (2005)
CFS (NCEP)	T62(1.8°)	64 (0.2hPa)	Mass flux (Hong and Pan 1998)	20 years	Wang et al. (2005)
CM2.1 (GFDL)	2° lat x 2.5° lon	24 (4.5hPa)	Mass flux (RAS; Moorthi and Suarez 1992)	20 years	Delworth et al. (2006)
ECHAM4/OPYC* (PCMDI)	T42(2.8°)	19 (10hPa)	Mass flux (Tiedtke 1989, adjustment closure Nordeng 1994)	20 years	Roeckner et al. (1996), Sperber et al. (2005)
GEOS5 (NASA)	1° lat x 1.25° lon	72 (0.01hPa)♪	Mass flux (RAS; Moorthi and Suarez 1992)	12 years 01DEC1993-30NOV2005	To be documented
SNUAGCM (SNU)	T42(2.8°)	20 (10hPa)	Mass flux (Numaguti et al. 1995)	20 years 01JAN1986-31DEC2005	Lee et al. (2003)
SPCAM (CSU)	T42(2.8°)	26 (3.5hPa)	Superparameterization (Khairoutdinov and Randall 2003)	19 years 01OCT1985-25SEP2005	Khairoutdinov et al. (2005)

MJO Simulation Diagnostics: Variance Precip & U850

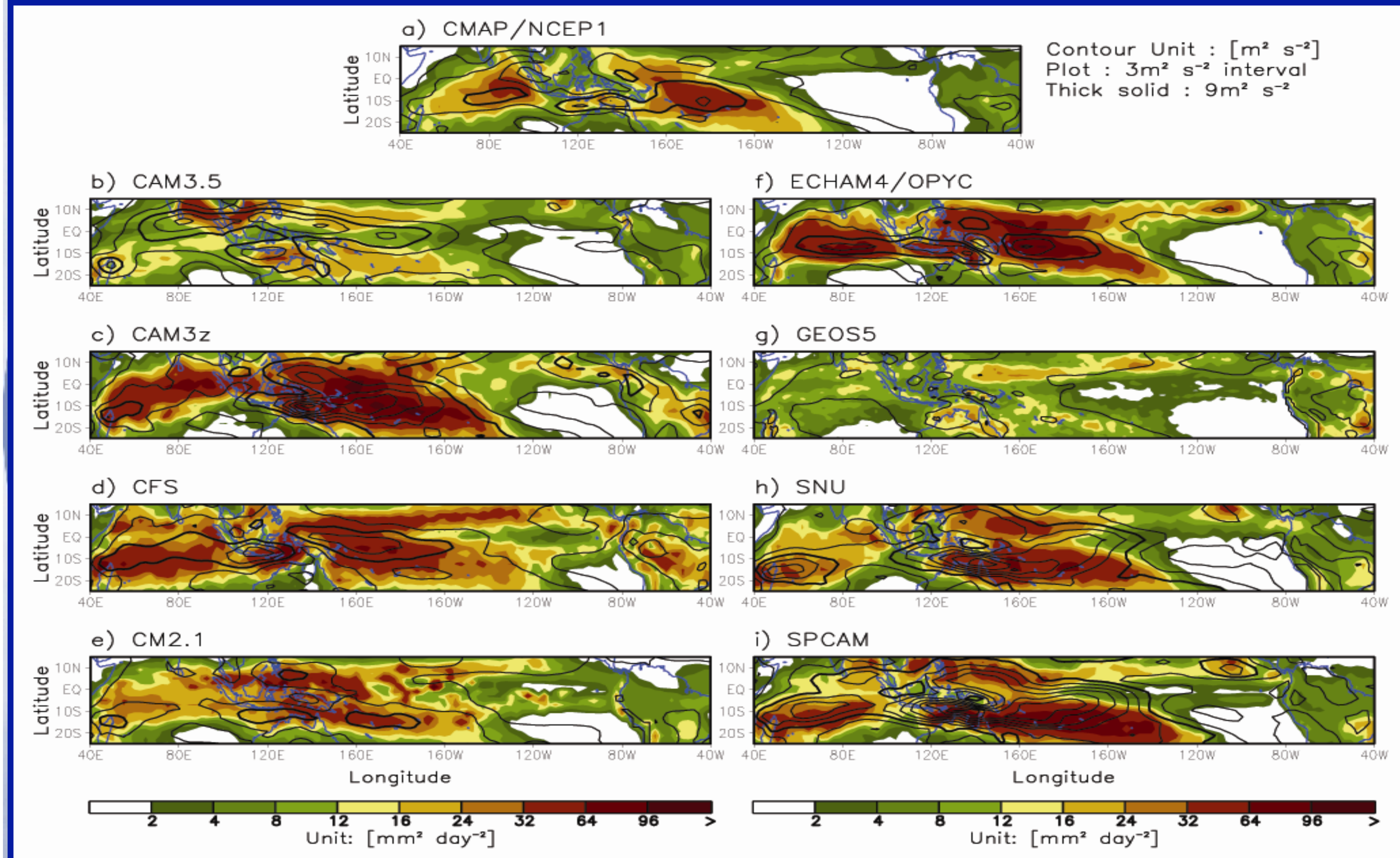


Figure 3 : As in Figure 1, except for variance of 20-100 day band pass filtered precipitation and 850hPa zonal wind. Contours of 850hPa zonal wind variance are plotted every 3 m2 s-2, 9 m2 s-2 line is represented by thick solid line. The unit is mm2 day-2 for precipitation and m2 s-2 for zonal wind.

MJO Simulation Diagnostics: W-F Precip & U850

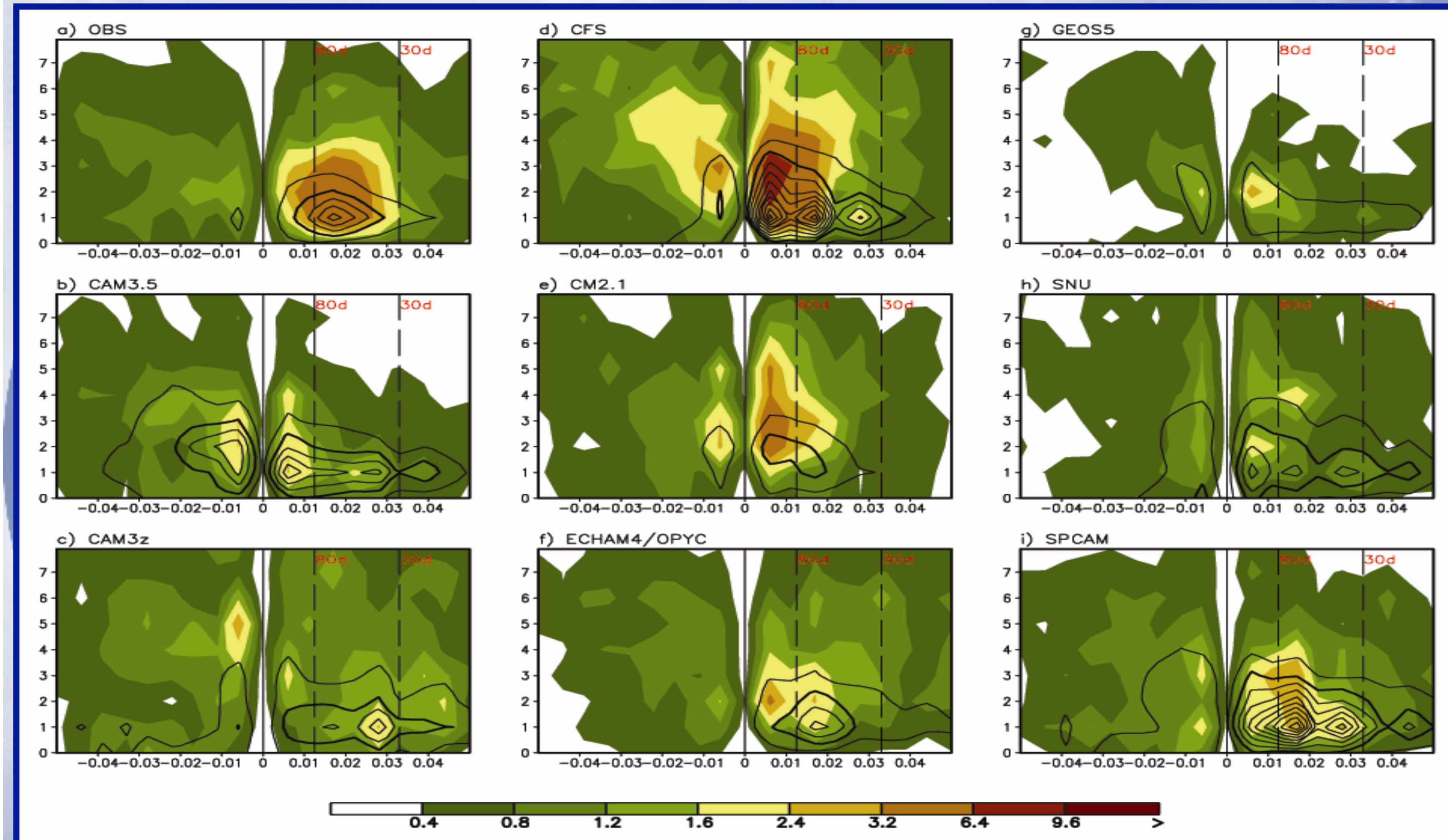


Figure 4 : November-April wavenumber-frequency spectra of 10oN-10oS averaged precipitation (shaded) and 850hPa zonal wind (contoured). a) CMAP/NCEP1, b) CAM3.5, c) CAM3z, d) CFS, e) CM2.1, f) ECHAM4/OPYC, g) GEOS5 h) SNU and i) SPCAM. Individual November-April spectra were calculated for each year, and 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

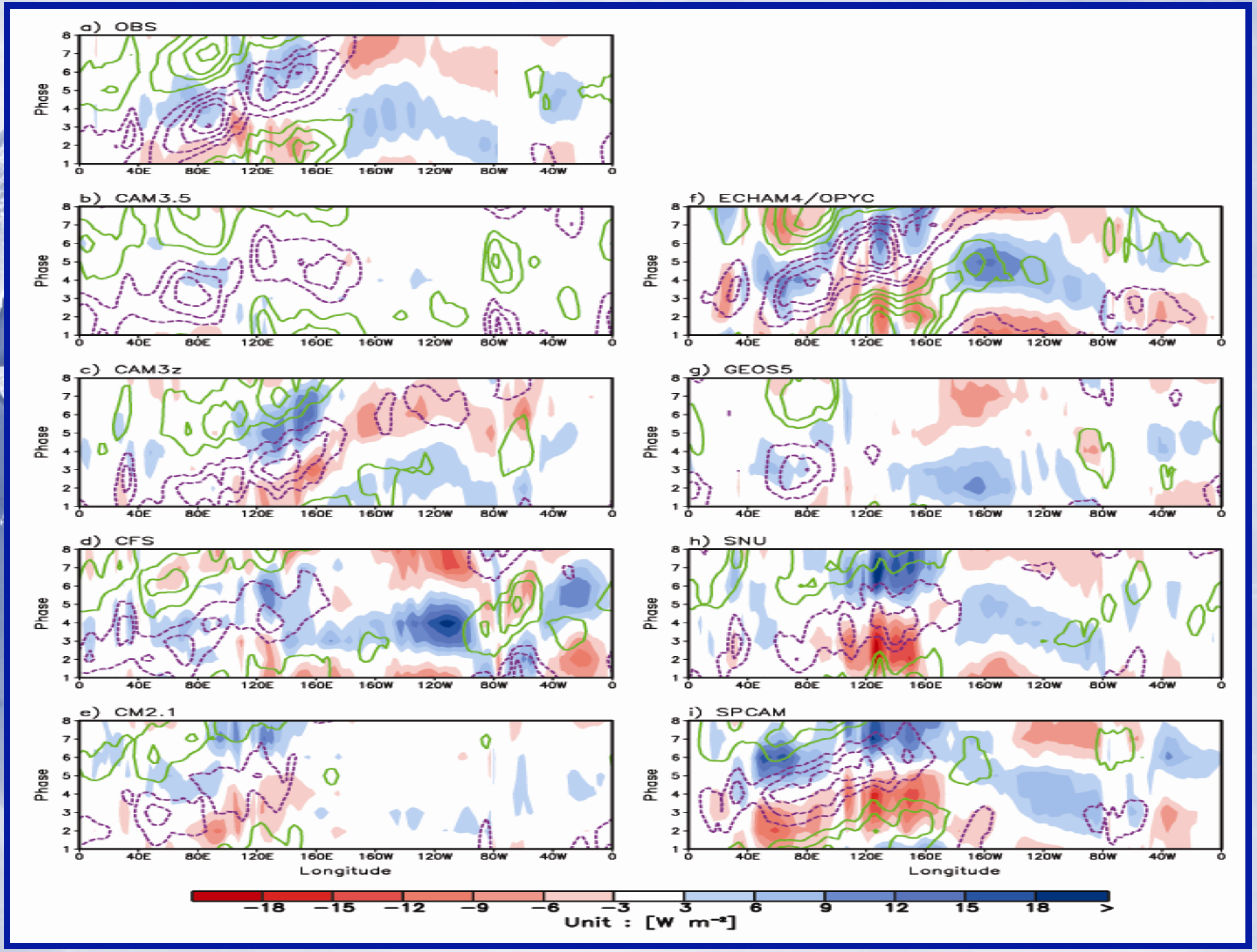


Figure 10: Phase-longitude diagram of OLR (contour, interval-5, green-positive/purple-negative) and evaporation (shaded). Phases are from MJO life-cycle composite and values are 5S-5N averaged. The unit of OLR and evaporation is W m-2.

I. MJO Working Group

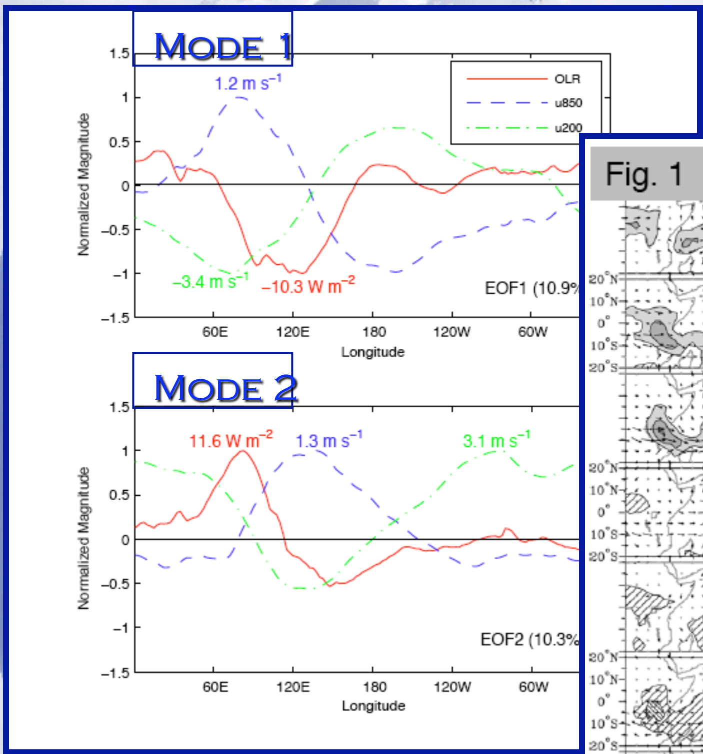
4. Metric for Operational MJO Forecasting

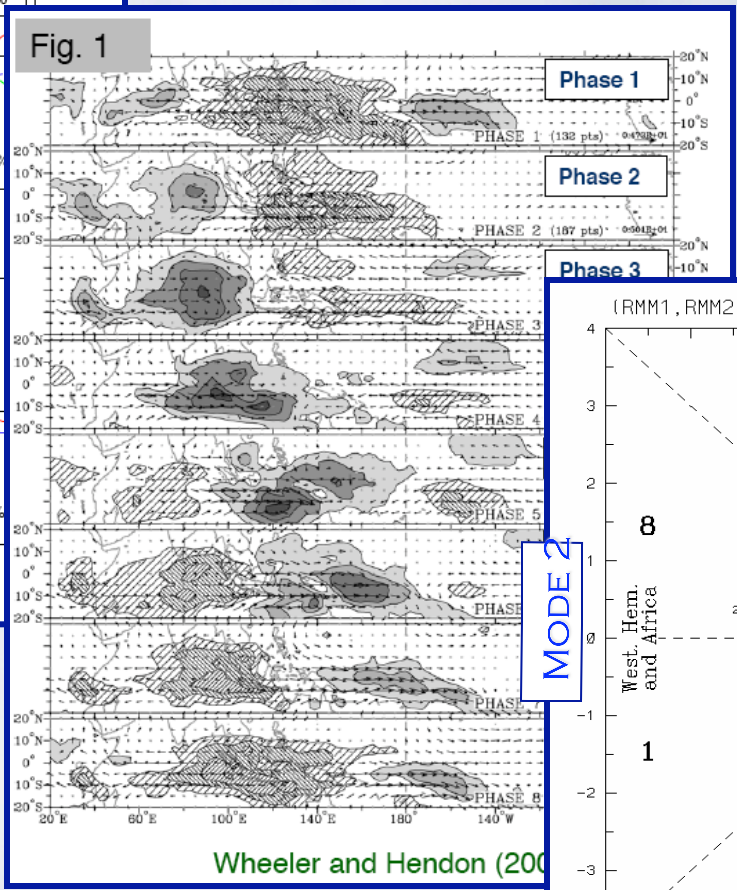
ENSO – "Nino 3.4 Index"
Weather – 500 mb heights
MJO - ?

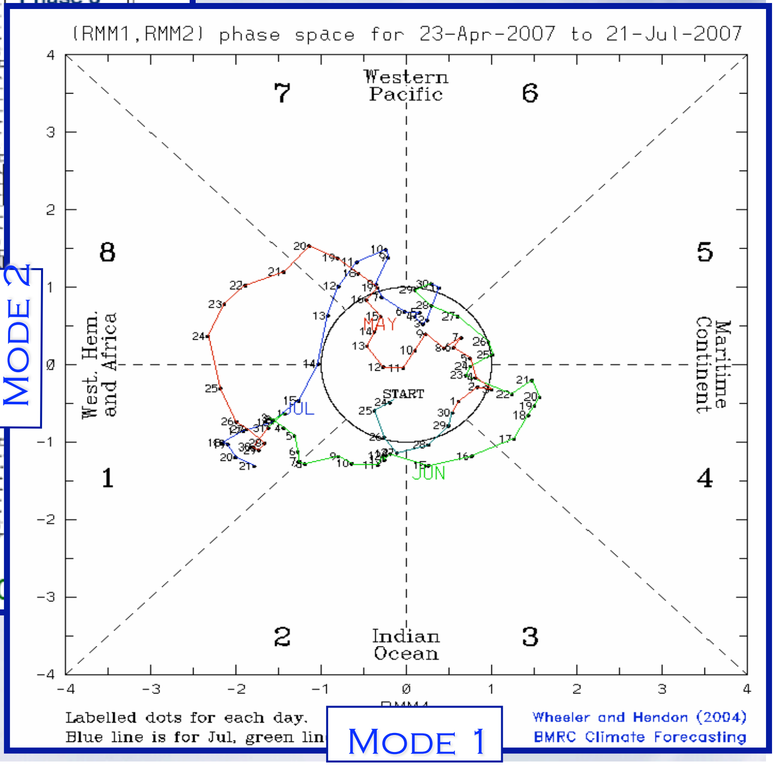
- Use of a common forecast metric allows for:
  - ✓ quantitative forecast skill assessment.
  - ✓ targeted model improvements.
  - ✓ even friendly competition to motivate further improvements.
  - ✓ developing a multi-model ensemble forecast of the MJO.

Development of an MJO Forecast Metric

Based on refinements of Wheeler & Hendon 2004 based on operational considerations







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 capabilites.

Contributors, Contents and Status

Courtesy of Jon Gottschalck and CPC/NCEP/NOAA

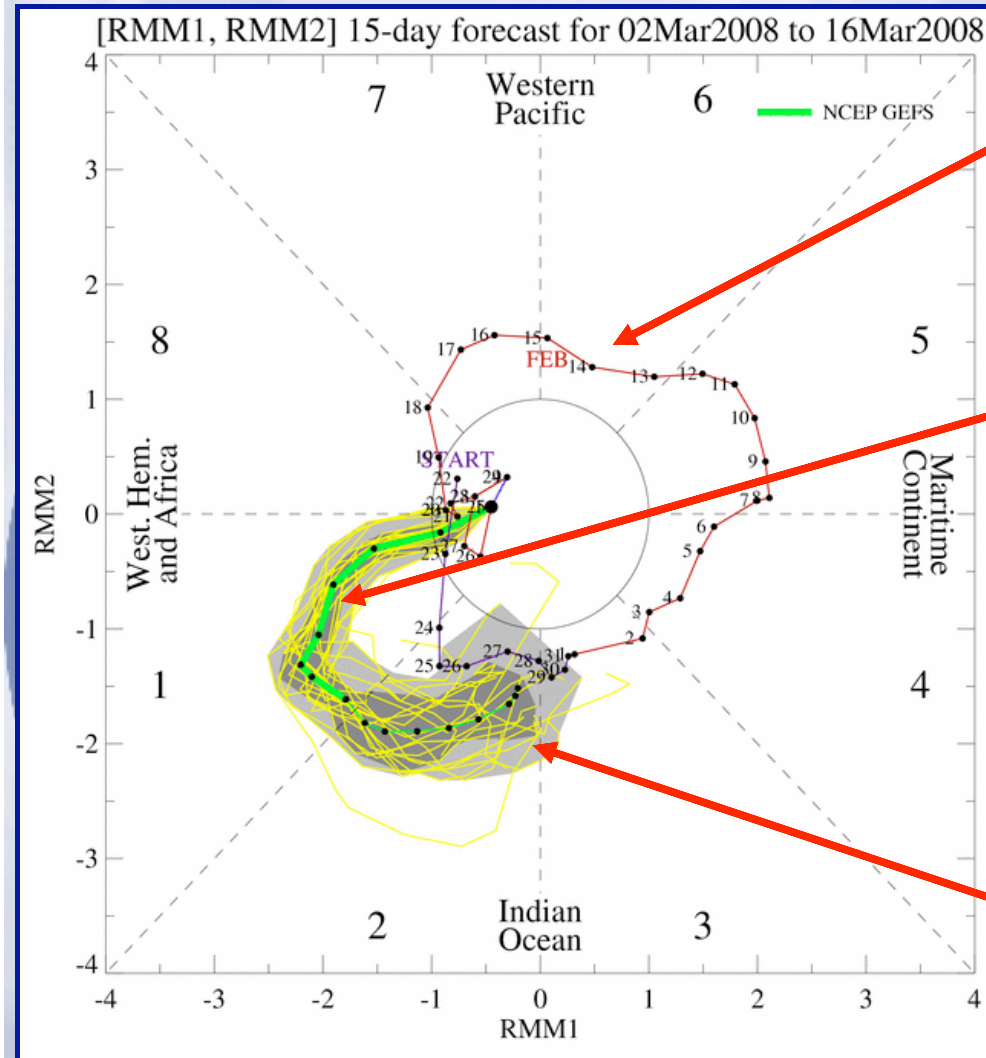
Center	Product ID	Ensemble Members	Forecasts Start	Forecast Length (Days)	Realtime Data FTP	Version 1 Plots	Model Climatology Available
NCEP	NCPE	21	11/1/2007	15	-----	Yes	No
NCEP	NCPA	1	1/1/2008	15	-----	Yes	No
NCEP	NCFS	4	1/1/2005	40	-----	Yes	Yes
CMC	CANM	20	6/8/2008	16	Yes	Yes	No
UKMO	UKMA	1	10/10/2007	15	Yes	Yes	No
UKMO	UKME	23	10/10/2007	15	Yes	Yes	No
ABOM	BOMA	1	1/1/2008	10	Yes	Yes	No
ABOM	BOME	32	------	10	No	No	No
ABOM	BOMC	1	1/1/2008	40	Yes	Yes	No
ECMWF	ECMF	51	6/9/2008	15	Yes	Yes	No
ECMWF	ECMM	51	6/9/2008	15	Yes	Yes	Yes
ECMWF	EMON	51 (W)	6/12/2008	32	Yes	Yes	No
ECMWF	EMOM	51 (W)	6/12/2008	32	Yes	Yes	Yes
JMA	JMAN	51	------	9	No	No	No
CPTEC	CPTC		------		Yes	No	No

See web page for key to Product IDs

W: forecast sent only once per week

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/clivar_wh.shtml

Examples – Display Format



Observational RMM1 / RMM2 values for the past 40 days

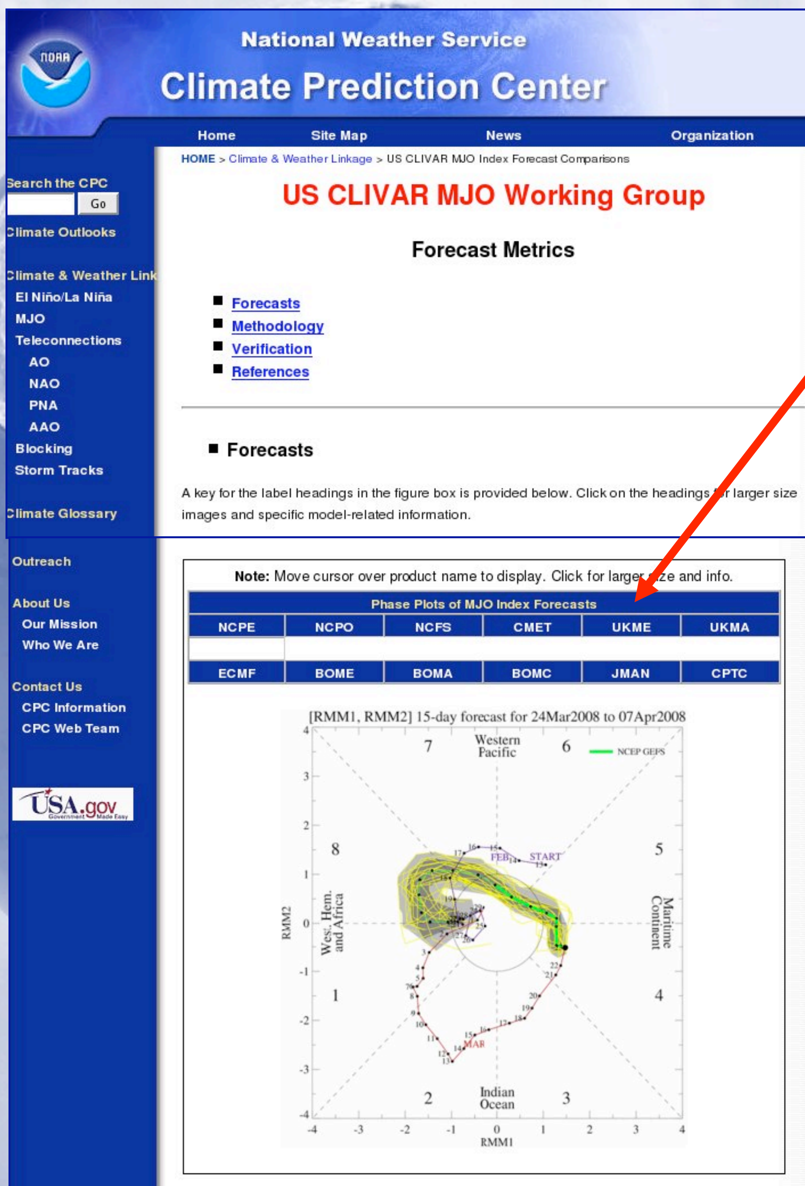
15-day model forecasts
--Green line: Ensemble mean week 1 (thick), week 2 (thin)

--Ensemble members

light gray shading: 90% of forecasts
dark gray shading: 50% of forecasts

Preliminary Website – Main Page

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/clivar_wh.shtml



- Scroll-over Heading Labels
- Links to Model Specific Information

- A BAMS article, led by J. Gottschalck, is in prepration that will report on this activity to the community.
- Furthermore, a proposal led by B. Wang was recently submitted to NOAA to work towards a multi-model ensemble forecast.

I. MJO Working Group

5. MJO Workshop - 2007

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

BAMS Meeting Summary In Press

http://www.usclivar.org/mjo.php

CLIVAR MJO Workshop Recommendations

Follow on activities & foci of collaboration

Floating a proposal to renew MJOWG via WCRP/WWRP?

- Where possible, develop scalar metrics of MJO model skill for use in multi-model comparisons and for tracking model fidelity.
- Develop process-oriented diagnostics that improve our insight into the physical mechanisms for robust simulation of the MJO.
- 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. (YOTC, CMMAP, CASCADE, AMY, etc)
- Expand efforts to develop and implement MJO forecast metrics under operational conditions. (e.g., boreal summer focus, ensembles)
- Develop an experimental modeling framework to assess MJO predictability as well as forecast skill from contemporary/ operational models. (B. Wang et al. / CTB NOAA proposal)