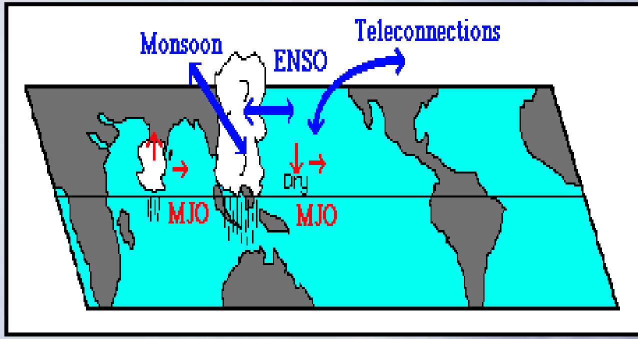
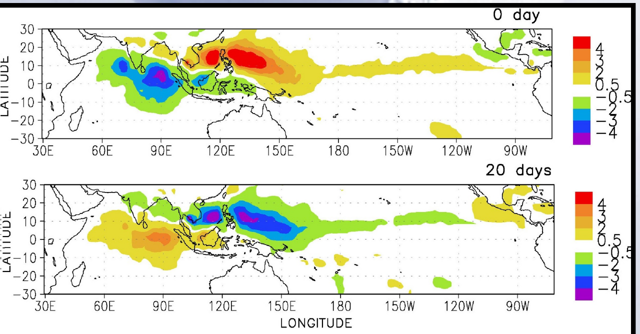
US CLIVAR MJO Working Group:
Efforts to Establish and Improve Subseasonal Predictions

D. Waliser, K. Sperber, J. Gottschalck, H. Hendon, W. Higgins, I. Kang, D. Kim, E. Maloney, M. Moncrieff, K. Pegion, N. Savage, S. Schubert, W. Stern, A. Vintzileos, F. Vitart, B. Wang, W. Wang, K. Weickmann, M. Wheeler, S. Woolnough, C. Zhang





US CLIVAR Summit, 2008

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

US CLIVAR MJO Working Group

Established Spring 2006

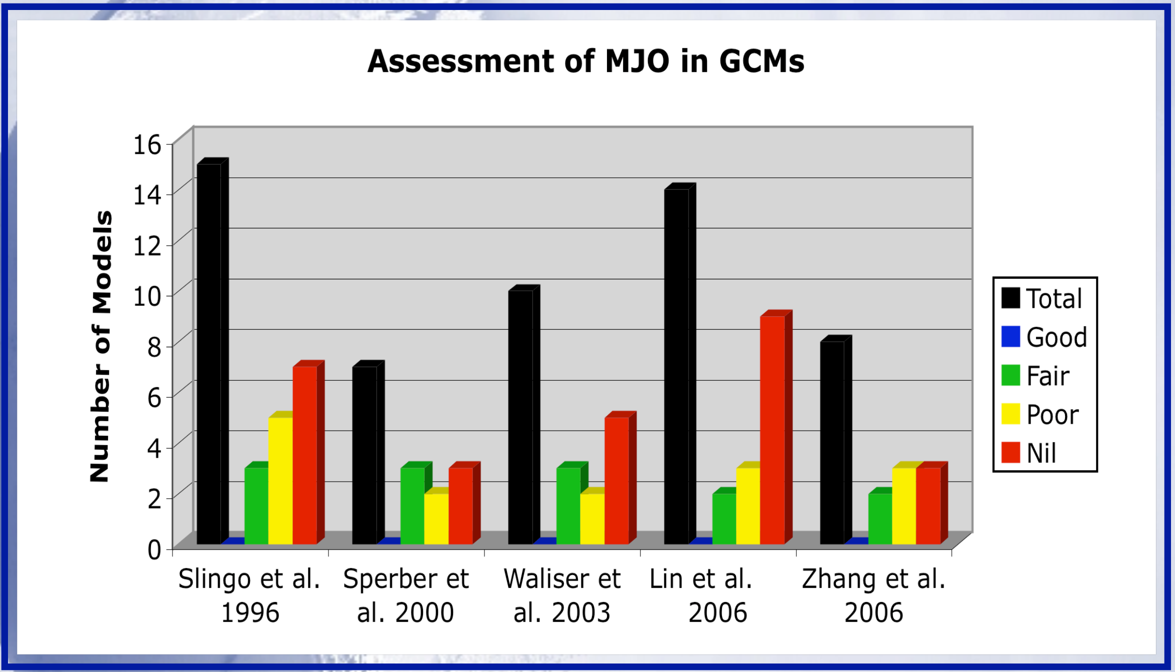
Additional Support from International CLIVAR

TERMS OF REFERENCE

- Develop a set of diagnostics to be used for assessing MJO <u>simulation</u> fidelity and <u>forecast</u> 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.

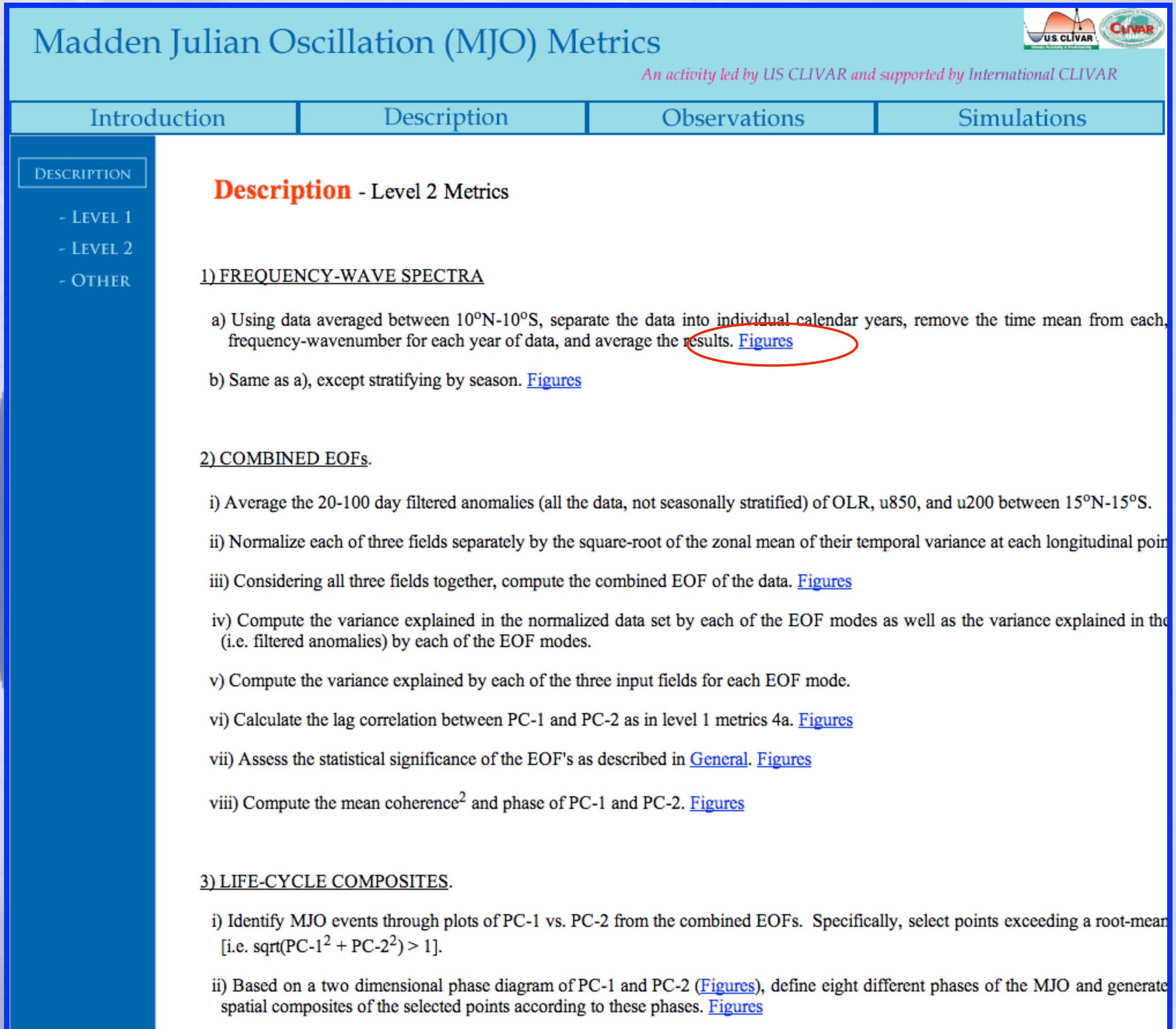
MJO Simulation Diagnostics

Motivation



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

Need a more formal / accepted process for model assessment.



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^{o}N-10^{o}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^{o}N-15^{o}S.

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

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($\text{PC-1}^2 + \text{PC-2}^2$) > 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

Web Site with Plots

Recipes for Calculating Diagnostics

Calculation Codes Available

Madden Julian Oscillation (MJO) Metrics

An activity led by US CLIVAR and supported by International CLIVAR

Introduction | Description | Observations | Simulations

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)

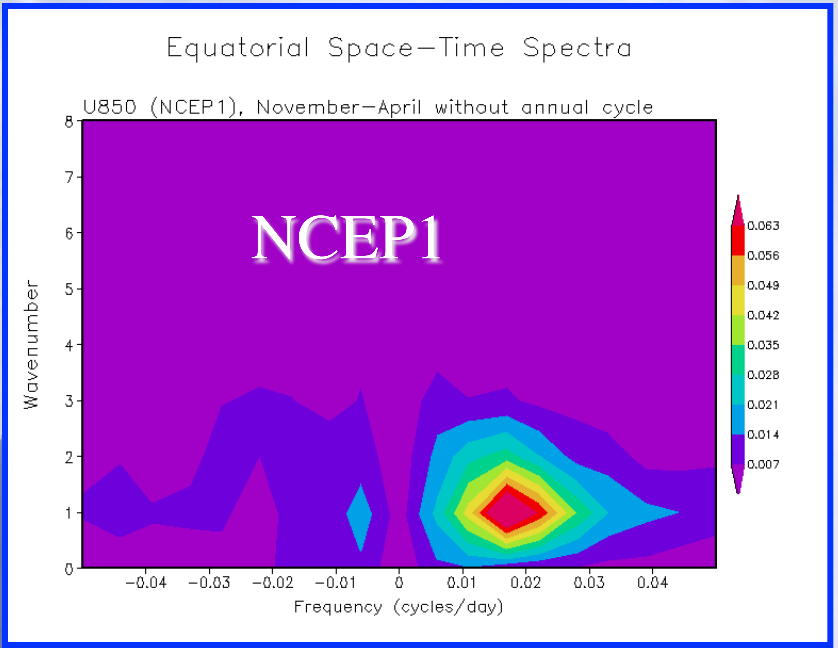
a) Combined EOFs

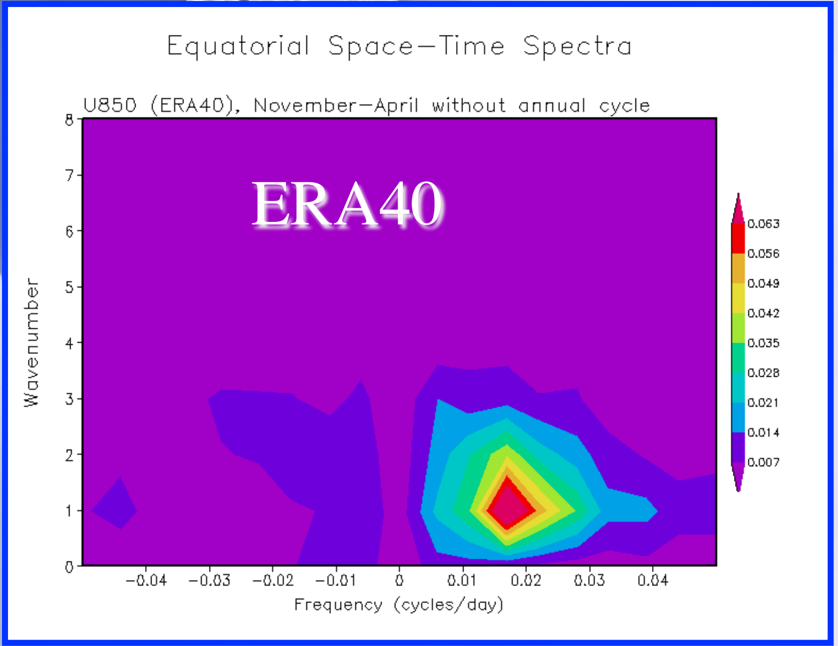
MJO Diagnostics

Standardized Diagnostics

Observational Uncertainty

Seasonal Stratification



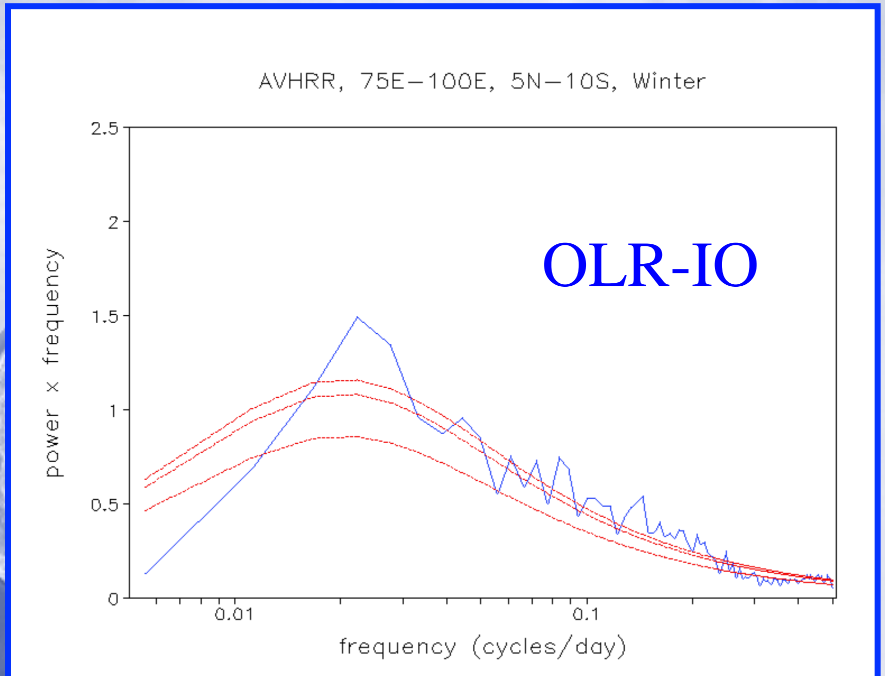


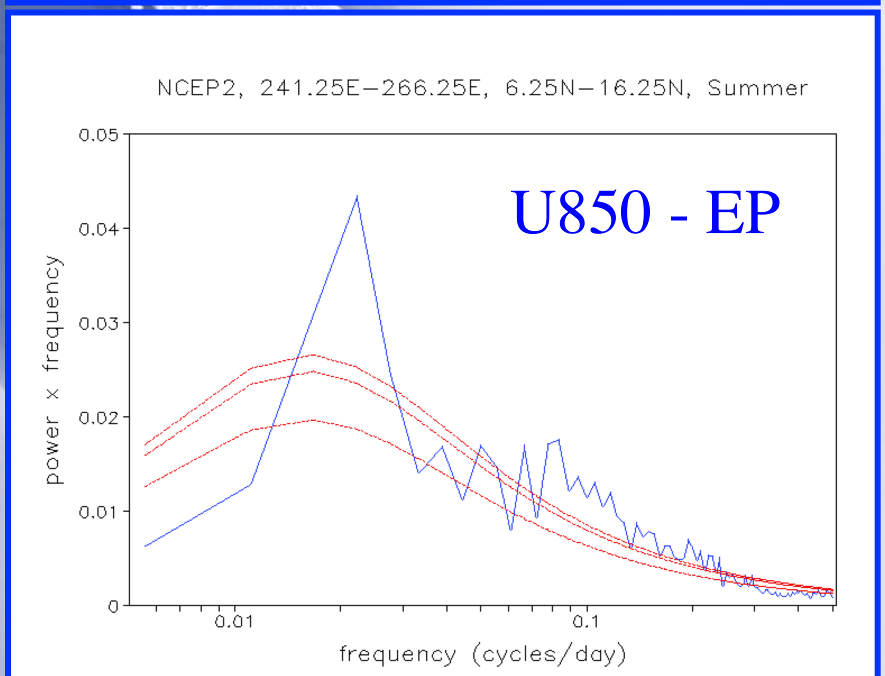
MJO Diagnostics

Equatorial Space-Time Spectra U, Rain, OLR

NCEP1, NCEP2, & ERA40

MJO Diagnostics





Time Series Spectra
U, Rain, OLR

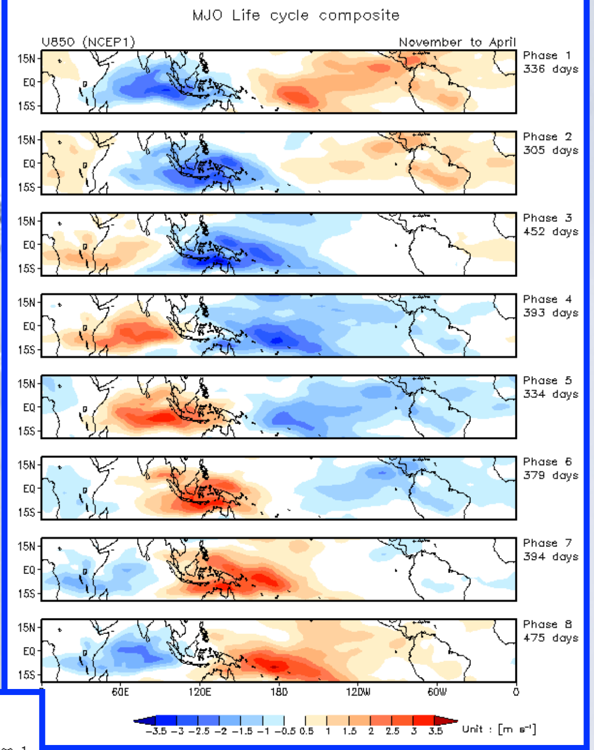
Domains of Interest

Table 1. Domains for time series power spectra metrics

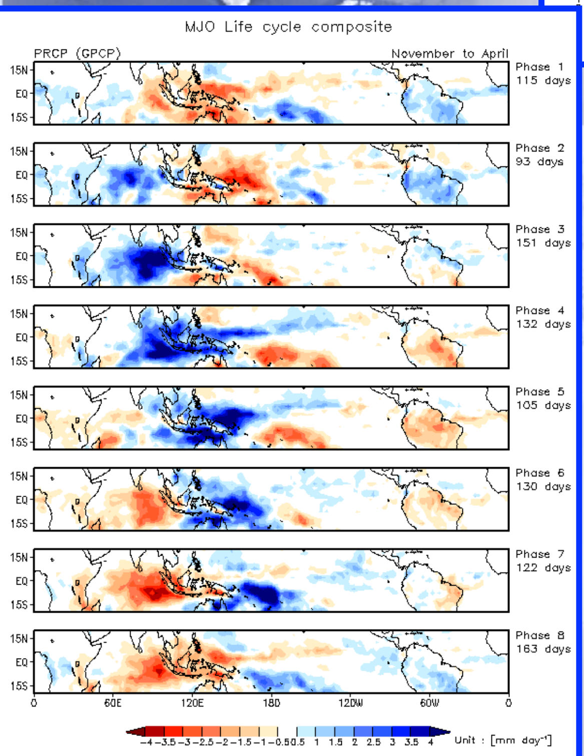
	OLR	Precipitation	u_{850}	u_{200}
	Boreal Winter (November to April)			
IO	10S-5N, 75-100E	10S-5N, 75-100E	1.25°S-16.25°S, 68.75°E-96.25°E	3.75N-21.25N, 56.25E-78.75E
WP	20S-5S, 160E-185E	20S-5S, 160E-185E	1.25°N-13.75°S, 163.75°E-191.25°E	3.75N-21.25N, 123.75E-151.25E
MC	2.5S-17.5S, 115-145E	2.5S-17.5S, 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

<u>Satellite Rain/Cloud</u>: AVHRR, GPCP, TRMM
<u>Analysis Data:</u> NCEP1,NCEP2

MJO Diagnostics

Paper #1 - Submitted

MJO Simulation Diagnostics

US CLIVAR Madden-Julian Oscillation Working Group:

L. Donner, J. Gottschalck, H. Hendon, W. Higgins, I. Kang, D. Kim, D. Legler, E. Maloney, M. Moncrieff, S. Schubert, K. Sperber, W. Stern, F. Vitart, D. Waliser[&]*, B. Wang, W. Wang, K. Weickmann, M. Wheeler, S. Woolnough, C. Zhang*

**Co-Chairs*

Please cite as:

US CLIVAR Madden-Julian Oscillation Working Group, 2008: MJO Simulation Diagnostics, *J. Clim., Submitted.*

Submitted to the Journal of Climate

June 2008

MJO Simulation Diagnostics

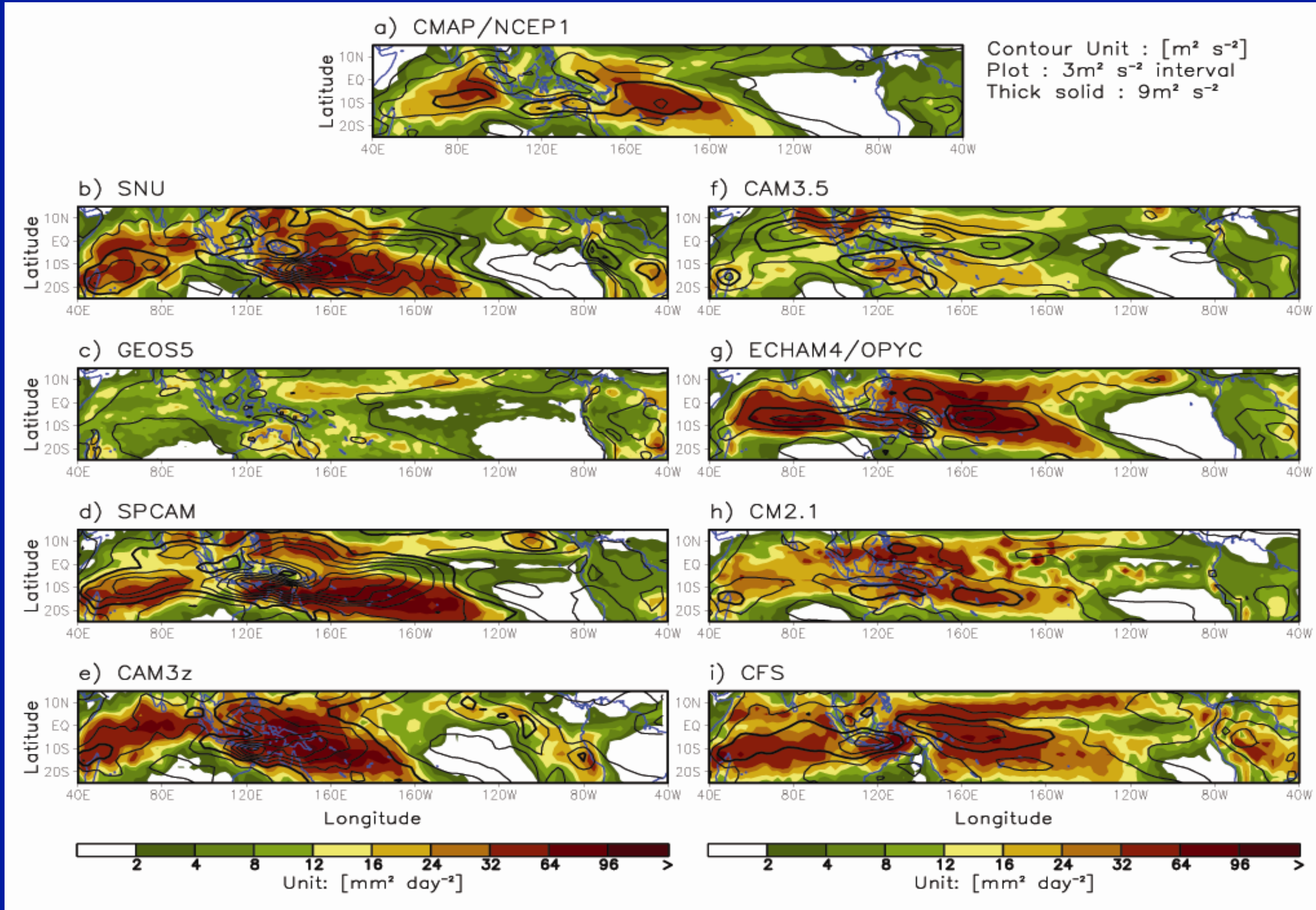
Application to Contemporary Models

Model	Horizontal Resolution	Vertical Resolution (top level)	Cumulus parameterization	Integration	Reference
CFS - NCEP	T62(1.8°)	64 (0.2hPa)	Mass flux (Hong and Pan 1998)	20 years	Wang et al. (2005)
ECHAM4 /OPYC* - PCMDI	T42(2.8°)	19 (10hPa)	Mass flux (Tiedtke 1989, adjustment closure Nordeng 1994)	20 years	Sperber 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)
SPCAM - CSU	T42(2.8°)	26 (3.5hPa)	Superparameterization (Khairoutdinov and Randall 2003)	19 years 01OCT1985-25SEP2005	Khairoutdinov 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
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)
SNUAGCM - SNU	T42(2.8°)	20 (10hPa)	Mass flux (Numaguti et al. 1995)	8 years 01JAN1997-31DEC2004	Lee et al. (2003)

Assess Current Capabilities for Simulating the MJO

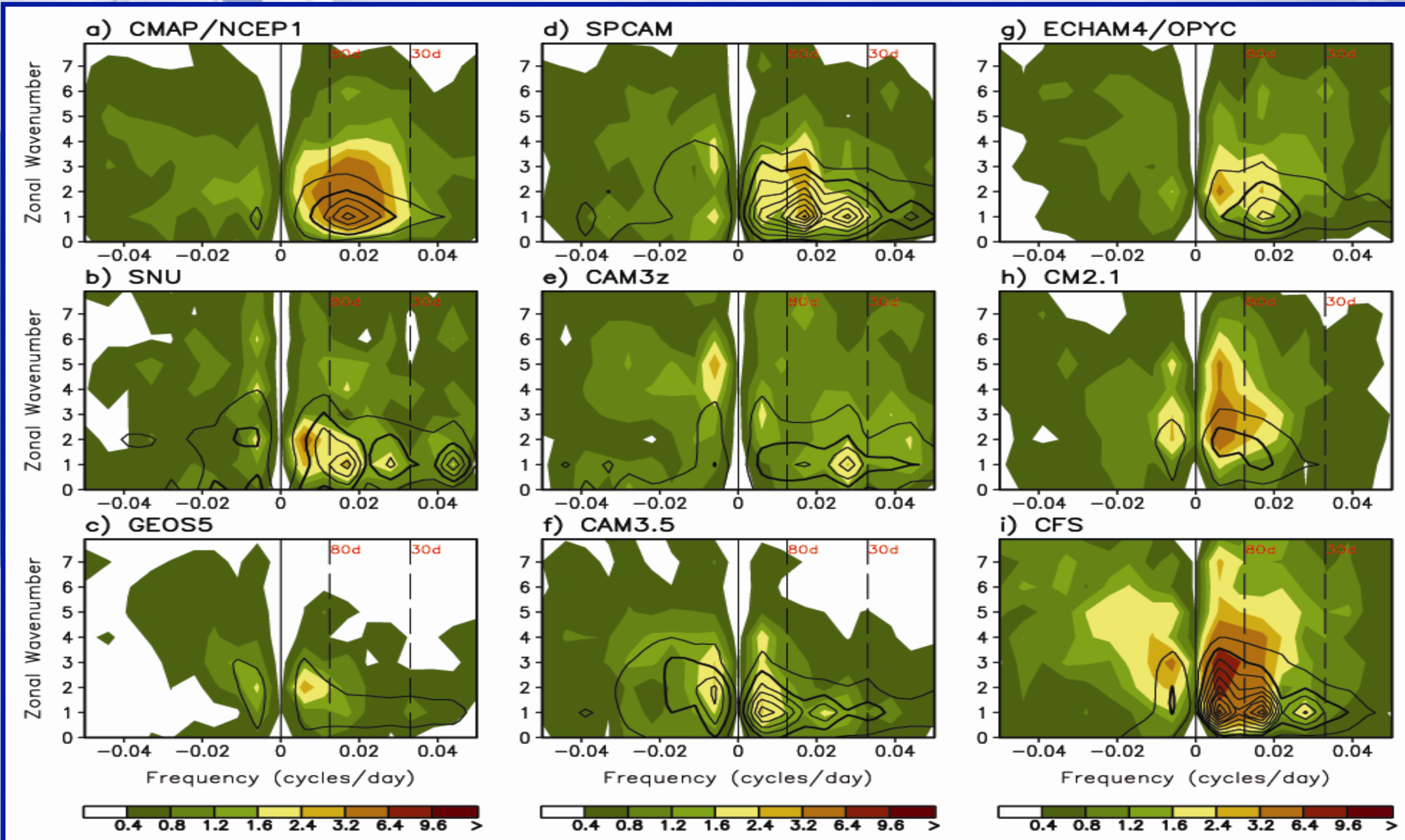
MJO Simulation Diagnostics

Subseasonal Variance: Precip & U850



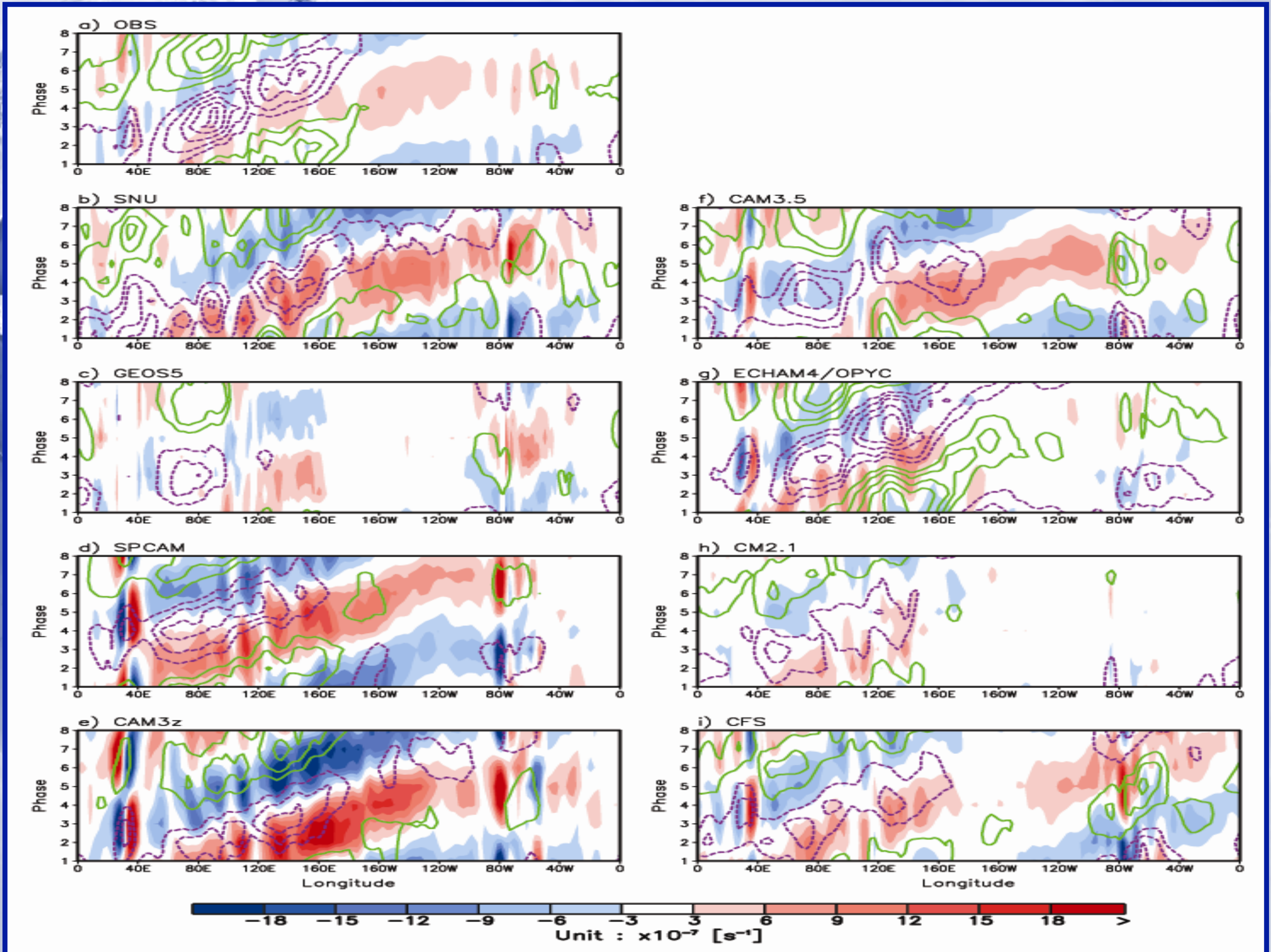
MJO Simulation Diagnostics

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

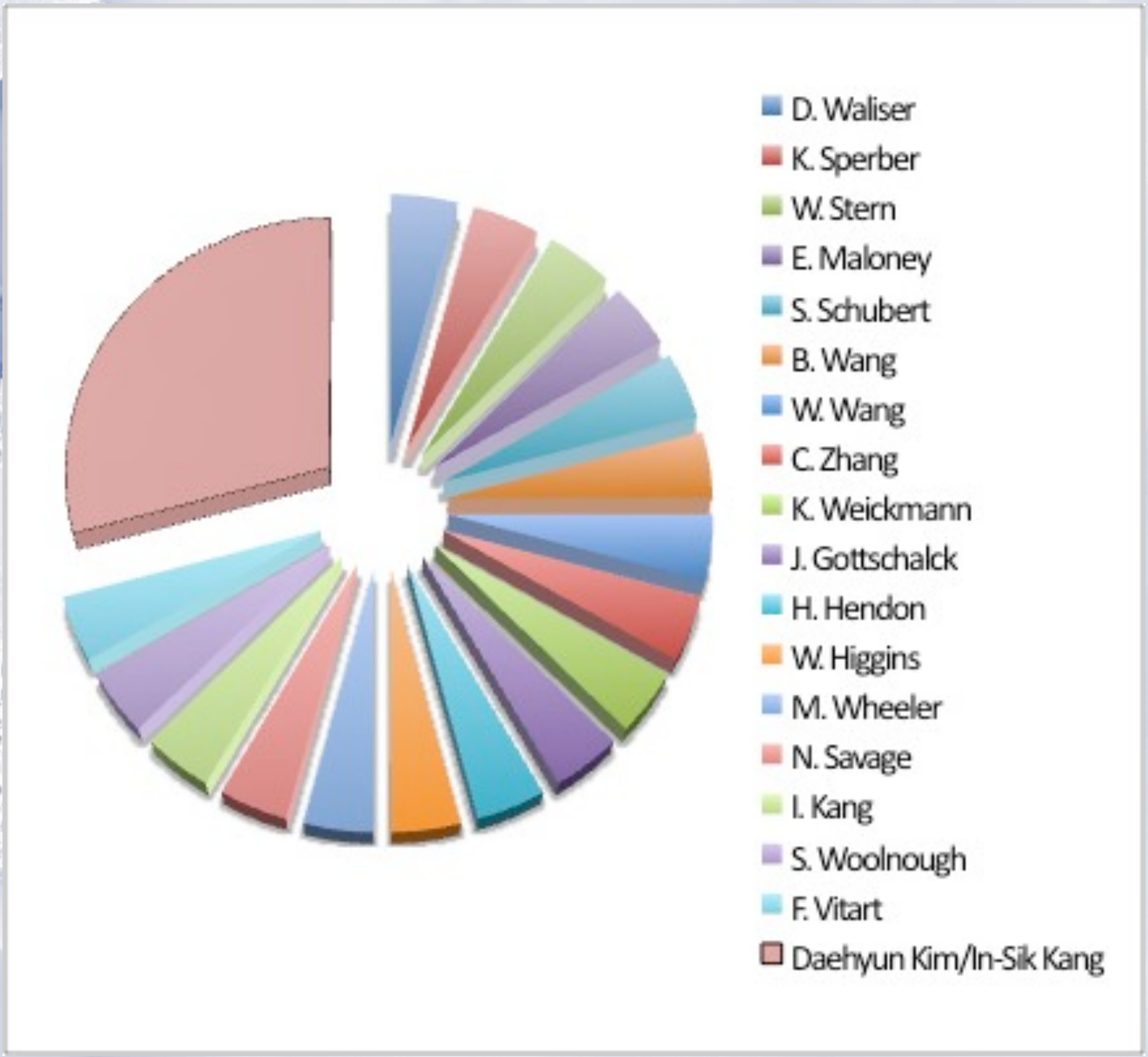
US CLIVAR Madden-Julian Oscillation Working Group:

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 benfit from simple forecast metrics.

e.g. ENSO – "Nino 3.4 Index"

Weather – 500 mb heights

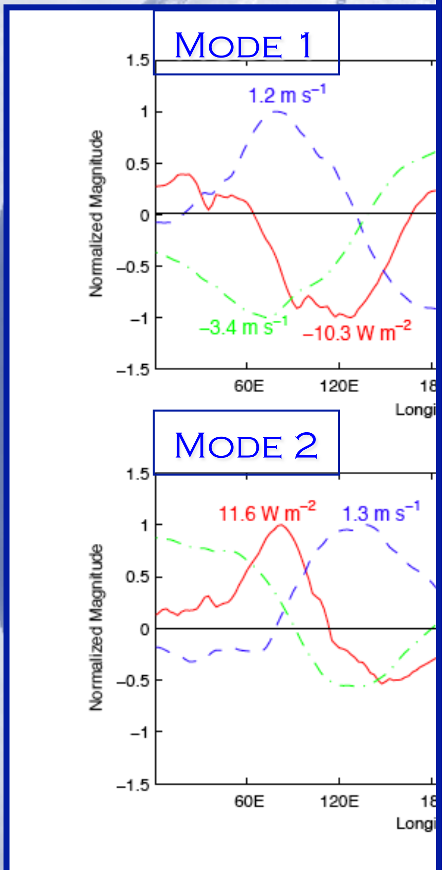
MJO - ?

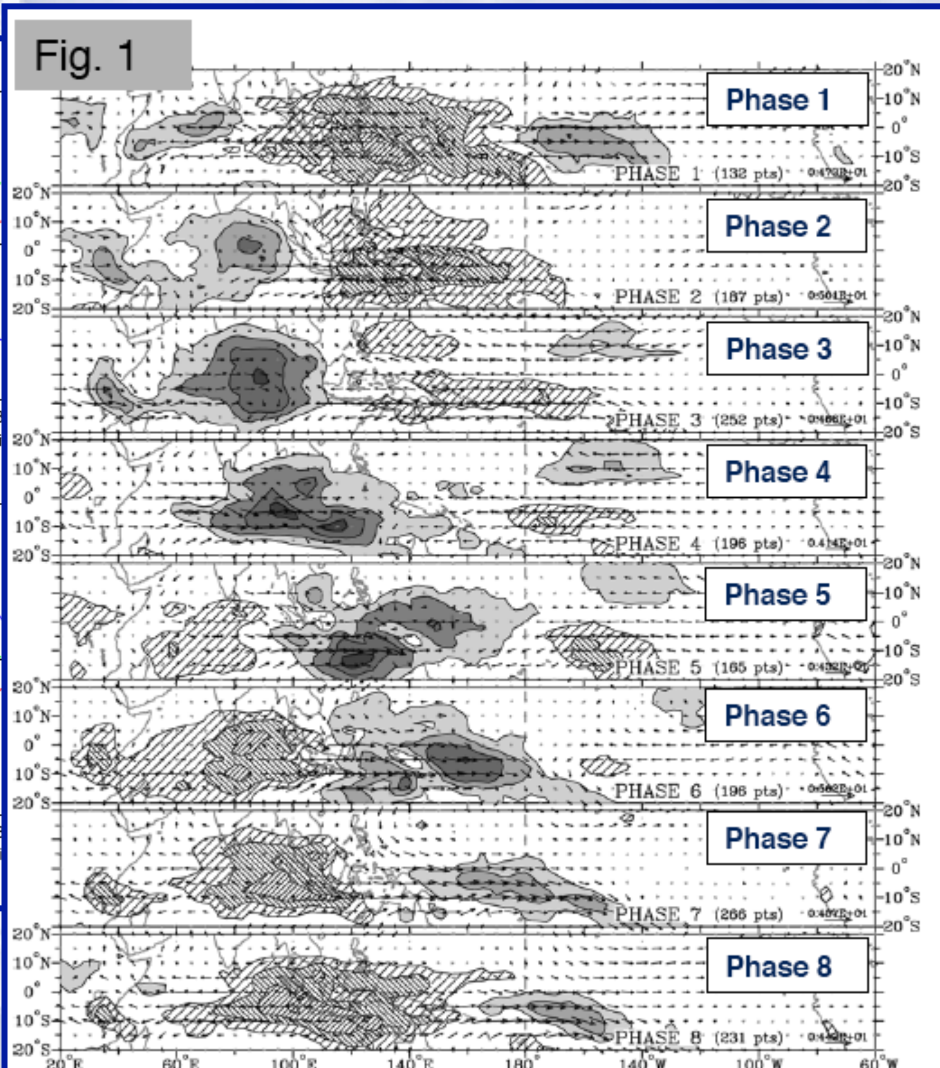
In the case of the MJO, a common forecast metric allows for:

- ✓ 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.

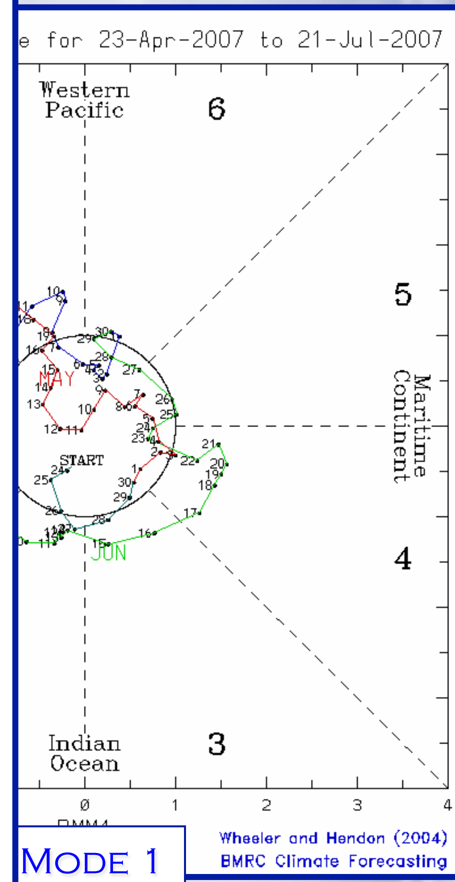
Developing an MJO Forecast Metric

US CLIVAR MJO WG – Based on Wheeler & Hendon 2004





Wheeler and Hendon (2004)



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

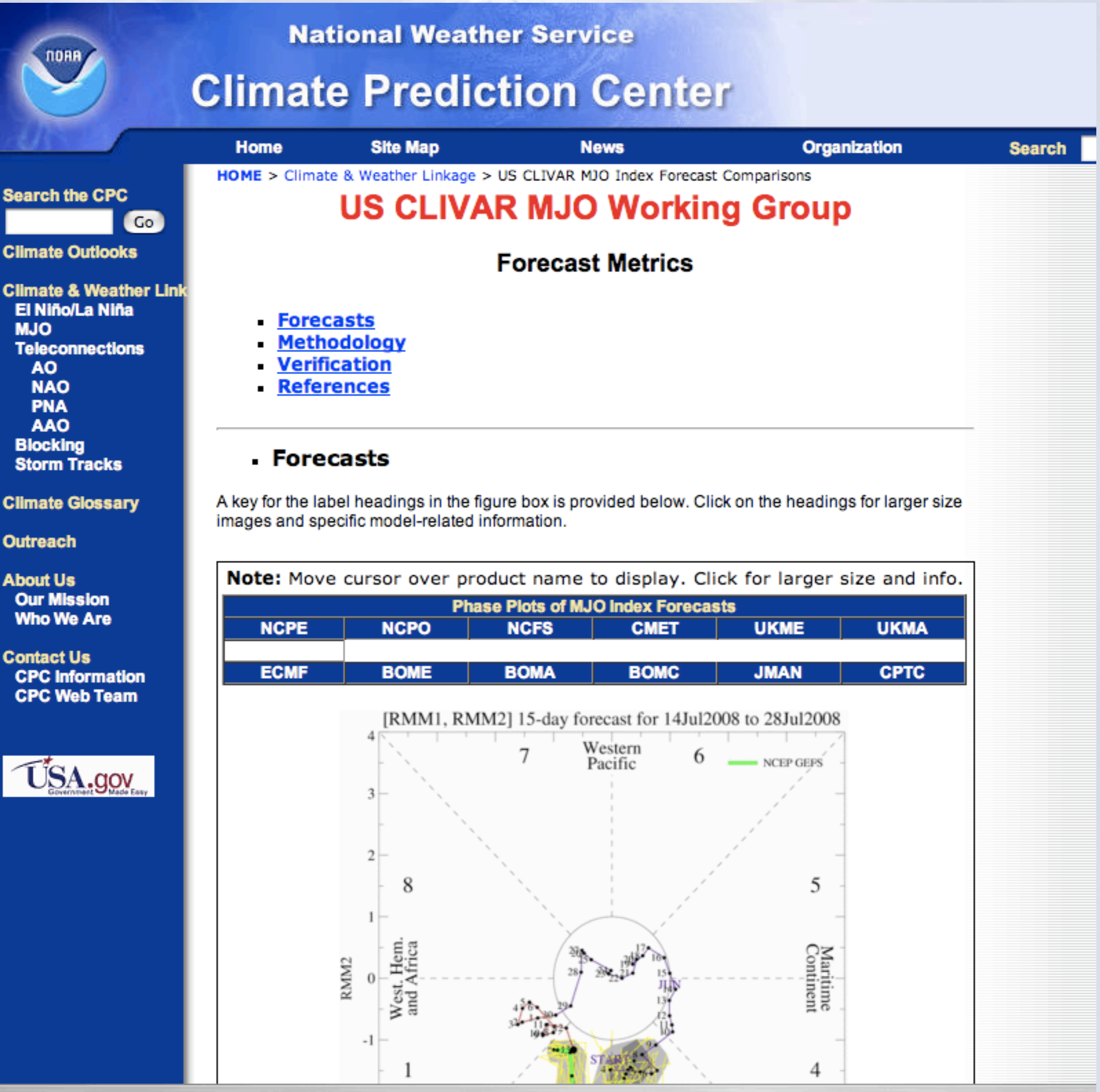
Prepare and send – operationally - a select set of forecast fields (U850, U200, OLR) in order to join the fun and the Multi-Model Ensemble.

Contributors, Contents and Status

Courtesy of Jon Gottschalck and CPC/NCEP/NOAA

Center	PID	Members	Forecasts Start Date	Days	Realtime	Model Clim
NCEP	NCEP	21	1/1/08	15	Yes	Yes
CMC	CANM	20	6/8/08	16	Yes	No
UKMO	UKMA	1	10/10/07	15	Yes	No
UKMO	UKME	23	10/10/07	15	Yes	No
ABOM	BOMA	1	1/1/08	10	Yes	No
ABOM	BOME	32		10	No	No
ABOM	BOMC	1	1/108	40	Yes	No
ECMWF	ECMF	51	6/9/08	15	Yes	No
ECMWF	ECMM	51	6/9/08	15	Yes	Yes
ECMWF	EMON	51 (wkly)	6/12/08	32	Yes	No
JMA	**JMAN**	**51**		**9**	**No**	**No**
CPTEC	CPTC				No	No

Central Analysis and Presentation Site



<u>Courtesy of</u>

<u>Jon Gottschalck and CPC/NCEP/ NOAA</u>

<u>&</u>

<u>Contributing Operational Centers</u>

Paper #3
BAMS Article in Prepration

CLIVAR MJO Workshop

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

5-7November 2007, Irvine, California

CLIVAR MJO Workshop Recommendations

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

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.

BAMS Meeting Summary In Press

CLIVAR MJO WG Follow-On

Relevant Activities and Near-Term Events:

NSF CMMAP – MJO Focus Group

AAMP – International CLIVAR, Bejing, Oct 2008

ICTP Monsoon+MJO Workshop, Trieste, Aug 2008

4th WMO Monsoon Workshop, Bejing, Oct 2008

YOTC – WMO/WCRP/WWRP/THORPEX, 2008-09

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.