The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

IAEA International Atomic Energy Agency

1956-20

Targeted Training Activity: Seasonal Predictability in Tropical Regions to be followed by Workshop on Multi-scale Predictions of the Asian and African Summer Monsoon

4 - 15 August 2008

Intraseasonal variability: MJO Working Group progress and YOTC plans

WALISER Duane Edward

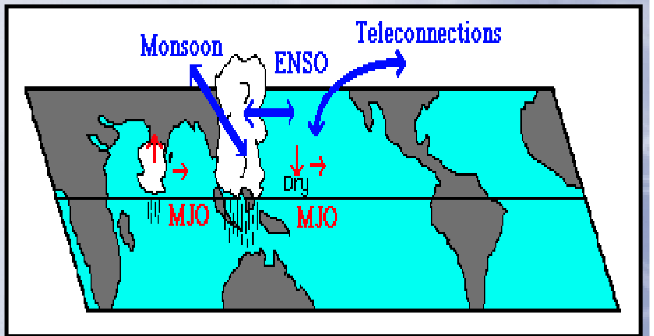
Jet Propulsion Laboratory
Department of Physics California Institute of Technology, CALTECH
4800 Oak Grove Drive, Pasadena CA 91109
U.S.A.

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

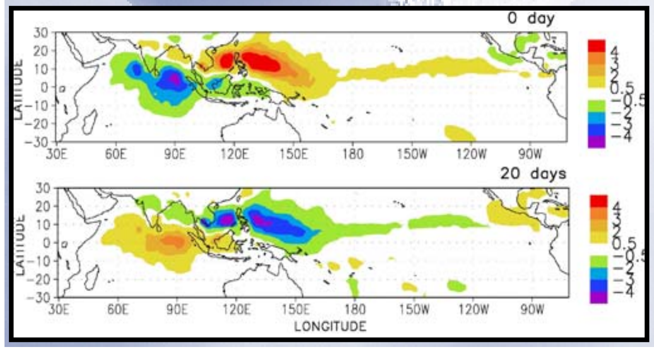
D. Waliser, K. Sperber, J. Gottschalck, H. Hendon, W. Higgins, I. Kang, D. Kim, E. Maloney, M. Moncrieff, K. Pegion, N. Savage, S. Schubert, W. Stern, A. Vintzileos, F. Vitart, B. Wang, W. Wang, K. Weickmann, M. Wheeler, S. Woolnough, C. Zhang

& Year of Tropical Convection Plans

D. Waliser & M. Moncrieff + YOTC Science Planning Group

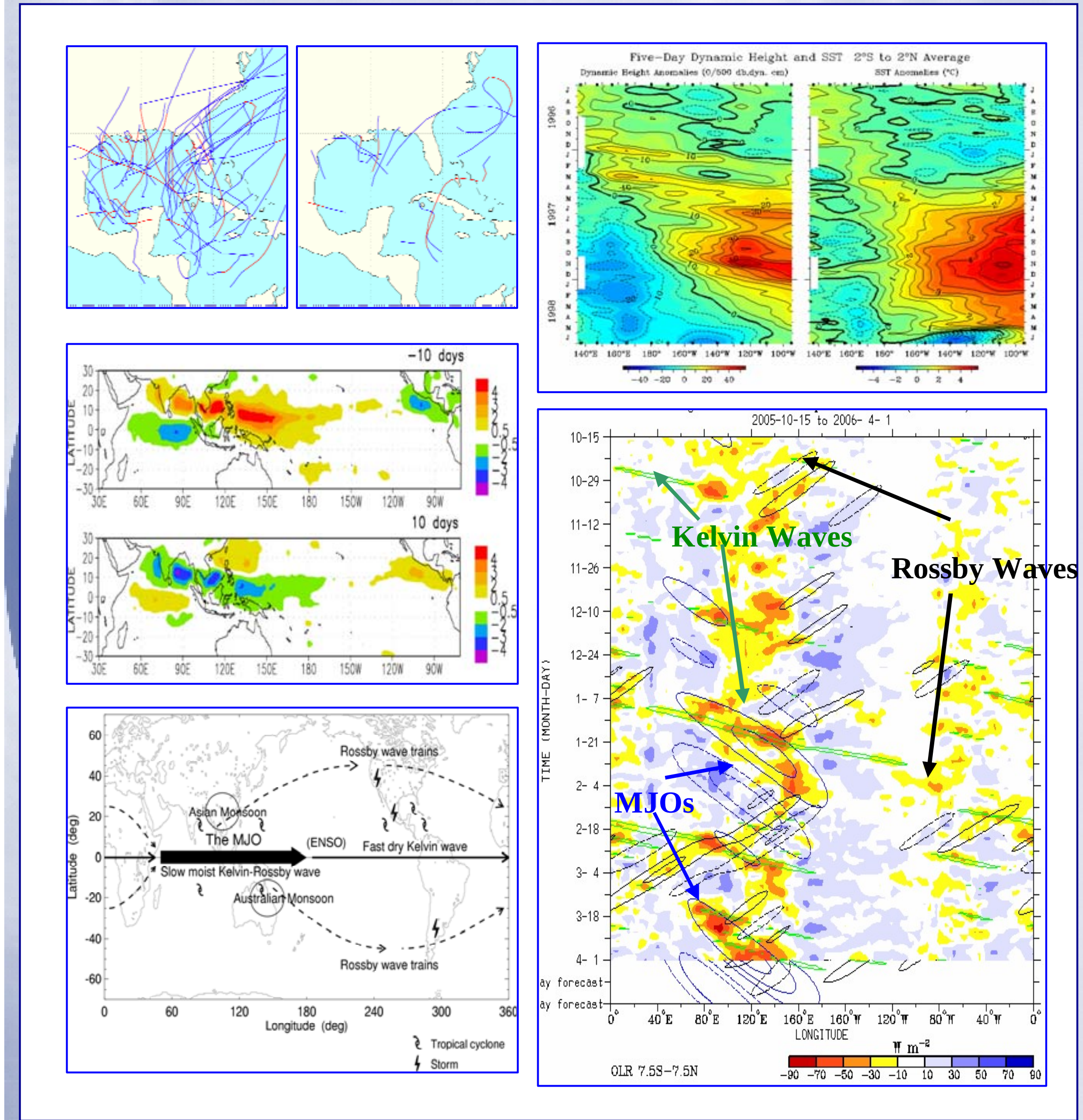


ICTP, Aug 2008



With Support from International CLIVAR

MOTIVATION



Figures: E. Maloney, PMEL/TAO, M. Wheeler, J. Lin, D. Waliser

- The MJO is the dominant form of intraseasonal variability in the Tropics.
- The MJO impacts a wide range of weather & climate phenomena.
- Our weather & climate models have a relatively poor representation of the MJO.
- Great benefit could be derived from better predictions of the MJO - Helps to fill gap between weather and seasonal predictions.

US CLIVAR Established MJO Working Group : 2006-08

Goals/Progress: Summary

1) Develop MJO WG Web Site. Done.

   Diagnostics Link, Meeting & Telecon Updates, Theme Pages

1) Diagnostics for Asessing Model Simulations of the MJO. Done. Journal of Climate Article Submitted. (WG - Lead)

2) Application of Diagnostics to Models. Analysis and Journal of Climate Article In Progress - (D. Kim and WG Lead).

3) Prediction Targets and Metrics for MJO Forecasts. Designed, Implemented at Several Opertional Centers. BAMS-like Article Planned (J. Gottschalck & WG Lead).

   ICTP 1-Day Workshop Focus: Aug, 2008

4) Workshop/Experimentation Planning. Done. November 2007, Irvine, CA. BAMS meeting summary in press.

I. MJO Working Group

1. Web Site & Information

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

MJO Weather Climate Interactions

- ENSO
- Hurricanes
- Australian Monsoon
- High Latitude Weather
- Ocean Chlorophyll
- Global Benefits and Hazards
- African Rainfall
- MJO and Atmospheric Composition: Total Column Ozone
- Atmospheric Angular Momentum and Length of Da

MEETINGS

Relevant Science Meetings and Workshops

- Workshop on the Organization and Maintenance of Tropical Convection and the Madden Julian Oscillation 13-17 March 2006 (Trieste, Italy)
- Diagnosing, Modeling and Forecasting Subseasonal Atmospheric Variability, AGU, 23-25 May 2006(Baltimore, MD)
- Tropical Convection and The Weather Climate Interface 10-14 July 2006 (NCAR - Boulder, CO)
- MJO WG meeting 24-25 July 2006 (Breckenridge, CO - prior to the U.S. CLIVAR Summit)
- Posting of initial version of MJO simulation metrics 7 February 2007
- 3rd WGNE Workshop on Systematic Errors in Climate and NWP Models 12-16 Feb 2007 (San Francisco, CA)
  - Presentation from the workshop (pdf)
- CLIVAR Asian-Australian Monsoon Panel (AAMP) Meeting 19-21 February 2007 (Honolulu, HI)
  - MJO Metrics presented and Collaborations with MJOWG discussed
- NSF STC CMMAP Meeting (Kauai, Hawaii)
  - Metrics presented and Collaborations with MJOWG discussed (pdf)
- Celebrating the Monsoon 24-28 July 2007 (Centre for Atmospheric & Oceanic Sciences Indian Institute of Science - Bangalore)

Working Group Meetings/Teleconferences

- Teleconference Agenda (pdf) and Minutes (pdf) from 3 May 2006
- Teleconference Agenda (pdf), Minutes (pdf) and Attachment 1 (pdf) from 31 May 2006
- Teleconferece Minutes (pdf) and Attachment (pdf) from 27 June 2006
- Teleconference Minutes (pdf) from 18 July 2006
- MJO Metrics (26 July 2006) (pdf)
- 1st MJO WG Meeting (July 2006) at the U.S. CLIVAR Summit
  - Climate Weather Interface presentation by A. Ray(pdf)
  - Experimental Global Tropics Benefits/Hazards Assessment presentation by W. Higgins(pdf)
  - MJO Simulation Metrics - Summary to Date (pdf)
  - Summary presentation of WG Activities at US CLIVAR Summit (pdf)
- Teleconference Agenda (pdf), MInutes (pdf) and Draft Metric Calculations (pdf) from 16 October 2006
- Teleconference Minutes (pdf), Attachment (ppt) and Draft Metric Website from 29 November 2006
- Teleconference Minutes (pdf) from 19 March 2007

Web Site Resources

Theme Pages & WG Activities

MJO Weather-Climate Theme Pages

The U.S. contribution to

Climate Variability and Predictability

MJO Weather-Climate Interactions

The MJO and Hurricanes:

Could MJO Predictions Help Forecast Periods of Enhanced Hurricane Activity?

Motivation

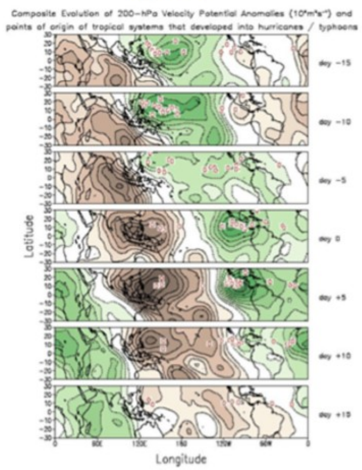
The MJO produces a strong modulation of tropical cyclone activity in many regions of the tropics, including the Atlantic Ocean, Gulf of Mexico, and east Pacific Ocean. The MJO is associated with variations in sea surface temperature, organized precipitation, low-level winds, vertical wind shear, and atmospheric humidity and temperature, important factors in tropical cyclone formation and maintenance. Forecasts of the MJO at 2-3 week lead times might aid in forecasting periods of enhanced tropical cyclone formation.

Research Summary

Tropical cyclogenesis preferentially occurs during certain phases of the MJO. Figure 1 shows the composite eastward propagation of Northern Hemisphere summer velocity potential and tropical cyclone genesis locations associated with the MJO during 1979-1997 (adapted from Higgins and Shi [2001]). Green areas indicate anomalous upper level divergence, where precipitation is enhanced and tropical cyclogenesis preferentially occurs. Brown areas indicate anomalous upper level convergence, where precipitation and tropical cyclogenesis are suppressed. One notable feature is the enhancement of tropical cyclogenesis in the Americas during periods of enhanced upper level divergence and enhanced precipitation (e.g. Day 0 and Day +5 of Figure 1). For example, an analysis during 1949-1997 indicates that the MJO strongly modulates Gulf of Mexico and Caribbean Sea hurricanes and tropical storms (Figure 2, adapted from Maloney and Hartmann 2000). Gulf of Mexico and Caribbean Sea hurricanes are four times more likely to occur when the MJO is producing enhanced precipitation and divergent upper level winds than when precipitation is suppressed and upper level winds are convergent. The modulation of major hurricanes (Categories 3-5) by the MJO is even more pronounced. Similarly, when the divergent (convergent) phase of the MJO is located over the Indian or west Pacific Ocean, typhoon activity in increased (decreased).

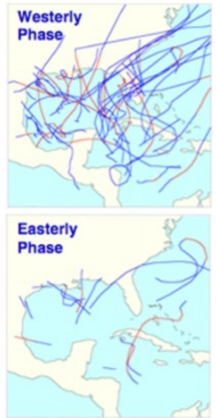
Example: MJO & Hurricanes by Eric Maloney

Figure 1.



Adapted from Higgins and Shi (2001)

Figure 2.



Maloney and Hartmann (2000)

Implications

Given the evidence that the MJO is predictable with 2-3 week lead-times, periods of enhanced or suppressed hurricane activity may be predicted at similar lead times. Such knowledge would have implications for public safety, energy production, recreation/tourism, among other interests.

Future Work

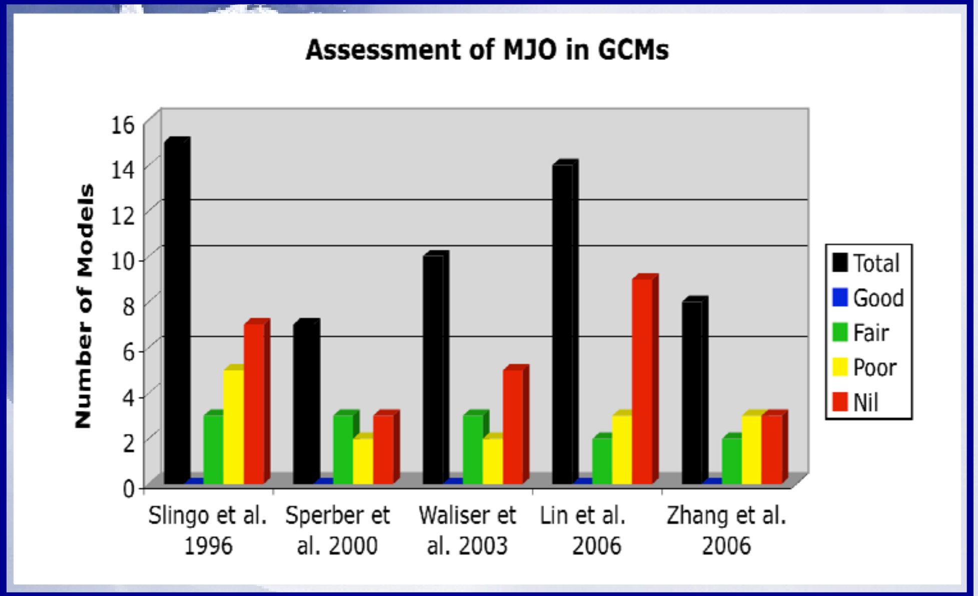
Two avenues of further investigation include: 1) understanding how the MJO modulates hurricane activity, and 2) determining whether 2-3 week predictions of the MJO can be used to predict periods of enhanced tropical cyclone activity.

Selected References

- Bessafi, M., and M. C. Wheeler. 2006: Modulation of south Indian Ocean tropical cyclones by the Madden–Julian Oscillation and convectively coupled equatorial waves. *Mon. Wea. Rev.*, **134**, 638–656.
- Hall, J. D., A. J. Matthews and D. J. Karoly. 2001: The Modulation of tropical cyclone activity in the Australian region by the Madden–Julian oscillation. *Mon. Wea. Rev.*, **129**, 2970–2982.
- Higgins, W and W. Shi, 2001: Intercomparison of the principal modes of interannual and intraseasonal variability of the North American monsoon system. *J. Climate*, **14**, 403-417.
- Liebmann, B., H. H. Hendon, and J. D. Glick, 1994: The relationship between tropical cyclones of the western Pacific and Indian Oceans and the Madden-Julian oscillation. *J. Meteor. Soc. Japan*, **72**, 401-411.
- Maloney, E. D., and D. L. Hartmann, 2000: Modulation of hurricane activity in the Gulf of Mexico by the Madden-Julian Oscillation. *Science*, **287**, 2002-2004
- Mo, K. C., 2000: The association between intraseasonal oscillations and tropical storms in the Atlantic basin.

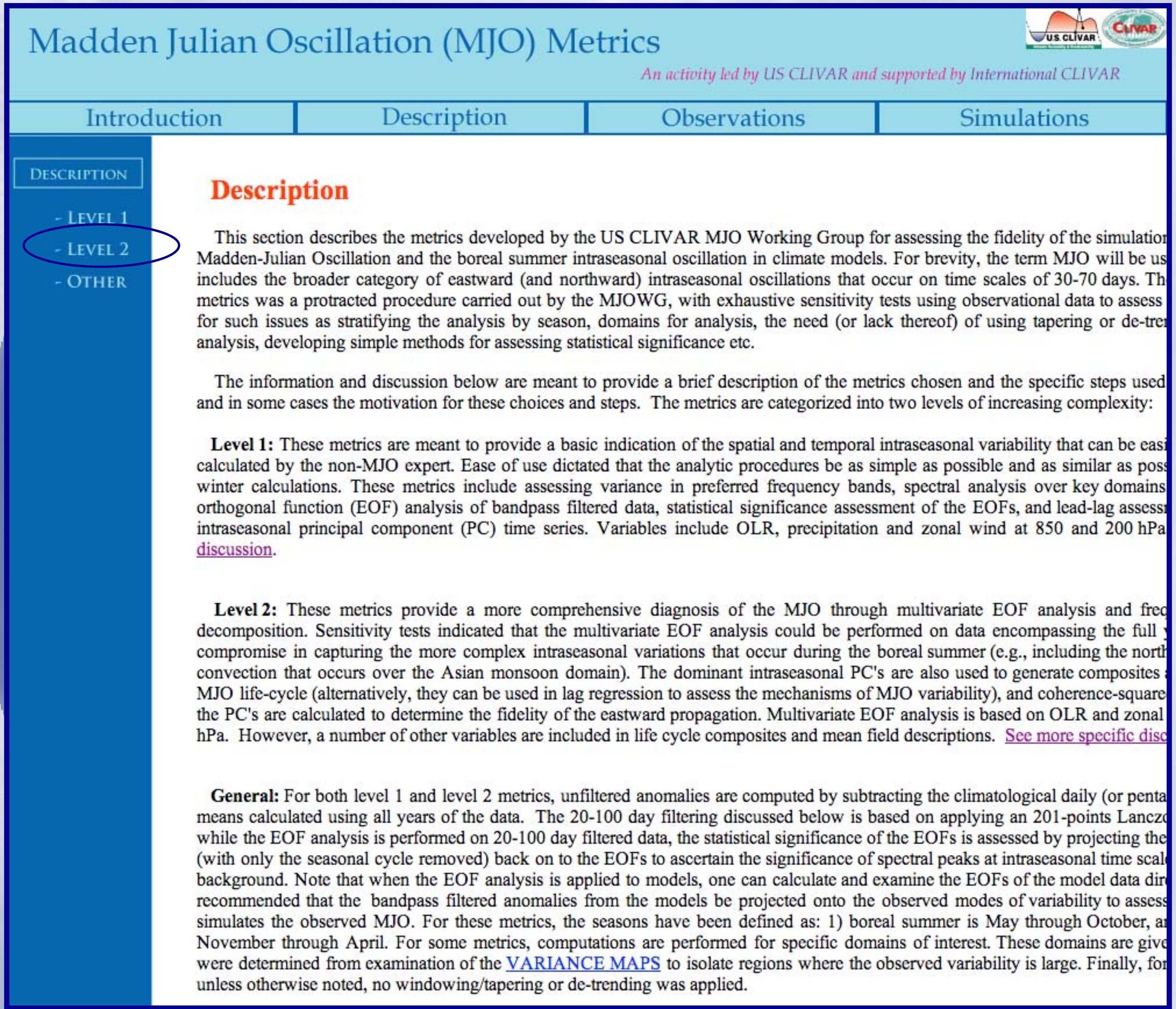
I. MJO Working Group

2. Developing Model Simulation Diagnostics



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

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



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

This section describes the metrics developed by the US CLIVAR MJO Working Group for assessing the fidelity of the simulatio Madden-Julian Oscillation and the boreal summer intraseasonal oscillation in climate models. For brevity, the term MJO will be us includes the broader category of eastward (and northward) intraseasonal oscillations that occur on time scales of 30-70 days. Th metrics was a protracted procedure carried out by the MJOWG, with exhaustive sensitivity tests using observational data to assess for such issues as stratifying the analysis by season, domains for analysis, the need (or lack thereof) of using tapering or de-tre analysis, developing simple methods for assessing statistical significance etc.

The information and discussion below are meant to provide a brief description of the metrics chosen and the specific steps used and in some cases the motivation for these choices and steps. The metrics are categorized into two levels of increasing complexity:

Level 1: These metrics are meant to provide a basic indication of the spatial and temporal intraseasonal variability that can be easi calculated by the non-MJO expert. Ease of use dictated that the analytic procedures be as simple as possible and as similar as poss winter calculations. These metrics include assessing variance in preferred frequency bands, spectral analysis over key domains orthogonal function (EOF) analysis of bandpass filtered data, statistical significance assessment of the EOFs, and lead-lag assess intraseasonal principal component (PC) time series. Variables include OLR, precipitation and zonal wind at 850 and 200 hPa discussion.

Level 2: These metrics provide a more comprehensive diagnosis of the MJO through multivariate EOF analysis and freq decomposition. Sensitivity tests indicated that the multivariate EOF analysis could be performed on data encompassing the full compromise in capturing the more complex intraseasonal variations that occur during the boreal summer (e.g., including the nort convection that occurs over the Asian monsoon domain). The dominant intraseasonal PC's are also used to generate composites MJO life-cycle (alternatively, they can be used in lag regression to assess the mechanisms of MJO variability), and coherence-square the PC's are calculated to determine the fidelity of the eastward propagation. Multivariate EOF analysis is based on OLR and zonal hPa. However, a number of other variables are included in life cycle composites and mean field descriptions. See more specific disc

General: For both level 1 and level 2 metrics, unfiltered anomalies are computed by subtracting the climatological daily (or penta means calculated using all years of the data. The 20-100 day filtering discussed below is based on applying an 201-points Lancz while the EOF analysis is performed on 20-100 day filtered data, the statistical significance of the EOFs is assessed by projecting the (with only the seasonal cycle removed) back on to the EOFs to ascertain the significance of spectral peaks at intraseasonal time scal background. Note that when the EOF analysis is applied to models, one can calculate and examine the EOFs of the model data dir recommended that the bandpass filtered anomalies from the models be projected onto the observed modes of variability to assess simulates the observed MJO. For these metrics, the seasons have been defined as: 1) boreal summer is May through October, a November through April. For some metrics, computations are performed for specific domains of interest. These domains are giv were determined from examination of the VARIANCE MAPS to isolate regions where the observed variability is large. Finally, fo unless otherwise noted, no windowing/tapering or de-trending was applied.

MJO Diagnostics

General Strategy & Description

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

MJO Diagnostics

Recipe 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 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

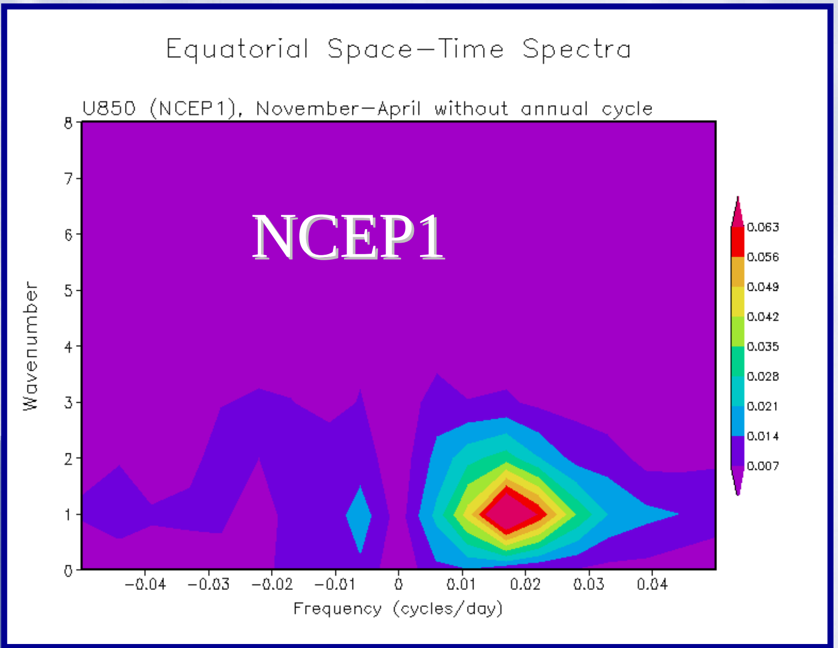
2) COMBINED EOFs (see Description)

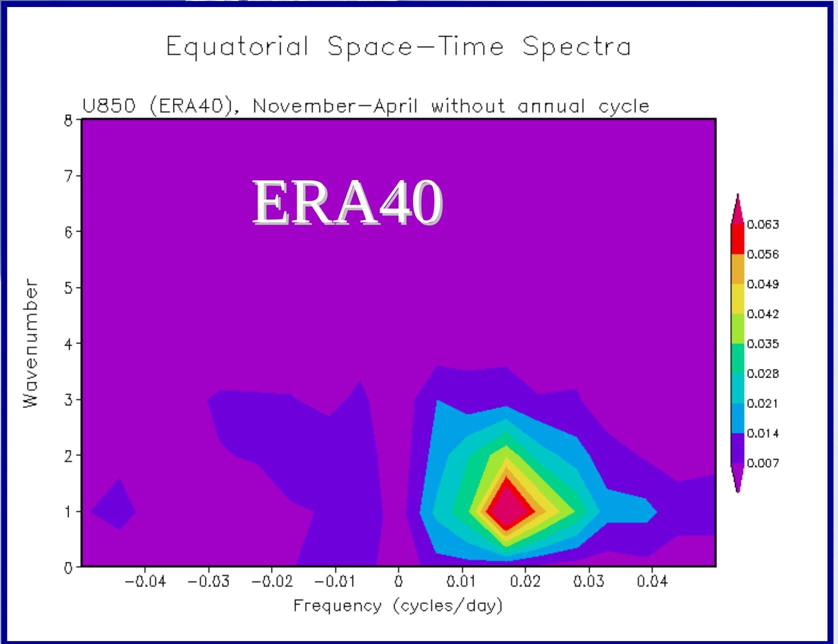
a) Combined EOFs

MJO Diagnostics

Plan To Make The Actual Map/Plot Data Available

Results Are Summarized in a Journal Of Climate Article To Be Submitted





MJO Diagnostics

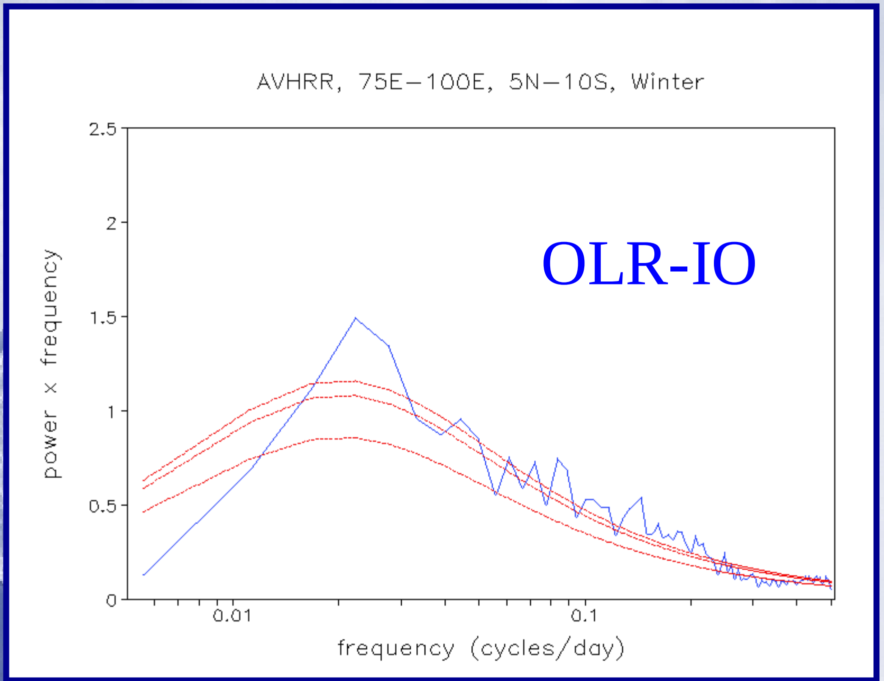
Equatorial Space-Time Spectra
U, Rain, OLR

NCEP1,
NCEP2,
& ERA40

MJO Diagnostics

Time Series Spectra U, Rain, OLR

Domains of Interest



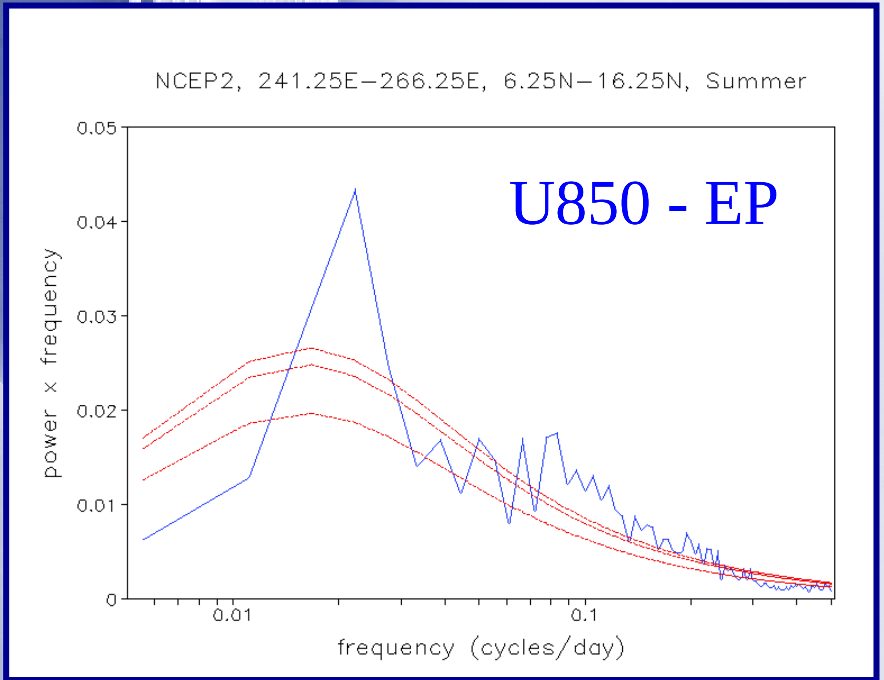
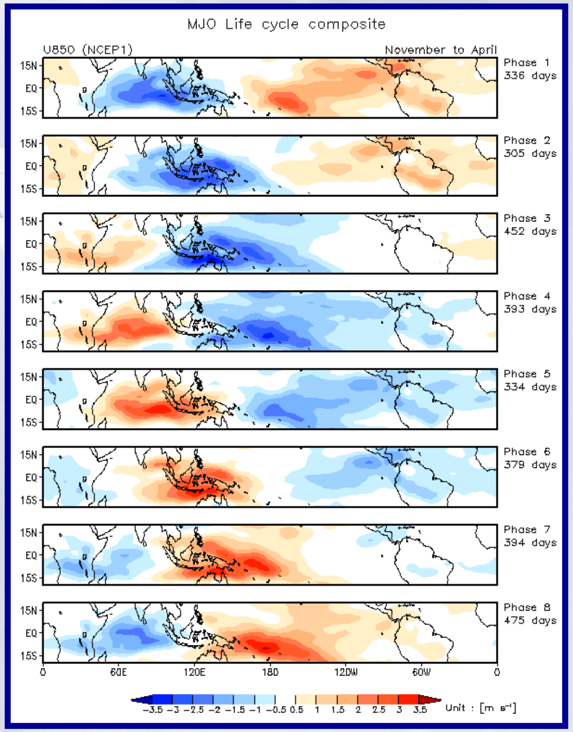


Table 1. Domains for time series power spectra metrics

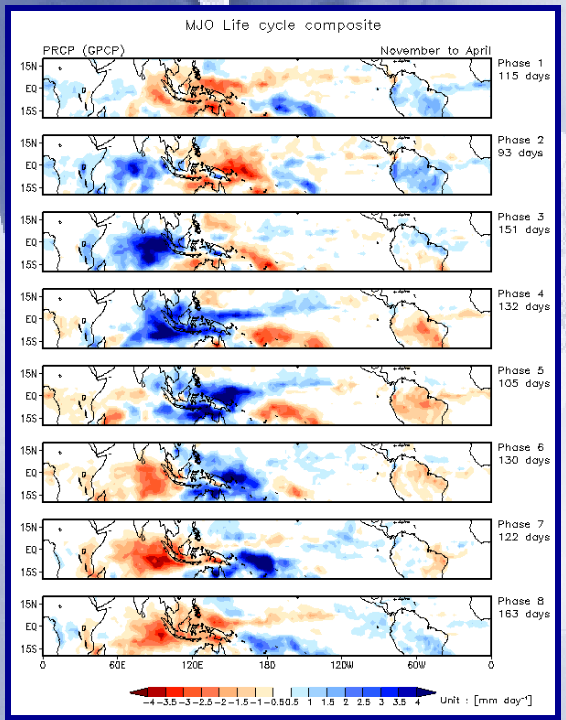
	OLR	Precipitation	u_{850}	u_{200}
	Boreal Winter (November to April)			
IO	10S-5N, 75-100E	10S-5N, 75-100E	1.25°S-16.25°S, 68.75°E-96.25°E	3.75N-21.25N, 56.25E-78.75E
WP	20S-5S, 160E-185E	20S-5S, 160E-185E	1.25°N-13.75°S, 163.75°E-191.25°E	3.75N-21.25N, 123.75E-151.25E
MC	2.5S-17.5S, 115-145E	2.5S-17.5S,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



U850

Rainfall



Life-Cycle Composites

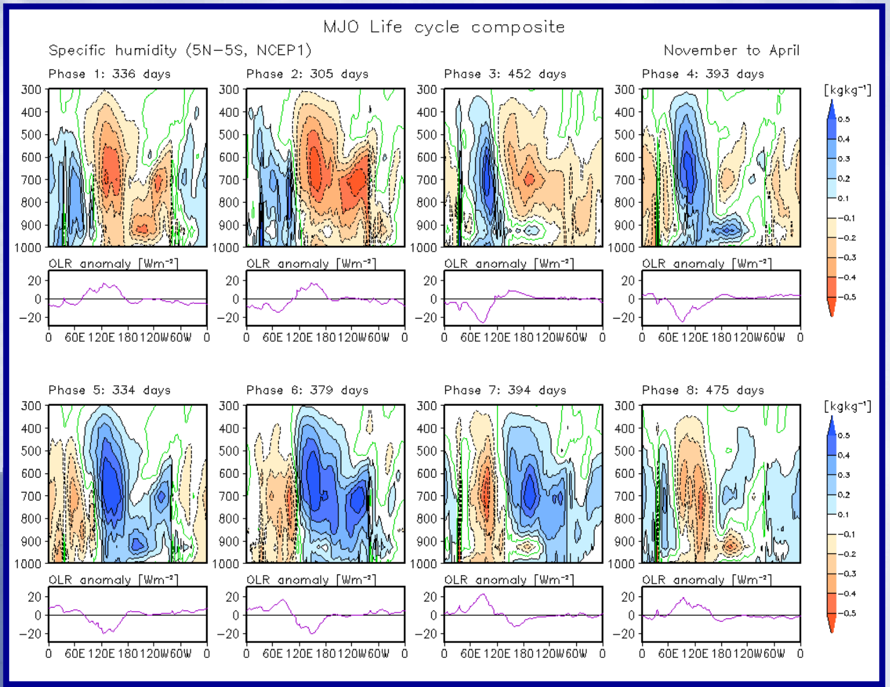
U, Rain, OLR, SLP, SF

<u>Satellite Rain/Cloud</u>: AVHRR, GPCP, TRMM

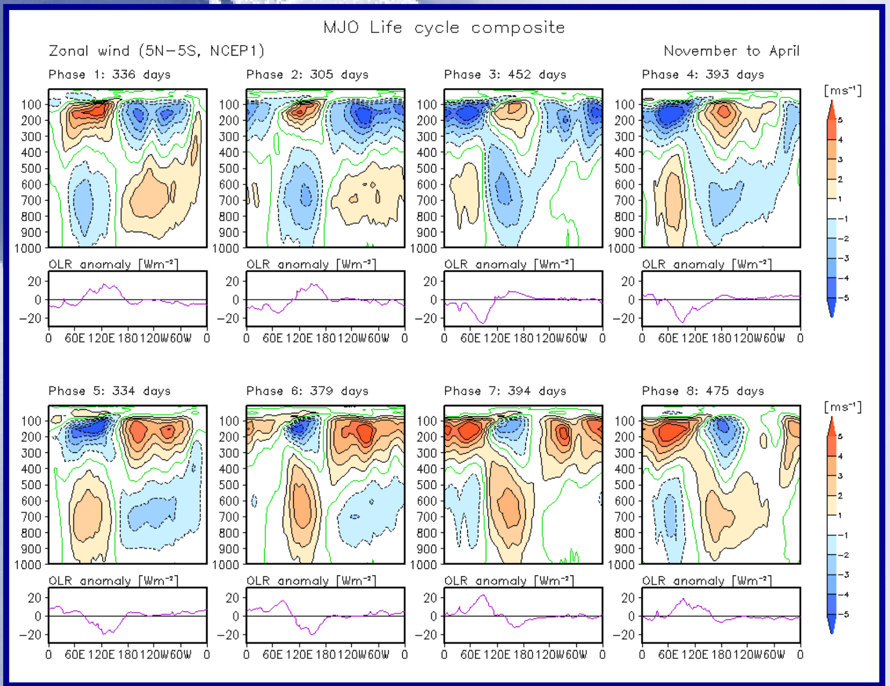
<u>Analysis Data:</u> NCEP1,NCEP2

MJO Diagnostics

Life-Cycle 3D Composites T, Q, U, W



Specific Humidity (x,p)

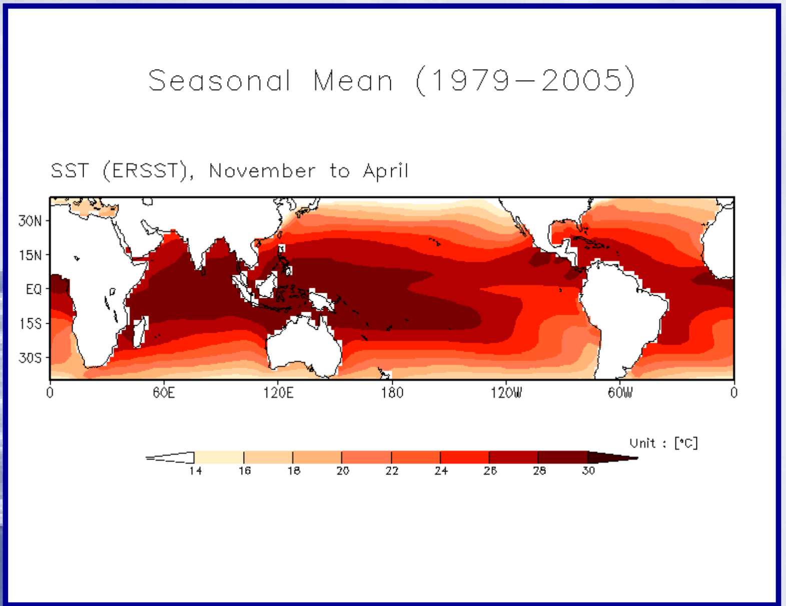


Zonal Wind (x,p)

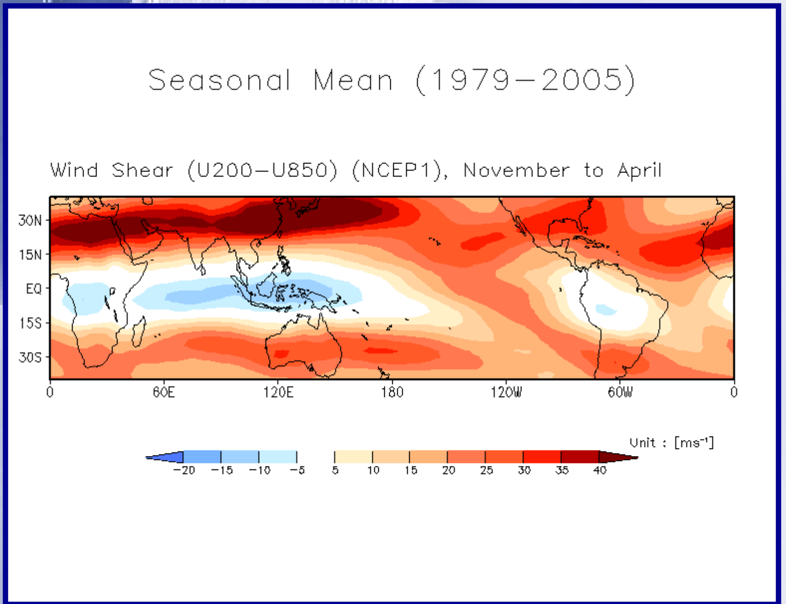
MJO Diagnostics

Important Mean State Quantities

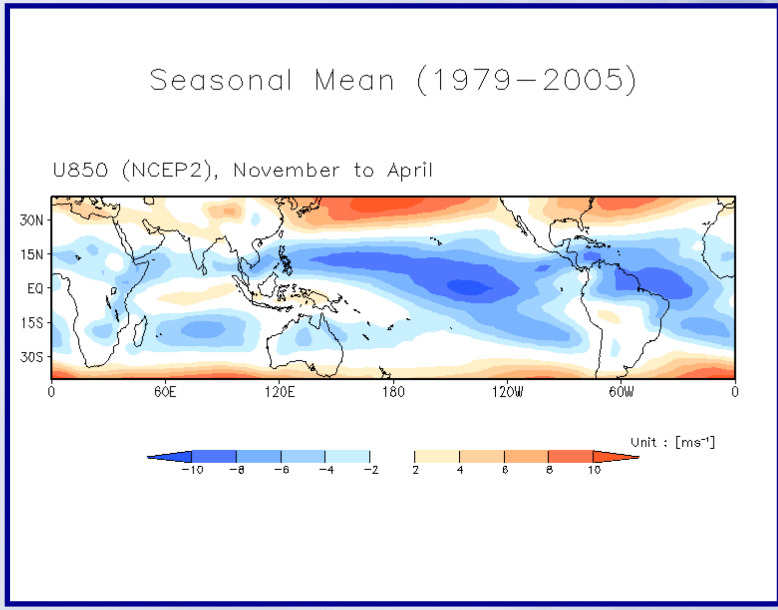
Mean SST



Mean Zonal Wind Shear



Mean 850 hPa Zonal Wind



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

I. MJO Working Group

3. Applying Diagnostics to Contemporary Climate Models

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

Application of MJO Diagnostics

Paper #2 – In Preparation

2nd draft

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

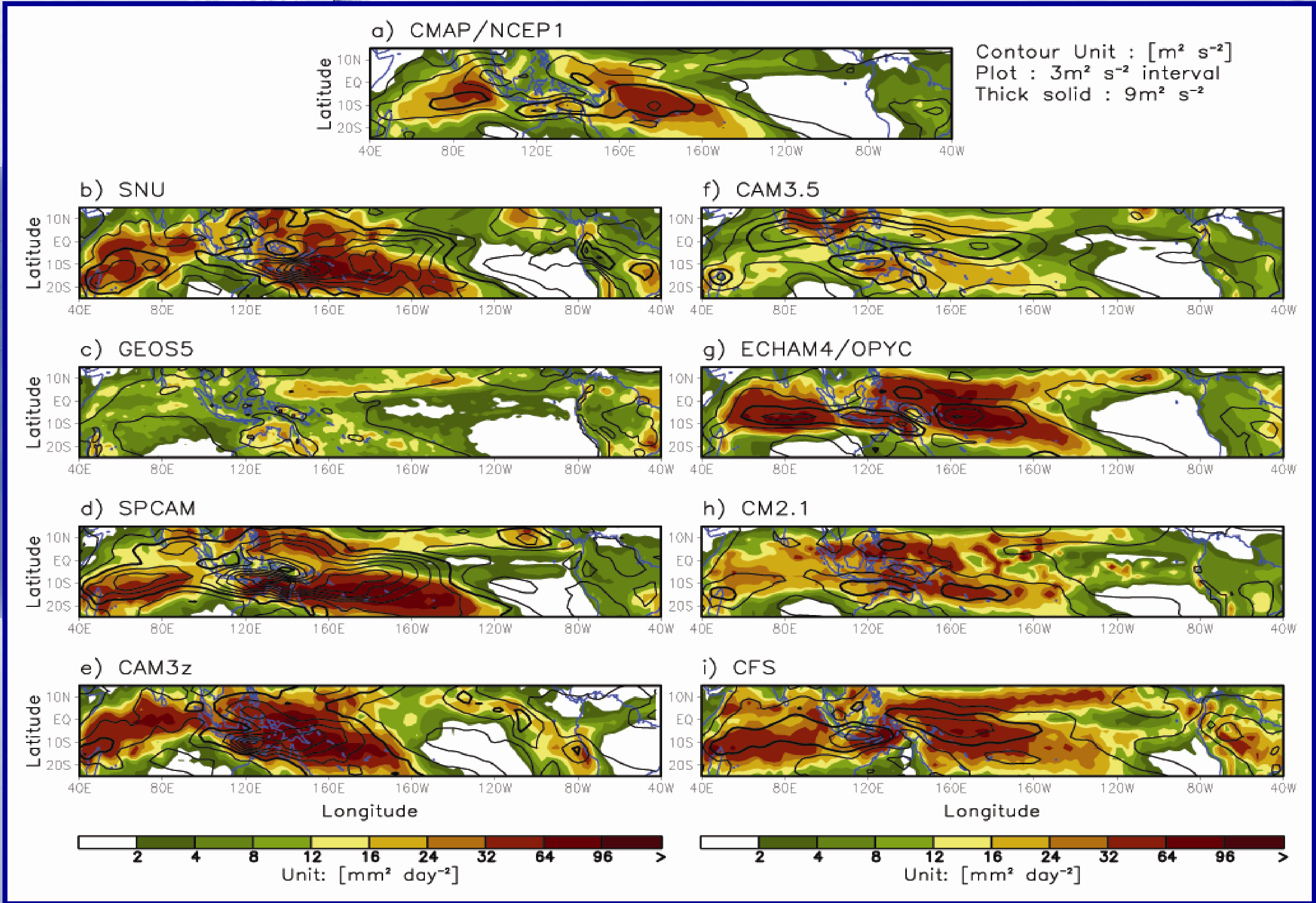
Application to Contemporary Models

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

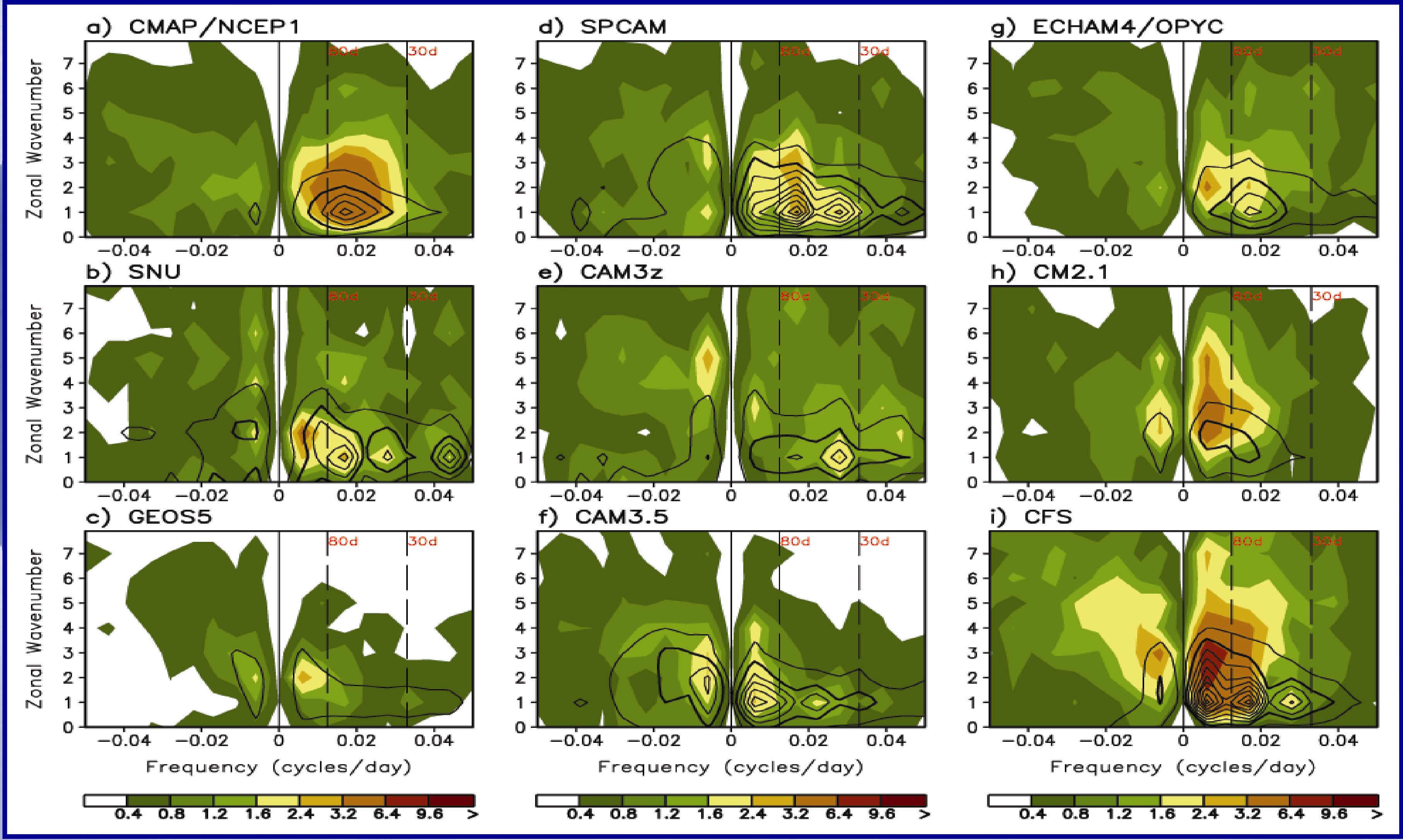
MJO Simulation Diagnostics

Subseasonal Variance: Precip & U850



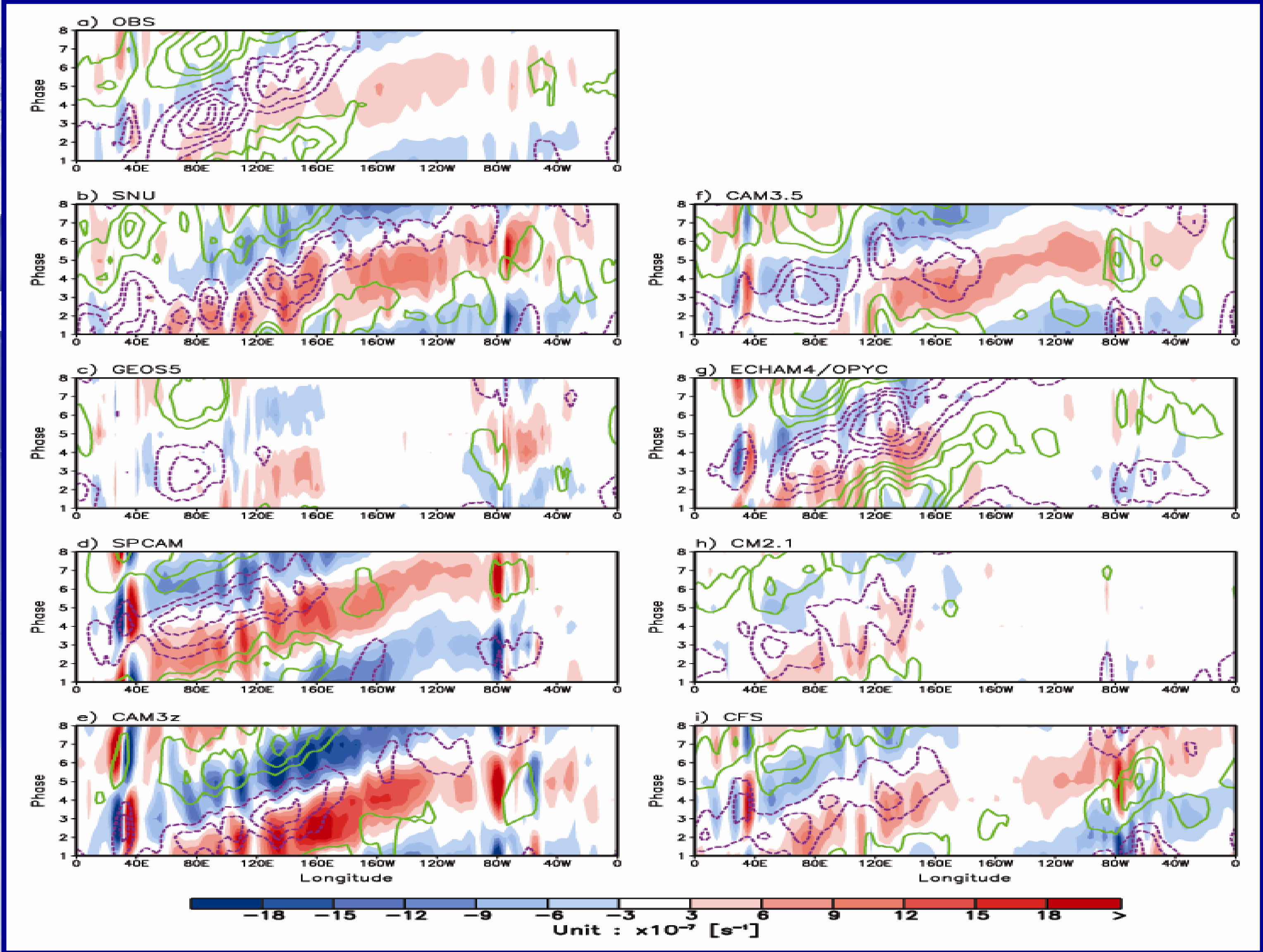
MJO Simulation Diagnostics

Wavenumber-frequency: Precip & U850



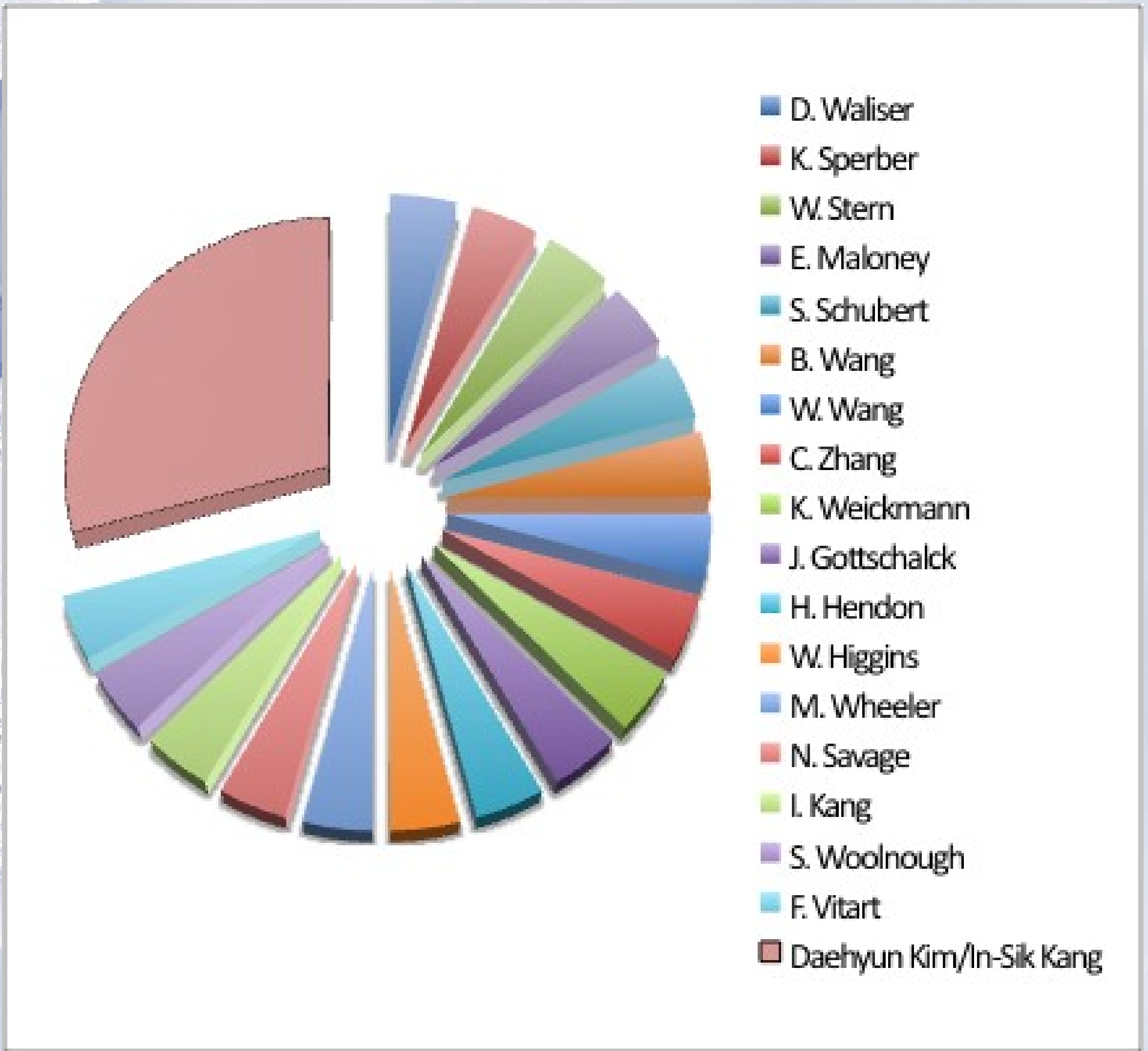
MJO Simulation Diagnostics

Time-Longitude: OLR & Near Surface Convegence



MJO Simulation Diagnostics & Their Application

Contributions & Acknowledgement



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.

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

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.

Participants now include ECMWF, US, Canada, UK, Australia

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

- 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, etc)
- Expand efforts to develop and implement MJO forecast metrics under operational conditions. (Trieste/ICTP – Aug. 2008)
- Develop an experimental modeling framework to assess MJO predictability as well as forecast skill from contemporary/operational models. (B. Wang, I.-S. Kang, et al. working on it)

II. YOTC

Year of Tropical Convection

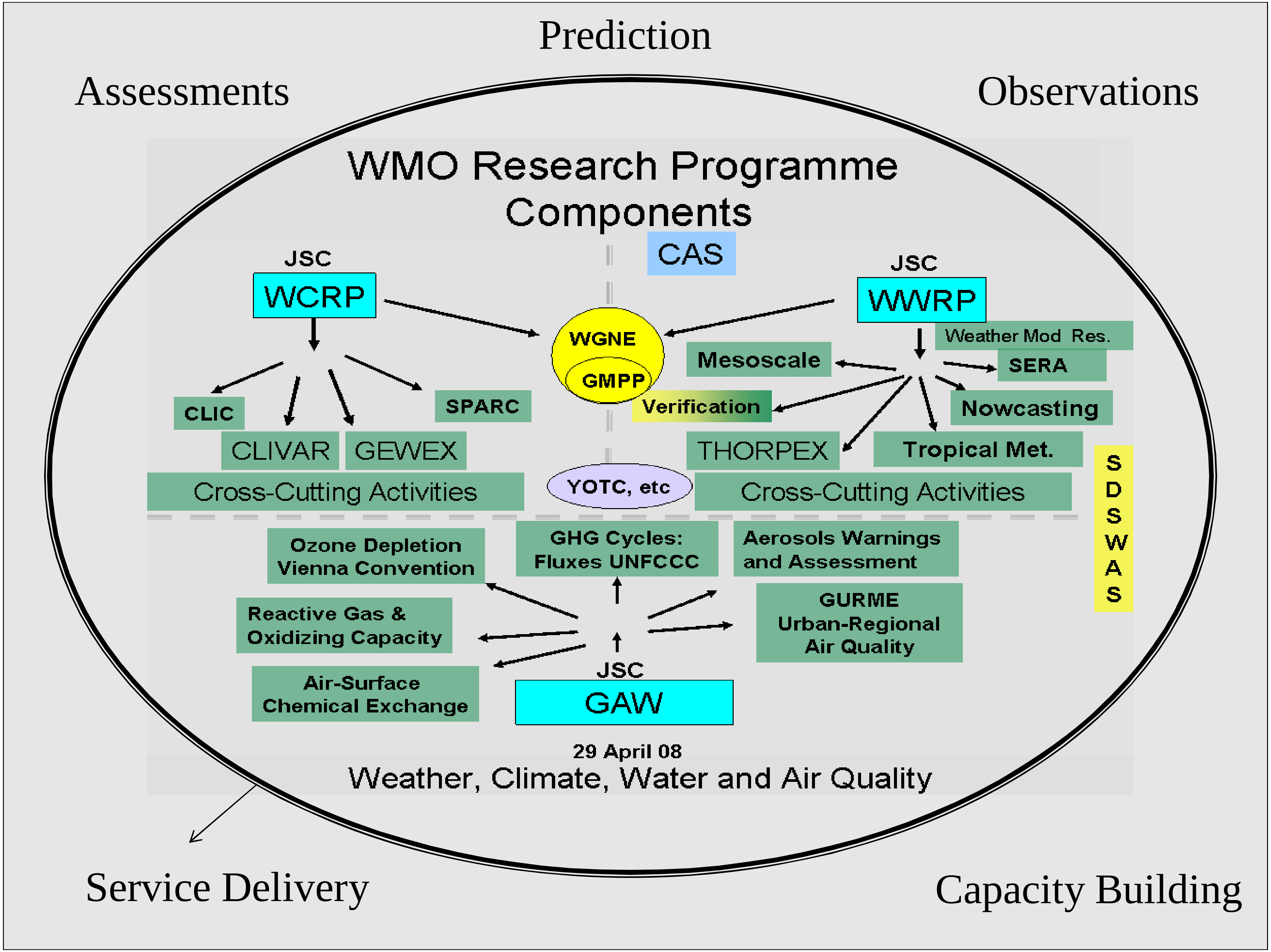
Coordinating Observing, modeling and Forecasting to Addressing the Challenge of Organized Tropical Convection

WWRP WORLD WEATHER RESEARCH PROGRAMME

THORPEX A World Weather Research Programme

WMO

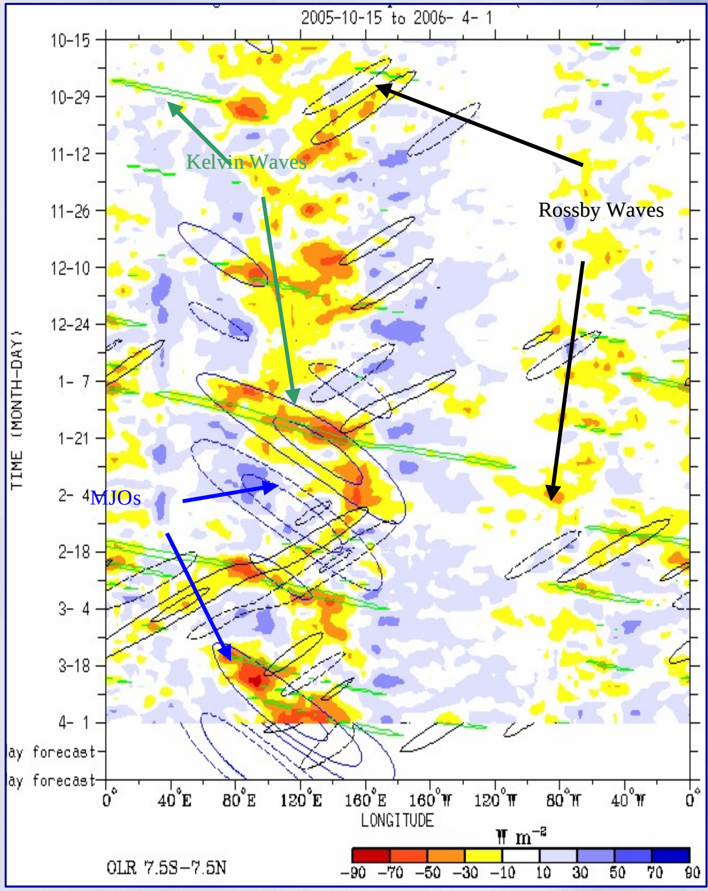
WCRP


Prediction
Assessments
Observations
WMO Research Programme Components
CAS
JSC
WCRP
JSC
WWRP
WGNE
GMPP
Weather Mod Res.
Mesoscale
SERA
Verification
Nowcasting
CLIC
SPARC
CLIVAR
GEWEX
THORPEX
Tropical Met.
Cross-Cutting Activities
YOTC, etc
Cross-Cutting Activities
S D S W A S
Ozone Depletion Vienna Convention
GHG Cycles: Fluxes UNFCCC
Aerosols Warnings and Assessment
Reactive Gas & Oxidizing Capacity
GURME Urban-Regional Air Quality
Air-Surface Chemical Exchange
JSC
GAW
29 April 08
Weather, Climate, Water and Air Quality
Service Delivery
Capacity Building

Our shortcomings in tropical convection severely limit the representation of key physics in weather & climate models

- Diurnal cycle - strongest "forced" signal in the climate system.
- Synoptic waves and easterly waves, including development & evolution of hurricanes and Tropical cyclones
- Madden-Julian Oscillation (MJO) and other large-scale convectively-coupled waves
- monsoon variability, including onset and break activity.
- Tropical mean state, including ITCZ and distributions of rainfall over oceans & continents

Winter 2005-6



Dominant Convectively-Coupled Tropical Waves Projected onto OLR Anomalies. Wheeler and Weickmann, 2001

New Steps to Make Progress
Step Back & Recognize:
We are in a new era!

The Tropical Atmosphere-Ocean-Land Systems Have Never Been So Well Observed.

New/Improved Resources

- **Satellite Observations (e.g., EOS)**
- **In-Situ Networks (ARM, CEOP)**
- **GOOS (e.g., TAO, PRADA, drifters)**
- **IOPs (e.g., AMMA, VOCALS, T-PARC, AMY)**
- **TIGGE**
- **Higher Resolution Modeling & Analyses**

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Conceptual Framing

FGGE, GATE, TOGA COARE

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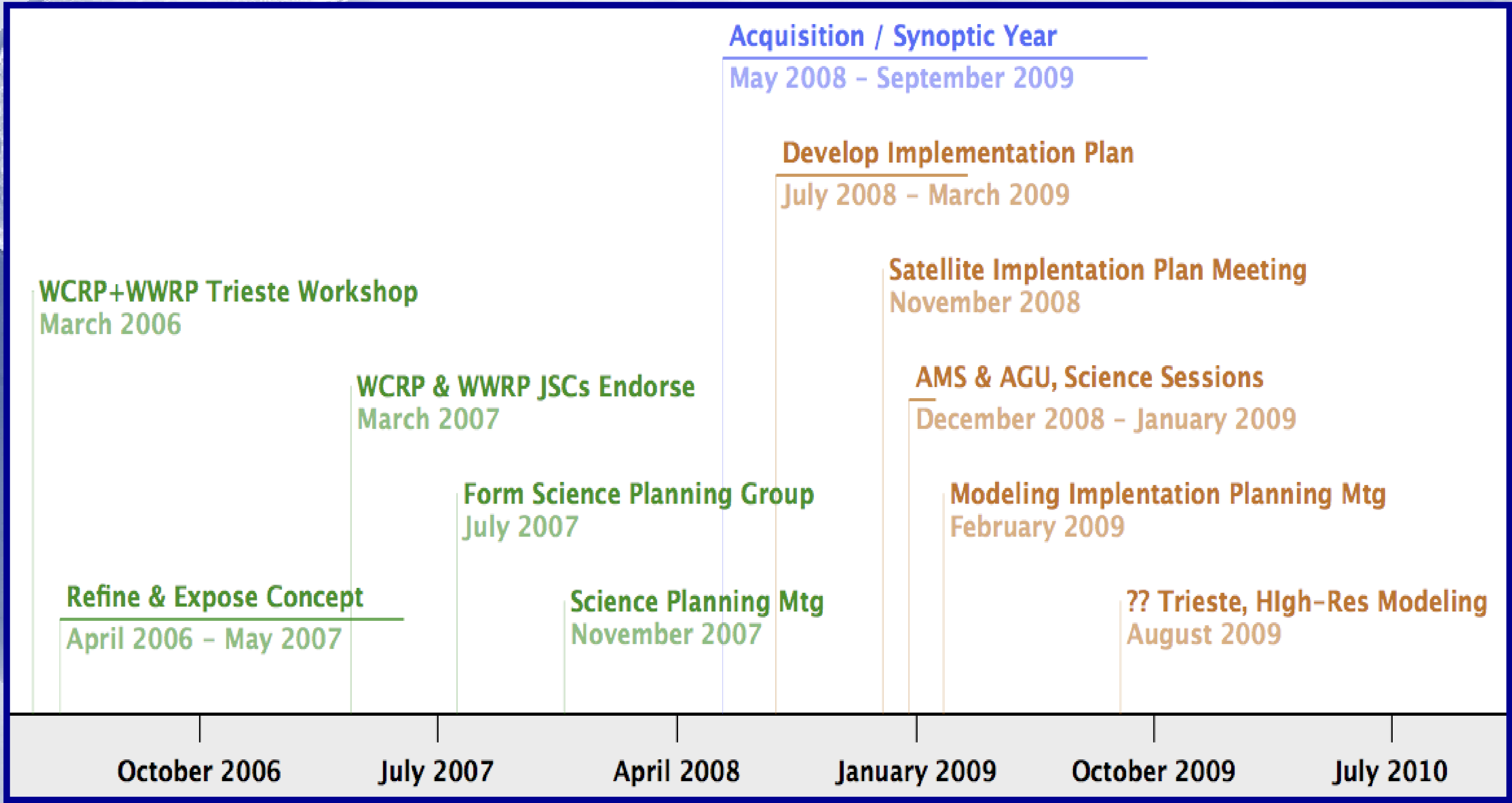
YoTC

Focus "Year" Virtual IOP

Year of Tropical Convection: Timeline

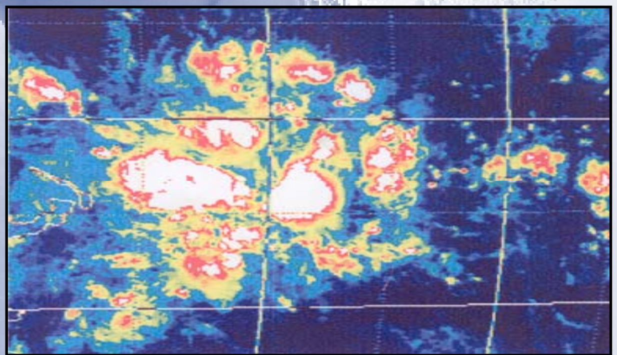


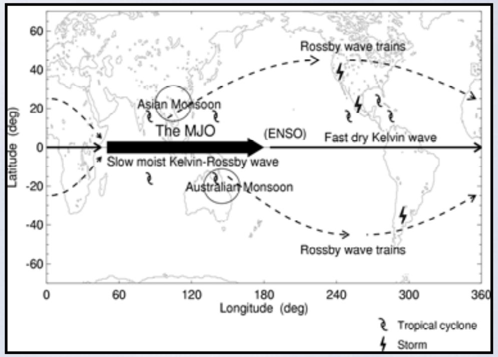
Membership of Science Planning Group - Established ~ July/August 2007

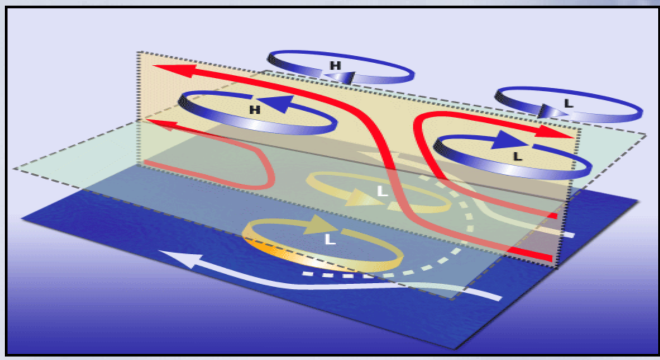
Caughey, J	THORPEX Scientific Officer and Meeting Secretary	WMO Geneva
Elsberry, R	WWRP, Tropical Meteorology Research Program	NRL, Monterey
Houze, R.	Cloud processes and microphysics	U. Washington, Seattle
Jakob, C.	GEWEX, cloud processes and modeling	Monash University
Johnson, R.	Tropical in-situ observations and analysis	CSU, Fort Collins
Koike, T	GEWEX/CEOP, data construction and analysis	U.Tokyo
Matsumoto	CLIVAR, WCRP International Monsoon Year	U.Tokyo
Miller, M.	WGNE, physical processes & NWP, ECMWF high res data	ECMWF
Moncrieff, M.	Co-chair THORPEX, convection modeling/theory	NCAR
Petch, J.	GEWEX GCSS, Precipitating Convective Cloud Systems	UKMO
Rossow, W.	ISCCP, satellite data construction & analysis, radiation	City College, NY
Shapiro, M.	WWRP JSC and THORPEX, extratropical dynamics	NOAA, Boulder
Szunyogh, I.	THORPEX, extratropical dynamics and predictability	U. Maryland
Thorncroft, C.	AMMA	SUNY, Albany
Toth, Z.	WWRP-THORPEX TIGGE data, NCEP high-res. data	NCEP
Waliser, D.	Co-chair International/US CLIVAR, satellite analysis, modeling	JPL/Caltech
Wang, B	CLIVAR, WCRP International Monsoon Year Connection	U. Hawaii,
Wheeler, M.	MJO, tropical analysis and forecasting	BMRC, Australia
Woolnough, S	MJO, large-scale modeling	U. Reading, UK
Thomas, D.	WMO Information System	WMO

Fundamental Science Questions

1. What are the global and regional characteristics of tropical convection over both land and ocean, including variability on diurnal to seasonal time scales?
2. What are the characteristics and relative roles of processes occurring (1) within the large-scale circulation, (2) on the mesoscale, and (3) internally on the storm scale that influence the development, organization, and maintenance of tropical convection?
3. Under what circumstances and via what mechanisms is water vapor, energy, and momentum transferred across scales ranging from the mesoscale to the large (or planetary) scale?
4. How does organized tropical convection interact with the extra-tropical circulation?







Strategy: Target Phenomena with Focused Working Groups

US CLIVAR
MJO WG

- **Madden-Julian Oscillation (MJO/CCEWs)** -Advances in our modeling capabilities in the MJO are expected to lead to significant untapped predictability in both tropical weather forecasts, monsoon onsets and breaks, extra-tropical weather, and provide a bridge between weather and climate predictions. Underlying the MJO are CCEWs, considered to be important building blocks of tropical convective variability and its organization on a wider range of time scales.

UK *Cascade*
US CMMAP

- **Easterly Waves / Tropical Cyclones** - Easterly waves are an important triggering mechanisms for tropical storms and cyclones and the latter represent one of the most severe of the high impact weather events that warrant continued improvements in track and intensity prediction.
- **Diurnal Cycle -** Our shortcomings in representing arguably the most basic and strongest forced mode of variability demands attention. Moreover, studies indicate that the diurnal scale can rectify onto longer time scale processes.

Asian Monsoon Year

- **Monsoons -**These are complex multi-scale processes and within the proposed activity could be considered as the ultimate challenge or integrating theme as their variability is strongly influenced by the diurnal cycle, CCEWs, the MJO, and land-atmosphere-ocean interaction.

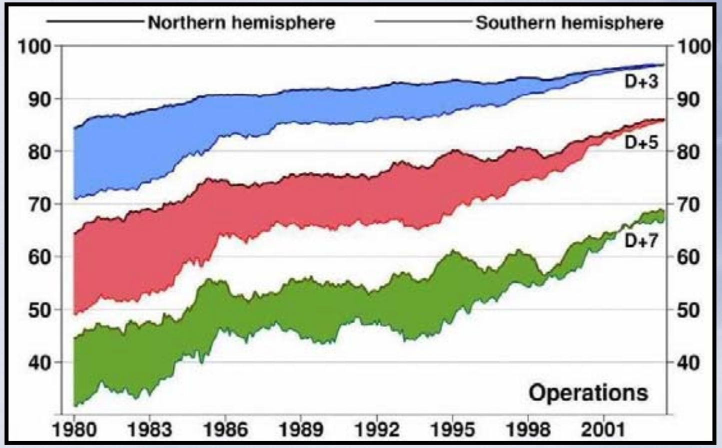
THORPEX

- **Tropical/Extratropical Interactions -** It is well known that convective variability in the tropics influences mid-latitude weather and climate. However, our predictions of the latter suffer due to poorly understood and simulated tropical convection. Moreover, there are still significant questions regarding the manner that the extra-tropics influences convection in the Tropics.

Overarching Goals

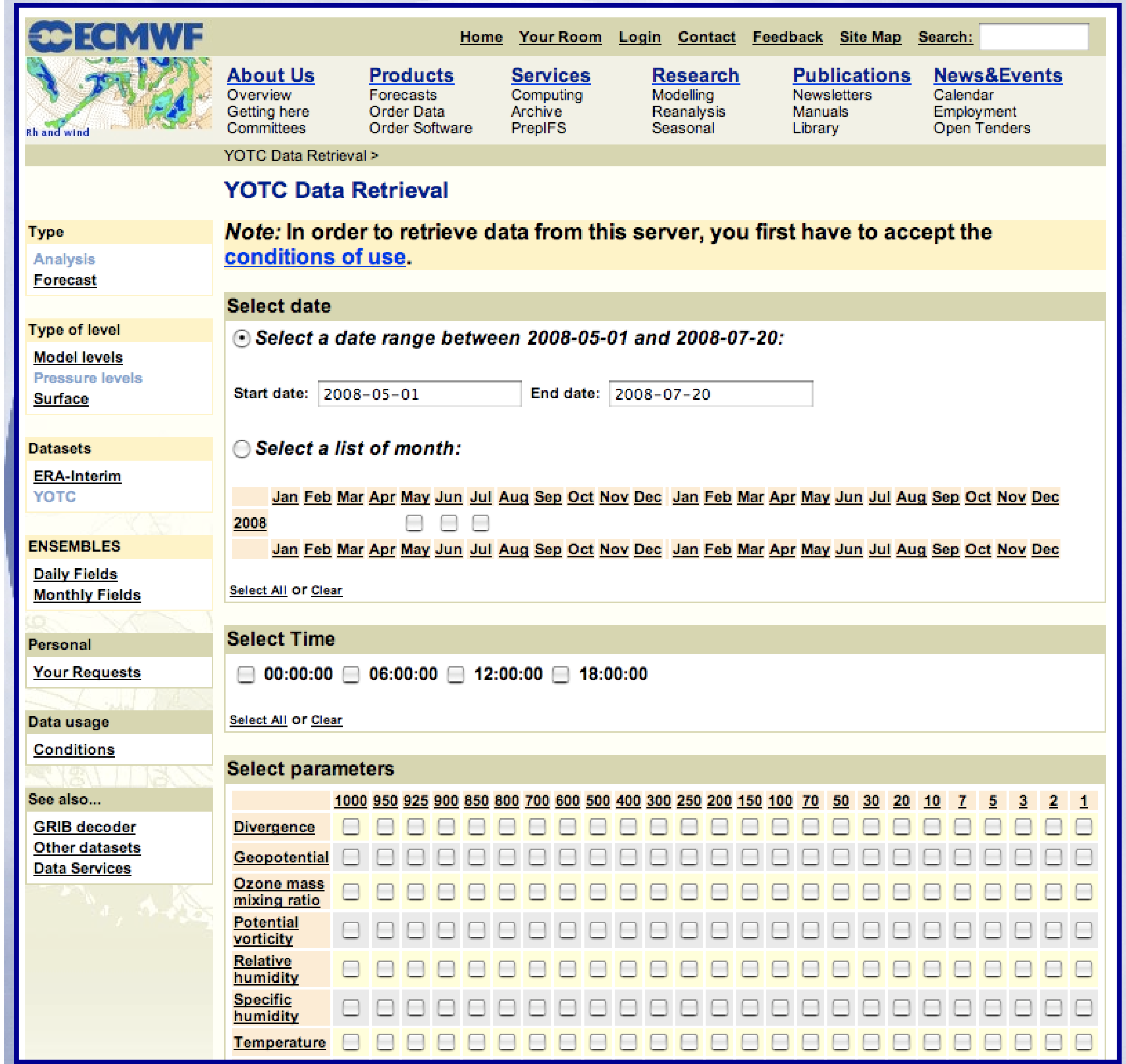
Through better understanding, improved data assimilation techniques/resources, and modeling capabilities, **achieve significant gains in forecast skill** by 2012 in:

- **Short-to-Medium-range tropical weather forecasts, particularly disturbed conditions associated with organized convection.**
- **Extended-range/subseasonal forecasts of the MJO.**
- **Medium-to-extended range extratropical forecasts derived from improved tropical weather/climate and tropical-extratropical interactions.**



Courtesy A. Simmons & M. Miller

YoTC : Analyses & Forecasts



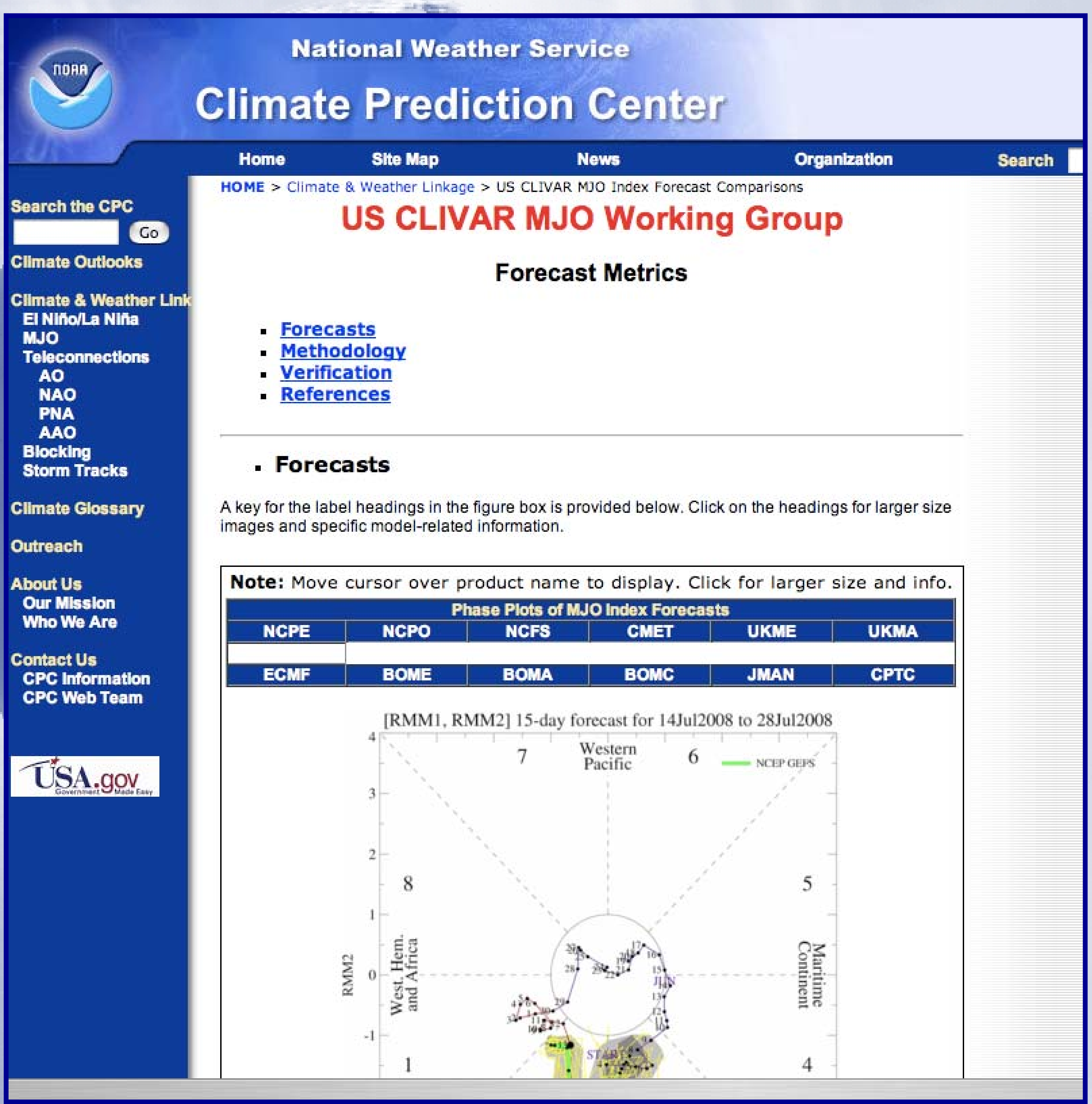
ECMWF:
T799 Analyses &
10-day Forecasts

- **Weather Analyses**
- **High-Res ICs & BCs**
- **Weather/Satellite Comparison**

$ Source: NSF + ONR

Analogous Products Solicited from NCEP & NASA/MERRA

US CLIVAR MJO Working Group
Operational MJO Forecasat Project



Participants to Date

- ECMWF
- NCEP
- CMC
- UKMO
- ABOM
- JMA
- CPTEC

Acknowledgments:

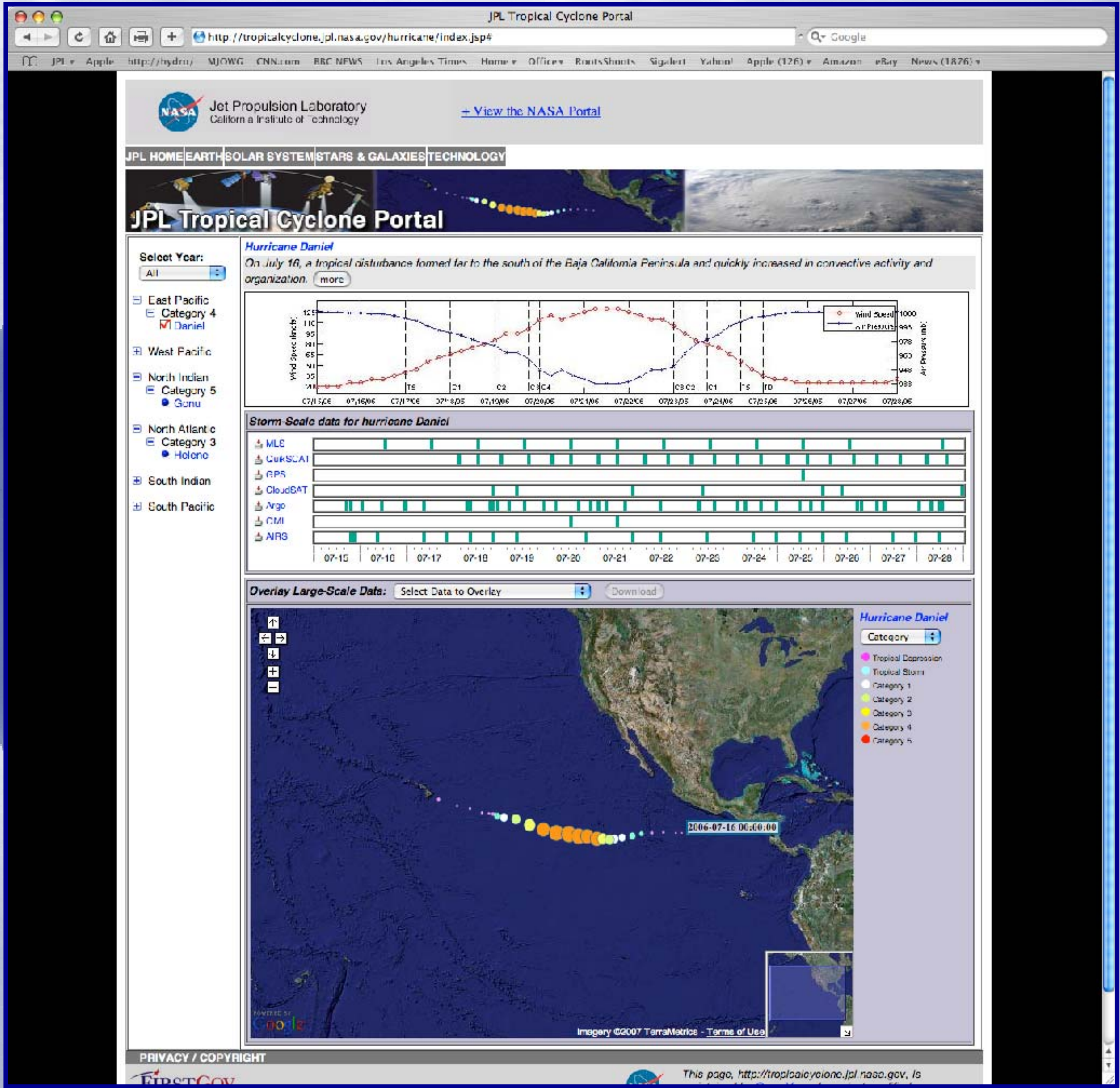
WGNE

&

Jon Gottschalck and CPC/NCEP/NOAA

&

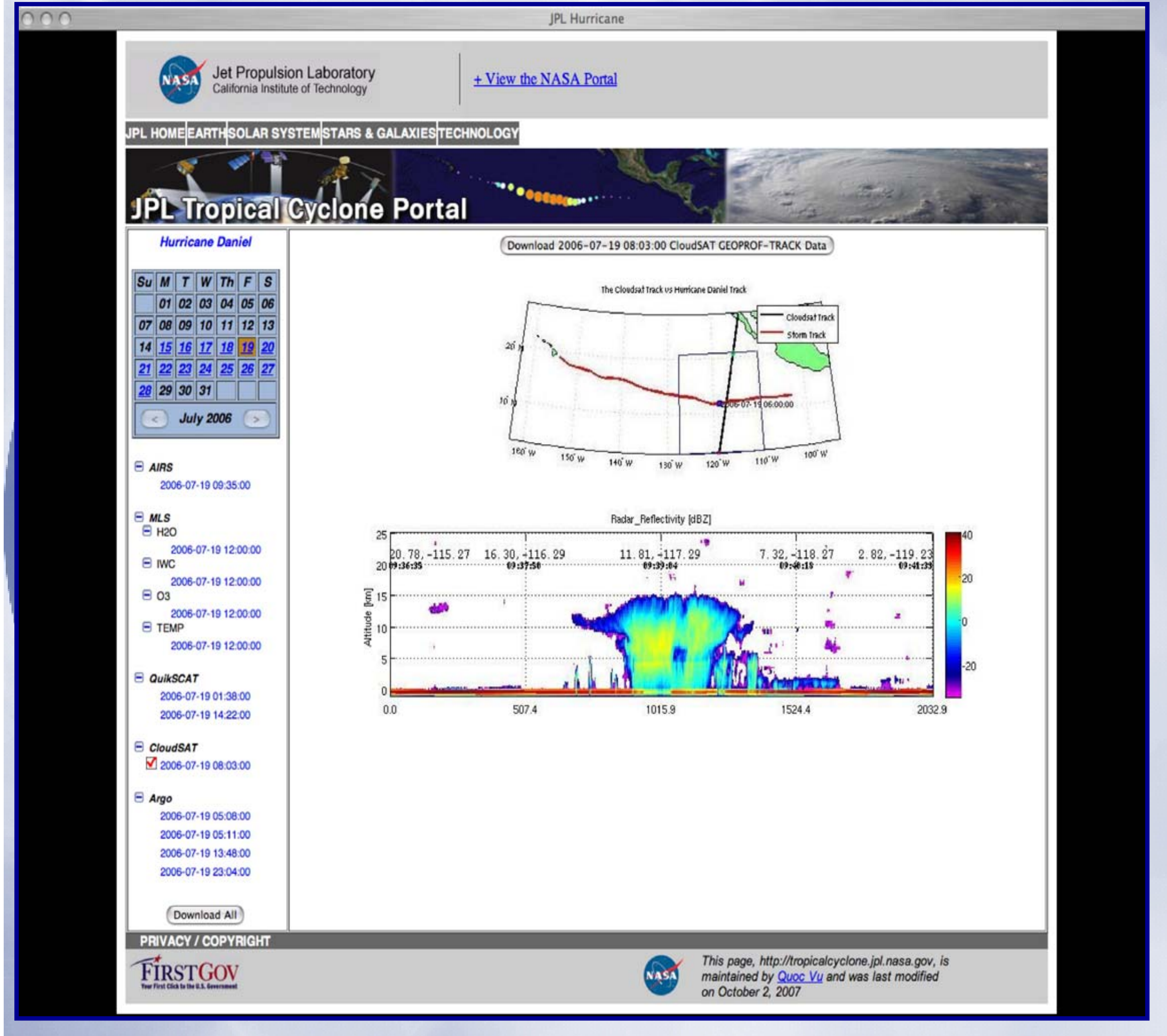
Contributing Operational Centers



Tropical Cyclone Resource

JPL Tropical Cyclone Portal (Y. Chao)

May Need Modest Funding to Develop YoTC Database



Tropical Cyclone Resource

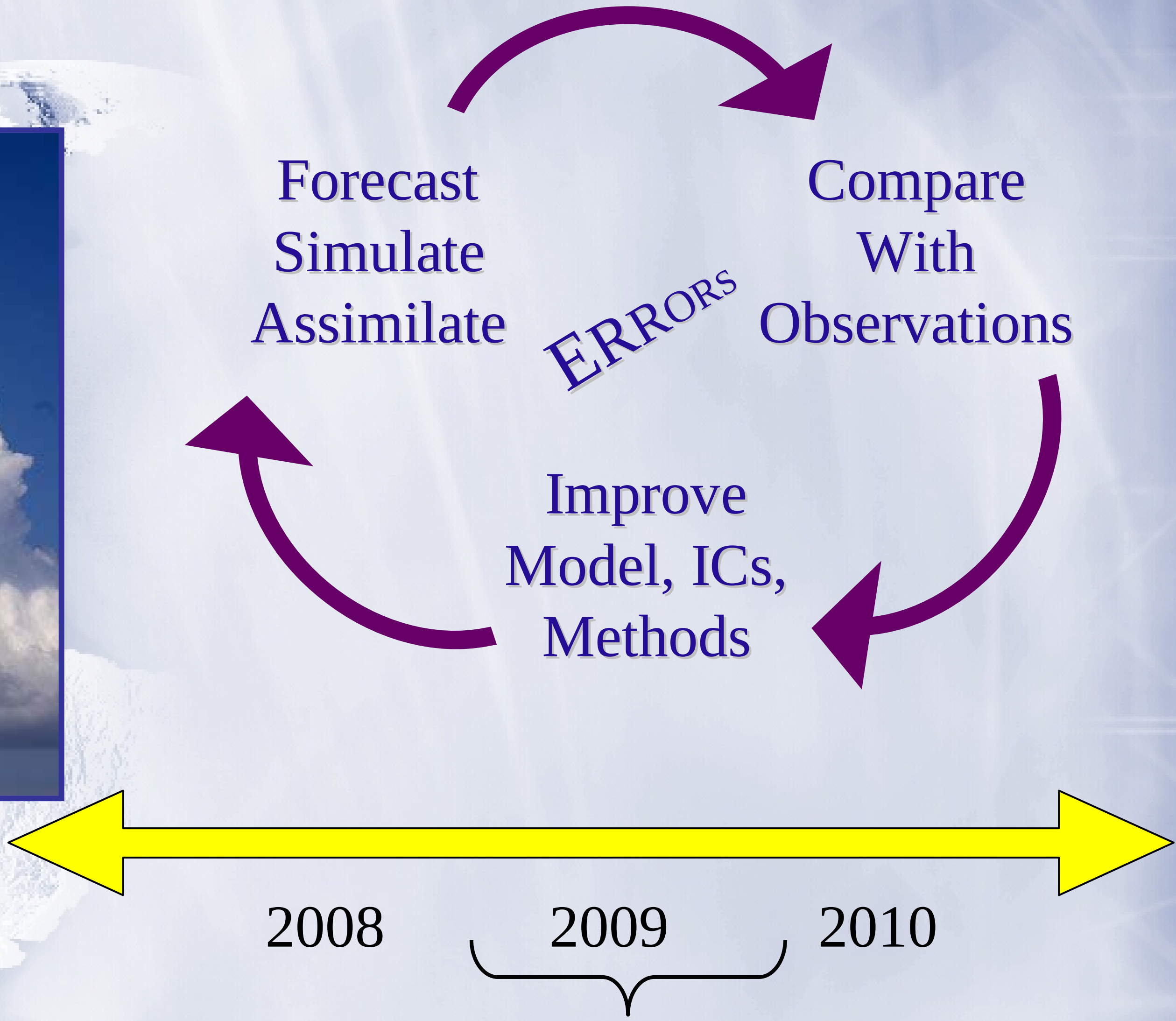
JPL Tropical Cyclone Portal (Y. Chao)

Year of Tropical Convection

Requests for Help & Participation

- "Synoptic" documentation & assessments during focus year.
- Graduate student & postdoc Attention - Training & Leadership Opportunity
- High-Resolution Model Participation
- Asian (local) Host Country/Institution for Implementation Planning Meeting in Late Fall '08 to be sponsored by WMO/WCRP/WWRP.

YoTC



diurnal cycle, synoptic systems,
intraseasonal, annual cycle, mean,
mesoscale-to-planetary-scale organization