

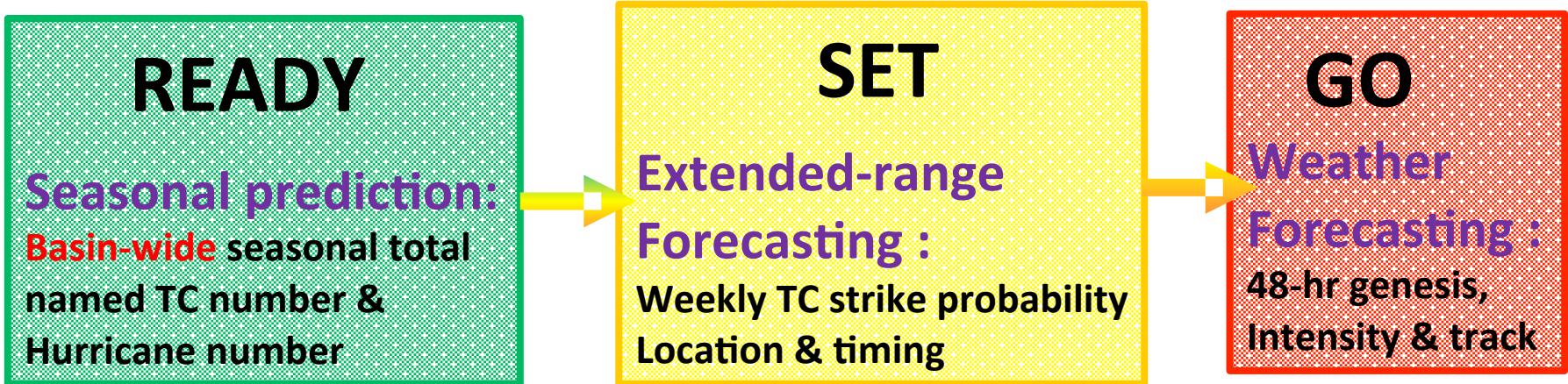
# Extended-range TC Forecasting: Opportunity and Challenge

Joshua Xiouhua Fu



**2012 U.S. CLIVAR Summit**  
Newport Beach, CA  
July 17–20, 2012

# A Seamless TC Forecasting System



2012 Hurricane Season (Jun 01 => Nov 30)

(<http://www.cpc.ncep.noaa.gov/products>)



Current: 6 TC/5 HC (Forecasted: 15/8)



Current: 4 TC/1 HC (Forecasted: 13/5)



**2012 U.S. CLIVAR Summit**  
Newport Beach, CA  
July 17-20, 2012

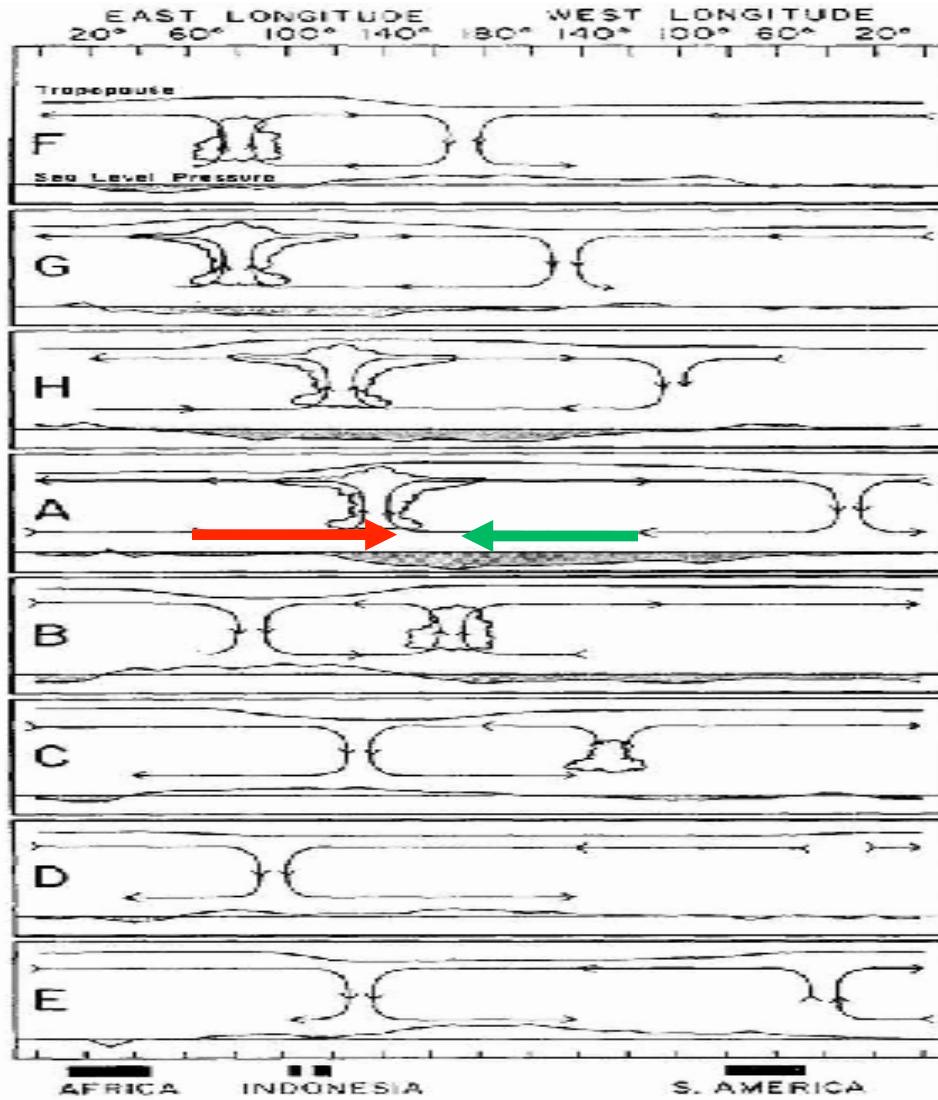
# Sources of Extended-range TC Forecasting

- Madden-Julian Oscillation (MJO)
- Boreal-summer Intra-Seasonal Oscillation (BSISO)
- Sea Surface Temperature (or Air-Sea Coupling)
- Easterly Waves
- Convectively Coupled Equatorial Waves (e.g., ER, Kelvin, MRG et al.)



**2012 U.S. CLIVAR Summit**  
Newport Beach, CA  
July 17–20, 2012

# What is MJO: Madden-Julian Oscillation?



*Baroclinic disturbance,  
Coupled with convection,  
Eastward along the equator,  
With a period of 30-60 days*

Madden and Julian, 1972



# Modulation of the MJO on Tropical Cyclones

## ➤ Western North Pacific

Nakazawa (1988); Liebmann et al. (1994)

## ➤ Eastern North Pacific

Molinari et al. (1997); Maloney and Hartmann (2000)

## ➤ Atlantic Basin

Maloney and Hartmann (2002); Mo (2002)

Klotzbach (2010)

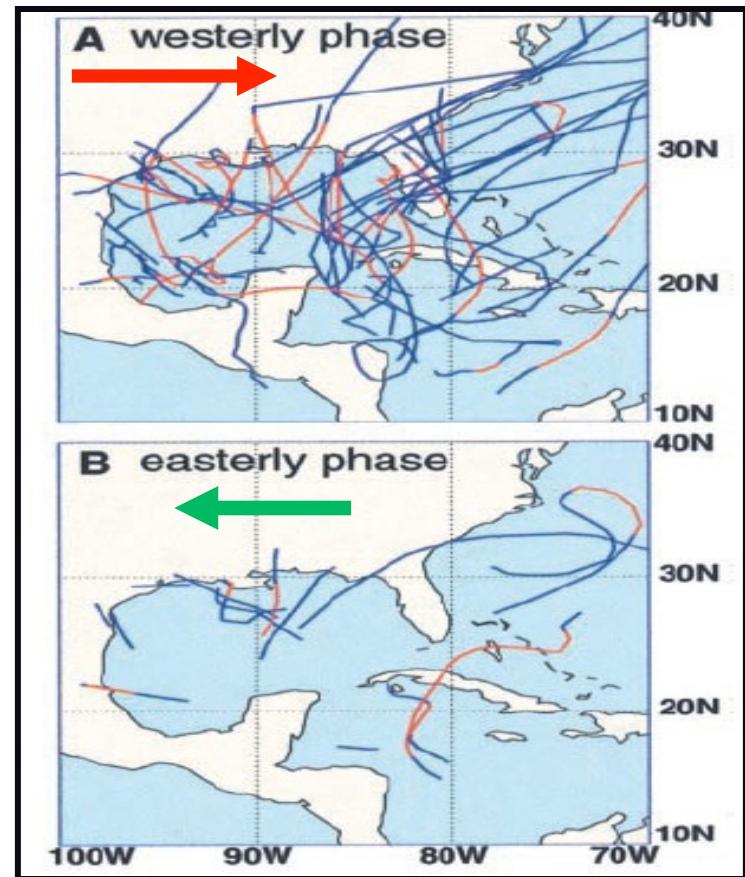
## ➤ Indian Ocean

Bessafi and Wheeler (2006); Ho et al. (2002)

Kikuchi and Wang (2009)

## ➤ Australian Region

Hall et al (2001); Chand and Walsh (2010)



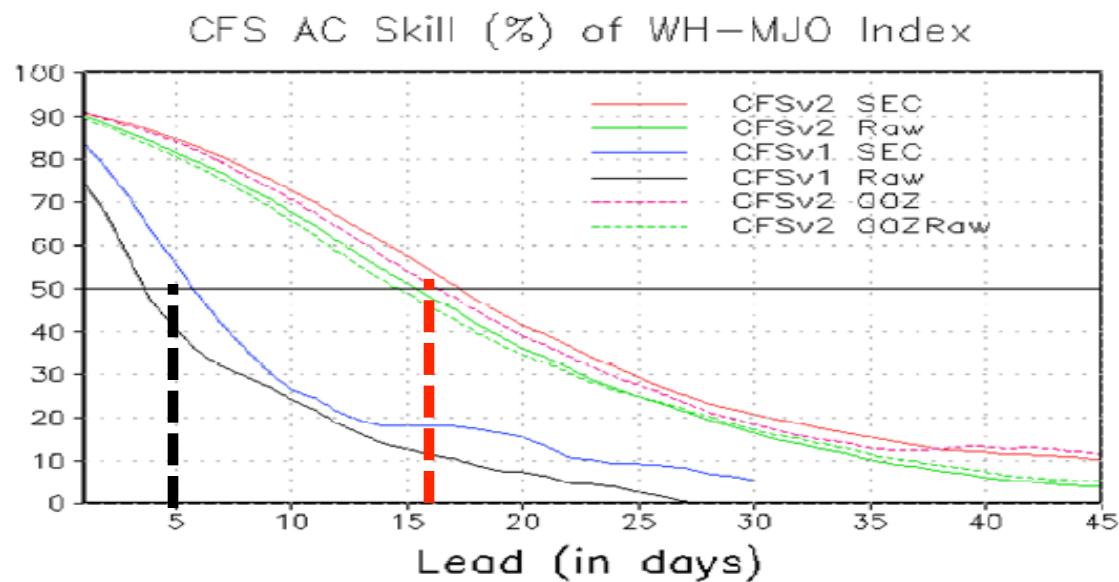
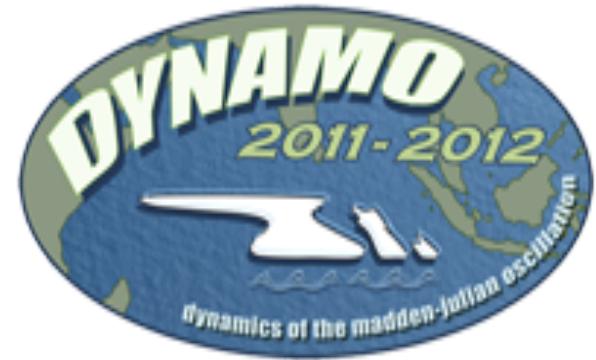
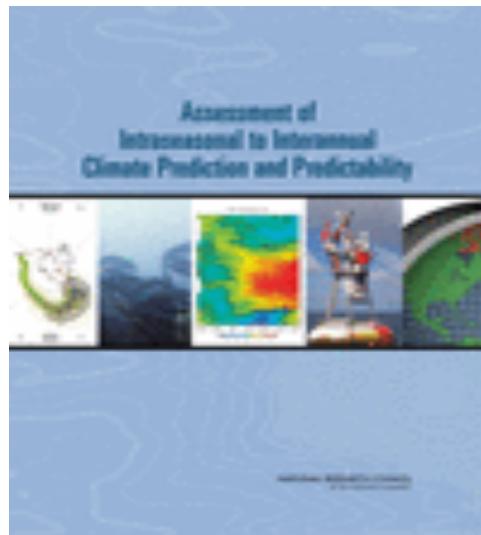
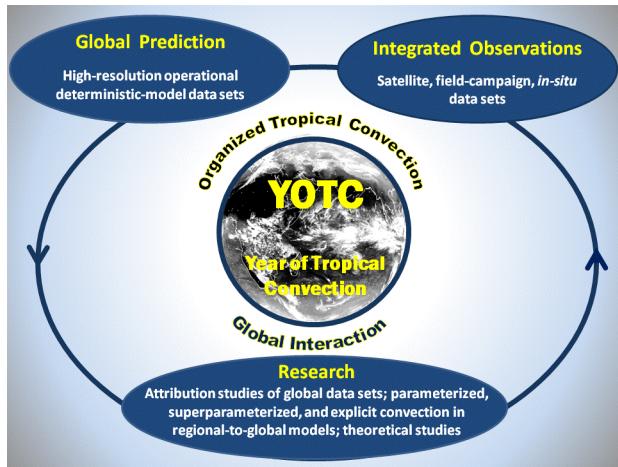
(Maloney and Hartman 2002, Science)



2012 U.S. CLIVAR Summit

Newport Beach, CA  
July 17-20, 2012

# A National Effort to Advance MJO (or IS) Prediction



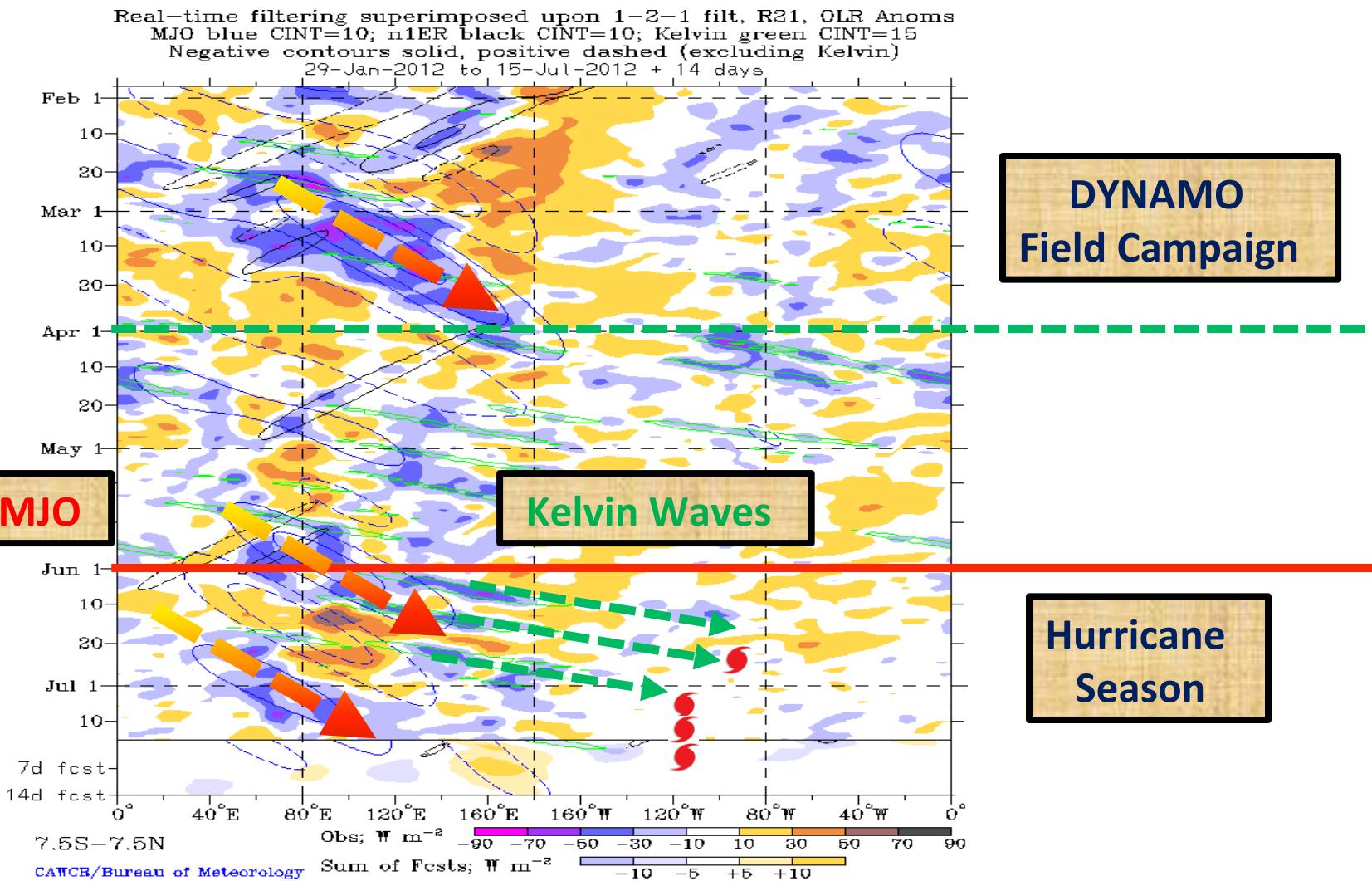
National (NOAA/NCEP CPC)  
MJO forecasting capability  
has been tripled from CFSv1  
to CFSv2.

Zhang and Van Den Dool  
(WAF, 2012)

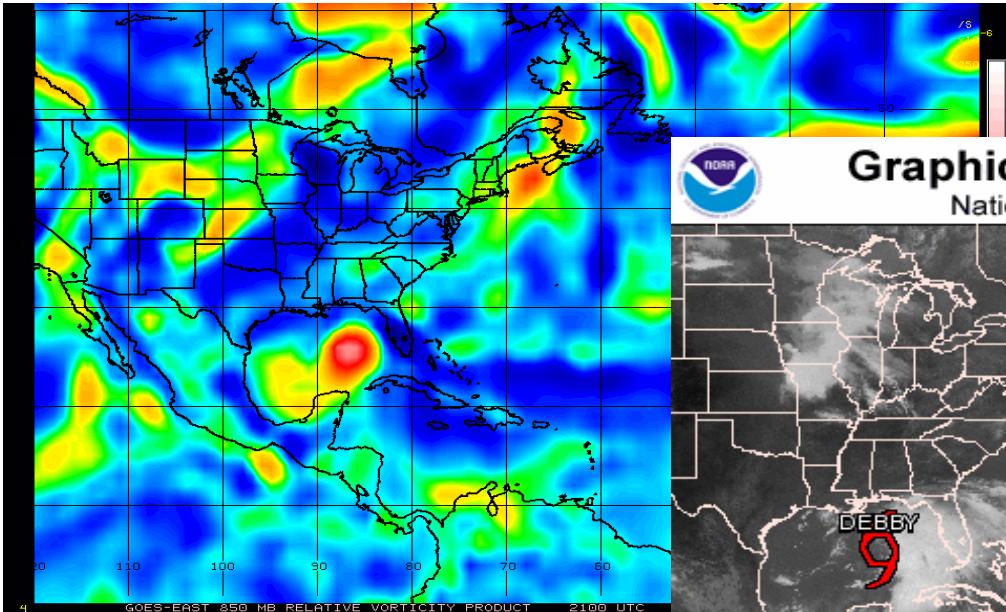


2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# MJO and Convective-Coupled Equatorial Waves



# CMISS Tropical Cyclones – University of Wisconsin-Madison



TS “Debby”: June 23-27, 2012

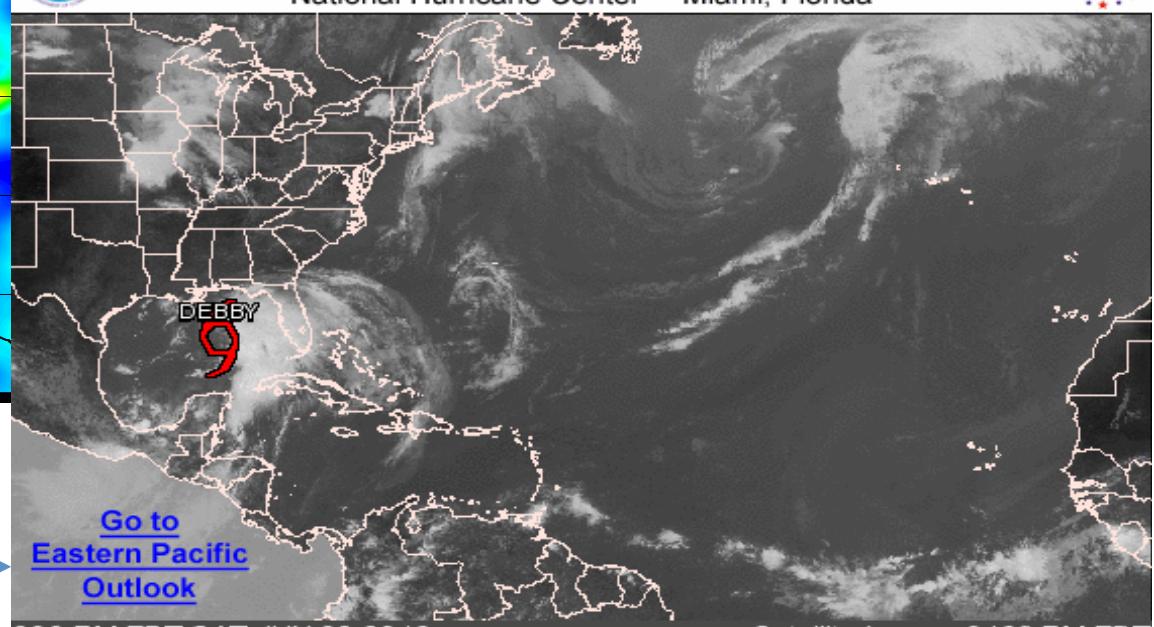


## Graphical Tropical Weather Outlook

National Hurricane Center Miami, Florida



National Hurricane Center



USA Today on June 23, 2012

Tropical Storm “Debby” disrupts Gulf oil, gas production



## 2012 U.S. CLIVAR Summit

Newport Beach, CA  
July 17-20, 2012

# NOAA/NCEP CPC Global Hazards Outlook (IC: June 13)



Global Tropical Hazards/Benefits Outlook - Climate Prediction Center



Week 1 - Valid: Jun 13, 2012 - Jun 19, 2012



Carlotta



Debby

False  
Alarm

Confidence  
High Moderate

- |                            |  |  |
|----------------------------|--|--|
| Tropical Cyclone Formation |  | Development of a tropical cyclone that eventually reaches tropical storm/cyclone strength. |
| Above-average rainfall     |  | Weekly total rainfall in the upper third of the historical range.                          |
| Below-average rainfall     |  | Weekly total rainfall in the lower third of the historical range.                          |
| Above-normal temperatures  |  | 7-day mean temperatures in the upper third of the historical range.                        |
| Below-normal temperatures  |  | 7-day mean temperatures in the lower third of the historical range.                        |

Produced: 06/12/2012

Forecaster: Marquardt

Product is updated once per week. The product targets broad scale conditions integrated over a 7-day period for US interests only.  
Consult your local responsible forecast agency.



中央氣象局  
Central Weather Bureau

UNIVERSITY AT ALBANY  
State University of New York



2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# NOAA/NCEP CPC Global Hazards Outlook (IC: June 20)

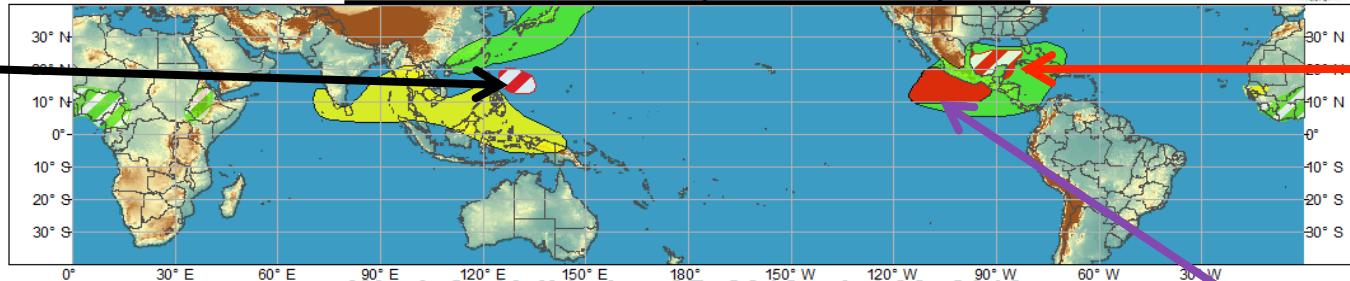


Global Tropical Hazards/Benefits Outlook - Climate Prediction Center



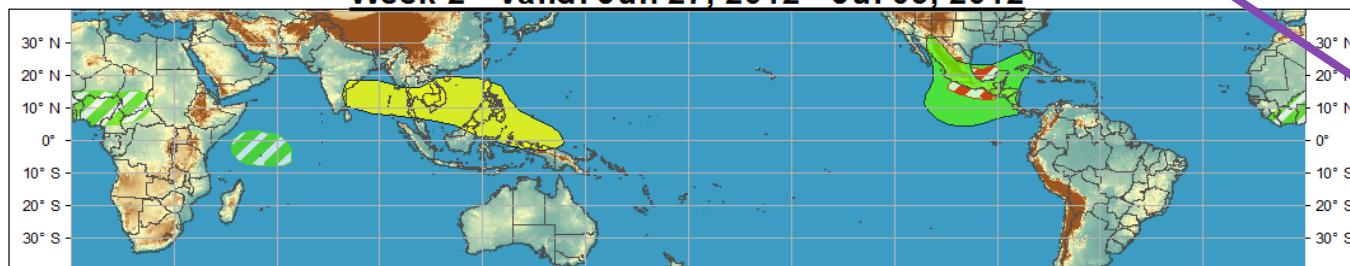
Week 1 - Valid: Jun 20, 2012 - Jun 26, 2012

Doksuri



Debby

Week 2 - Valid: Jun 27, 2012 - Jul 03, 2012



False  
Alarm

Confidence  
High Moderate

- Tropical Cyclone Formation Development of a tropical cyclone that eventually reaches tropical storm/cyclone strength.  
Above-average rainfall Weekly total rainfall in the upper third of the historical range.  
Below-average rainfall Weekly total rainfall in the lower third of the historical range.  
Above-normal temperatures 7-day mean temperatures in the upper third of the historical range.  
Below-normal temperatures 7-day mean temperatures in the lower third of the historical range.

Produced: 06/19/2012

Forecaster: Rosencrans

Product is updated once per week. The product targets broad scale conditions integrated over a 7-day period for US interests only.  
Consult your local responsible forecast agency.



中央氣象局  
Central Weather Bureau

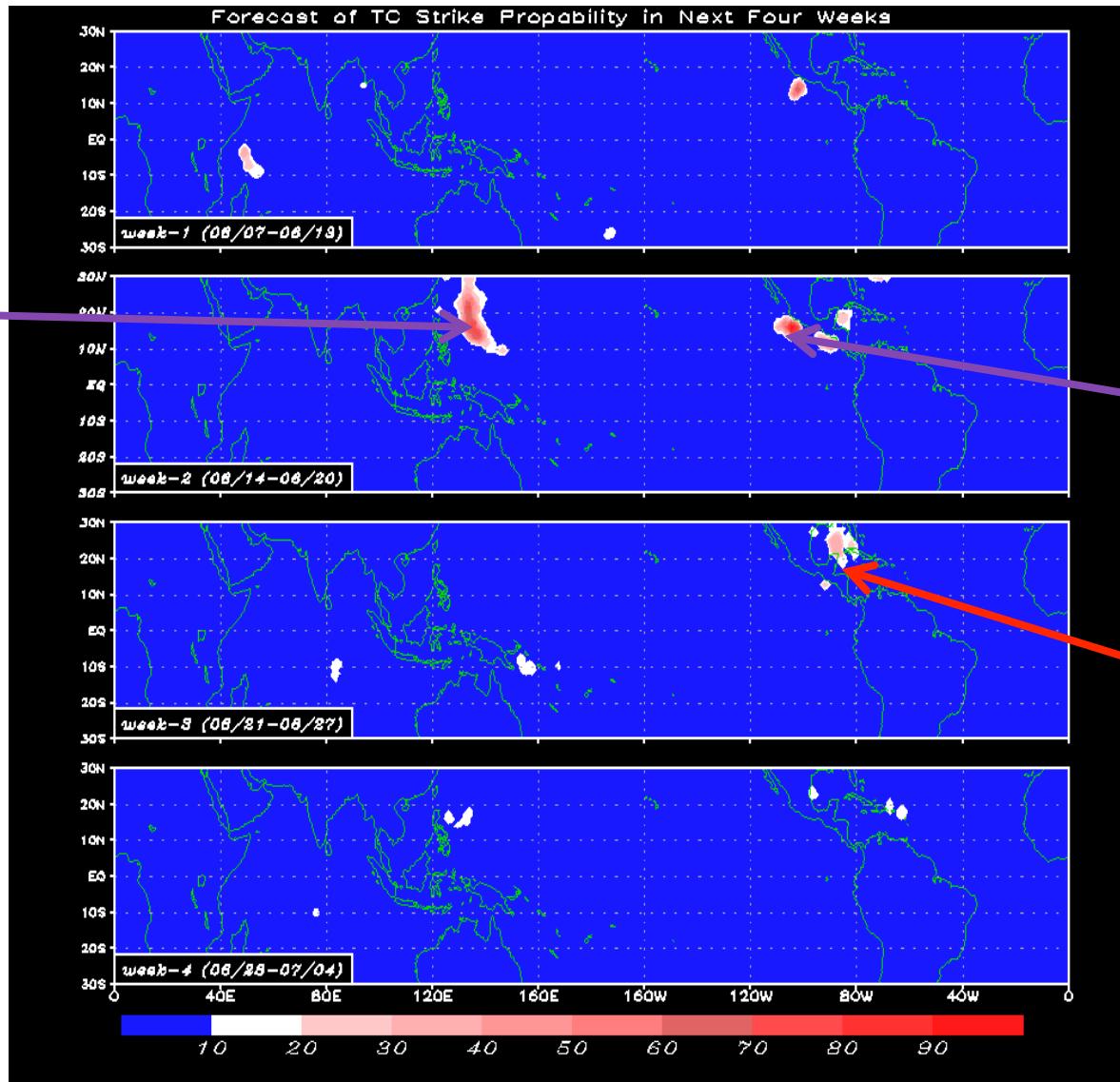


UNIVERSITY AT ALBANY  
State University of New York



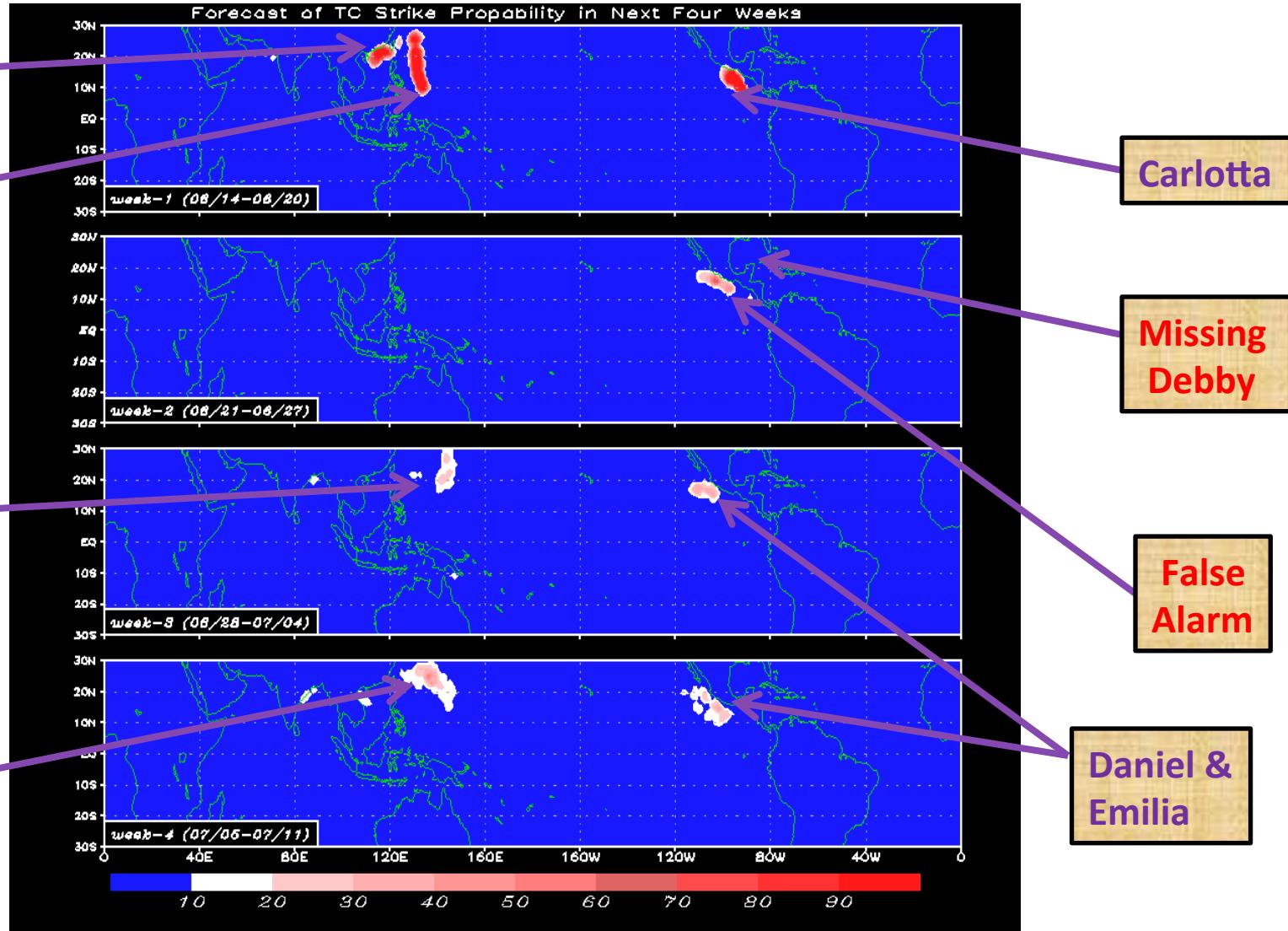
2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# UH Weekly TC Strike Probability (IC: June 07)

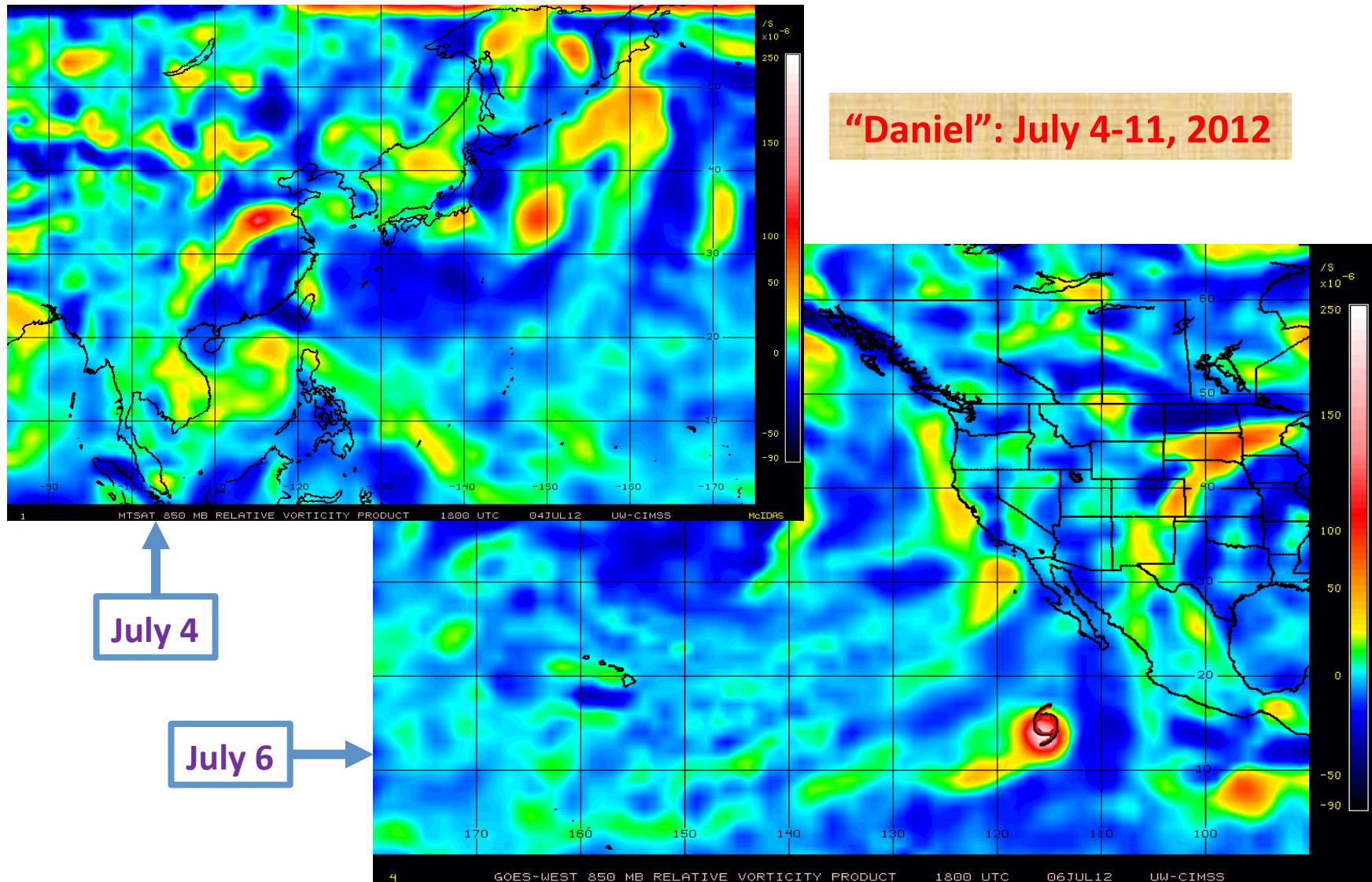


2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# UH Weekly TC Strike Probability (IC: June 14)



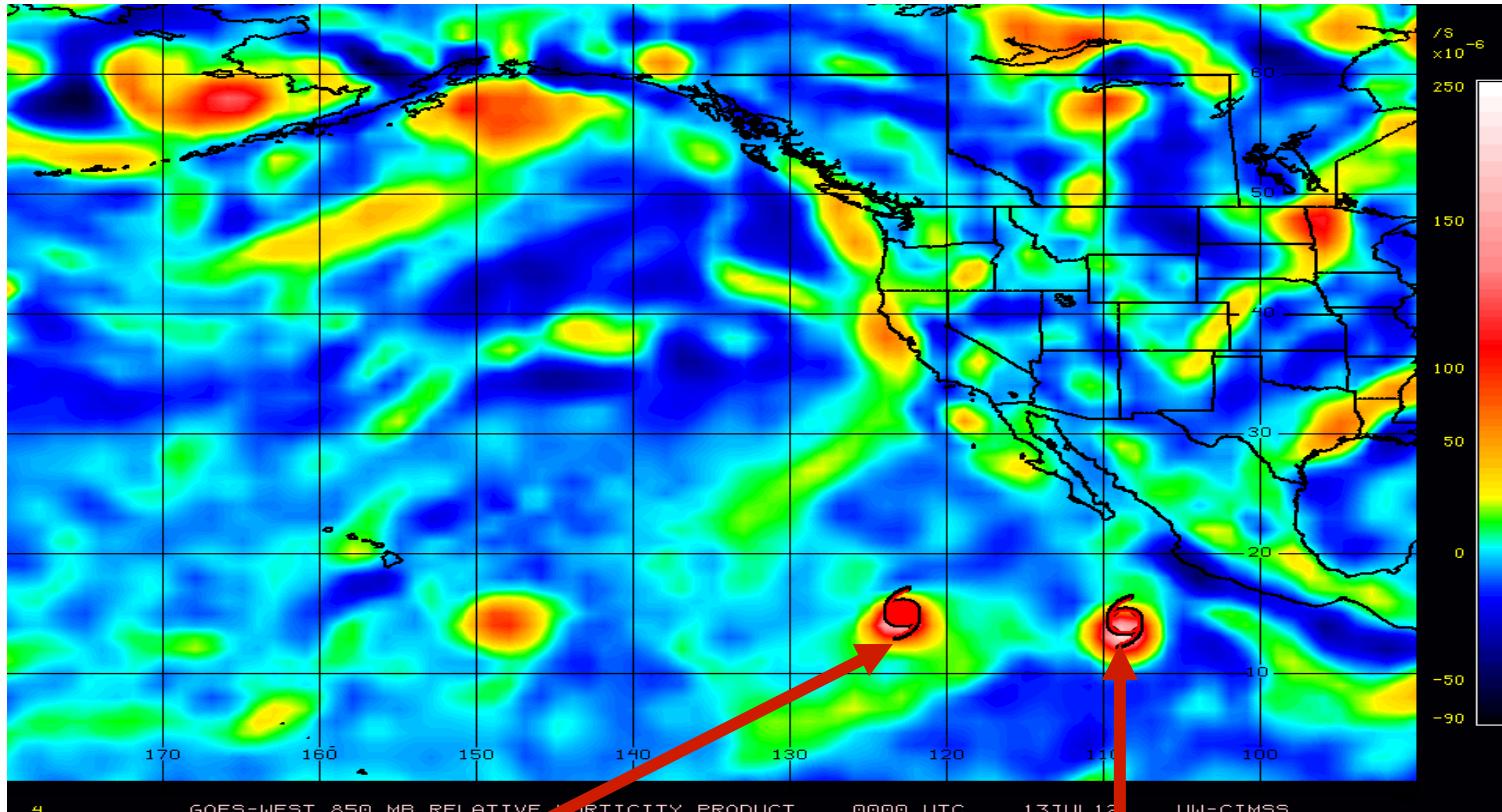
# CMISS Tropical Cyclones – University of Wisconsin-Madison



2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17–20, 2012

# CMISS Tropical Cyclones – University of Wisconsin-Madison

July, 13, 2012



2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

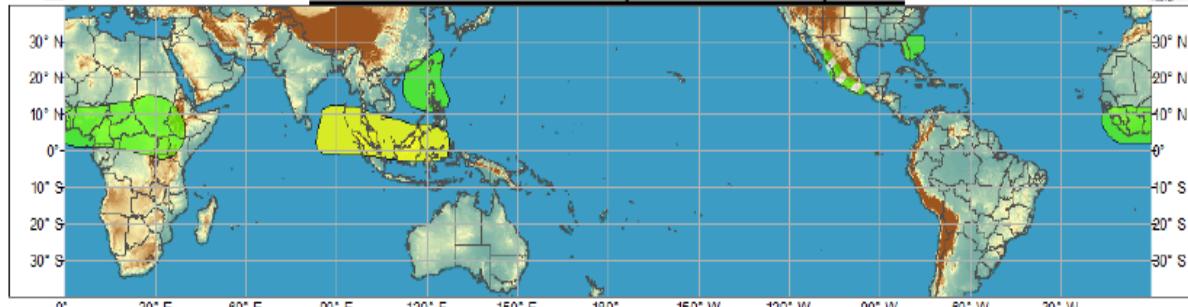
# NOAA/NCEP CPC Global Hazards Outlook (IC: June 27)



Global Tropical Hazards/Benefits Outlook - Climate Prediction Center



Week 1 - Valid: Jun 27, 2012 - Jul 03, 2012



Week 2 - Valid: Jul 04, 2012 - Jul 10, 2012



False  
Alarm

Daniel &  
Emilia

Confidence  
High Moderate

Tropical Cyclone Formation

Development of a tropical cyclone that eventually reaches tropical storm/cyclone strength.

Above-average rainfall

Weekly total rainfall in the upper third of the historical range.

Below-average rainfall

Weekly total rainfall in the lower third of the historical range.

Above-normal temperatures

7-day mean temperatures in the upper third of the historical range.

Below-normal temperatures

7-day mean temperatures in the lower third of the historical range.

Produced: 06/26/2012

Forecaster: Gottschalck

Product is updated once per week. The product targets broad scale conditions integrated over a 7-day period for US interests only.  
Consult your local responsible forecast agency.



中央氣象局

Central Weather Bureau



UNIVERSITY AT ALBANY  
State University of New York



Australian Government  
Bureau of Meteorology



2012 U.S. CLIVAR Summit

Newport Beach, CA  
July 17-20, 2012

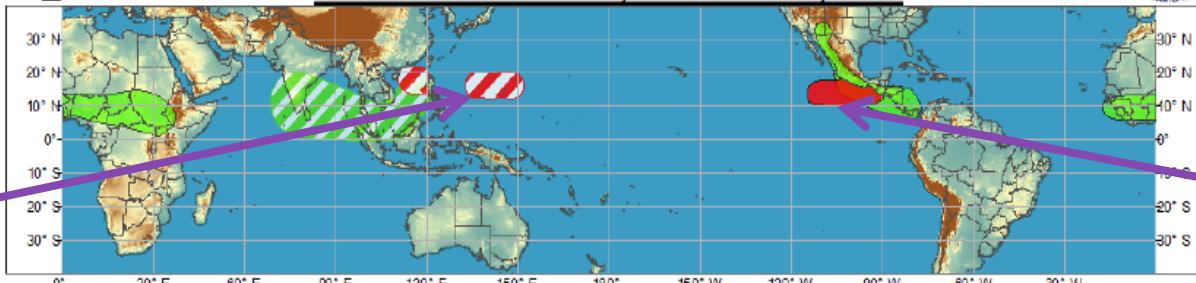
# NOAA/NCEP CPC Global Hazards Outlook (IC: July 04)



Global Tropical Hazards/Benefits Outlook - Climate Prediction Center



Week 1 - Valid: Jul 04, 2012 - Jul 10, 2012



False  
Alarm

Daniel &  
Emilia



Khanun

Fabio

Confidence  
High Moderate

Tropical Cyclone Formation		Development of a tropical cyclone that eventually reaches tropical storm/cyclone strength.
Above-average rainfall		Weekly total rainfall in the upper third of the historical range.
Below-average rainfall		Weekly total rainfall in the lower third of the historical range.
Above-normal temperatures		7-day mean temperatures in the upper third of the historical range.
Below-normal temperatures		7-day mean temperatures in the lower third of the historical range.

Produced: 07/03/2012

Forecaster: Gottschalck

Product is updated once per week. The product targets broad scale conditions integrated over a 7-day period for US interests only.  
Consult your local responsible forecast agency.



中央氣象局  
Central Weather Bureau

UNIVERSITY AT ALBANY  
State University of New York

Australian Government  
Bureau of Meteorology



2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

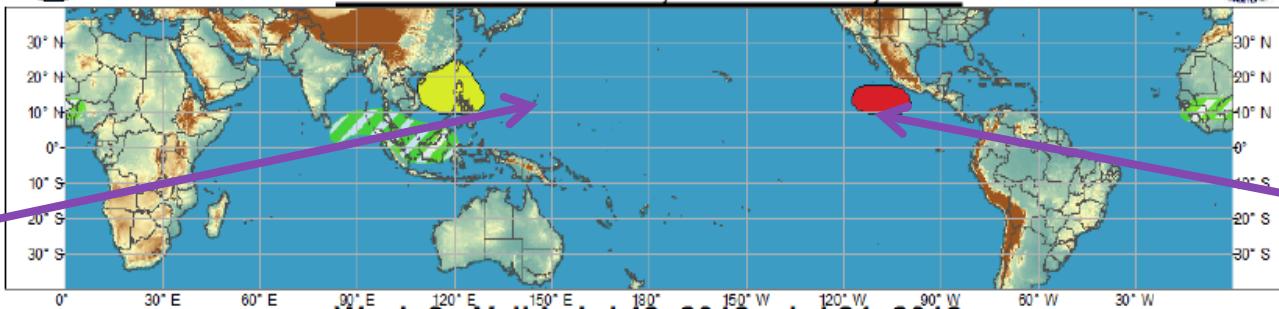
# NOAA/NCEP CPC Global Hazards Outlook (IC: July 11)



Global Tropical Hazards/Benefits Outlook - Climate Prediction Center



Week 1 - Valid: Jul 11, 2012 - Jul 17, 2012



Missing  
Khanun

Fabio

Week 2 - Valid: Jul 18, 2012 - Jul 24, 2012



Produced: 07/10/2012

Forecaster: Pugh

ment of a tropical cyclone that eventually reaches tropical storm/cyclone strength.

otal rainfall in the upper third of the historical range.

otal rainfall in the lower third of the historical range.

ean temperatures in the upper third of the historical range.

ean temperatures in the lower third of the historical range.

gets broad scale conditions integrated over a 7-day period for US interests only.

er Bureau

UNIVERSITY AT ALBANY  
State University of New York

Australian Government  
Bureau of Meteorology

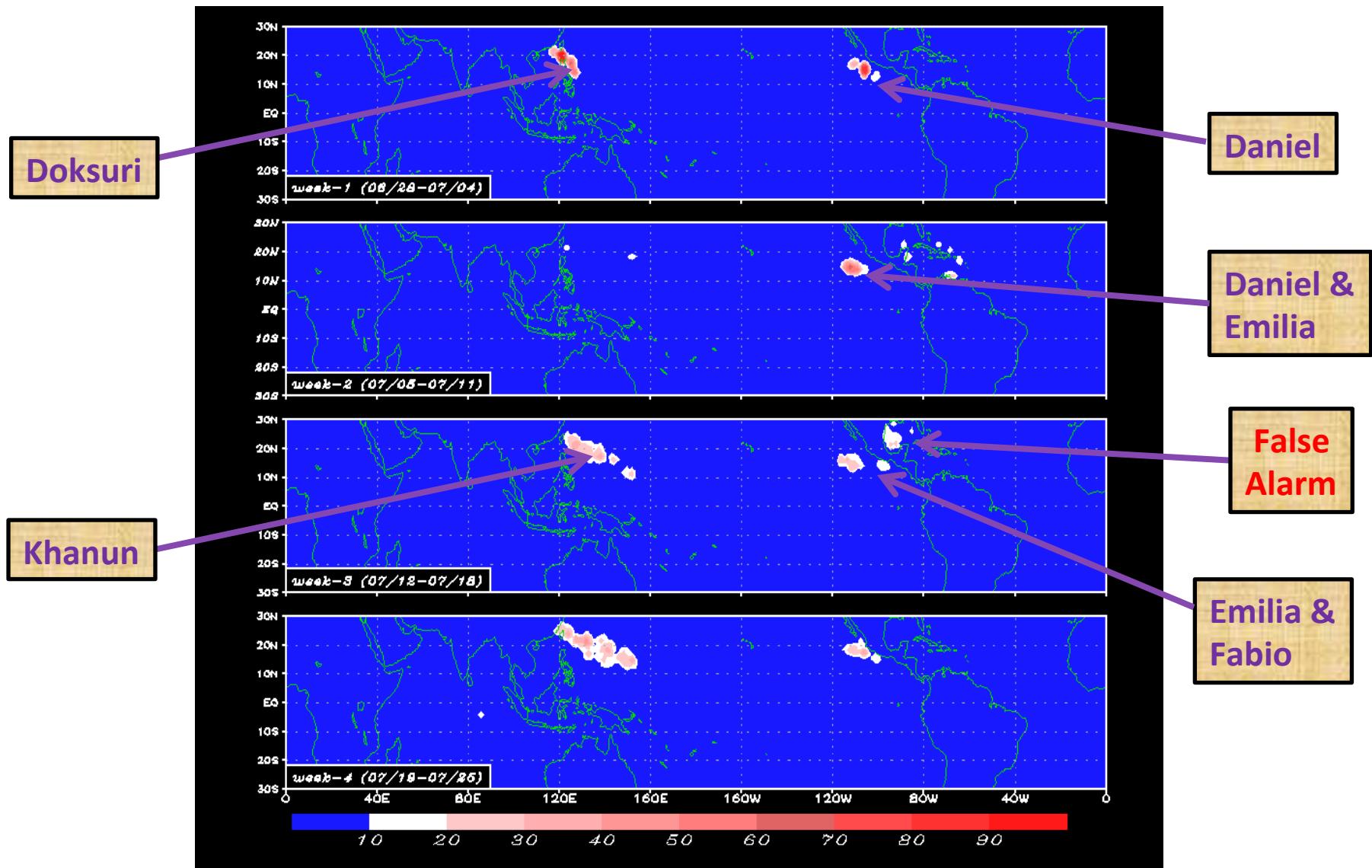


JTWC on July 16



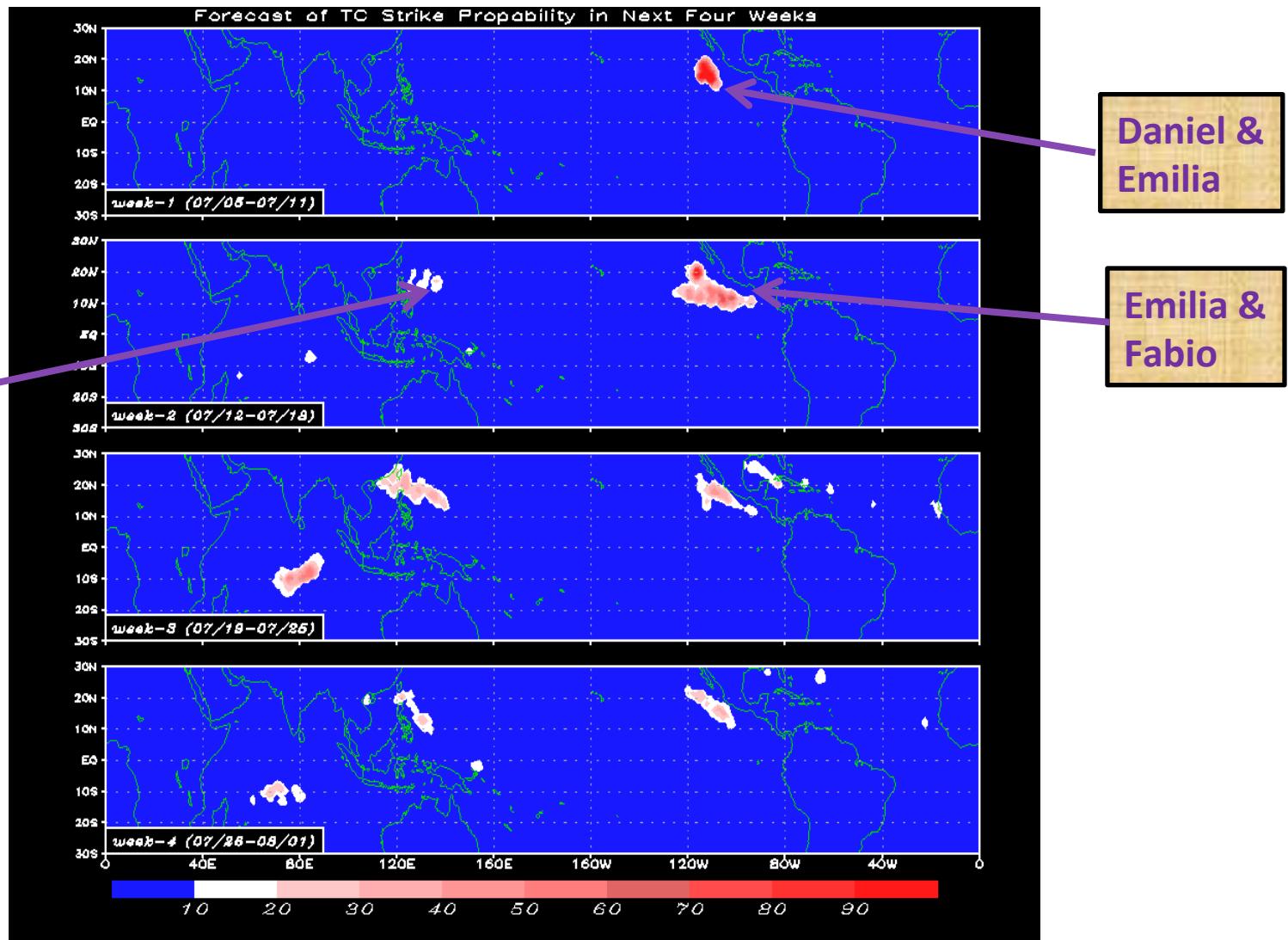
2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# UH Weekly TC Strike Probability (IC: June 28)



2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# UH Weekly TC Strike Probability (IC: July 05)

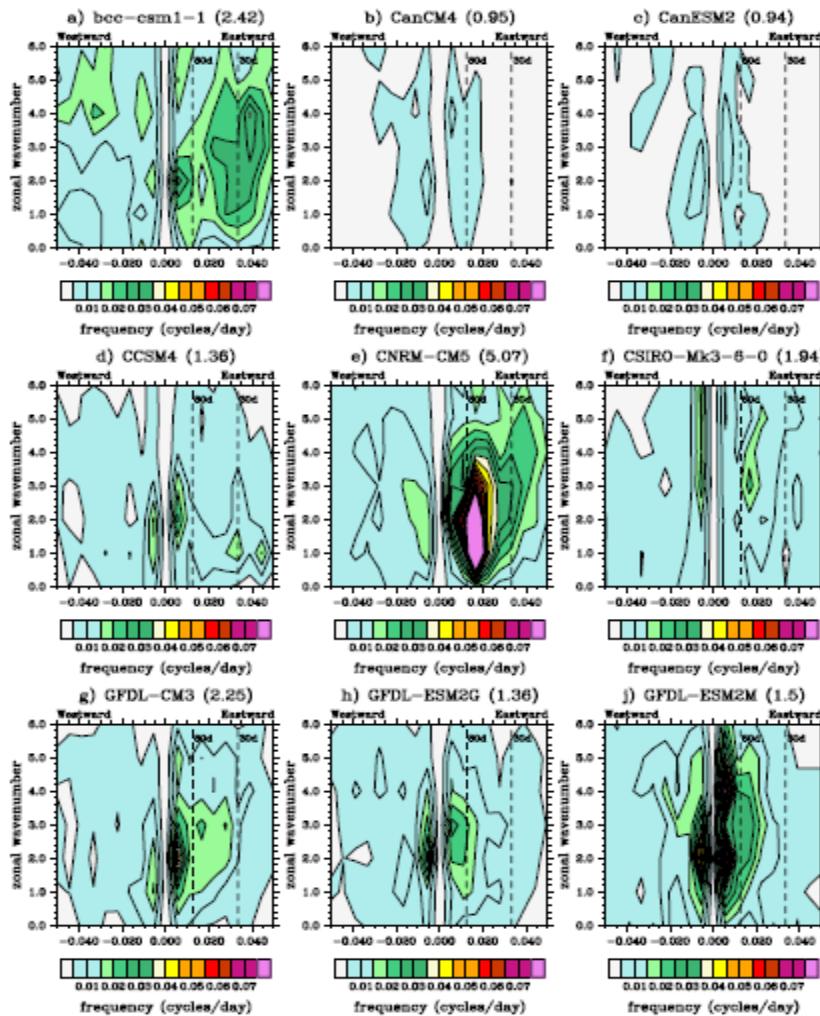


2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

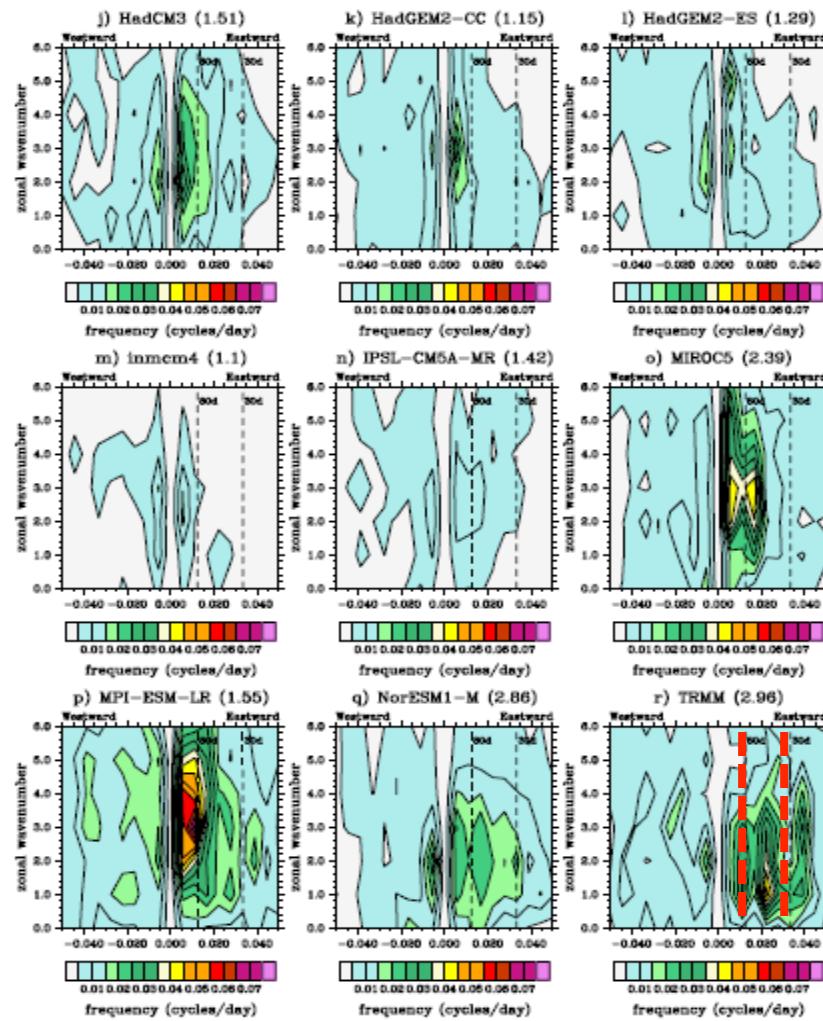
# MJO/BSISO/CCEW need to be better simulated

CMIP5

Precipitation (10S-10N averaged)



Precipitation (10S-10N averaged)



OBS



2012 U.S. CLIVAR Summit  
Newport Beach, CA  
July 17-20, 2012

# Scientific Issues and Questions

- Major uncertainties on extended-range TC forecasting:
  - False alarms
  - Missing events
  - “Jumpy” forecasts at different lead times
- Questions:
  - What are the major factors leading to TC false alarms?  
And how to reduce TC false alarms in operational extended-range forecasting models?
  - What cause the “missing” events? How to make improvement?
  - What cause the “jumpiness” in extended-range TC forecasting?
  - What are the misrepresented model physical processes responsible for the afore-mentioned uncertainties?
  - Will multi-model approach significantly reduce the above uncertainties?



**2012 U.S. CLIVAR Summit**  
Newport Beach, CA  
July 17–20, 2012

# THANK YOU VERY MUCH!



**2012 U.S. CLIVAR Summit**  
**Newport Beach, CA**  
**July 17–20, 2012**