S2S – MJOTF Joint Research Project

Understanding MJO Interactions with the Maritime Continent: The joint S2S-MJO Task Force

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Colorado State University

MJO Task Force : Background

- Renewed in early 2013 for a term of 3 years
- Sponsor: Working Group on Numerical Experimentation (WGNE)
- Follow on from the WCRP-WWRP/THORPEX/YOTC MJOTF and US CLIVAR MJO Working Group
- Website: http://www.wmo.int/pages/prog/arep/wwrp/new/MJO_Task_Force_index.html

Members

Steve Woolnough	University of Reading **(co-chair)**
Eric Maloney	Colorado State University **(co-chair)**
Charlotte DeMott	CMMAP/Colorado State Univ
Jon Gottschalck	National Centers for Environmental Prediction
Daehyun Kim	Columbia University
Tieh-Yong Koh	Nanyang Technological University
June-Yi Lee	Pusan National University
Adrian Matthews	University of East Anglia
Tomoki Miyakawa	AORI/ University of Tokyo
Richard Neale	National Center for Atmospheric Research
Camille Risi	IPSL/Laboratoire de Météorologie Dynamique
Ken Sperber	PCDMI/Lawrence Livermore National Laboratory
Duane Waliser	Jet Propulsion Laboratory/Caltech
Matthew Wheeler	Centre for Australian Weather and Climate Research
Prince Xavier	UK Met Office

Important others and former members

X. Jiang, N. Klingaman, J. Petch, F. Vitart, J. Benedict, H. Hendon, D. Raymond, Xiouhua Fu, Chidong Zhang, Augustin Vintzileos, Masaki Satoh, Hai Lin, Mitch Moncrieff, Min-Seop Ahn, Hae-Jeong Kim Surya Rao, Jerome Vialard

Overall Goal: Facilitate improvements in the representation of the MJO in weather and climate models in order increase the predictive skill of the MJO and related weather and climate phenomena.

Organized into 5 Subprojects

- **Process-oriented diagnostics/metrics for MJO simulation** *(leads: D. Kim, P. Xavier, E. Maloney, T. Miyakawa, C. Risi)*
- **Boreal summer monsoon ISV monitoring and forecast metrics** *(leads: J.-Y. Lee, M. Wheeler)*
- **Assessment of CMIP5 model capability to simulate realistic intraseasonal variability** *(leads: K. Sperber, D. Kim, M.-S. Ahn)*
- **MJO TF + GASS Multi-Model Diabatic Processes Experiment** *(leads: D. Waliser, X. Jiang, J. Petch, P. Xavier, S. Woolnough, N. Klingaman)*
- **Develop, coordinate, and promote analyses of MJO air-sea interaction** *(leads: C. DeMott, N. Klingaman, S. Woolnough, J. Vialard, S. Rao)*

Renewal of MJO Task Force in early 2016

Proposed research subprojects:

- Intraseasonal prediction (ongoing)
  - In collaboration with S2S, exploiting their database?
- Process-oriented model diagnostics (ongoing)
- Air-sea interaction (recent activity)
- Maritime Continent intraseasonal processes and prediction (recent activity)
  - joint project with S2S
- Tropical-extratropical interactions (new)
  - Related to new S2S project on tropical-extratropical interactions on subseasonal to seasonal timescales

New MJOTF-S2S Joint Effort on the Maritime Continent (MC)

- **Goal**: **To improve understanding of MJO propagation through the Maritime Continent region**, where prediction skill is limited by model deficiencies and the complexity of interactions among the atmosphere, ocean, and land-surface.
- **Motivation**:
- The MJO represents one of the high priority subprojects of the WMO Subseasonal-to-Seasonal (S2S) prediction program .
- S2S and the MJO Task Force deemed the interaction of the MC with the MJO as a high priority research question that has significant bearing on shortcomings/improving operational MJO predictions
- Motivating Principles:
  - To better understand processes and improve prediction
  - **Practicalities and Opportunities (i.e. why now?)**
    - **Significant interest across S2S, MJOTF, and AAMP**
    - **Existing modeling resources (S2S, MJOTF-GASS, and ISVHE databases)**
    - **Impending "Years of the Maritime Continent" project. Opportunity to help define objectives of campaign and make scientific progress**

- **Tieh-Yong Koh and Adrian Matthews** have joined TF to assist this effort
- 2016 boreal spring **MJOTF-S2S-YMC Singapore workshop** being developed on issues related to subseasonal variability, simulation and prediction in the MC region

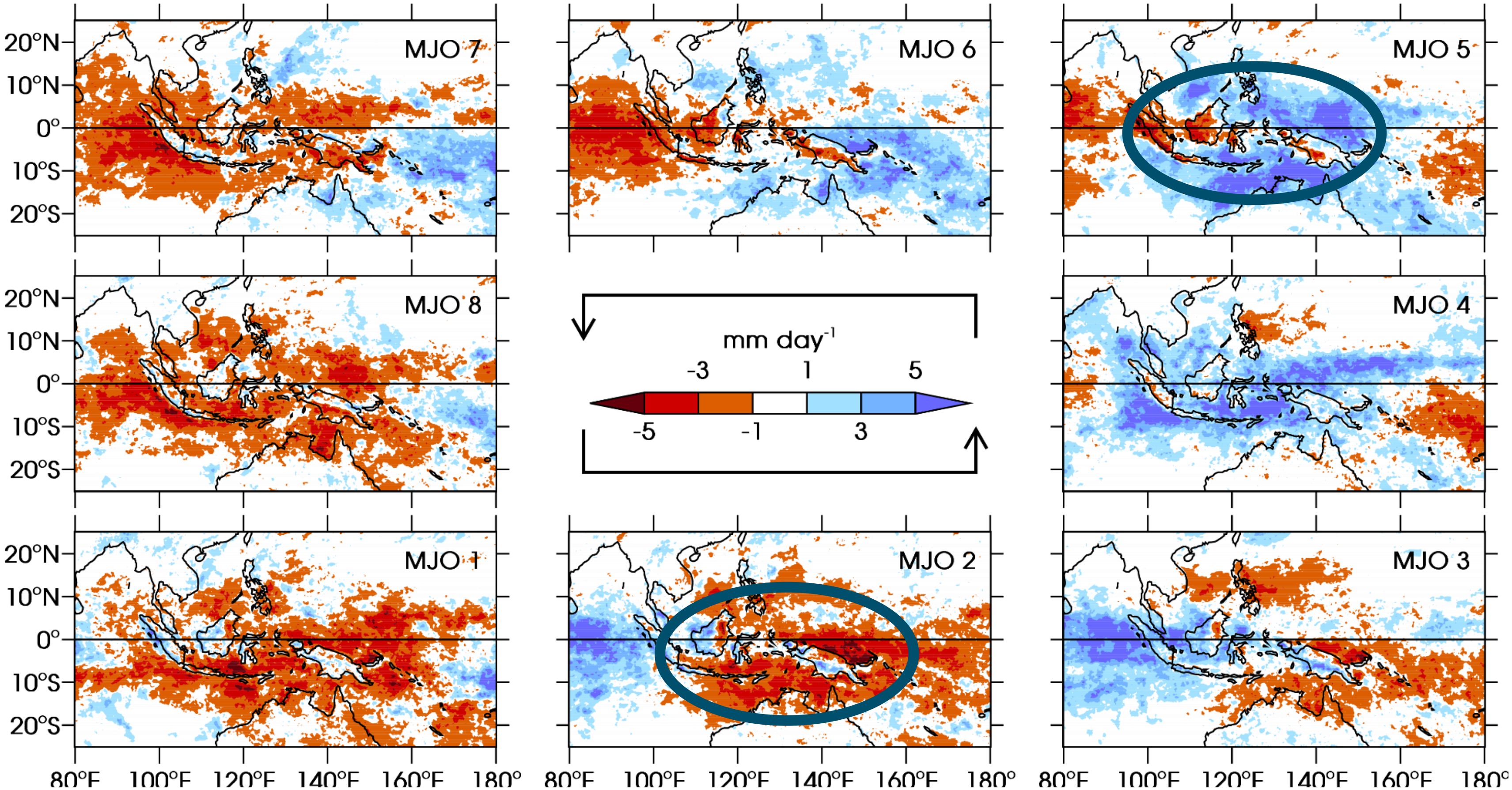
MJO cycle

Anomaly of daily mean TRMM precipitation

Peatman et al. (2013)

Courtesy of Adrian Matthews

- Vanguard of precipitation over maritime continent
- Precipitation anomaly has opposite sign over islands and surrounding sea



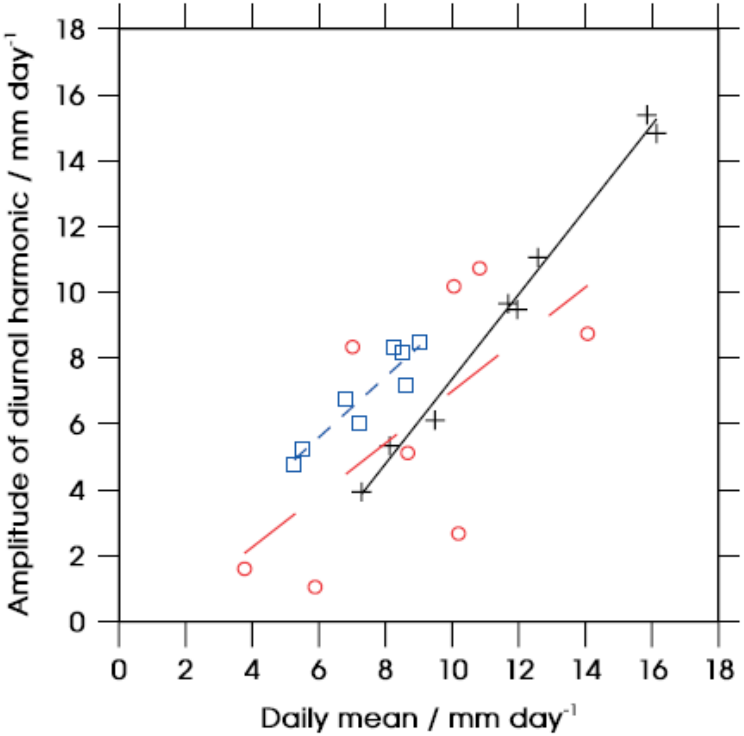


Figure 8. Scatterplot of the amplitude of the diurnal harmonic of precipitation against daily mean precipitation for the eight WH04 phases, for the three sample points 2.125°N, 113.125°E (Borneo; crosses and solid line), 5.125°S, 142.125°E (New Guinea; squares and short-dashed line), and 0.125°N, 103.125°E (Sumatra; circles and long-dashed line). Straight lines indicate the best fit according to linear regression; the gradient and correlation coefficient for all grid points are shown in Figure 9. This figure is available in colour online at wileyonlinelibrary.com/journal/qj

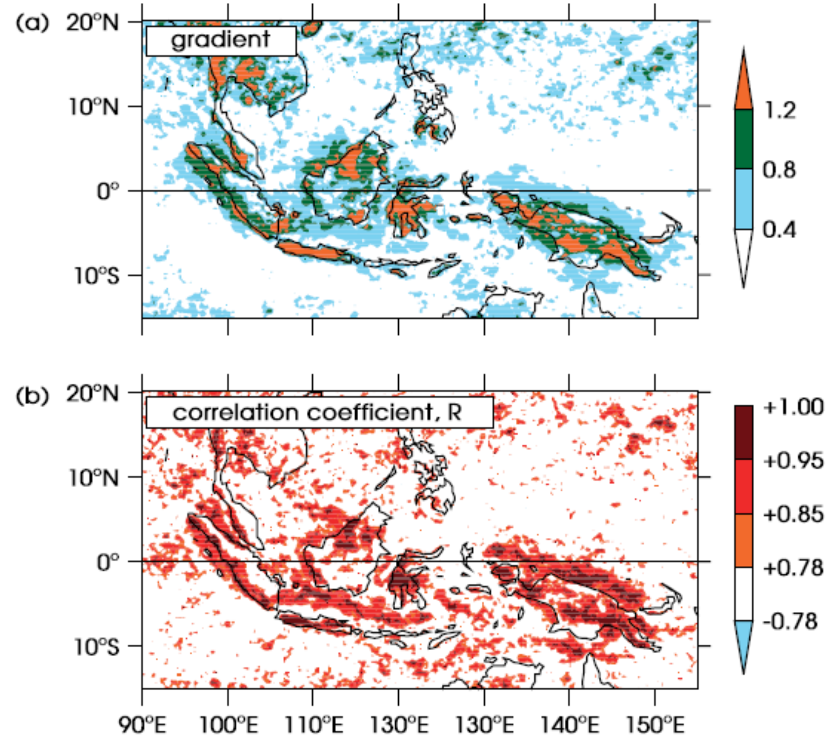


Figure 9. (a) Gradient and (b) correlation coefficient R of the linear relationship between the amplitude of the diurnal harmonic of precipitation for each MJO phase, and the daily mean precipitation in the corresponding MJO phase (both from TRMM 3B42HQ). (Figure 8 shows three example grid points.) In (b), regions in white are below the 95% confidence threshold of $|R| = 0.78$. This figure is available in colour online at wileyonlinelibrary.com/journal/qj

This suggests that where there is a strong diurnal cycle, the change in the amplitude of the diurnal cycle is the dominant contributor to the daily mean MJO precipitation.

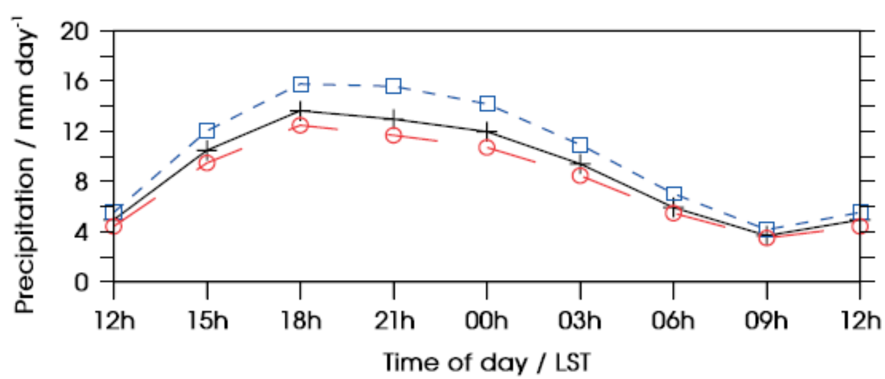


Figure 6. Diurnal cycle of land-mean precipitation r (mm day^{-1}) over Borneo: climatology (solid black with crosses) has $\overline{r} = 9.1$, $r_d = 6.3$; MJO phase 3 (short-dashed with squares) has $\overline{r} = 10.6$, $r_d = 8.0$; MJO phase 7 (long-dashed with circles) has $\overline{r} = 8.3$, $r_d = 5.7$. This figure is available in colour online at wileyonlinelibrary.com/journal/qj

Motivating Questions from MJO Task Force- S2S Collaboration

- What is the current skill of operation systems at predicting the passage of precipitating/active phases of the MJO into and across the MC, including aspects such as reliability?
- What processes determine whether individual MJOs propagate through the Maritime Continent?
- How is the simulated propagation of the MJO through the Maritime Continent related to biases in models?
- How does the partitioning of variability from diurnal to seasonal, including equatorial wave characteristics, influence the MJO and MC interaction?
- Does the above partitioning depend on model resolution, and is accordingly affected by the use of explicitly resolved convection versus parameterized convection?
- How does the ocean-atmosphere coupling in the context of the MC influence the MJO and MC interaction?
- How does topography versus land-sea contrast play a role in the MJO and MC interaction?
- How do land-atmosphere interactions (temperature, soil moisture, diurnal cycle) influence the MJO and MC interaction?
- How is forecast skill associated with the MJO over the MC influenced by the above science elements?

Model Resources

- **S2S Database**: This new modeling database will provide a comprehensive set of prospective state-of-the-art operational forecasts for the MJO, and in most cases associated hindcast data sets. This makes it well suited for studies of prediction diagnostics and skill, and to a lesser degree for studies of physical processes and multi-scale interactions.
- **MJOTF-GASS Experiment**: With full vertical profiles of all physical tendency terms for climatological simulations with 6 hour output from ~30 models and higher time resolution (time step, 3 hour) output from ~12 models for 2 specific MJO cases during YOTC (boreal winter 2009-10), this is well suited for physical processes and multi-scale interactions studies.
- **ISVHE**: presently the best hindcast data set targeting the MJO and related phenomena, albeit with limited output to study physical processes.
- **Ad hoc modeling:** Regional and global high resolution models, climate models (e.g. UK Met Office, NICAM, WRF, RAMS).

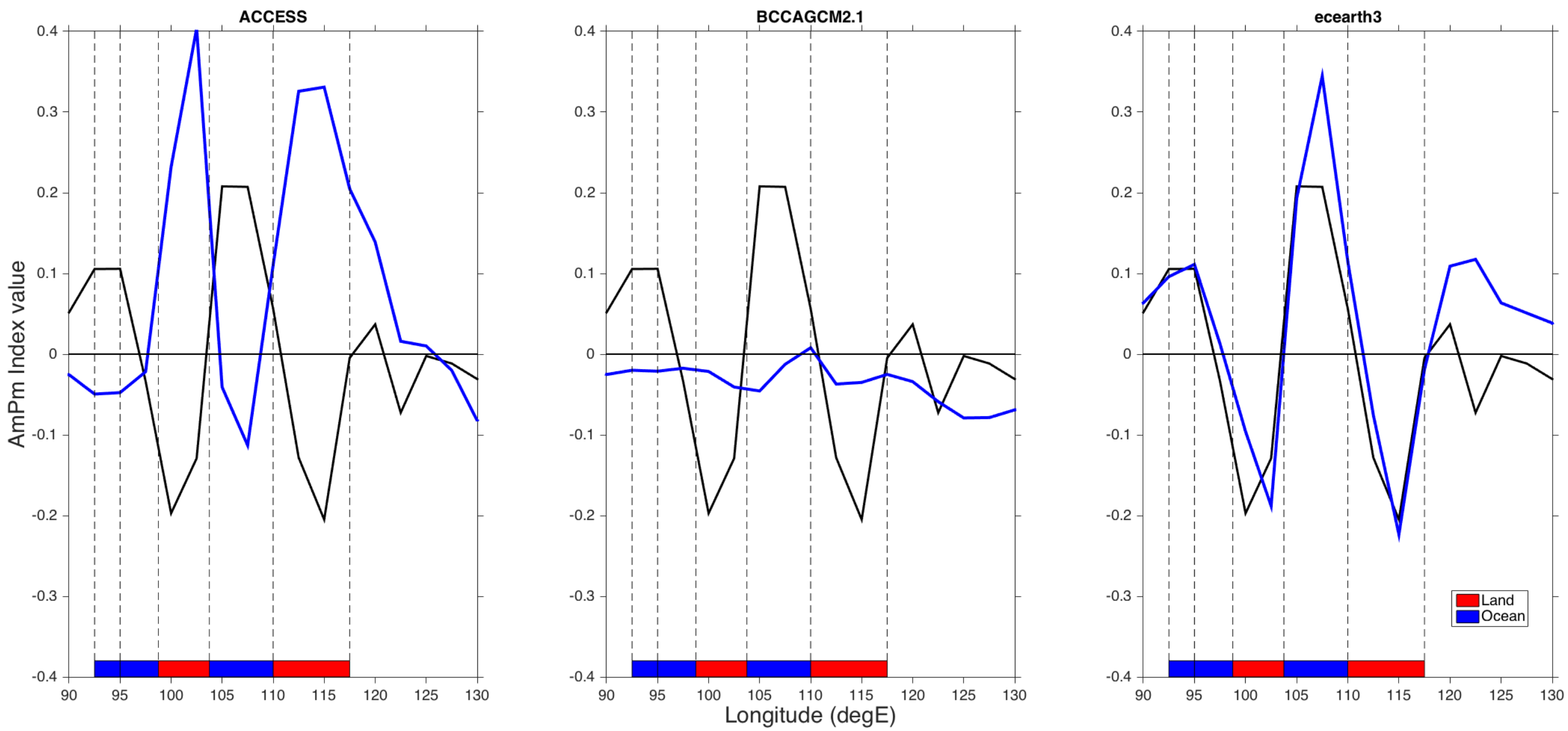
Zonal variability of the daytime/nighttime precipitation

AmPm index from LO TRMM(black) and GASS models (blue)

AmPm Index = (AMpr –PMpr)/(AMpr +PMpr); AM and PM in LST

From Darek Baranowski and Duane Waliser

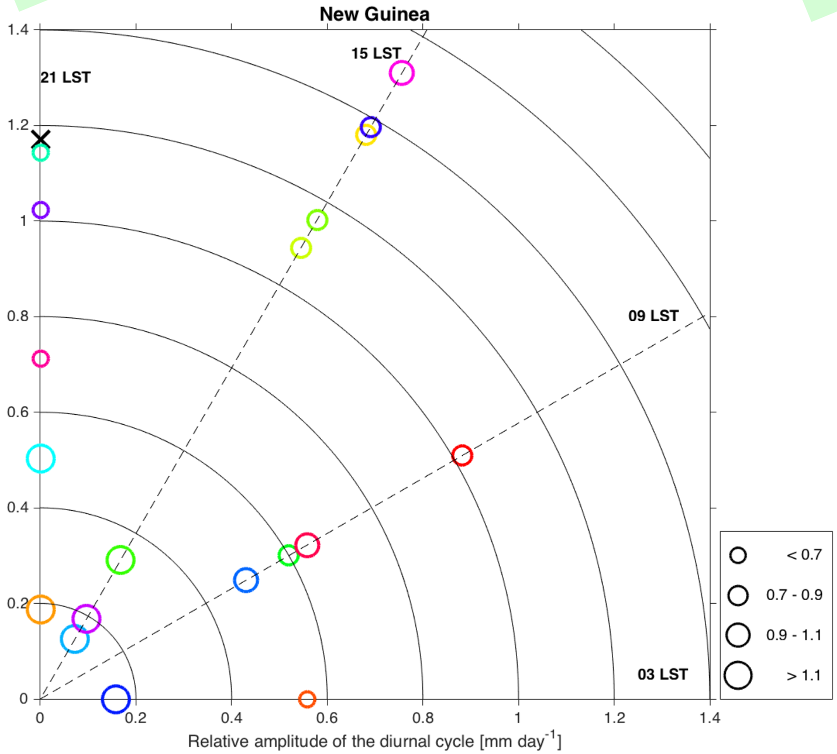
Reversed diurnal cycle | Weak diurnal cycle | Good diurnal cycle



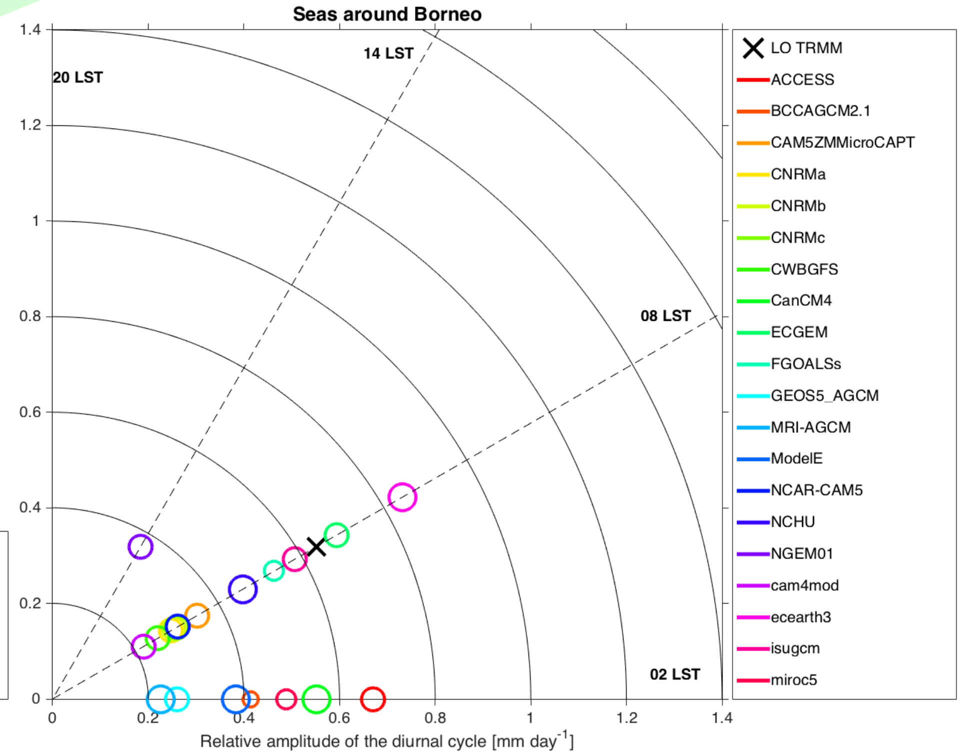
AmPm index indicates zonal variability in excess nighttime (positive values) or daytime (negative values) precipitation. It qualitatively shows skill of the model to reproduce the land-ocean contrast in phase and relative amplitude of the diurnal cycle

Combined Diurnal Cycle Phase, Amplitude and Mean Precipitation

Land Example



Ocean Example



Time refers to Maximum

From Darek Baranowski and Duane Waliser

Workshop on Intraseasonal Processes and Prediction in the Maritime Continent

11-13 April 2016, Singapore

- Objectives:
  - Address interactions between the MJO and the Maritime Continent, with the goal of improving weather forecasts and climate model simulations of the MJO and related phenomena
  - Interactions of the MJO in the MC region with diurnal cycle, synoptic variability, the monsoons, ENSO, the land surface, the ocean
  - Discuss NWP and climate model simulations of subseasonal variability in the MC region, focusing on: Model bias and other errors and subseasonal prediction
  - Foster future collaboration plans among S2S and MJOTF
- Participation from ~100 international and local participants

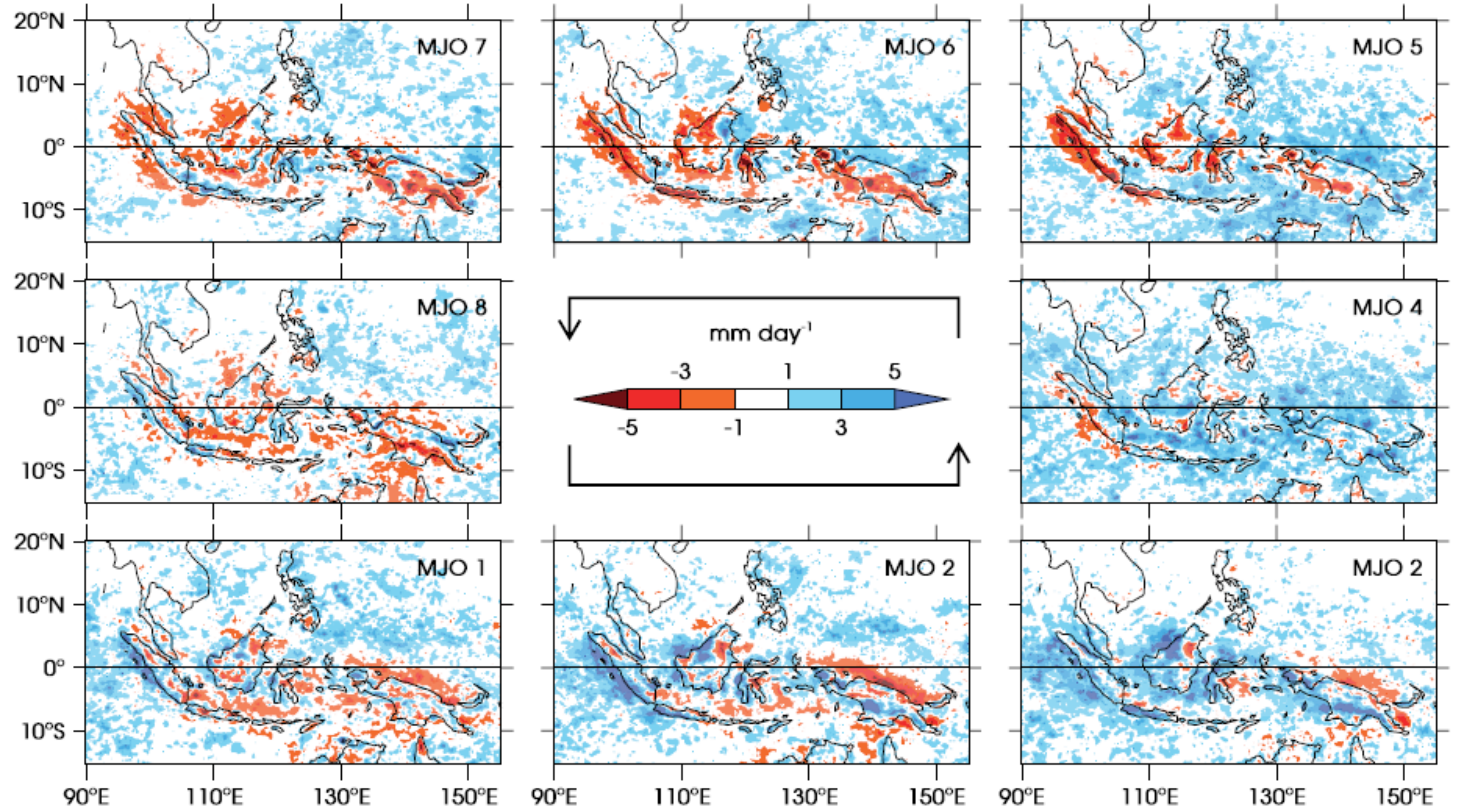


Figure 7. Anomaly of the amplitude r_d of the diurnal harmonic of precipitation from TRMM 3B42HQ in each phase of the MJO. This figure is available in colour online at wileyonlinelibrary.com/journal/qj

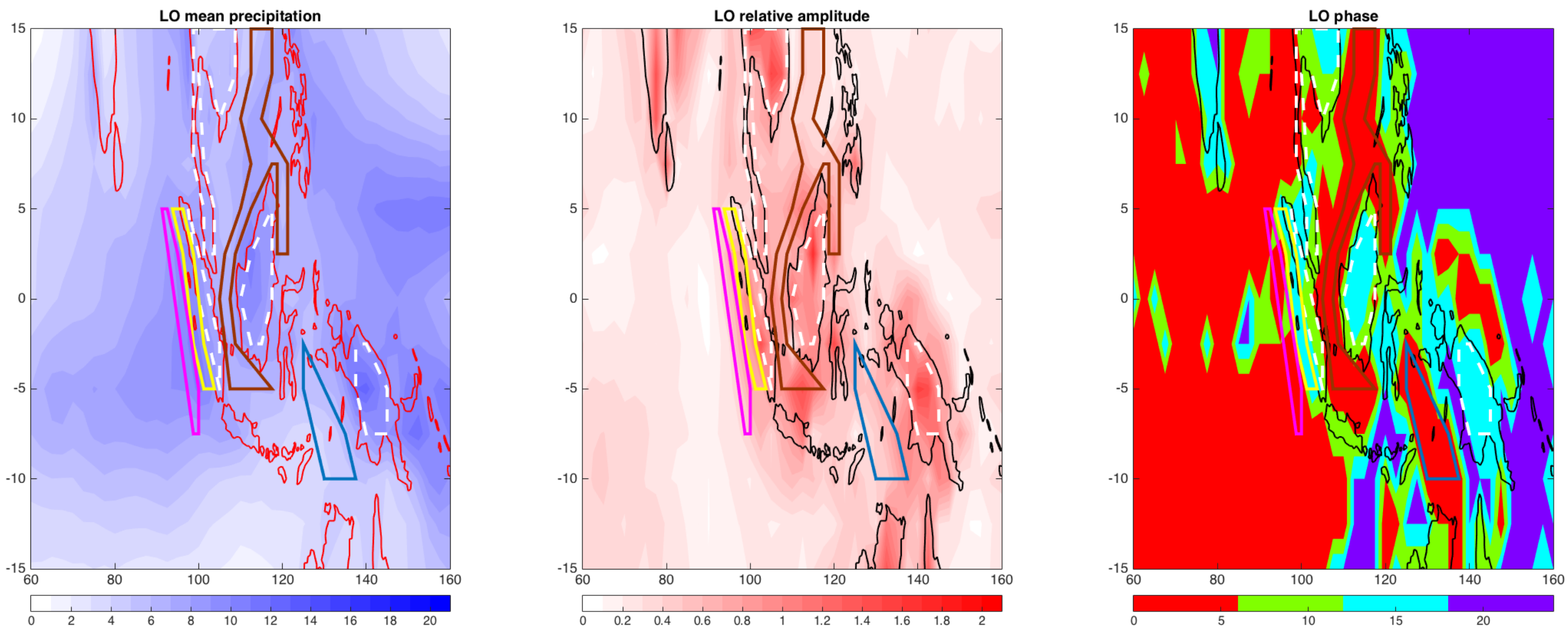
Peatman et al. (2013)

The modulation of the diurnal cycle by the MJO is much less spatially coherent than for the modulation of the mean MJO rainfall anomaly.

TRMM 3B42HQ rainfall, 1998-2012.
Nov-Apr

$$r = \bar{r} + r_d \cos\left\{\frac{2\pi}{\tau}(t - t_0)\right\},$$

Identify Variables and Regions for Focused Analysis



Variables:

- Mean precipitation (left)
- Amplitude of the diurnal cycle (middle)
- Phase (hour of the diurnal precipitation *minimum*) of the diurnal cycle (left)

Regions

- 4 land-surface regions

Sumatra, Borneo, New Guinea, SE Asia

- 4 ocean-surface regions

W. Sumatra, E. Indian Ocean, Banda Sea, Seas Around

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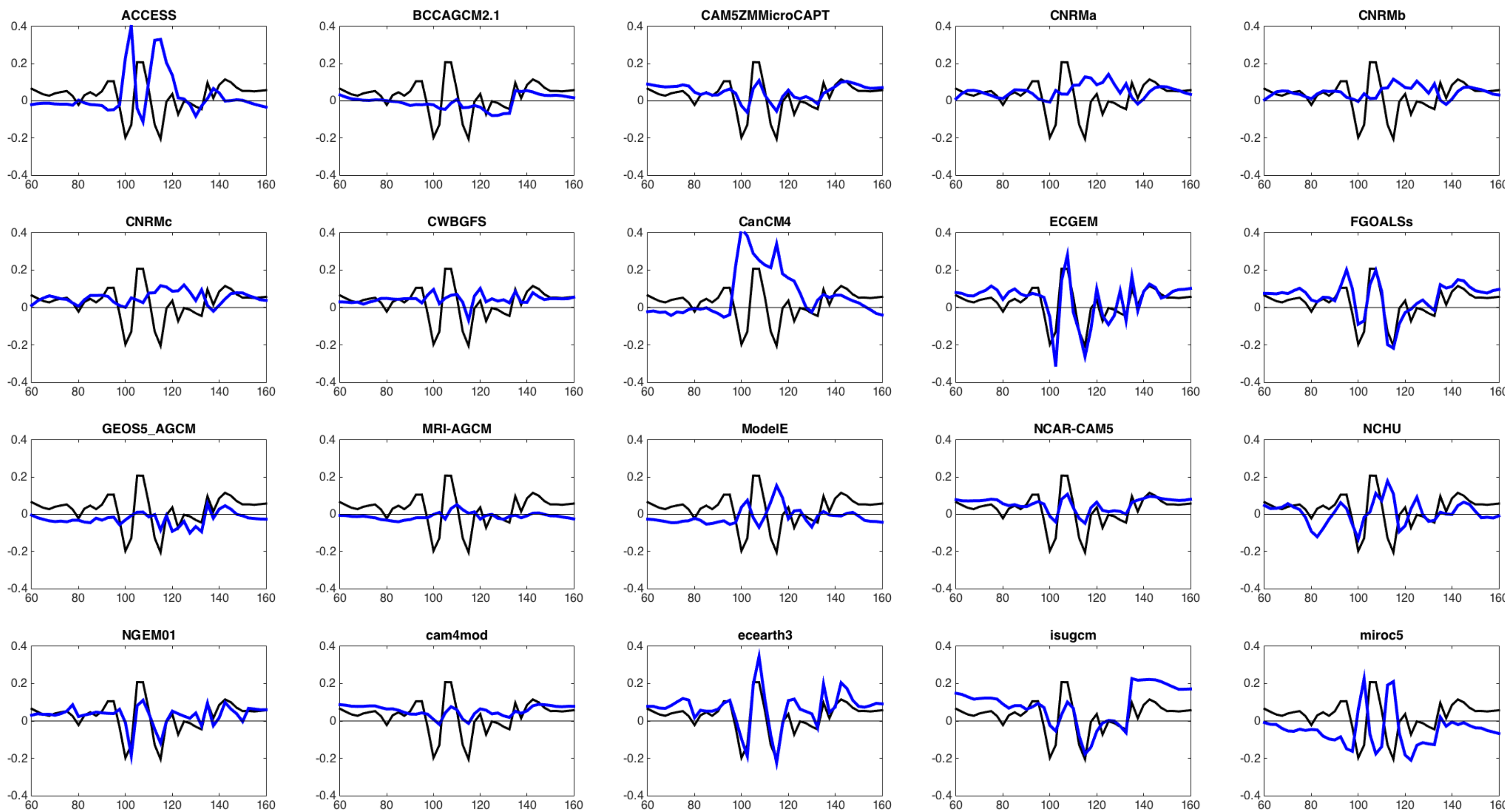

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