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CLOUD AND RAINFALL STATISTICS FROM THE MJO AND THE ITCZ OVER THE INDIAN OCEAN

Rachel Sodowsky*
University of Miami RSMAS, Miami, Florida

1. INTRODUCTION

The Madden-Julian Oscillation (MJO) is the largest source of intraseasonal variability in the tropics (Zhang 2005) and is an important link between weather and climate (Zhang 2013). The MJO is a key target for the improvement of subseasonal weather-climate forecasting, providing a major source of subseasonal (2-12 week) predictability (Waliser et al. 2003). Most global climate models are unable to reproduce the signal of the MJO (Hung et al. 2013), which limits interannual and seasonal forecast skill (Yoneyama et al. 2013). The Dynamics of the MJO (DYNAMO) field campaign was motivated by the low prediction skill of the initiation of the MJO and the inability of global models to simulate the MJO. One of the surprising outcomes of DYNAMO was the observed interaction between the MJO and ITCZ that was seen for the first time (Yoneyame et al. 2013). Before DYNAMO, the perception of MJO initiation was that it began from suppressed convective conditions over the Indian Ocean (IO), which graduallly transitioned to active convection. But during DYNAMO active convection was observed during the suppressed phase of the MJO in the ITCZ prior to the initiation of two of the observed MJO events.

The purpose of this study is to determine if there is a robust regime change in convection between the ITCZ and MJO at the initiation stage of the MJO by analyzing cloud and rainfall. This is the first step in determining the dynamical relationship between these two distinctive forms of convective organization, which has the potential to lead to a new mechanism for MJO initiation.

2. DATA AND METHODS

In this study, TRMM version 7 products are used to calculate convective properties of the ITCZ and MJO for the years 1998-2013. TRMM 3B42 has a temporal resolution of 3 hours and horizontal resolution of 0.25° X 0.25° but is converted to daily values for calculations. This product uses TRMM PR observations and passive-microwave measurements. TRMM 2A23 and TRMM 2A25 products are used to create daily rectilinear 1.0° gridded version of the TRMM PR rain rate and type. Type classifications include stratiform, convective, shallow convective and deep convective.

To objectively analyze the southern ITCZ over the IO, criteria have been developed to identify the ITCZ in TRMM rain rate data. The total rain rate composite for the years 1998-2013 shows an ITCZ like signal (Fig. 1). The longitudinal range is restricted to 60°E to 90°E. This range captures the strongest rain rate values over the IO and avoids capturing convection associated with the maritime continent to the east. Because this research is focused on the interaction between the ITCZ and the MJO, the rest of the criteria are based on the months of November, December, January, February, and March (NDJFM) when the MJO is most prevalent. PDFs of the position of maximum and minimum rain rates indicate rainfall peaks of the ITCZ are generally between 14°S and 3°S in NDJFM (not shown). The northern minimum rain rate of the ITCZ is between 3°S and 3°N. In order to further define the ITCZ, difference between the maximum and minimum rain rate averaged over 60 – 90˚E is taken for each day. The PDF of the difference shows that approximately 72% of cases have a difference of 0.5 mm/h or less (Fig. 2). Days are classified as an ITCZ day if the difference between the maximum and northern minimum rain rates is greater than 0.5 mm/hr. The southern edge of the ITCZ must reach the same value as the northern minimum rain rate value north of 15°S. Following these criteria 306 ITCZ events are found. ITCZ events lasting only one day are removed leaving 203 ITCZ events for analysis. Figure 3 shows the composite of all ITCZ days.

The MJO is identified by tracking the eastward propagation of organized rainfall across the IO. The local measure of the MJO, which is described in Ling et al. (2014), uses strength, eastward propagation speed, and timing of precipitation in a given longitudinal sector to identify MJO events.

Statistics of convection for the ITCZ are calculated in the box 15°S-3°S by 60°E-90°E. Statistics for the MJO are calculated in the box 15°S-15°N by 82°E-100°E. Both the ITCZ and MJO domains have the same area size for consistency.

3. RESULTS

Preliminary results suggest that there is little statistical difference between the rain statistics of the ITCZ and MJO. PDFs of rain rate for all identified ITCZ and MJO events (Fig. 4) show that the peak for the MJO (4 mm/h) is to the right of the peak for the ITCZ (3.5 mm/h). The convective rain rate PDF for the MJO is wider when compared to the ITCZ distribution, suggwsting that the MJO has higher and more variable rain rates compared to the ITCZ. However when the distributions are compared using the Kolmogorov-

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*Rachel Sodowsky, University of Miami RSMAS Miami, FL 33149; email: rsodowsky@rsmas.miami.edu

Smirnov (KS) test, they do not show significant difference.

Area fraction is calculated by dividing the all the rainy pixels in the domain by he total number of pixels in the domain. The area fraction PDF for both the ITCZ and MJO (Fig. 5) both peak at 20% area coverage but the MJO distribution is wider than the ITCZ distribution again suggesting the MJO is more varied than the ITCZ. But the KS test indicates no significant difference.

Convective-stratiform (CS) ratio is found by dividing the convective rain rate by the stratiform rain rate. The PDF of CS ratio is plotted for the ITCZ and MJO (Fig. 6), but the distributions have no significant difference based on the KS test.

4. SUMMARY

The ITCZ was defined by criteria base on analysis of rain rate data over the IO. Preliminary analysis of the ITCZ and MJO suggests little statistical differences between the two phenomena in the rain characteristics. Further analysis using a TRMM precipitation feature data set (Liu et al. 2008) will be conducted to determine the validity of this. Radar data collected during the DYNAMO field campaign needs to also be analyzed to study MJO and ITCZ characteristics on a case study basis.

5. FIGURES

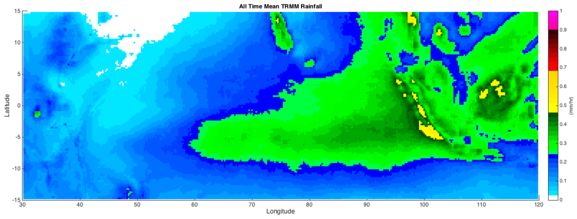

Figure 1. Composite of the total rain rate from 1998-2013 using TRMM 3B42 0.25°X0.25° 3 hourly data.

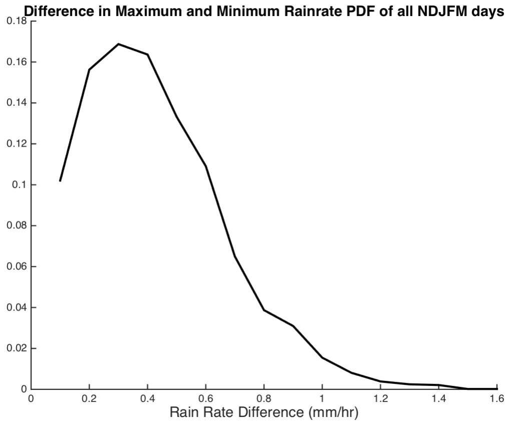

Figure 2. PDF of the difference between the maximum and minimum rain rate averaged over the longitudinal rang of 60 – 90˚E.

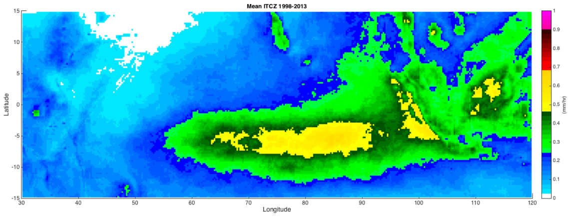

Figure 3. Composite of the total rain rate of all ITCZ days from 1998-2013 using TRMM 3B42 0.25°X0.25° 3 hourly data.

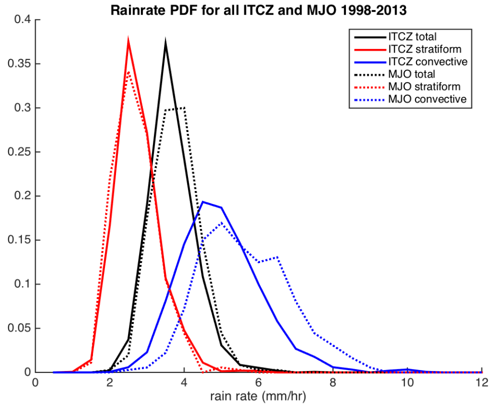

Figure 4. PDFs for total rain rate (black), stratiform rain rate (red), and convective rain rate (blue) for all ITCZ (solid lines) and MJO (dashed lines) events from 1998-2013.

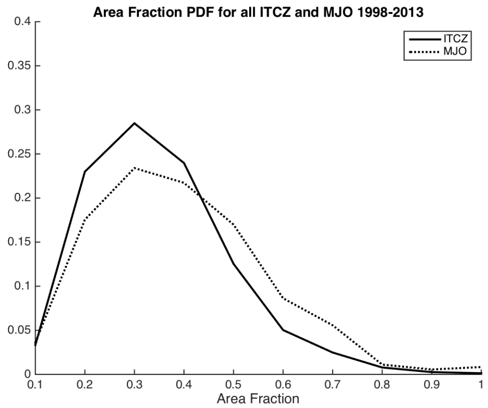

Figure 5. PDF of area fraction for all ITCZ (solid lines) and MJO (dashed lines) events from 1998-2013.

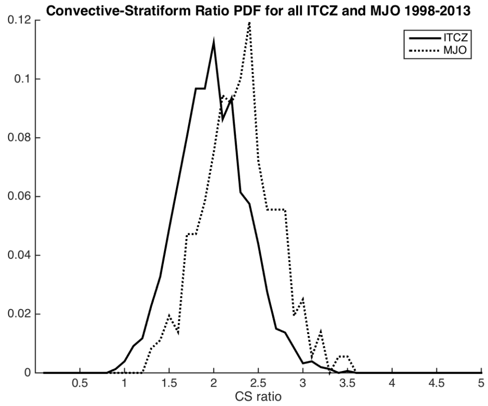

Figure 6. PDF of convective-stratiform ratio for all ITCZ (solid lines) and MJO (dashed lines) events from 1998-2013.

6. REFERENCES

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