Statistics of the Madden-Julian Oscillation (MJO) Amplitude

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ABSTRACT: The MJO is the dominant intraseasonal (20-100 day) variability in the tropics. It propagates eastward at 5 m/s. An MJO event is separated into eight phases that correlates to the location of the MJO event. An MJO is measured by an amplitude per day. The amplitude is comprised of three components: outgoing longwave radiation (OLR) at the top of the atmosphere, 200 hPa zonal wind, and 850 hPa zonal wind. A relative index was created to categorized the amplitude from weak to strong. This index was used to break down the total days of data into the individual phases and showed that phase seven has the highest amount of days in the strong index. The three components that make up the amplitude were also broken down to find their relative contributions, which shows that the MJO amplitude is dominated by circulation anomalies and not convection. The spring and summer seasons were also compared by phases and the three contributing components.

INTRODUCTION

In 1971, Roland Madden and Paul Julian discovered Madden-Julian Oscillation (MJO) as a center of strong deep convection and precipitation that propagates eastward at 5 m/s in the tropics (Madden and Julian 1972). It is the major fluctuation in tropical weather on a weekly to monthly timescale (20-100 day) implying that there can be multiple MJO events within a season. An MJO event is separated into eight phases, which geographically correlates with the location of the MJO event. Each phase is approximately five to seven days creating a life cycle of 40-60 days (Fig. 1). This event appears every 20-100 days equaling five to six events per year. MJO events influence precipitation over the West Coast of the United States, Pacific maritime continents, and Australia (Zhang 2005). They also influence El Nino events, and tropical cyclones in Pacific Ocean and Caribbean Sea (Zhang 2005). The strength of an MJO event is measured by an amplitude per day. This amplitude is comprised of three components: Outgoing Longwave Radiation (OLR), 200 hPa zonal winds, and 850 hPa zonal winds (Wheeler and Hendon 2004). The 200 hPa winds are diverging aloft and 850 hPa winds are converging near the surface creating a strong MJO convective center.

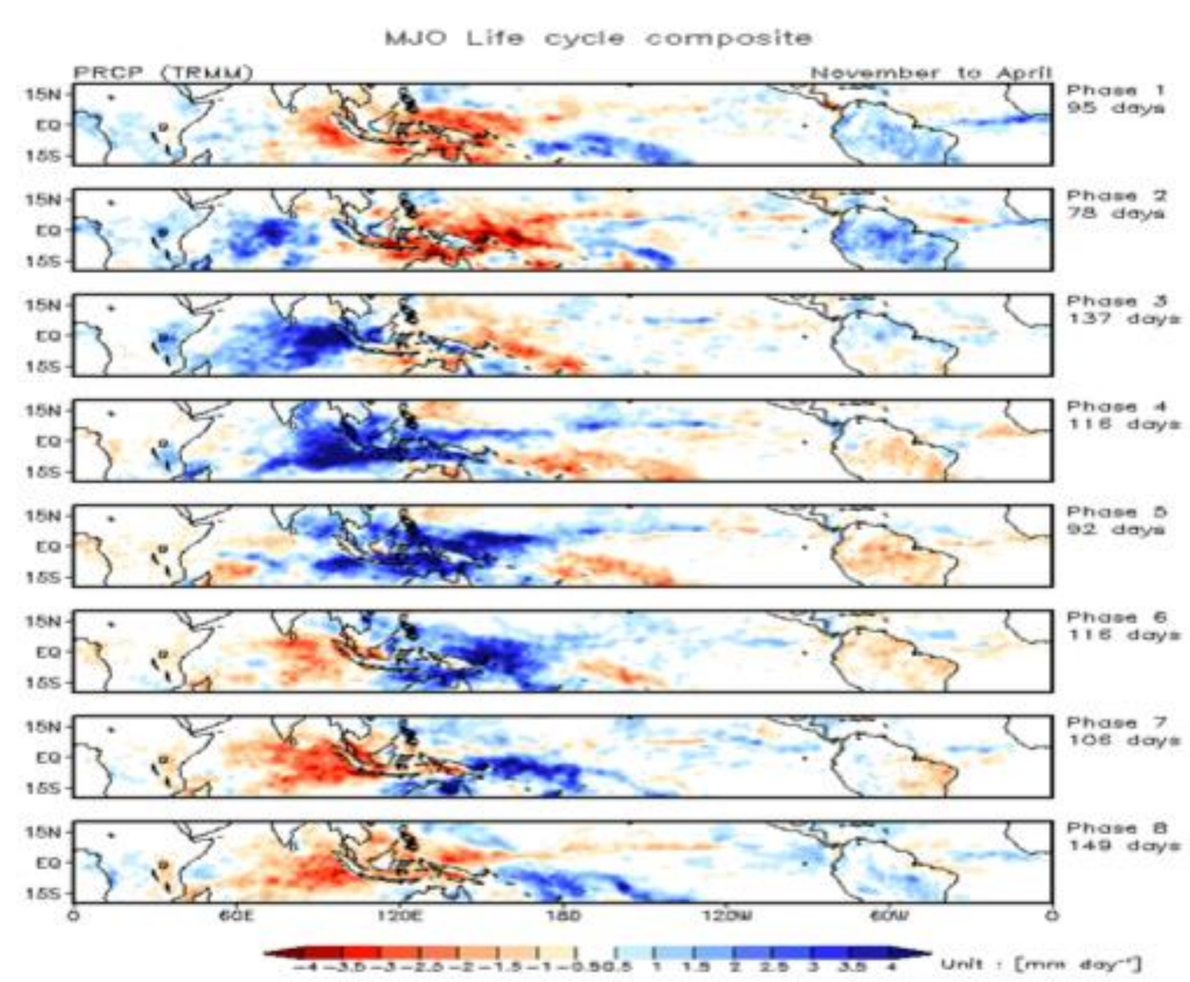

Figure 1. MJO life cycle for November to April from CLIVAR MJO working group.

METHODS

Data was collected from The Centre for Australian Weather and Climate Research for the MJO amplitude and the three components. Then, using Matthew Wheeler and Harry Hendon's index of amplitude from zero to four, I created a relative index of strength to separate the daily amplitudes.

Excel was then used to separate the amplitude and the three components for the total number of days, January 1, 2002 to July 14, 2015, into the four strength categories and eight phases. Then the amplitude and three components were separated by season: spring, summer, winter, and fall.

Index	Relative Intensity
≥3	Strong
2.0-2.99	Medium
1.0-1.99	Normal
<1	Weak

Table 1. MJO subjective amplitude strength index.

RESULTS

When looking at the distribution of the MJO amplitude between the eight phases for the total data series (Figure 2) interesting conclusions can be made. First, phase seven has the most days in the strong category. Second, phase five does not have a strong category. Third, there are a large amount of days in the normal and weak categories in phases one, two, and four through six. The MJO in phases seven and eight create wet conditions for the West Coast of the United States meanwhile the MJO in phases one, two, and four create dry conditions (Bond 2003). The three fractional components were plotted to find the mean contribution from each component. It is seen that the OLR contribution is approximately 14% whereas the 200 hPa zonal wind contributes 45% and 850 hPa zonal wind contributes 41%.

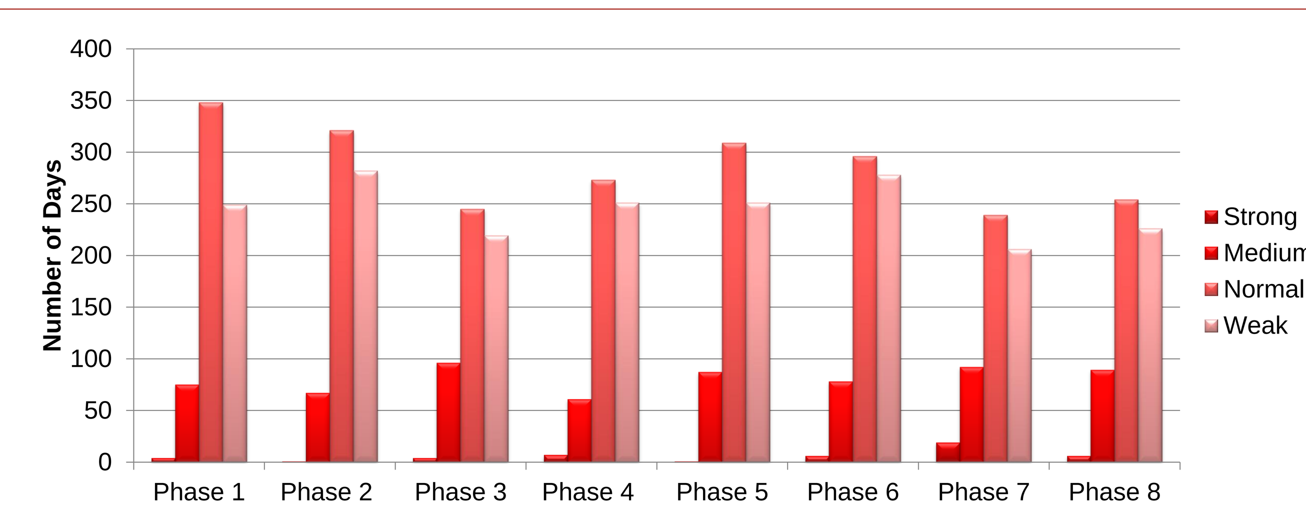

Figure 2. Distribution of MJO amplitudes from using data from January 1, 2002 to July 14, 2015

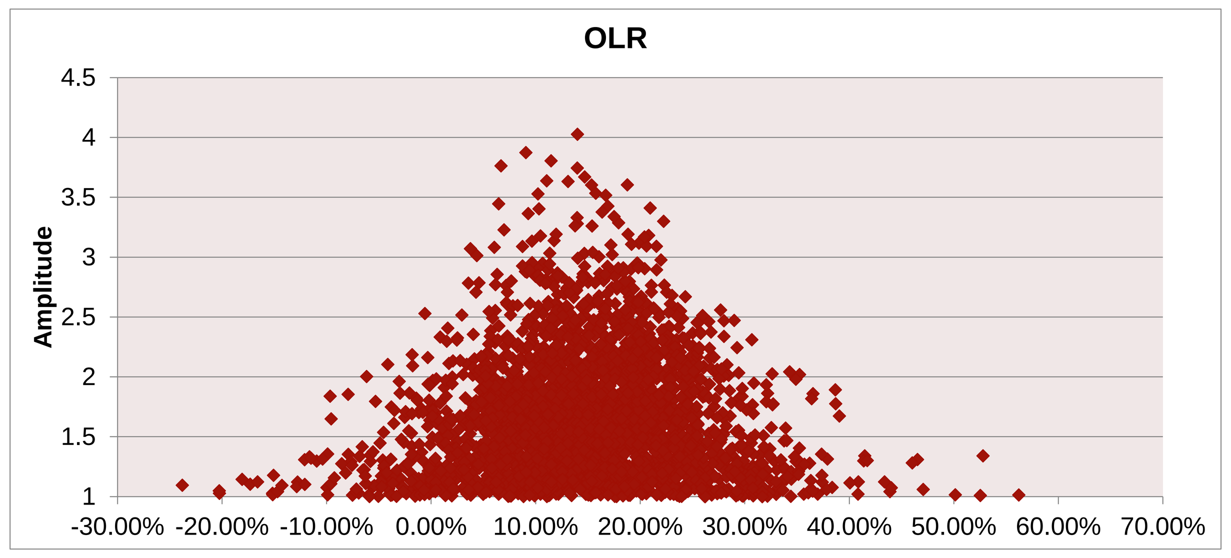

Figure 3. OLR fractional component mean contribution

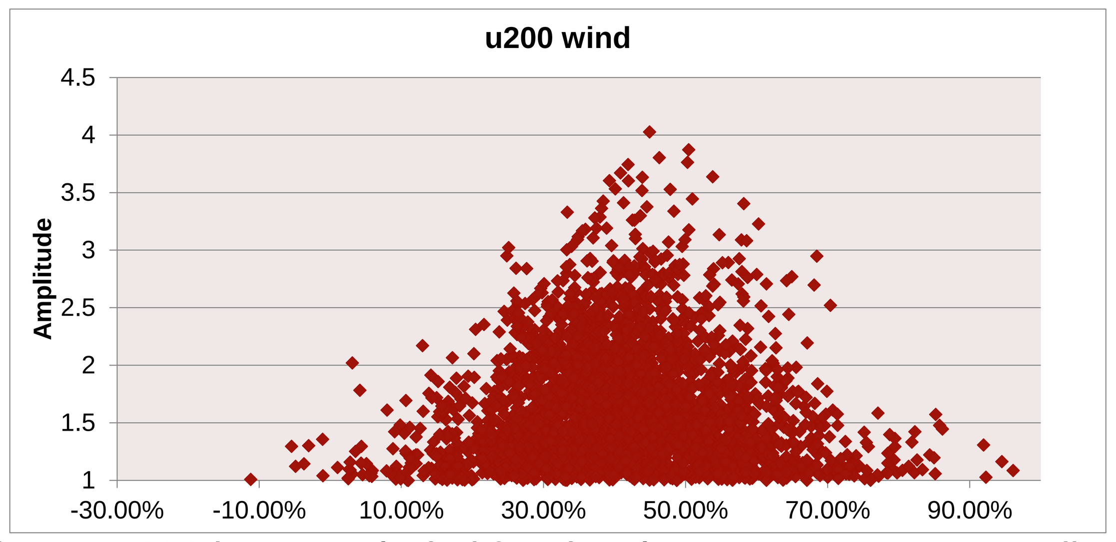

Figure 4. 200 hPa zonal wind fractional component mean contribution

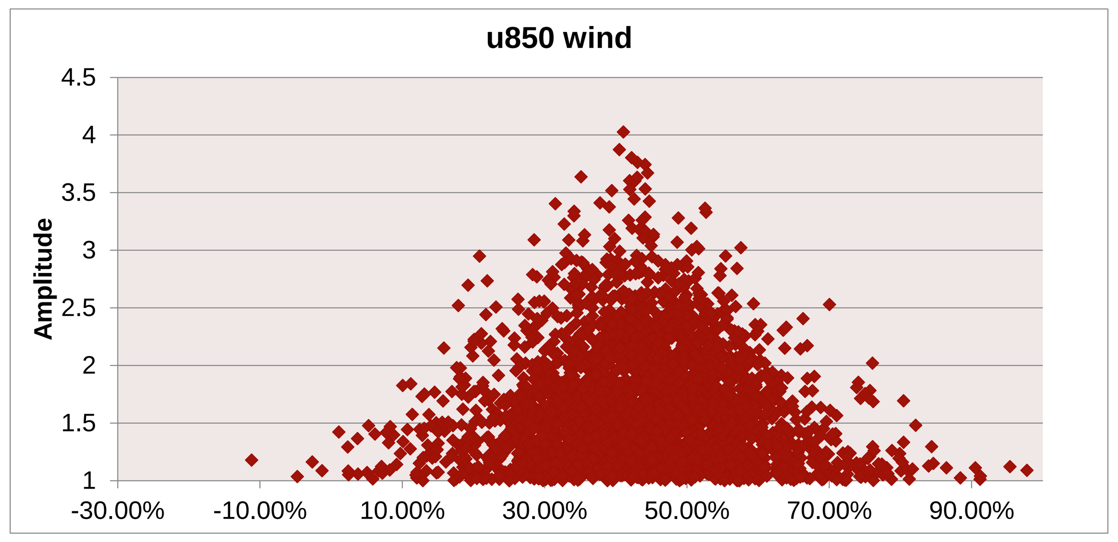

Figure 5. 850 hPa zonal wind fractional component mean contribution

DISCUSSION and CONCLUSIONS

An MJO event is relatively new in meteorological sciences and has many characteristics that can be studied further. Using a relative index, phase seven has the highest amount of days in the strong category. This is due to the warm SST that influences the MJO amplitude in multiple ways. It was found that MJO amplitudes are driven by circulation anomalies and not convection when looking at the three fractional components. When comparing spring and summer seasons, it was found that spring has the highest amount of strong events whereas summer has yet to see a strong event until just this past year. For the fractional component breakdown of the spring and summer seasons, the 850 hPa zonal wind is consistent at 43% whereas the 200 hPa zonal wind and OLR components varies. Future work for the MJO amplitude includes changing the relative index to percentiles and comparing other season and their respective contributions. Also the time range can be extend from January 1, 2002 to June 1, 1976 by calculating the contributions by three components.

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Acknowledgements

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Engineering & Science Student Design Showcase at Florida Institute of Technology