Improving Atlantic Hurricane Predictions with the Madden-Julian Oscillation

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Introduction

The Madden-Julian Oscillation (MJO) and Atlantic hurricanes

- The MJO is a pattern of tropical winds and precipitation that repeats on average every 30-60 days.
- We found that the oscillation, which travels eastward from Asia to Africa, modulates Atlantic hurricanes.
- This information might be used to predict Atlantic hurricane activity a few weeks in advance.

Objective

- To improve the prediction of Atlantic hurricanes with the MJO for better preparedness and preparation.

Data

- National Hurricane Center HURDAT data
- Matthew Wheeler's RMM1 and RMM2 indices for 1974-2008

Methods

- RMM1 and RMM2 are times series that when combined give the strength and sign of the MJO.
- RMM1 and RMM2 are derived from empirical orthogonal function analysis on equatorial winds in the upper and lower troposphere and tropical convection.
- With this data, Figure 3 was created which breaks the data into the MJO phases.
- Hurricane genesis locations from HURDAT are related to the MJO index.
- The next step was to match the phase dates with their corresponding hurricane date.
- Figure 4 was produced to display the genesis locations of the Atlantic hurricanes as a function of the MJO.

Results

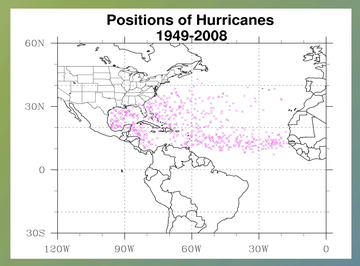
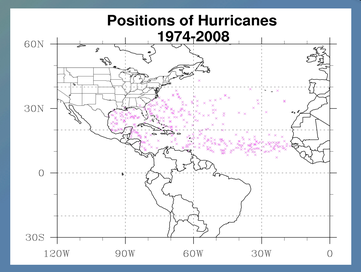


Figure 1 (left). Genesis locations of Atlantic hurricanes from 1949-2008. Figure 2 (right). Genesis locations of Atlantic hurricanes from 1974-2008



- In Figure 1 and 2 the pink dots represent the genesis locations of the hurricanes.
- Genesis locations were concentrated near the Atlantic ITCZ and the Gulf of Mexico.

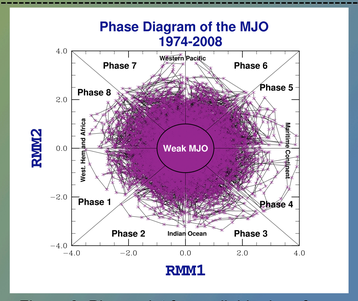


Figure 3. Phase plot for available days from 1974-2009. Also labeled are the weak MJO and approximate locations of the signal.

- This phase plot allowed us to use RMM1 and RMM2 to break the data into different MJO phases.
- After generating these phases, Figure 4 was produced.

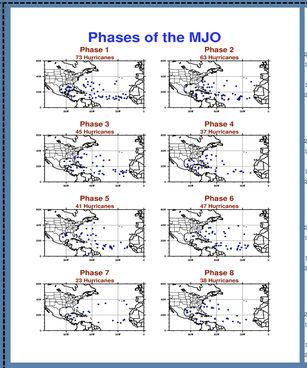


Figure 4. Position of genesis locations of Atlantic hurricanes as a function of MJO phase.

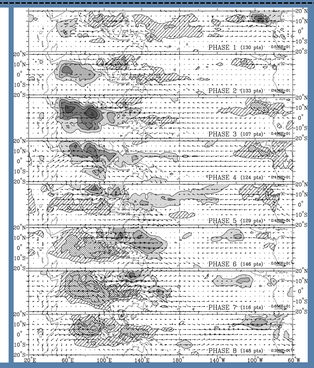


Figure 5. Composite of OLR and 850-hPa wind vector anomalies (Wheeler and Hendon 2004)

- Figure 4 allows two conclusions to be made: Phase 1 and 2 have the most genesis locations while Phase 7 had the least amount.

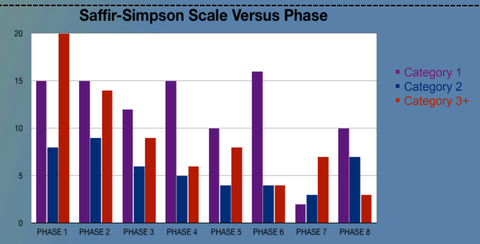


Figure 6. Bar graph showing strength of hurricanes per phase.

- Producing Figure 6 allowed us to see the varying strength of hurricanes as the MJO evolves.
- Major hurricanes (> Category 3) are preferred during MJO phases 1 and 2.

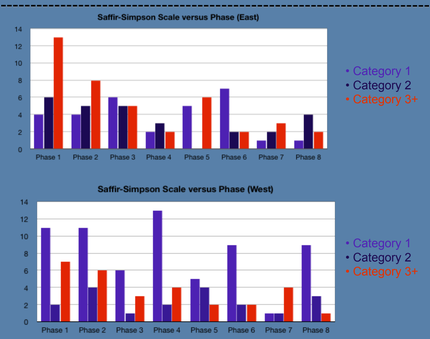


Figure 7 (top). Bar graph showing Category strength in the East Atlantic Ocean. Figure 8 (bottom) Bar graph showing Category strength in the West Atlantic Ocean

- Figures 7 and 8 partition hurricane activity for the East and West Atlantic basins.
- These graphs lead to conclusions about the strength in the East and West Atlantic Ocean.

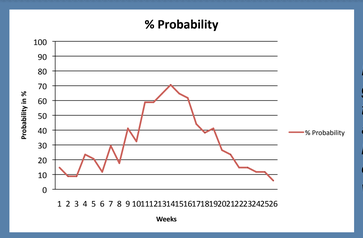


Figure 9. Line graph showing the probability of a hurricane happening in one of the given weeks.

- The MJO and hurricane climatology can be used to improve forecast.
- This graph contains 26 weeks that have 7 days in one week. The starting date is May 1st and the ending date is December 5th.
- The probability of a hurricane is higher between the weeks 11 and 17 or Mid-August to October.

Conclusion

- We demonstrated a strong cycle in Atlantic hurricane activity as a function of MJO phase.
- Phase 7 of the MJO does not produce many hurricanes, while Phases 1 and 2 have increased hurricane activity.
- Category 3 and higher hurricanes were four times more likely to form in the eastern part of the basin during Phases 1-3 than during Phases 6-8.

Future Work

- Use knowledge of the MJO, El Niño and seasonal cycle of hurricane activity to make hurricane activity forecast.

References

- Leroy, Anne, and Matthew C. Wheeler, 2008 Statistical Prediction of Weekly Tropical Cyclone Activity in the Southern Hemisphere. *Mon. Wea. Rev.*, **136**, 3637-3654
- Wheeler, Matthew C., and Harry H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development and Index for Monitoring and Prediction. *Mon. Wea. Rev.*, **132,** 1917-1932
- Maloney, Eric D. and Dennis L. Hartmann, 2000: Modulation of Hurricane Activity in the Gulf of Mexico by the Madden-Julian Oscillation. *Science*, **287**, 2002-2004.

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