The Madden - Julian Oscillation and severe convective storm hazards in the U.S.

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Introduction

- Severe wind results in significant economical and safety impacts across the United States.
- It is not well studied how planetary-scale systems might impact weather on smaller scales such as synoptic or mesoscale, in the United States.
- The leading cause of atmospheric variability on intraseasonal (30-60 day) timescales is the Madden-Julian Oscillation (MJO; Madden and Julian 1972).
- The atmospheric response to MJO is planetary-scale wavetrains in the upper-atmosphere, and these might affect local weather events in the central U.S.
- MJO modulates many synoptic-scale weather phenomena: precipitation, air temperature, cloud cover and circulation.
- MJO is not the primary determinant of local scale weather, however understanding the link between MJO and extreme weather, such as wind, could significantly improve modeling and forecasting of extreme weather phenomena.

Methods

- Create MJO phase composites using the Wheeler-Hendon Real-time Multi-variate MJO Index (Fig. 1; Wheeler and Hendon 2004)
- Divide the MJO into 8 phases that roughly follow the original description of Madden and Julian (Fig. 2); define an active phase as one with the square root of the sum of squares of both empirical orthogonal functions larger than 1 ("neutral" phase less than or equal to 1).
- Use the following data sets: (1) U.S. storm reports (maintained by SPC WCM); (2) North American Regional Reanalysis (NARR); and (3) Wheeler-Hendon Real-time Multivariate MJO Index (RMM)
- Create a wind-day dataset for a 1° x 1° lat-lon grid.
- Create composites of atmospheric circulation (300-hPa height), convective available potential energy (CAPE), and surface to 6 km bulk shear, from 1990-2013, for the months of April, May, and June (months with the most wind reports).
- $CS06 = CAPE \times Shear^{1.67}$, where shear is weighted higher than CAPE
- Calculate anomalies for each of the 8 MJO phases for each variable

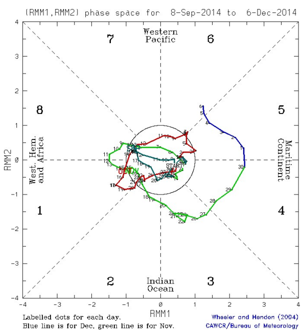


Fig. 1: Example of Wheeler-Hendon RMM progression

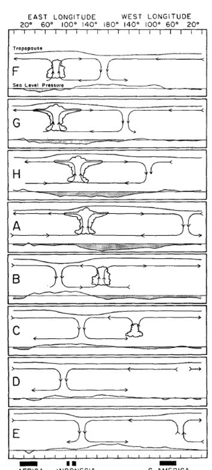


Fig. 2: Phases of MJO (Madden and Julian 1972).

Purpose

- Examine teleconnections between the leading mode of atmospheric intraseasonal variability, the Madden-Julian Oscillation, and extreme weather events in the central U.S.
- Stratify April, May, and June U.S. severe wind frequency by phase of the Wheeler-Hendon RMM Index
- Connect observed trends in severe wind activity with variability, by MJO phase, of atmospheric circulation, stability, and wind shear

Results: wind-day climatology

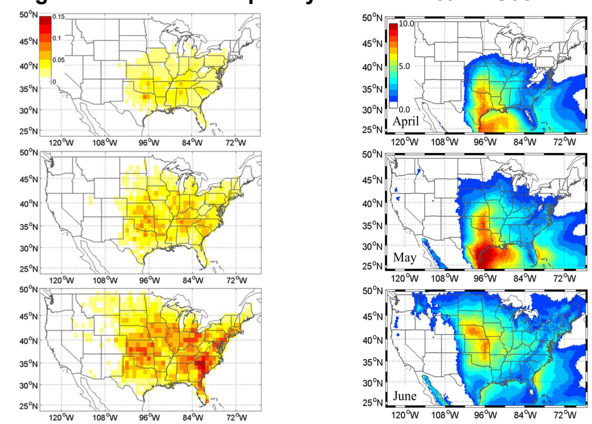
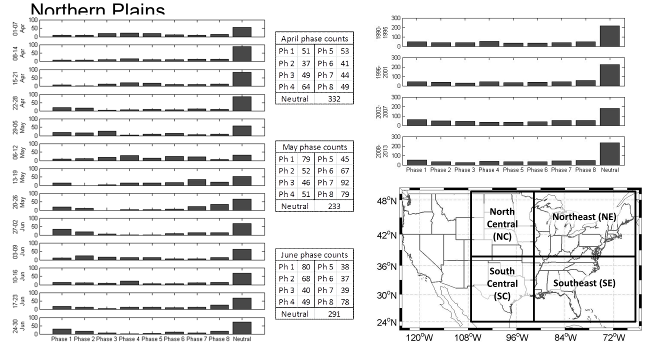


Fig. 3: Average severe wind frequency (left panel) and climatology of CAPE x 0-6 km shear (CS06; right panel), for April-June 1990-2013.

- Severe wind frequency increased from April to June, particularly in the SE.
- CS06 increases from April to May, with maximum in the Southern Plains in May. By June, CS06 maximum shifts northward into the Central and Northern Plains



April phase counts			
Ph 1	51	Ph 5	53
Ph 2	37	Ph 6	41
Ph 3	49	Ph 7	44
Ph 4	64	Ph 8	49
Neutral	332		

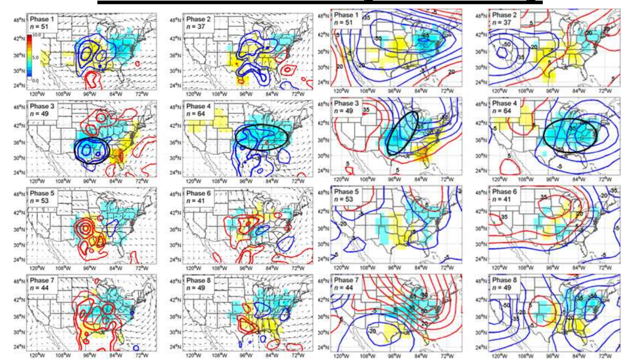
May phase counts			
Ph 1	79	Ph 5	45
Ph 2	52	Ph 6	67
Ph 3	46	Ph 7	92
Ph 4	51	Ph 8	79
Neutral	233		

June phase counts			
Ph 1	80	Ph 5	38
Ph 2	68	Ph 6	37
Ph 3	40	Ph 7	39
Ph 4	49	Ph 8	78
Neutral	291		

Fig. 4: Counts of MJO phases (RMM 1-8 and neutral) by week (left panel), month (central tables), and 6-year period (upper-right panel). Regional divisions used in this study (lower-right panel).

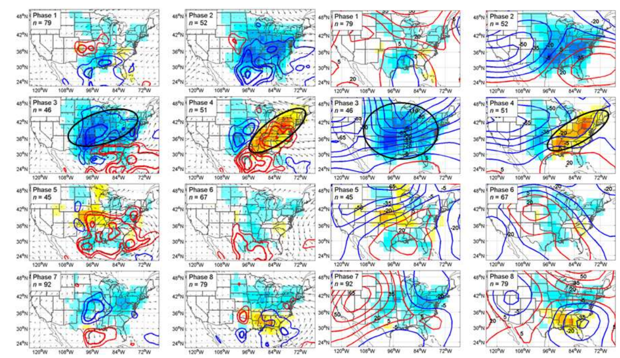
- MJO phases showed some week-to-week variability, however were approximately evenly distributed throughout each month (April, May, and June)
- MJO phases were approximately evenly distributed for each 6-yr period for this study

Results: wind-day variability



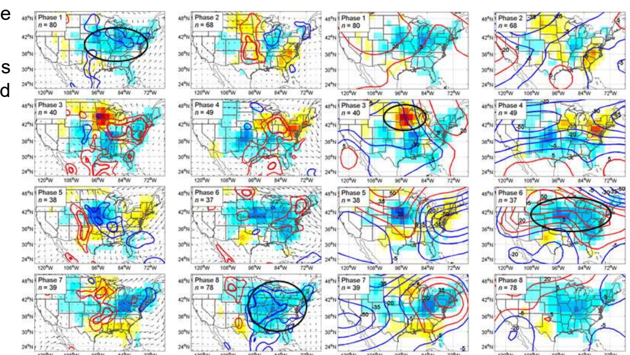
April

Best agreement between wind day anomalies and both CS06 and 300-hPa height anomalies were phases three and four.



May

Best agreement between wind day anomalies and both CS06 and 300-hPa height anomalies were phases 3 and four.



June

Best agreement of CS06 anomalies and wind day anomalies were phases one and eight. Best agreement for 300-hPa height anomalies and wind day anomalies were phases three and six.

Conclusions and future work

- Generally, positive CS06 anomalies were co-located with positive severe wind anomalies and vice versa
- .Less agreement between 300-hPa height anomalies and wind day anomalies, compared to CS06 figures, but still shows strong correlations in certain phases.
- The likelihood of severe wind varies by phase of MJO.

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