P 5 Using the Daily Change in the Southern Oscillation Index to Develop Analogues and the Relationship to Severe Weather Outbreaks

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Introduction

- Renken et al. (2017) show that there is periodicity in the large-scale flow on the time-scales of two to four weeks. They also showed that this predictability can be exploited to project the occurrence of extreme conditions (two-sigma) over the central USA in advance via teleconnectivity in the PNA pattern.
- They defined an East Asian Rule (one –to – two week) and a Bearing Sea Rule (three-to-four weeks) that corresponded to statistically significant peaks in the Fourier decomposed PNA Index time series and likely based on long period Rossby waves.

Motivation/Objective/Goal

- Renken et al. (2017) showed that a severe weather outbreak in late April 2014 was correlated with negative BSR Index values during the event as well as 20-21 days prior to the event itself.
- The goal of this work was to correlate changes in the daily Southern Oscillation Index with the outbreaks of severe weather and determine if severe weather could be anticipated days in advance.
- Thompson and Roundy (2013) correlated Madden-Julian Oscillation and U.S. violent tornado outbreaks in the spring.
- Allen et al. (2015) correlated the Influence of the El Niño/Southern Oscillation on tornado and hail frequency in the United States.

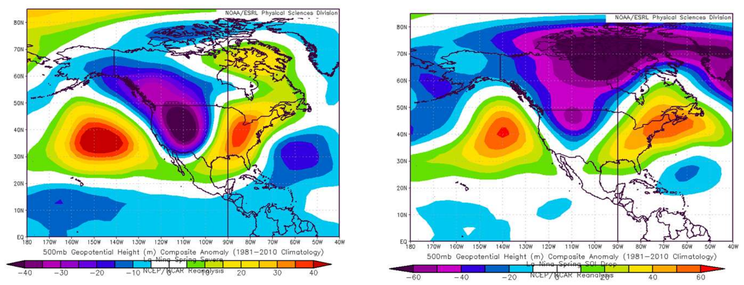

Figure 1. The observed 500 hPa height anomalies for 108 La Nina type spring season severe weather days (left) and the 500 hPa height anomalies for 17 days previous to the severe weather and with a 10 point or more daily Southern Oscillation decrease.

Table 1. the 10-point daily changes in the SOI by ENSO Phase for days with 20 or more tornado reports 9 – 11 days (EAR) and 19-21 days (BSR) before outbreak. The total number of outbreaks identified does not include events identified by both. The percentages are probability of detection.

	LN	EN	NEU	Total
a)				
9 – 11 day	28 / 43%	53 / 42%	79 / 42%	150 / 42%
19 – 21 day	19 / 29%	45 / 44%	73 / 39%	137 / 39%
No SOI change	22	29	56	107
Total w/o overlap	43 / 66%	74 / 72%	131 / 70%	248 / 70%
b)				
9 to 11 day	31 / 48%	45 / 44%	82 / 44%	158 / 45%
19 – 21 day	20 / 31%	38 / 37%	72 / 39%	130 / 37%
No SOI change	22	39	66	127
Total w/o overlap	43 / 66%	64 / 62%	121 / 65%	228 / 64%
Total Outbreaks	65	103	187	355

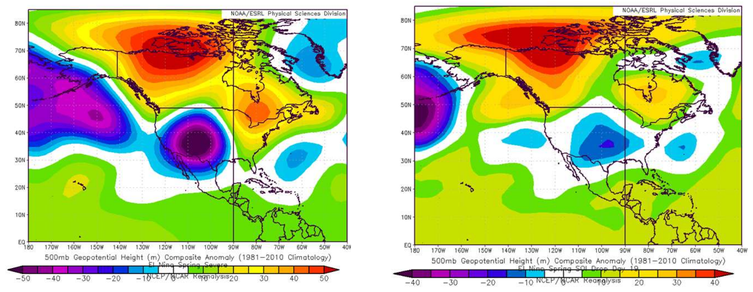

Figure 2. As in Fig. 1, except for 80 El Nino type composites and 18 days previous to the event.

Table 2. As in Table 1, except for 145 reports or more of high winds.

	LN	EN	NEU	Total
a)				
9 – 11 day	43 / 57%	55 / 50%	85 / 51%	183 / 52%
19 – 21 day	28 / 37%	57 / 52%	76 / 43%	161 / 45%
No SOI change	23	27	51	101
Total w/o overlap	52 / 69%	83 / 75%	121 / 70%	256 / 72%
b)				
9 – 11 day	39 / 52%	57 / 52%	80 / 48%	176 / 50%
19 – 21 day	28 / 37%	49 / 45%	79 / 45%	156 / 43%
No SOI change	23	33	51	107
Total w/o overlap	52 / 69%	77 / 70%	121 / 70%	250 / 70%
Total Outbreaks	75	110	172	357

Table 3. As in Table 1, except for 135 reports or more of hail greater than 1 inch.

	LN	EN	NEU	Total
a)				
9 – 11 day	27 / 41%	42 / 56%	75 / 45%	144 / 47%
19 – 21 day	25 / 38%	35 / 44%	79 / 47%	139 / 45%
No SOI change	25	17	44	86
Total w/o overlap	41 / 62%	58 / 77%	124 / 74%	223 / 72%
b)				
9-11 day	35 / 53%	31 / 41%	72 / 43%	138 / 45%
19-21 day	25 / 38%	38 / 51%	76 / 45%	139 / 45%
No SOI change	18	21	55	94
Total w/o overlap	48 / 73%	54 / 72%	113 / 67%	215 / 69%
Total Outbreaks	66	75	168	309

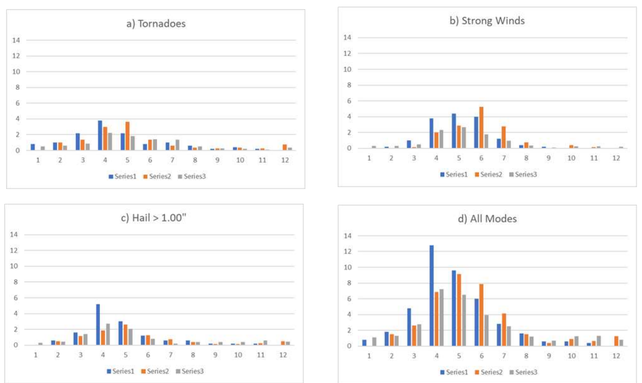

Figure 3. The mean monthly occurrence of days with; a) 20 or more tornado reports, b) 155 or more strong wind reports, c) 135 or more hail (greater than or equal to 25.4 mm) reports, and d) all modes. The ordinate is a mean monthly number of days and the abscissa is the month of the year. The blue, orange, and grey bars represent La Nina, El Nino, and Neutral years, respectively.

Data and Methods

- The data used were the NCEP / NCAR reanalyses (500 hPa heights) on a 2.5o latitude / longitude grid.
- Severe weather reports between 1991 through 2020 were taken from the Severe Storms Prediction Center archive in Norman, OK.
- The Daily Southern Oscillation Index (base period 1887 – 1989) was obtained from the website: https://data.longpaddock.qld.gov.au/SeasonalClimateOutlook/SouthernOscillationIndex/SOIDataFiles/DailySOI1887-1989Base.txt
- The probability of detection (number of correct forecasts / number of events) was calculated for each mode of severe weather.
- Severe weather showed a correlation with 10 unit decreases / increases in the SOI a number of days before the occurrence of severe weather, or a 20 unit increase/decrease over three days.
- Only the largest severe weather days during the period from 1991-2020 were chosen for the territory of the United States (135 reports or more for hail > 1.0 inches, 145 reports or more of high wind, and 20 or more reports of tornadoes. This produced 355 tornado days, 357 high wind days, and 309 hail days.

Table 4. As in Table 1, except for all modes of severe weather.

	LN	EN	NEU	Total
a)				
9 – 11 day	98 / 48%	140 / 49%	239 / 46%	477 / 47%
19 – 21 day	72 / 35%	137 / 48%	228 / 43%	437 / 43%
No SOI change	70	73	151	294
Total w/o overlap	136 / 66%	215 / 75%	376 / 71%	727 / 71%
b)				
9 – 11 day	105 / 51%	133 / 46%	234 / 45%	482 / 48%
19 – 21 day	73 / 35%	125 / 43%	227 / 43%	425 / 41%
No SOI change	63	93	172	328
Total w/o overlap	143 / 69%	195 / 68%	355 / 67%	693 / 68%
Total Outbreaks	206	288	527	1021

Summary and Conclusions

- An examination of 10 point daily changes in the SOI index before the outbreak of large US severe weather events from 1991 – 2020 one-to two weeks in advance (EAR) and two to four weeks in advance (BSR) was examined in order to determine if these indexes could detect severe weather events.
- All modes of severe weather were detected 72% of the time by the BSR and EAR combined. 70% of events were preceded by strong changes in the SOI index in either range (9 – 11 and 19 – 21 day) for a one-day SOI change of 10 points, and 64% for a three-day change of 20 points in SOI.
- In general, the EAR performed better than the BSR in detecting larger severe weather events day. This is to be expected since there is less lead time.
- For large hail and high winds, combined POD was about 70 – 77% during El Nino and Neutral years, but 66-72% for tornado outbreaks during El Nino and La Nina years.
- High wind events had the largest POD among all severe weather types.

References

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- Allen, J.T., Tippett, M.K., and Sobel, A.H. 2015: Influence of the El Niño/Southern Oscillation on tornado and hail frequency in the United States. *Nature, Geoscience*, https://doi.org/10.1038/ngeo2385.
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