

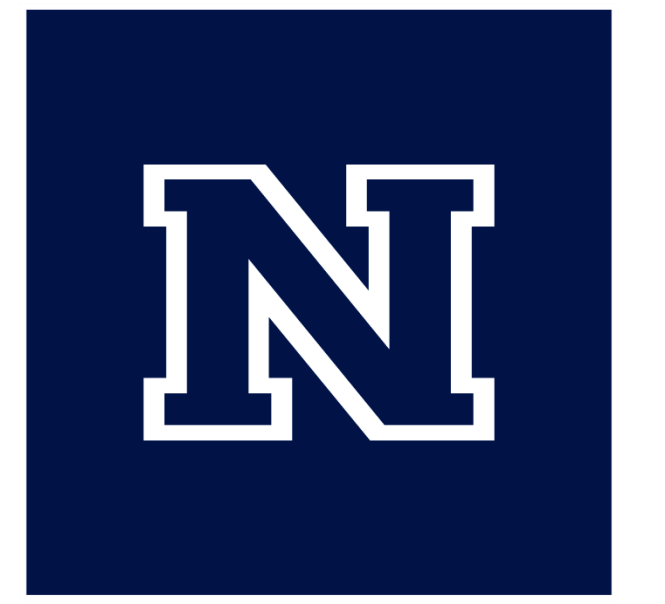
# EXPLORING DERECHO OCCURRENCE AND CLIMATE VARIABILITY

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## OVERVIEW

Derechos are considered to be weakly-forced, “warm-season” severe weather events. As such, 139 derecho events were identified during the eleven warm seasons from 2012-2022 for evaluation against a variety of climate indices. The correlations between derecho occurrence during each warm season and these climate indices were then calculated. The results of this statistical analysis reveal some intriguing insights into how the El Niño-Southern Oscillation (ENSO) may impact severe convection and, in particular, derechos.

Studies have been conducted in attempts to link tornado and hail occurrence with larger-scale climate variability, but no such study (to the author’s knowledge) has been conducted with respect to derechos and climate indices. This work aims to fill that knowledge gap and gain insight into anticipating derecho occurrence on a seasonal basis.

## INTRODUCTION

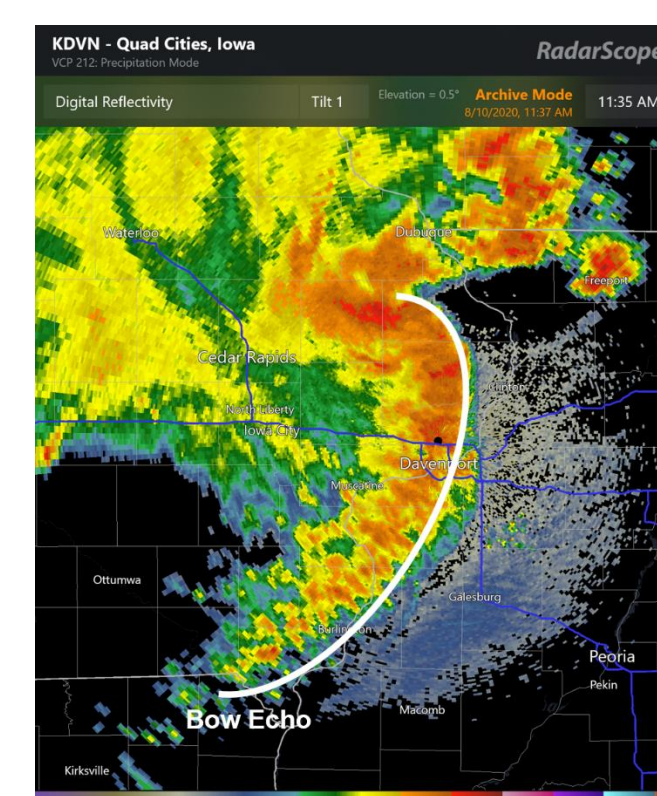
While severe weather forecasting has improved markedly over the decades, the ability to link larger-scale climate variability to seasonal severe weather frequency is still not well understood. A number of studies have attempted to link severe convection, tornado, and hail occurrence in the United States to the El Niño-Southern Oscillation (ENSO) amongst other climate indices, and have found loose links between tornado occurrence and certain climate indicators.

For example, Lee et al. 2013 found that positive values of the Trans-Niño index may be useful in predicting tornado occurrence. Lee et al. also found that ENSO itself is not statistically correlated to tornadoes. However, Allen et al. 2015 found that both tornado and hail occurrence increase during La Niña conditions. Weaver et al. called for advancing the nation’s ability to anticipate tornado and severe weather events more than a week out which is the current standard. It is anticipated that the use of climate indices will accomplish this goal, though much more work needs to be done on the subject before operational, seasonal severe weather forecasts can become useful.

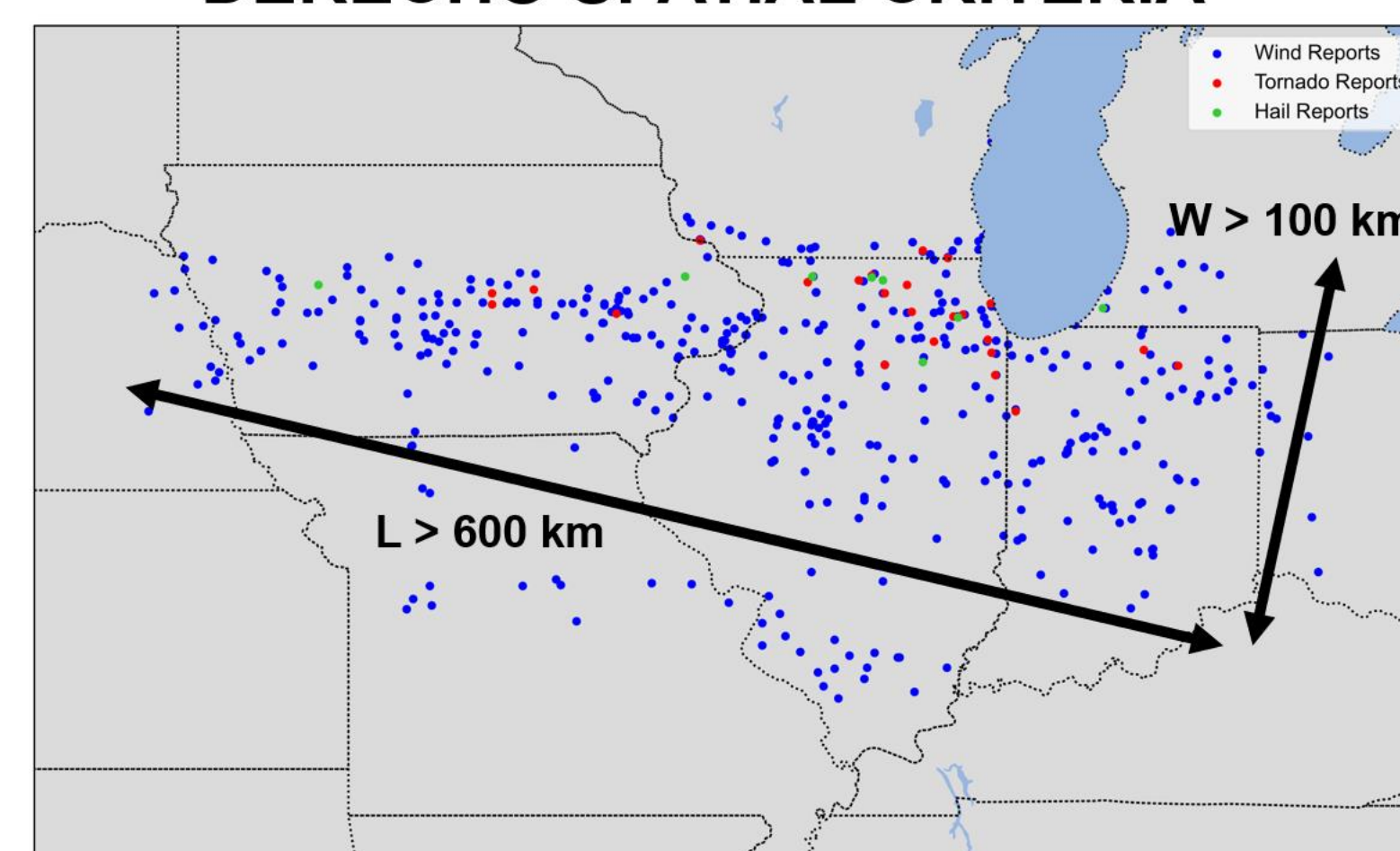
## METHODS

Eleven warm seasons (May, June, July, and August) were evaluated for derecho events between 2012-2022. 139 derecho events were identified based on the following criteria:

- Wind damage path at least 600 km long
- Wind damage path at least 100 km wide
- Consistent severe wind gusts (58+ mph)
- Radar-observed features such as bow echoes and rear-inflow jets



### DERECHO SPATIAL CRITERIA



These criteria are mostly consistent with the current operational definition of a derecho with the exception that a derecho path length should be at least 650 km (previously 400 km) and include at least three significant (75+ mph) wind damage reports. The requirement for significant severe wind reports was left out for consistency with the Coniglio and Stensrud 2004 (CS04) and Bentley and Mote 1998 derecho climatology criteria.

Each of the 139 identified derecho events was then classified as either a Low-End, Moderate, or High-End event as in CS04.

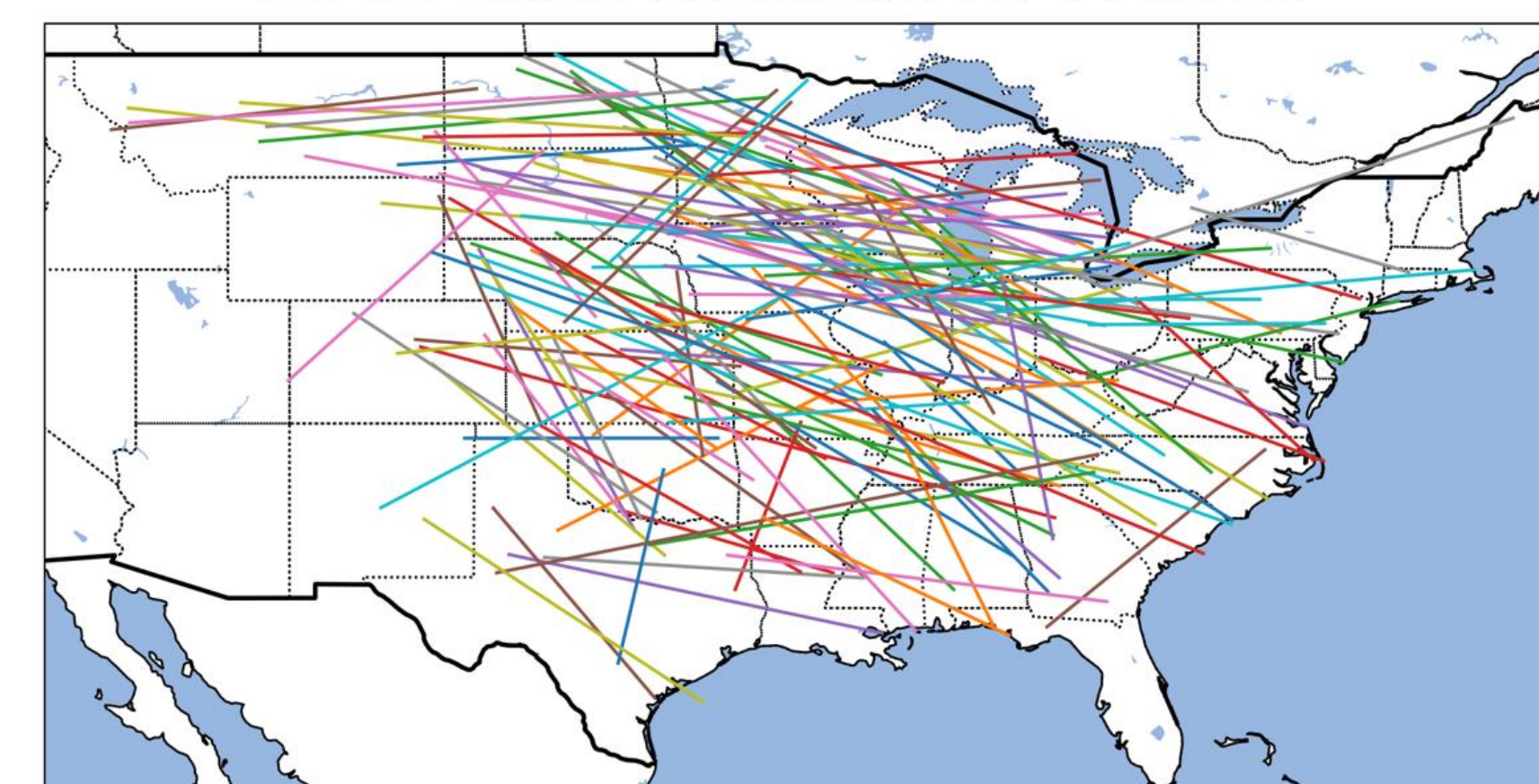
Statistics were then calculated for derecho occurrence (both total and Moderate/High-End only) and various climate indices which are peer-reviewed and publicly available, including the Pacific-North American pattern (PNA), Pacific Decadal Oscillation (PDO), North Atlantic Oscillation (NAO), Oceanic Niño Index (ONI), Trans-Niño Index (TNI), and Niño 1+2/3.4/4 sea surface temperatures.

## RESULTS

The most statistically significant signal as determined by Pearson Correlation Coefficients is the ONI. Specifically, positive values of ONI seem to be correlated to derecho occurrence. In fact, a “Very Strong El Niño” (i.e., ONI  $\geq 2.0$ ) occurred leading up to and during the 2016 warm season which had the highest occurrence of moderate and high-end derecho events out of the 11 seasons examined. Consistent with the correlation between ONI and derechos, Niño-4 and Niño-3.4 sea surface temperatures (SST) are also correlated with derecho occurrence.

Although the correlation between TNI and derechos was not calculated to be statistically significant, it is important to note that negative TNI values are present leading up to (i.e., during the winter prior) 8 out of 11 warm seasons. Negative TNI values are present during 10 out of 11 warm seasons, with the remaining positive TNI warm season producing the least number of derechos.

### 2012-2022 DERECHO PATHS



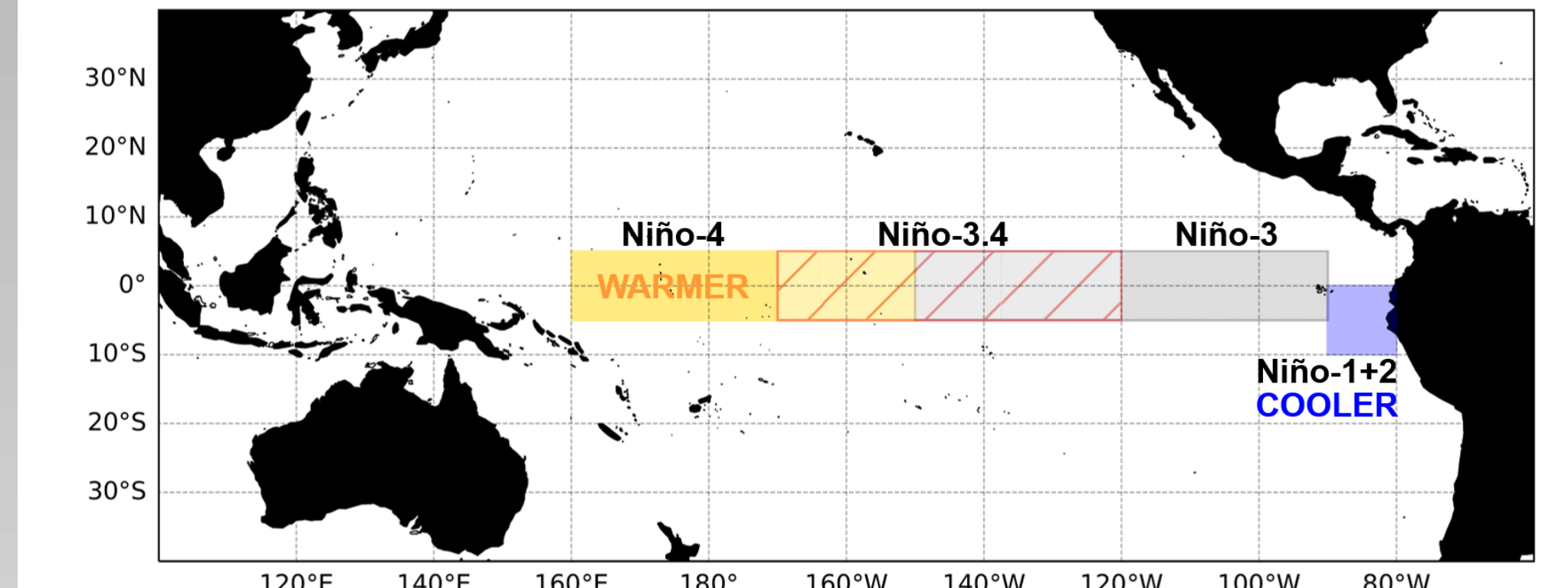
Interestingly, though not surprisingly, the signals which seem important for derecho occurrence are the opposite of those thought to precede periods of higher tornado occurrence (i.e., La Niña and positive TNI years). Lee et al. 2012 found that positive TNI years increase Gulf of Mexico moisture transport over the central U.S. and also increase atmospheric vertical wind shear, both of which contribute to conditions conducive to tornado development. Conversely, Lee et al. also found that years transitioning from El Niño favored the development of anomalous anticyclonic circulations over North America which would be conducive to derecho events (“ridge rollers”), which is consistent with the findings of the present study.

## CONCLUSIONS

While the effects of the El Niño-Southern Oscillation on North American warm-season weather are not particularly well known, there is growing evidence to suggest that severe convection in North America is influenced by ENSO teleconnections.

The results from the work presented here may provide a basis for seasonal forecasts of derecho occurrence. The ONI and TNI may be the most useful for such forecasts, as the correlation between derechos and ONI, Niño-4 SSTs, and Niño-3.4 SSTs are all statistically significant, and ten of the eleven warm seasons examined had negative TNI values.

### NEGATIVE TRANS-NINO SST PATTERN



Additional numerical modeling similar to that of Lee et al. 2012 is necessary to better understand if/how ENSO modulates the North American general circulation in favor of derecho development. Conditions conducive to elevated mixed-layer development will be of particular interest.

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