The Interannual and Interdecadal Variability of Soil Moisture and Recent Tornado Activity (EF2 or greater) in the Central USA.

Lukas J. McGuire
Corey E. Clay
Anthony R. Lupo
Atmospheric Science Program
School of Natural Resources
University of Missouri
Columbia, MO 65211

The 3rd International Electronic Conference on Atmospheric Science

Introduction

- Many studies have demonstrated that El Nino and Southern Oscillation (ENSO) have a distinct impact on the occurrence of severe weather and the environment in the eastern two-thirds of the USA.

- Typically, La Nina years experience a greater number of tornado events in the central USA. Recent studies have suggested that the real ENSO variability in tornado occurrences shifts where the maxima occur (“Tornado Alley” versus “Dixie Alley”).

Introduction

- A previous study of tornado activity over the second half of the 20th century demonstrated that tornado activity was higher in the mid-century than toward the end of the century within the State of Missouri (USA) and neighboring states (Iowa, Kansas, Nebraska).

- There has been an increase in the number of tornado cases during first two decades of the 21st century in Missouri. There has been some indication that this may be true in the other three states.

Motivation and Goals

- The previous study performed by this research group examined tornado activity in the central United States from 1950 – 2002, thus this study endeavored to extend the time period 2019.

- The goal is to determine whether the tornado activity of the most recent years was consistent with that of the previous study. The environment of representative years will be examined as well.

- There was a correlation between soil moisture and tornado activity, and this will be explored.

Data Used

- The datasets used in this study were the National Centers for Environmental Prediction / National Center for Atmospheric Research (NCEP / NCAR) re-analyses for the study of the environmental conditions

- The National Oceanic and Atmospheric Administration (NOAA) Storm Prediction Center (SPC) event archive was used to compile the climatological statistics. EF2 tornadoes or greater were chosen for study since EF0 and EF1

Methods

- The study region.

Methods

- The tornado counts were broken down by ENSO phase following Lupo et al. (2019 - *Atmosphere*) for blocking events. ENSO is defined using the JMA definition. The interdecadal variability is assumed to be associated with the Pacific Decadal Oscillation since that will impact ENSO.

Table 1. List of ENSO years used here. The years below are taken from [30]

El Niño	Neutral	La Niña
1969	1968	1967
1972	1977–1981	1970–1971
1976	1983–1985	1973–1975
1982	1989–1990	1988
1986–1987	1992–1996	1998–1999
1991	2000–2001	2007
1997	2003–2005	2010
2002	2008	2017
2006	2011–2013	
2009	2016	
2014–2015		

- Statistical testing was done using standard methods found in Wilks (2006).

Results

- An examination of the current two decades demonstrated that the variability with respect to ENSO was similar to that of the Akuyz et al. (2004 – *Trans. MO Acad. Sci.*) study.

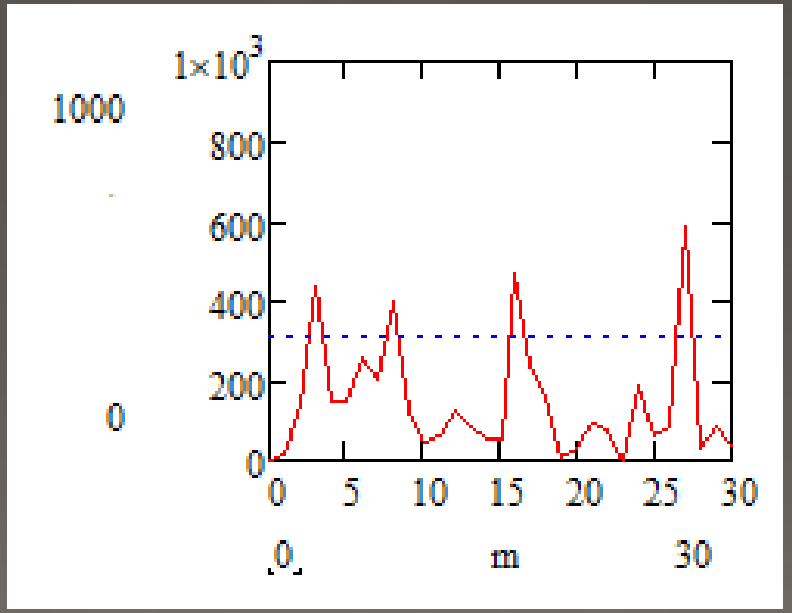
- Tornadoes separated by state and ENSO phase (total tornadoes – left, annual mean – right)

State	La Nina (3)	Neutral (8)	El Nino (6)	Total
Missouri	32 / 10.7	91 / 11.4	48 / 8.0	171 / 10.1
Iowa	31 / 10.3	42 / 5.3	28 / 4.7	101 / 6.0
Kansas	42 / 14.0	54 / 6.8	76 / 12.7	172 / 10.1
Nebraska	17 / 5.7	57 / 7.1	21 / 3.5	95 / 5.6

Results

- Adding these events to the 52-year Akyuz et. al. study and decomposing the time series using Fourier analysis shows that the periodicities identified previously are still present.

- The x-axis is wave number and the y-axis is spectral power (detrended). The blue dashed line is (p = 0.05).



Results

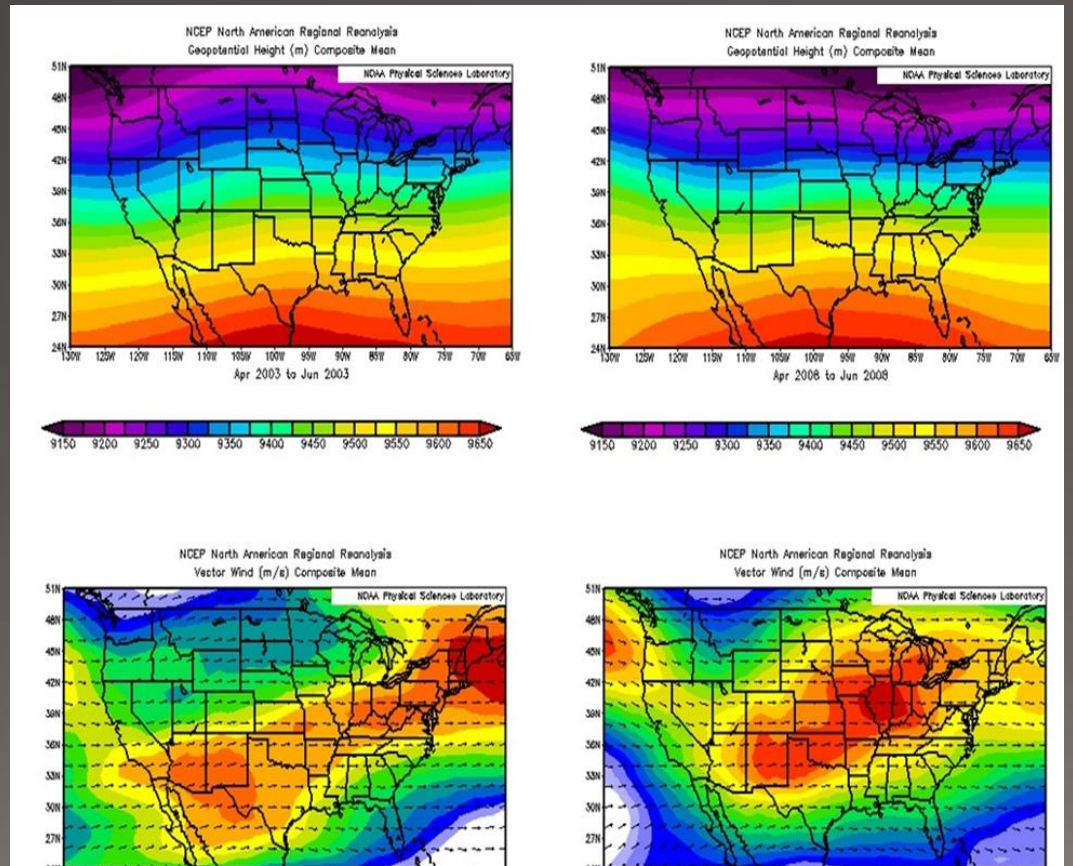
- The variability with respect to the PDO showed that there may be a signal in the southern states (MO, KS) but not in the northern (IA, NE).

- Data separated by PDO phase (negative / 1950 – 1976, 1999-present – Positive (1999 – present).

State	1950 - 1976	1977- 1998	1999 - present
Missouri	10.2	4.5	9.0
Iowa	12.7	8.2	5.8
Kansas	15.3	6.3	9.2
Nebraska	7.7	6.2	5.3
Total	45.8	25.1	29.3

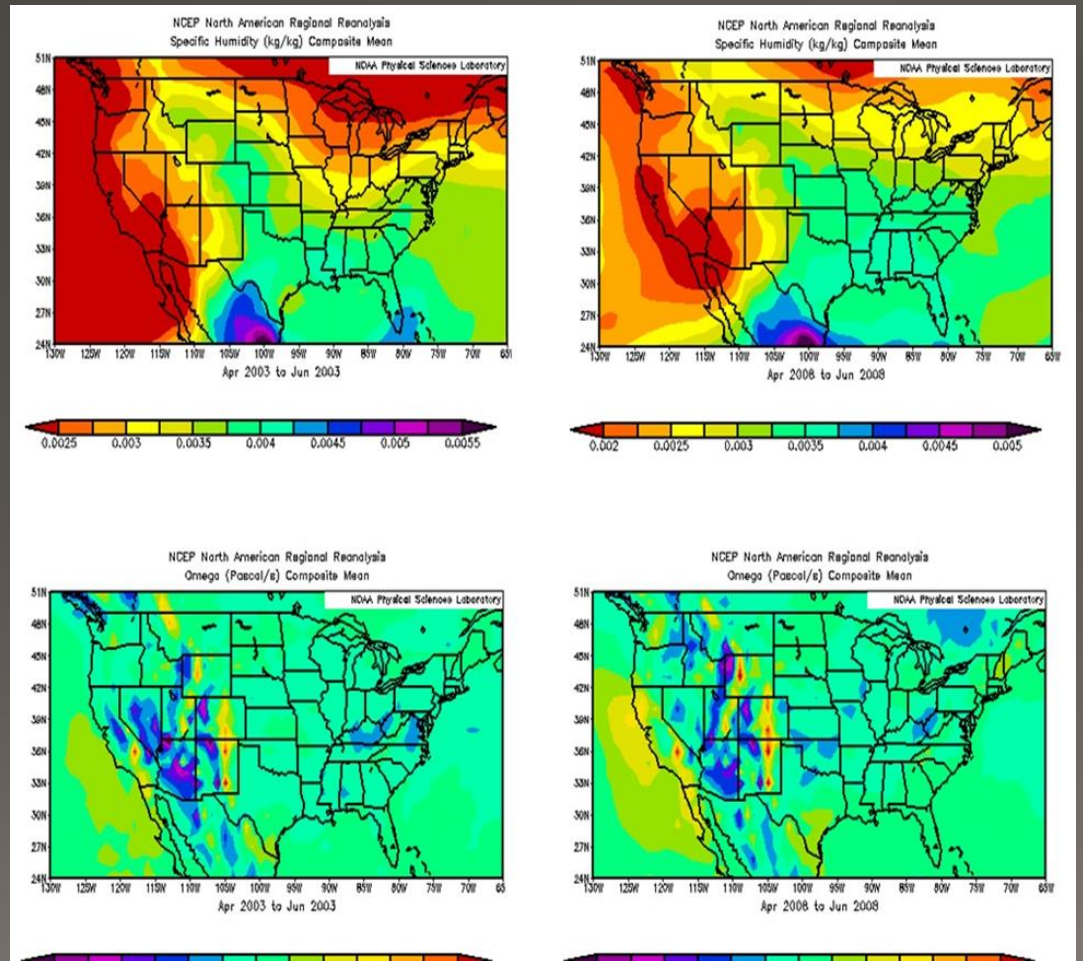
Results

- Composite maps for April to June 2003 (El Nino - left) and 2008 (La Nina - right). We show 300 hPa heights (m) (top) and winds (m s^{-1}) (bottom).



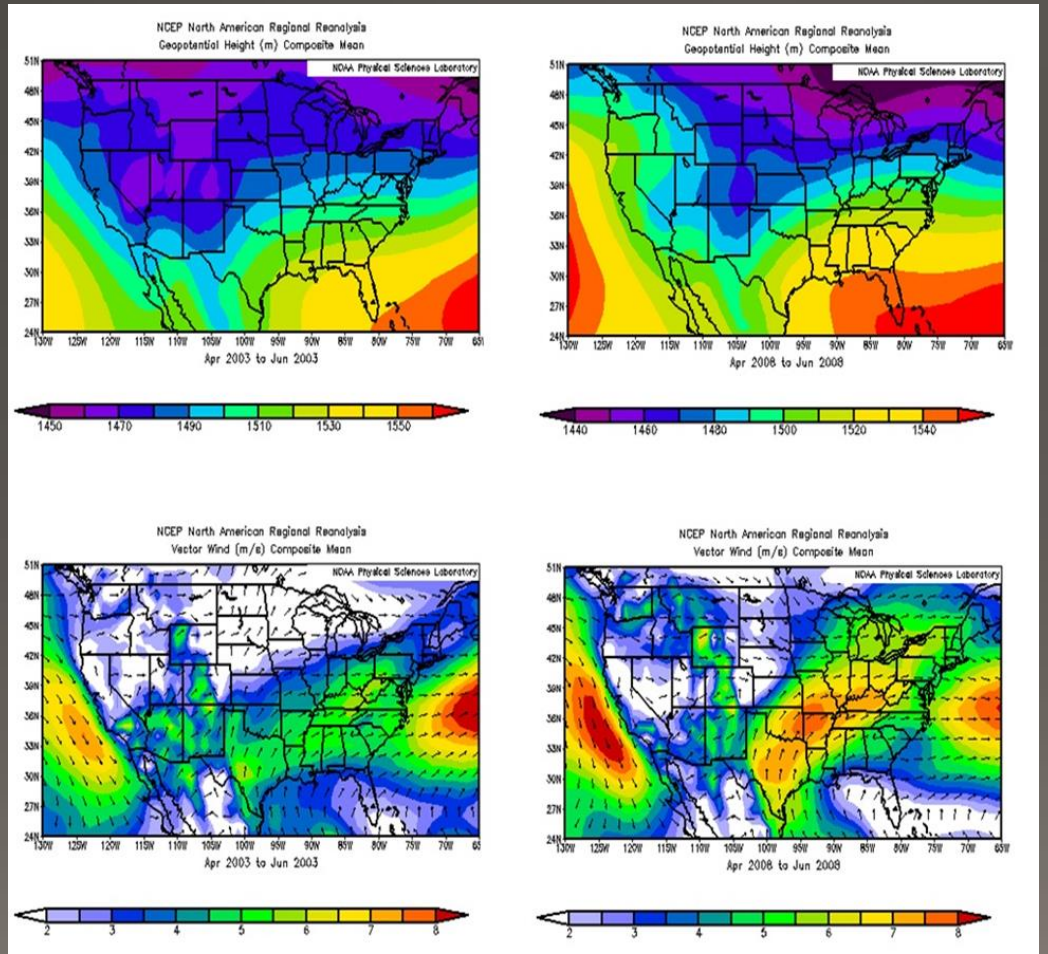
Results

- The surface specific humidity (kg kg^{-1}) (top) and 700 hPa Omega ($\mu b\ s^{-1}$) (right).



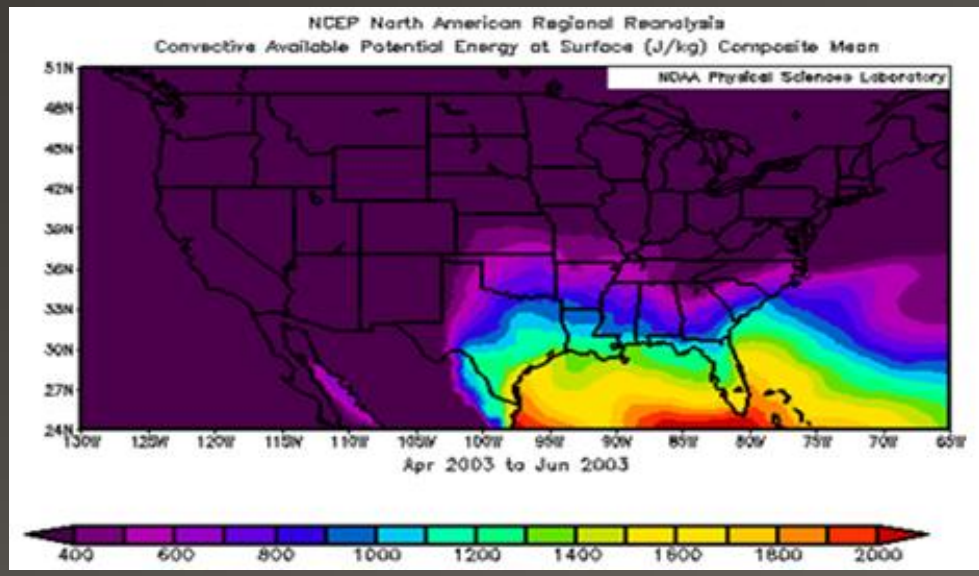
Results

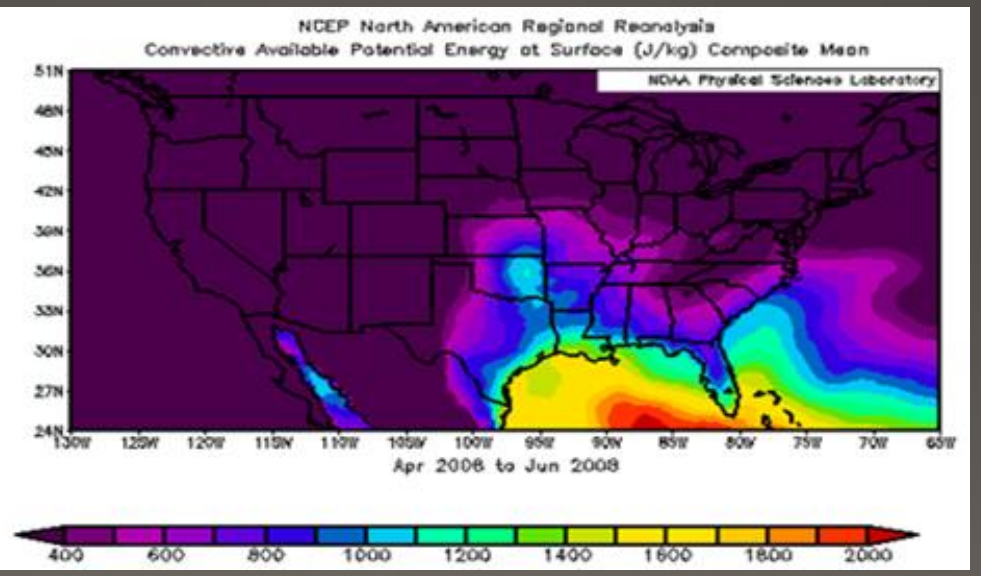
- The 850 hPa heights (m) and winds (m s^{-1})



Results

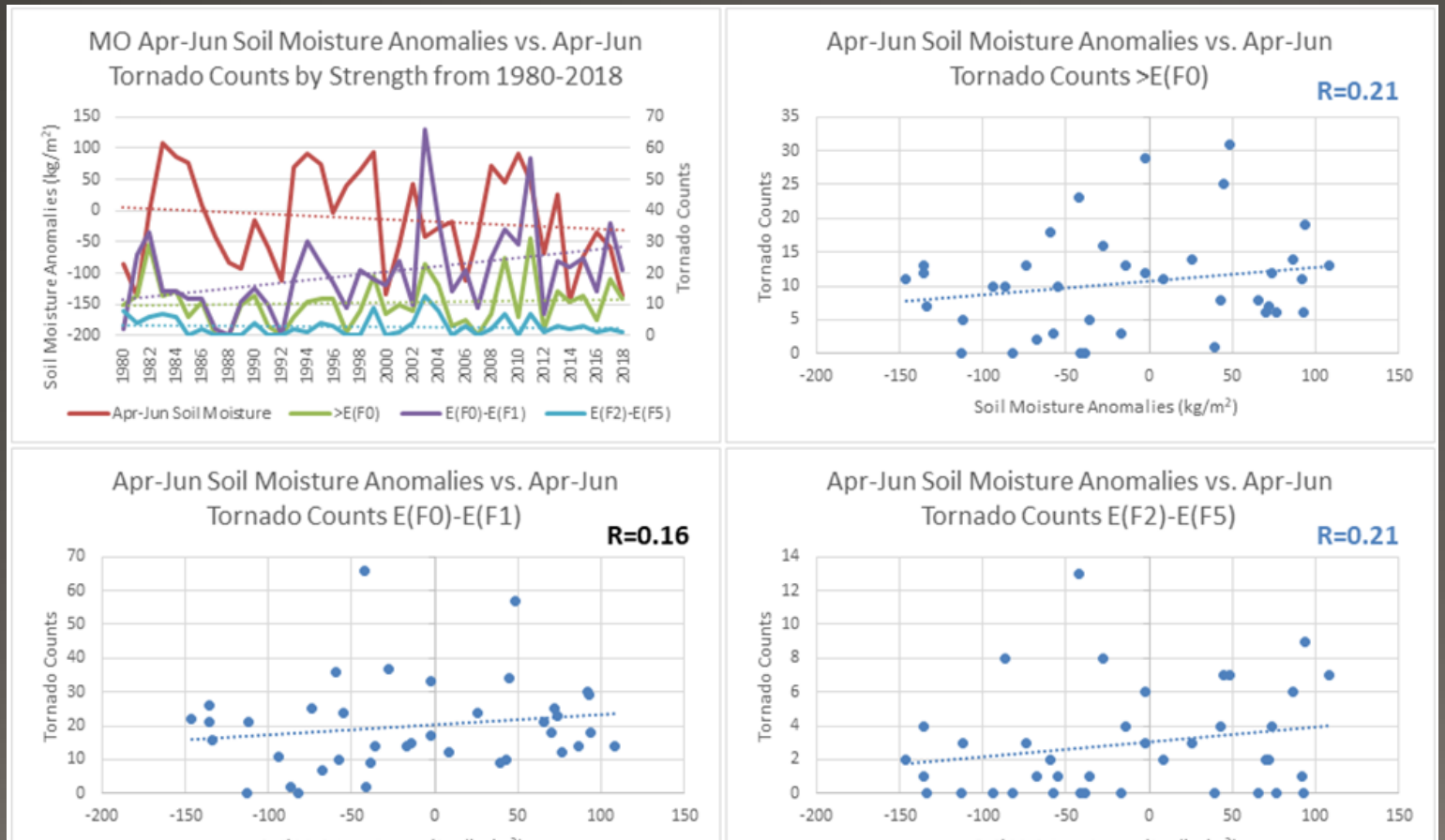
- Surface Based CAPE (J kg^{-1})





Results

- Soil Moisture versus tornado counts for April – June versus in Missouri (p = 0.10 – light blue). Note the significant correlation between EF2 – EF5 events.



Summary and Conclusions

- The tornado counts for the central USA were examined from 2003 – 2019 in order to update the Akyuz et al. (2004) study of the tornado climatology (1950 – 2002).

- The same pattern of interannual variability was present as in Akyuz et. al. and examining the environments of the primary tornado season (Apr – Jun) shows that La Nina years are more conducive to larger outbreaks (e.g. 2011) over this region.

Summary and Conclusions

- Akyuz et al. used a correction factor to remove perceived over-counts of tornadoes occurring before 1977. Thus, the original study showed no interdecadal variability.

- The Fourier analysis of 'corrected' data here suggests interdecadal variability is present, although it is difficult to extract this because of the perceived over-count. Nonetheless, MO and KS showed interdecadal variability related to the PDO while IA and NE did not.

Summary and Conclusions

- Questions?
- Comments?
- Criticisms?
- ljmdyn@mail.missouri.edu ceczpd@mail.missouri.edu
lupoa@missouri.edu