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Mesoclimatic analysis of severe weather and ENSO interactions in North Carolina

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Abstract. Connections between regional severe weather occurrences and El Niño/Southern Oscillation (ENSO) are investigated. Monthly (1950 – 1989) occurrences of tornado and wind / hail frequency are compared with sea surface temperature (SST) indices and anomalies in the tropical Pacific. Analyses indicate increase in wind/ hail events/ days, during the months of April through June of La Niña years. No direct evidence is found between tornado frequency and ENSO classes. Using seasonal composite anomalies of upper-air patterns, it is concluded that La Niña patterns leads to enhanced convection over North Carolina.

1. Introduction

El Niño-Southern Oscillation (ENSO) refers to a complex atmosphere – ocean interaction resulting in anomalies in sea surface temperatures (SST) and surface pressure distribution in the tropical Pacific, changes occurring irregularly over periods of 3 to 7 years. El Niño is the phase of the southern oscillation when a low pressure, high trade wind region is over the eastern tropical Pacific Ocean (Philander 1990). La Niña is the reverse of El Niño when sea surface temperatures in the central and eastern tropical Pacific are unusually low and trade winds are very intense resulting in above normal SST in the central to eastern basin of the Pacific. Understanding ENSO is important as it has significant implications not only on the tropical Pacific, but also global and local weather and climate patterns including socioeconomic characteristics of the region. Majority of the research concerns the large-scale implications on global climate including changes in planetary and synoptic flow patterns. Nonetheless, in recent years, there is a growing concern regarding the local scale as against global effects of synoptic scale events such as ENSO (cf. Guetter and Georgakakos, 1996, Roswintiarti et al., 1998). Accordingly, this study presents a hierarchy of statistical methods for investigating possible connections between ENSO and regional severe weather occurrence taking North Carolina as a case example.

The complexity and diverse scales of ENSO events preclude an investigation based solely on dynamical methods. We therefore present a series of grouping and statistical methods to focus on possible connections, and then investigate the dynamical explanation for the results. The underlying philosophy is that, ENSO is not directly responsible for the formation of individual thunderstorms, however, the formation of thunderstorms is directly related to synoptic flow patterns. For instance, near surface air masses could be linked to mid-tropospheric flow patterns (Schwartz and Skeeter, 1994). Additionally, for various ENSO phases, height anomalies and resulting flow patterns are already established (Ropeleweski and Halpert, 1986). Hence a regional / local scale analysis of ENSO effects on severe weather is achievable. This is the motivation for the present research involving investigation of possible relationships between severe weather and ENSO at a mesoclimatic scale.

2. Data

Severe weather data were obtained from the National Severe Storms Forecast Center (NSSFC), and the National Climatic Data Center (NCDC). For North Carolina, monthly tornado frequency from 1950 through 1989, wind and hail events for 1957 through 1988 were utilized (with exception of 1968 and 1969 due to missing values). Several studies (cf., Schaefer and Livingston, 1993) report deficiencies in this dataset (such as, geographical biases as well as an increase in reported tornadoes with time due to increasing population and awareness). However, the dataset represents the most reliable accounting of severe weather occurrence available over the United States (Bieringer et al, 1996). Therefore, these data will be used but with the knowledge that certain limitations are present.

Monthly SST indices from 1950-1989 were used in the classification and analysis of ENSO events through the Climate Prediction Center. This data set includes monthly values for all Niño regions in the tropical Pacific (Niño1+2, Niño3, Niño4, Niño3.4), and the corresponding anomalies (Philander, 1990). Individual data points exceeding the five and ninety-five percentile were considered outliers and removed from the data set by replacing them with the five and ninety-five percentile values. The data were analyzed for normality, and conversion approaches were attempted (Niyogi et al. 1997). Based on these results and that the data were only used to determine ENSO phases and linear correlation with Niño regions, the original data set (outliers removed) was retained.

3. Methodology

SST indices were compiled and correlated with severe weather events. Results show that severe weather in North Carolina is most highly correlated with Niño34 (and not significantly with other Nino modes, see also Roswintiarti et al., 1998). Accordingly, El Niño is defined when the 5-month running mean of SST anomalies in the Niño34 region exceeds

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