Spatiotemporal Variability of Extreme Convective Wind Events

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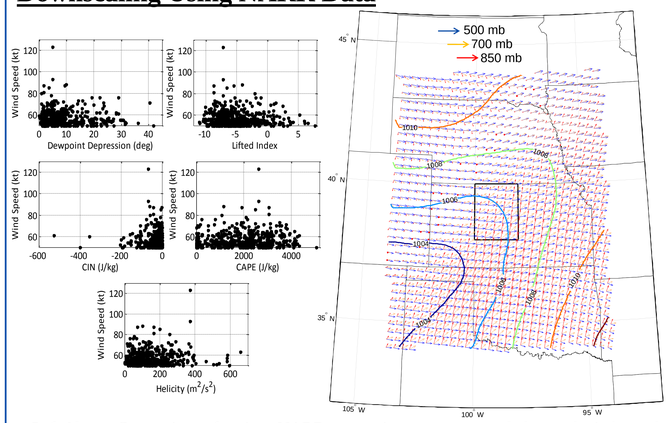
Abstract

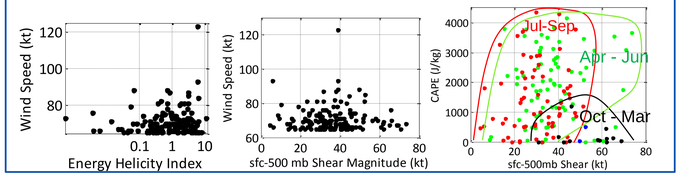
The months of April and May 2011 produced a number of extreme convective events including six EF-5 tornadoes. These events included the highest fatality count for a single tornado (May 22, Joplin, MO) and the greatest single daily tornado outbreak (April 27). In addition, monthly large-scale parameters such as CAPE and wind shear were higher than normal (NOAA, 2011a). These events bring to light the inevitable question of climatological factors enhancing the frequency and intensity of extreme convective events which has not been studied in detail. The lack of research can be attributed to difficulties in representing small scale phenomena in models, uncertainties in the rating process (e.g. F or EF scale for tornadoes), a lack of measured wind speed data for any extreme wind producer, and the relatively short length of official data records among others. These difficulties have been highlighted by the latest IPCC report on extremes (IPCC, 2011) and by the NOAA Undersecretary for Commerce (NOAA, 2011b). The lack of detailed understanding about the spatial and temporal distributions of extreme wind events is coupled by the fact that the convective windstorms routinely cause the majority of natural disaster deaths and damage in the U.S. (NOAA, 2011c) and the current wind load standard routinely uses this data for consideration in structural design.

Large scale climatological parameters were collected from the North American Regional Reanalysis (NARR) dataset from 1979-2010. In addition, storm reports from the NOAA SPC database were obtained (1979-2010) as well as observed extreme wind speeds extracted from the Integrated Surface Hourly Database (ISH) (1973-2010). West Texas Mesonet (WTM) data (2000-present) and Oklahoma Mesonet data (1996-present) were also utilized. Data from these observing systems were combined to create a comprehensive spatiotemporal database of extreme measured wind speeds. The time and location of observed extreme wind speed was matched with the closest spatiotemporal grid point of the NARR dataset. Relevant parameters from the NARR data were then associated with the magnitude of the gust. NARR parameters were also used in an attempt analyze potential large-scale patterns associated with extreme wind events. In addition, storm reports available from NOAA were "clustered" by event to analyze spatiotemporal variability in the data and to assess any emerging trends/patterns in the data as compared to both the observed and NARR databases.

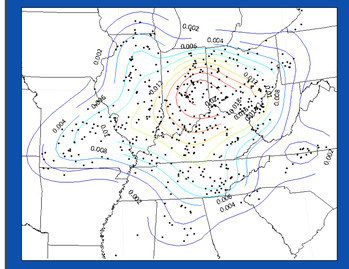
Downscaling Using NARR Data



Left Above*:** Comparison of various NARR convective parameters and observed wind speed data for June 2010. ***Right Above: Mean flow vectors and surface pressure from NARR for 18 extreme wind events within box. ***Below*:** Derived parameters (EHI, Shear) and measured wind speed > 65 kt and CAPE v. shear distributions separated by season for all of 2010.

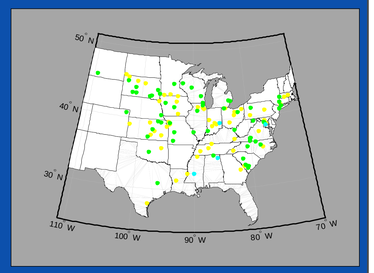


"Event" Clustering



Event density for storm reports from 26 October 2010. The event density is essentially a spatial probability density function of the storm reports for a particular time period of interest.

Event density for all 2010 events. Yellow dots represent events during April-June, green for July-September, and blue for October-December.



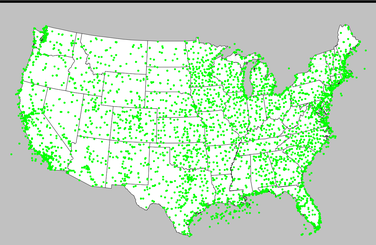
Preliminary Conclusions

- Approximately 1,000 convective measured gusts were found in the ISH database from 1971-2010; normalized extreme wind reports by number of stations yielded no discernible trend.
- Climatology of measured wind gusts and NARR parameters show diurnal, seasonal and directional tendencies
- Qualitative downscaling of NARR parameters revealed that extreme winds occur at a range of parameter values.
- Clustering by event showed that larger-scale events (> 30 reports) are most likely to occur east of the Rockies and northward of 30°N.

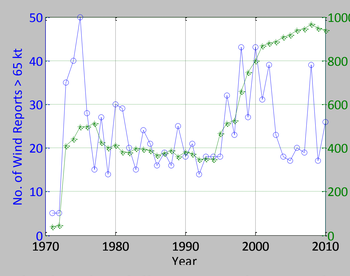
Future Work

- Further quality control of measured extreme winds, such as standardization and separation by season, location, and year.
- A more detailed validation of NARR parameters with observed data (e.g., soundings) in close proximity to the extreme wind report will be performed as well as consideration of storm type.
- Expanding to include all years and sources of available data will give a better understanding of the spatiotemporal properties of this phenomena.
- Further interpretation of all large-scale parameters and their effect on extreme wind production will be done in addition to accounting for the numbers of large-scale severe weather environments that occurred regardless of the presence of a extreme wind report.

Measured Extreme Wind Database

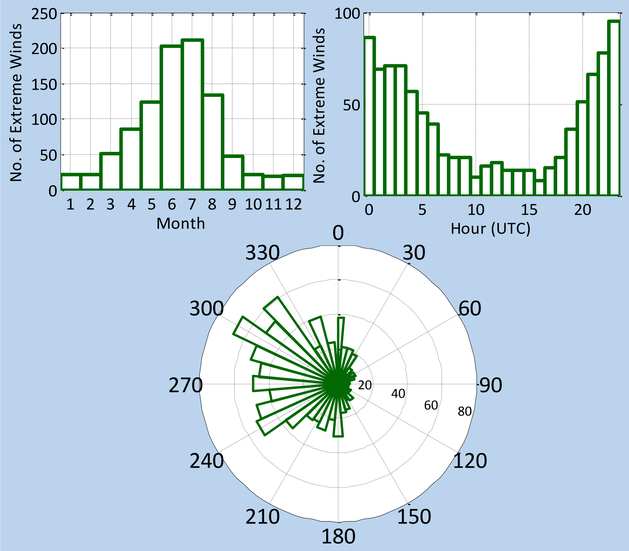


Extreme wind speeds were extracted from over 1200 ISH stations, denoted in the map above, in addition to storm reports from the SPC Severe Storm Database.



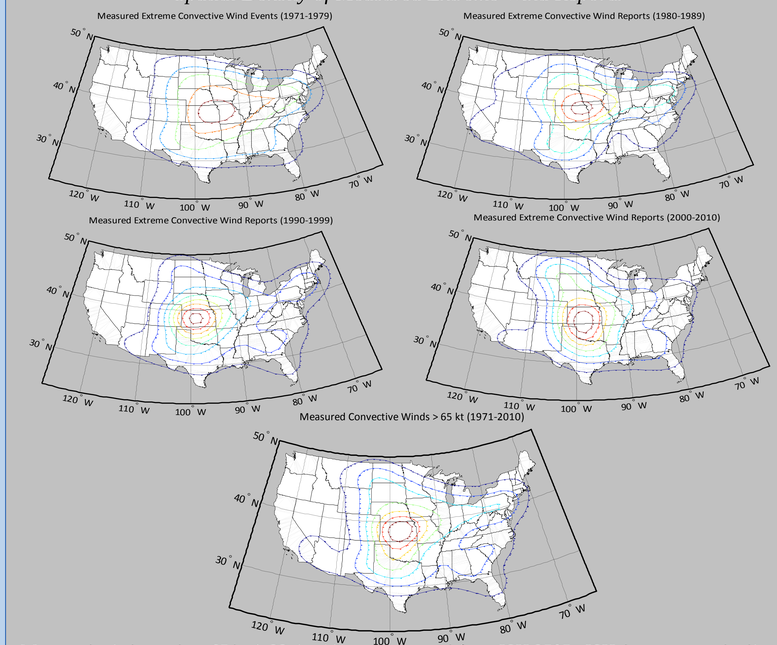
Normalized number of all extreme wind events and convective extreme wind events from1971-2000. Number of reports increased with the number of stations until the early 2000's

Climatology of Extreme Wind Reports



A breakdown of extreme wind reports by time of year and day as well as by wind direction. As shown in previous studies the times/dates of occurrence are diurnal and seasonal in nature. Wind direction plot shows a vast majority (~80%) of extreme convective winds have a westerly component.

Spatial Density of Measured Extreme Wind Reports



Measured wind speeds > 65 kt (~33.4 m/s) were extracted from ISH 3505. ISH data was standardized to 10m height and 3s gust. The data revealed ~1,000 independent convective reports.

References

IPCC (2011). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)*. Online at: http://ipcc-wg2.gov/SREX/images/uploads/SREX-SPM_Approved-HiRes_opt.pdf

NOAA (2011a). http://www.esrl.noaa.gov/psd/csi/events/2011/tornadoes/climatechange.html

NOAA (2011b). http://www.noaanews.noaa.gov/stories2011/20111207_speech_agu.html

NOAA (2011c). http://www.nws.noaa.gov/om/hazstats.shtml

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For Further Information:

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