Climatology of Severe Weather Outbreaks

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Objectives

•Determine the average or sum values of severe weather diagnostic variables and synoptic variables in the regions associated with significant severe weather events over a long period. Relate these average or sum values to the severity of the outbreaks.

•Associate the magnitudes of severe weather diagnostic variables (SWDVs) to the density of severe weather reports in a probabilistic manner.

•Use the magnitudes of SWDVs to find probabilities of severe weather occurring within a certain distance of a point, with the only conditions being severe weather must have occurred at least once in the period of analysis at the grid point of interest and a cluster of severe weather reports were observed in the conterminous United States (CONUS) at the time of analysis.

Data and Methods

•North American Regional Reanalysis (NARR; Mesinger et al. 2006) data are used for analyses. Data bilinearly interpolated to an 18-km horizontal grid encompassing the CONUS.

•A set of 4437 severe weather outbreaks from 1979–2010 are identified using a linear-weighted multivariate index and kernel density estimation (KDE; Bowman and Azzalini 1997), as proposed by Shafer and Doswell (2011; see Figs. 1-3).

•The magnitudes of the selected variables at each grid point are summed, and the average or sum value for all grid points is computed for each outbreak (Figs. 5-6).

•Probability density functions (PDFs) as estimated using KDE are matched with the magnitudes of SWDVs to determine probabilities of PDF exceedance for each event (Figs. 4 and 7).

•The probabilities of severe weather (of any type or of a specific type) occurring within a grid point in a 40-km horizontal grid are determined for incremented thresholds of SWDVs (Figs. 8-9).

Results

•There is a strong preference for relatively strong winds from the southwest or west in midlevels and southerly to westerly in low-levels, which more commonly occur in the cool season (Fig. 5). SWDVs appear to separate a subset of the most significant severe weather events from the remaining events (Fig. 6).

•The magnitudes of severe weather diagnostic variables are associated with report density (Figs. 4 and 7) and the probabilities of severe weather occurring in a given location (Figs. 8 and 9). However, sample size concerns and secular trends in the severe weather reports dataset impede generalization of these values.

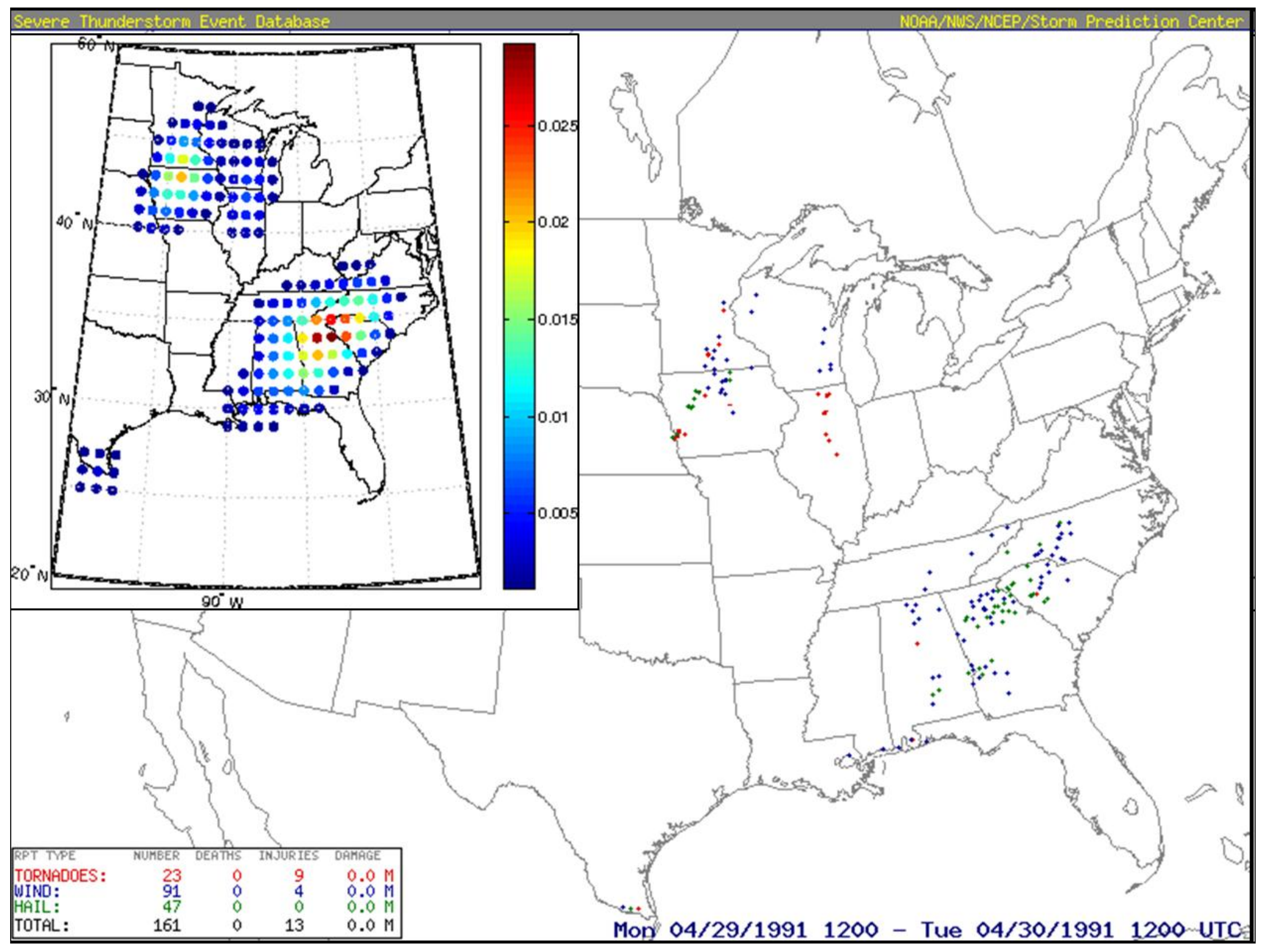

Figure 1: Severe reports from 1200 UTC 29 April 1991 to 1200 UTC 30 April 1991, and the regions associated with the severe weather report clusters (inset), as determined by the KDE technique developed by Shafer and Doswell (2011).

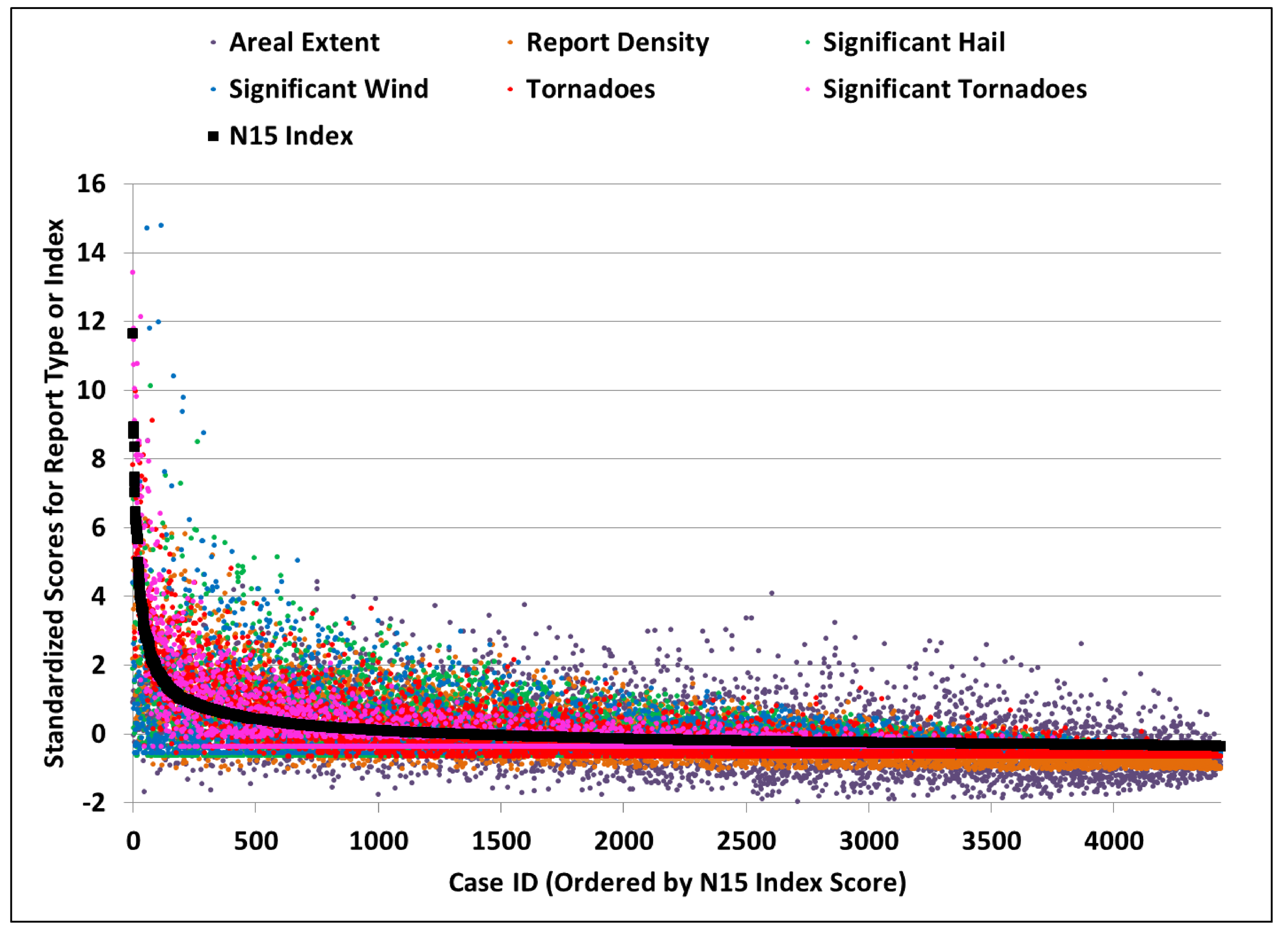

Figure 2: Outbreak ranking index (N15) scores (black) and individual report variable scores (detrended and standardized) as a function of each outbreak's ranking. A set of 4437 events from 1979–2010 were ranked.

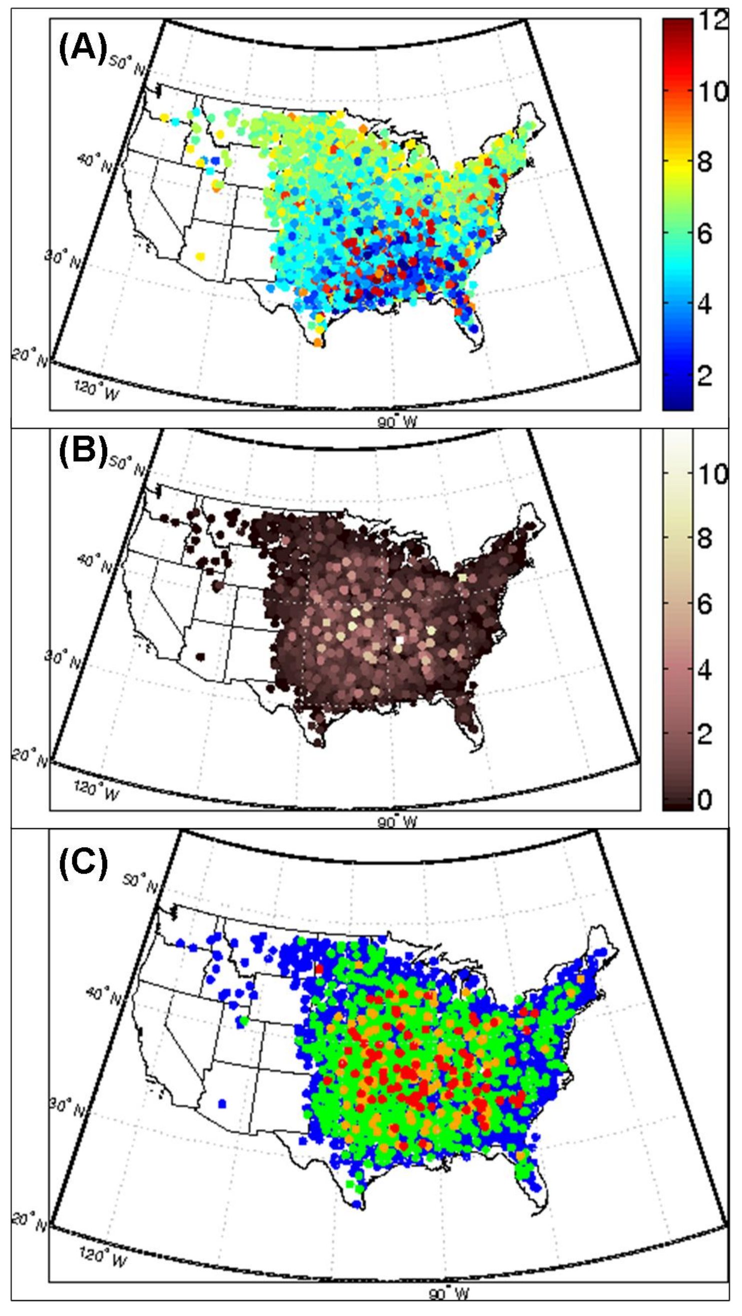

Figure 3: (a) Centroids of the 4437 severe weather outbreaks from 1979–2010. Colors indicate month number of the event. (b) As in (a), except the outbreak ranking index (N15) score (see Fig. 2) is indicated. (c) As in (b), except the events are separated into four classes: N15 scores below 0 (blue), between 0 and 1 (green), between 1 and 2 (orange), and above 2 (red).

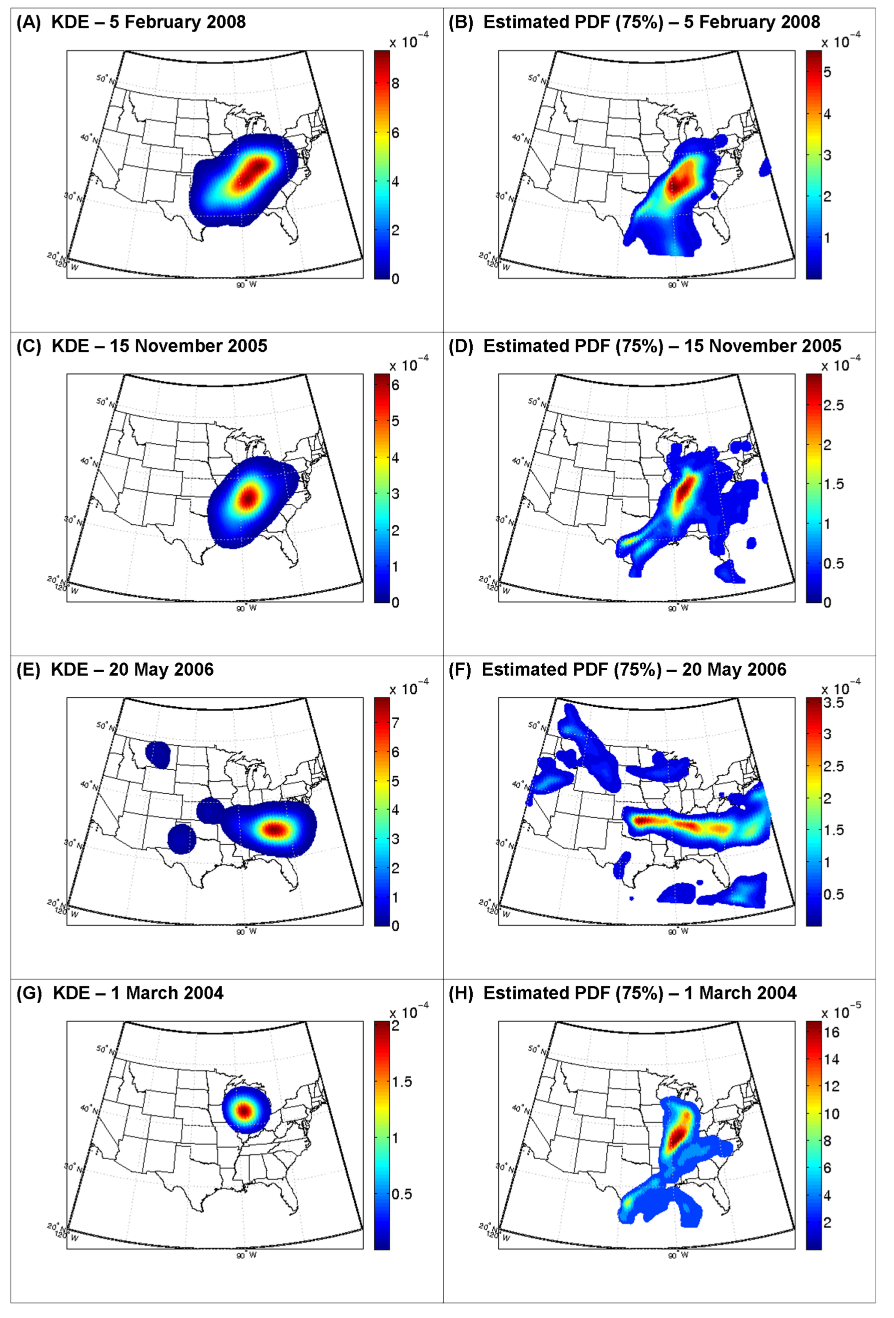

Figure 4: (a) Estimated PDF from the KDE method developed in Shafer and Doswell (2011) for the 5 February 2008 severe weather outbreak. (b) The 75% estimated PDF from the previous five years of training data, determined by magnitudes of the supercell composite parameter (SCP), for the 5 February 2008 outbreak. (c)-(d) As in (a)-(b), for 15 November 2005. (e)-(f) As in (a)-(b), for 20 May 2006. (g)-(h) As in (a)-(b), for 1 March 2004.

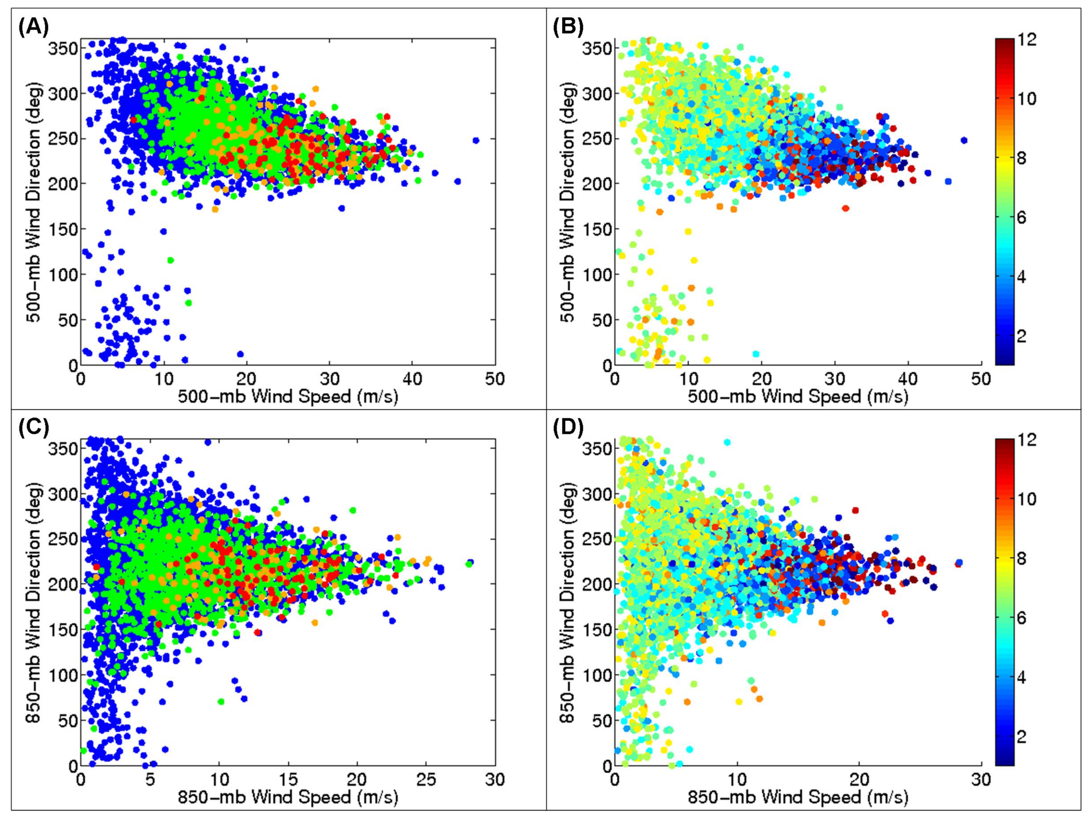

Figure 5: (a) Average value of 500-mb wind speed (x-axis) and 500-mb wind direction (y-axis) for each of the 4437 severe weather outbreaks considered. Events indicated as in Fig. 3c. (b) As in (a), except events indicated by the month number in which they occur. (c) As in (a), except using 850-mb wind speed and direction. (d) As in (b), except using 850-mb wind speed and direction.

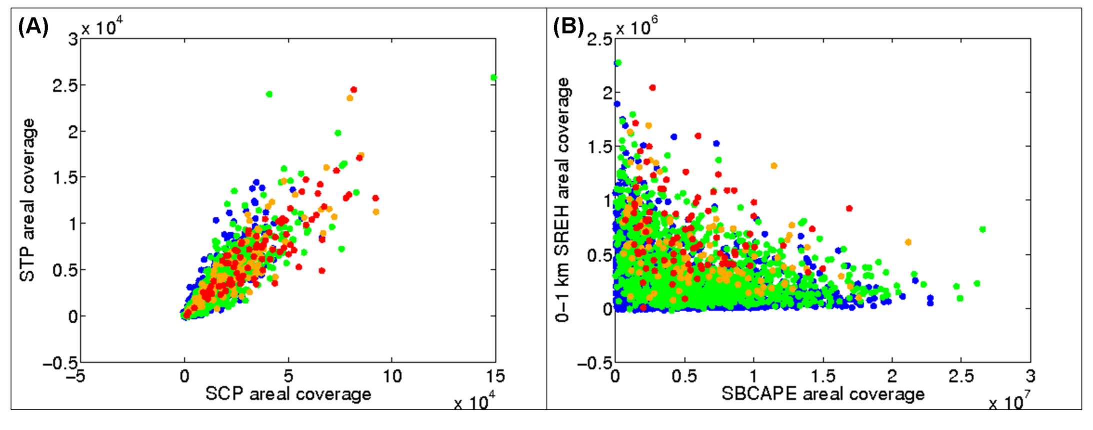

Figure 6: (a) As in Fig. 5a, except using the sum value of SCP (x-axis) and significant tornado parameter (STP; y-axis). (b) As in (a), except using the sum value of SBCAPE (x-axis) and 0-1 km storm-relative environmental helicity (SREH; y-axis).

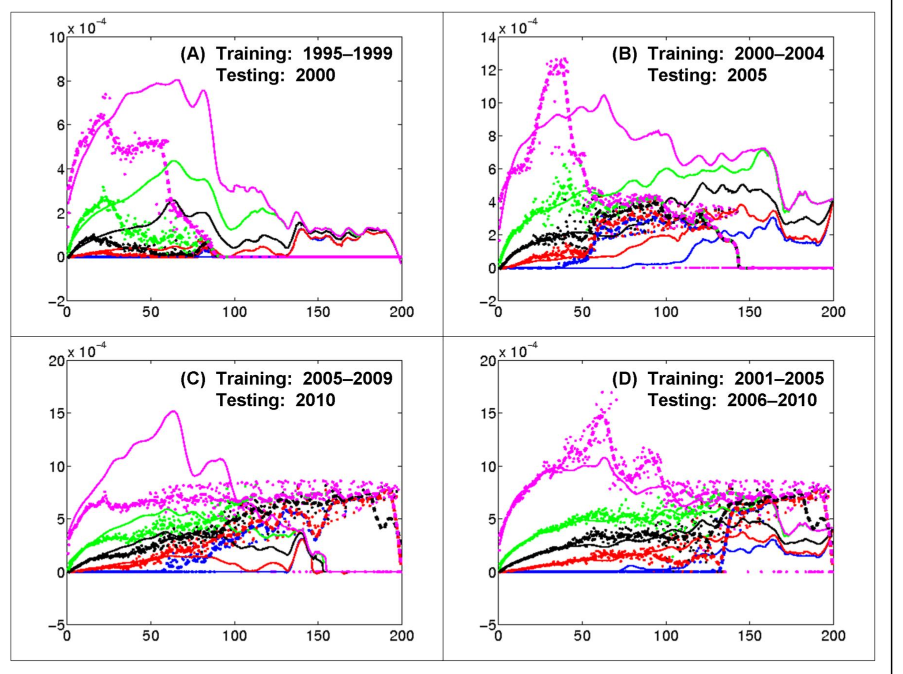

Figure 7: Percentile values (2.5% blue, 25% red, 50% black, 75% green, 97.5% magenta) of the estimated probability density function (PDF) of all severe reports using the magnitude of SCP (x-axis) as a predictor. The training model years (solid lines – local regression) and testing model years (points and dashed lines – local regression) are indicated. See Fig. 4 for examples of estimated PDF using KDE.

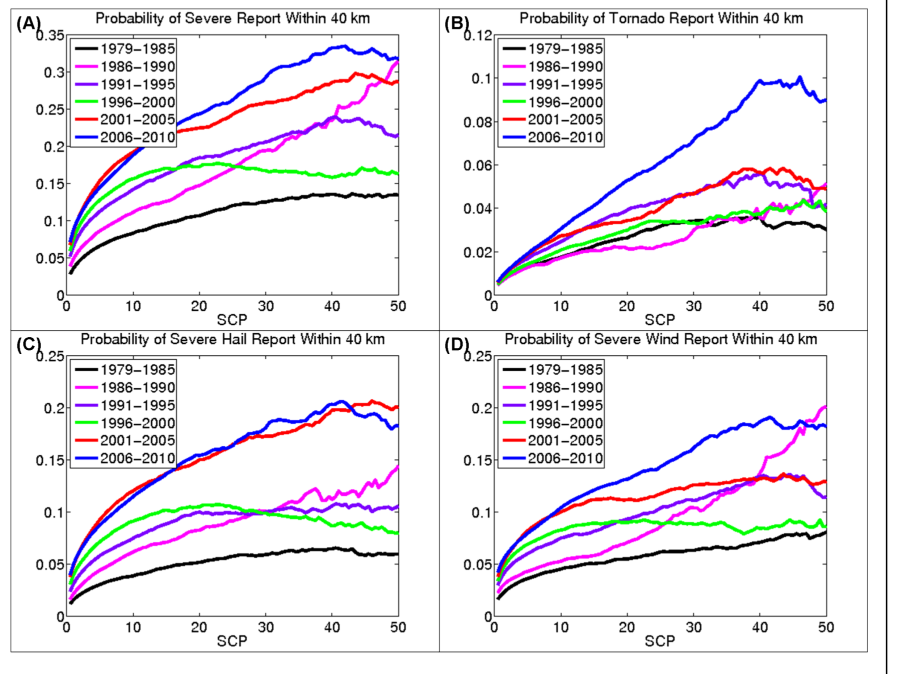

Figure 8: Probabilities of (a) any severe report, (b) a tornado report, (c) a severe hail report, and (d) a severe wind report occurring in a grid box of a Lambert-conformal 40-km horizontal grid for which the magnitude of the supercell composite parameter (SCP) equals or exceeds the threshold indicated (x-axis).

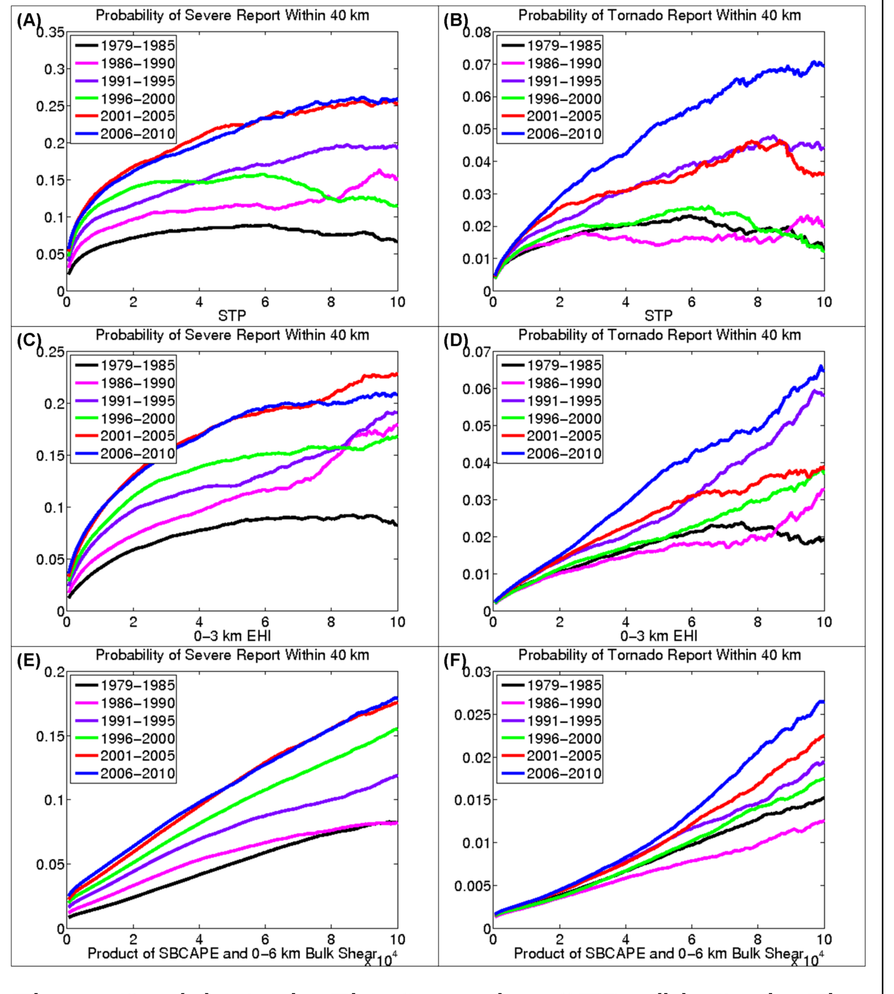

Figure 9: (a) As in Fig. 8a, using STP. (b) As in Fig. 8b, using STP. (c)-(d) As in (a)-(b), using 0-3 km energy-helicity index (EHI). (e)-(f) As in (a)-(b), using the product of SBCAPE and 0-6 km bulk shear.

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