Probabilistic Techniques in the Diagnosis of Severe Weather Outbreaks

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Objectives

•Using the outbreak ranking scheme developed by Shafer and Doswell (2011) and the areal coverage techniques proposed by Shafer et al. (2012), develop a probabilistic framework for diagnosing major severe weather outbreaks.

•Quantify the uncertainty associated with the diagnosed probabilities using bootstrapping (Efron and Tibshirani 1993).

•Compare diagnoses from North American Regional Reanalysis (NARR; Mesinger et al. 2006) data to WRF simulations initialized at 0000 UTC on the nominal dates of the outbreaks.

Data and Methods

•A set of 4437 severe weather outbreaks from 1979 to 2010 are ranked according to their perceived severity (as in Figs. 2 and 5) and are diagnosed as major or minor severe weather outbreaks based on the areal coverage of a preselected severe weather diagnostic variable (SWDV). Note that the preliminary findings herein are **conditional**. A severe weather event is required for a particular day to be considered.

•WRF simulations initialized with NARR for 970 cases from 2003–2010 are compared to NARR data at the valid times of the events.

•Areal coverage is computed in three ways. The **kernel density estimation method** (KM) sums the magnitudes of a preselected SWDV at each grid point determined to be associated with the outbreak (the so-called KDE region, as discussed by Shafer et al. 2012). The **intersect method** (IM) finds the largest contiguous region in which the SWDV exceeds a predetermined threshold (the value of 1 is used herein for SCP and 0-3 km EHI) that also intersects the KDE region. Each grid point in the SWDV region is summed. The **maximum method** (MM) is the same as the IM, except that intersection with the KDE region is not required.

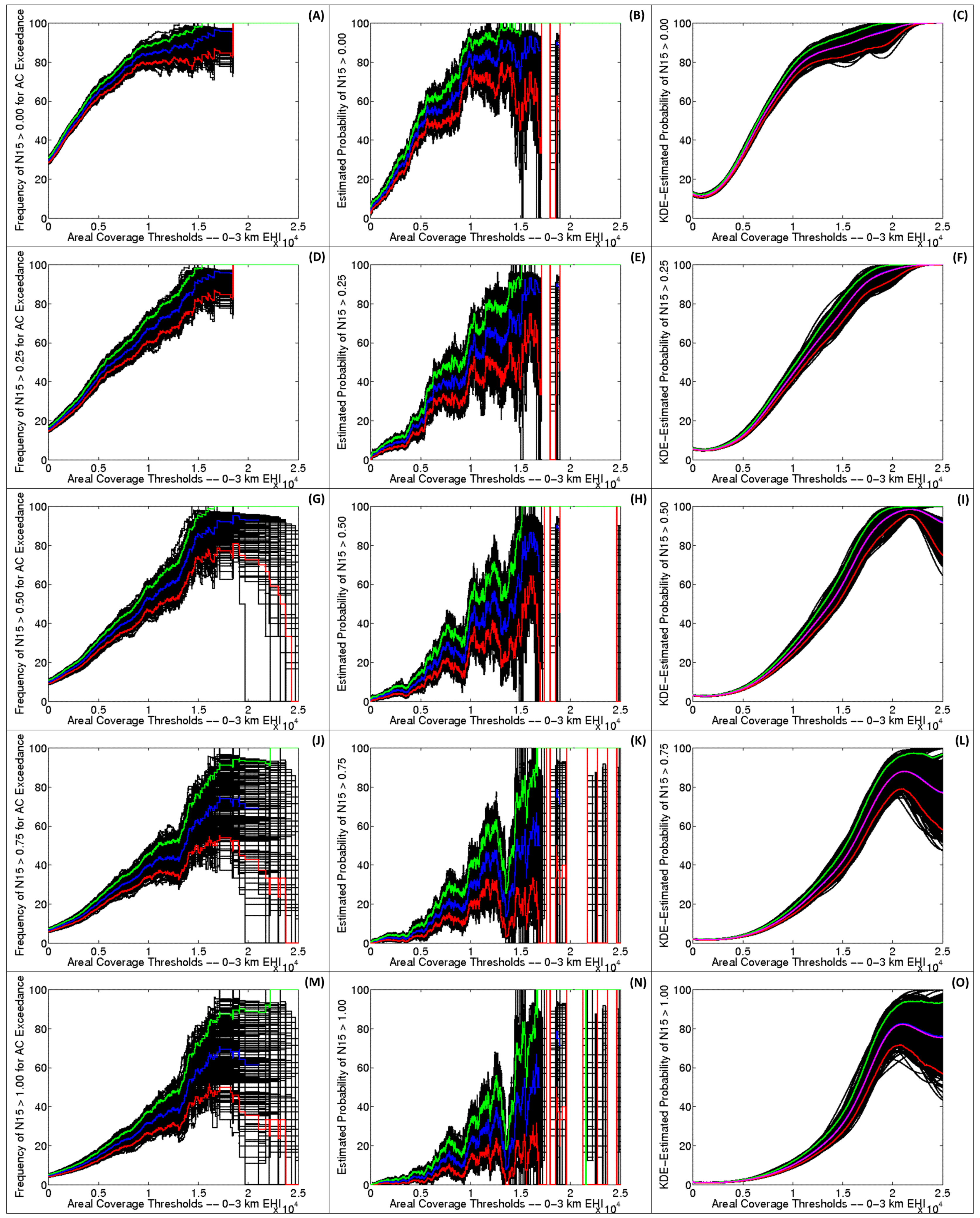

Figure 1: (a) Relative frequency of events with N15 outbreak ranking index scores (Figs. 2 and 5) exceeding zero if areal coverage of 0-3 km EHI (KM) exceeds a threshold value (*x*-axis). (b) Probability of events with N15 outbreak ranking index scores exceeding zero if areal coverage of 0-3 km EHI is the given magnitude (± 250). (c) As in (b), using kernel density estimation. (d)-(f) As in (a)-(c), for N15 > 0.25. (g)-(i) As in (a)-(c), for N15 > 0.50. (j)-(l) As in (a)-(c), for N15 > 0.75. (m)-(o) As in (a)-(c), for N15 > 1. Each member of the bootstrap (black), the 95% confidence interval (red and green curves), the median (blue), and the observed value (magenta) are indicated.

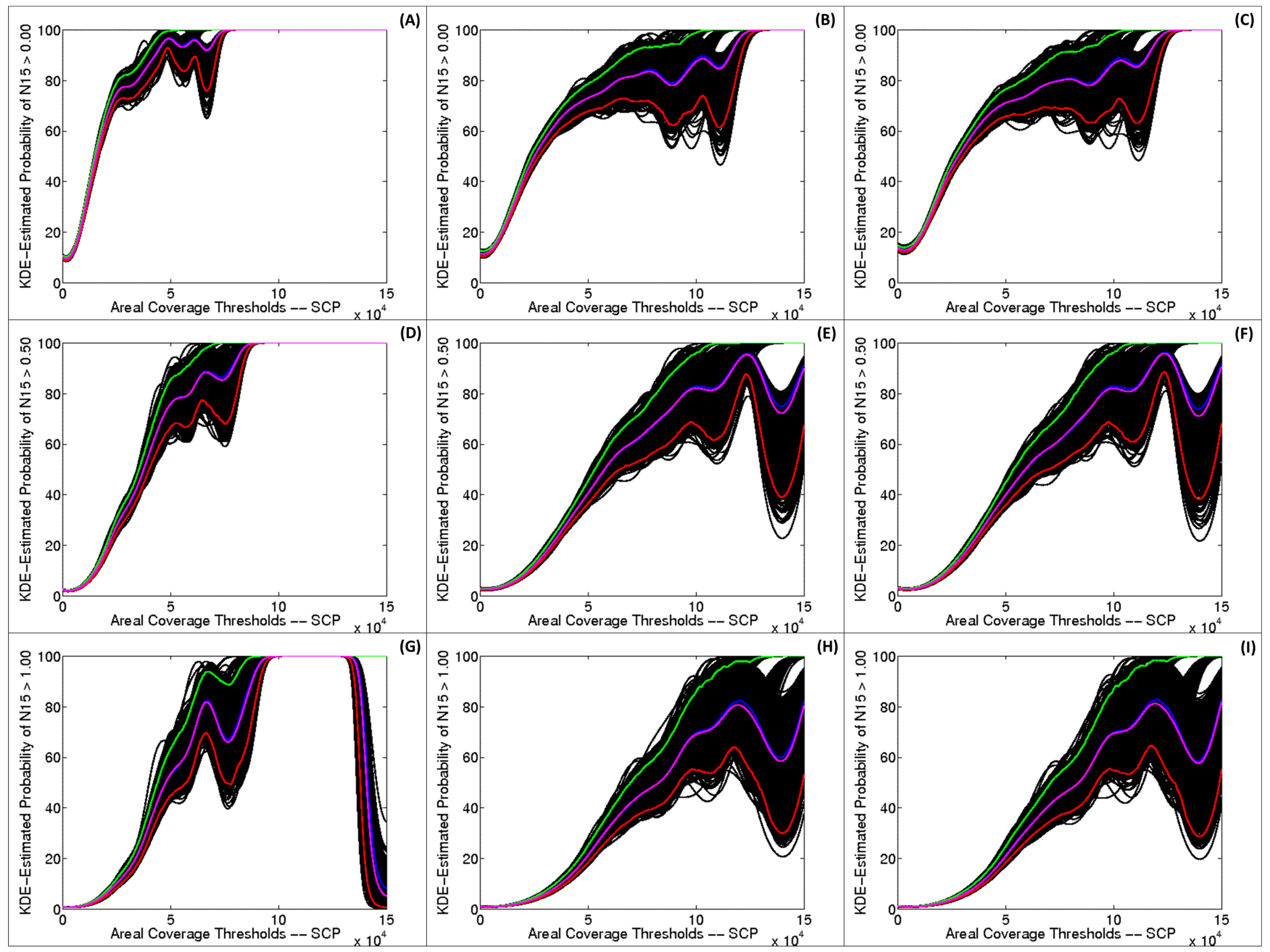

Figure 4: (a) As in Fig. 1c, using SCP. (b) As in (a), using the intersect method (IM). (c) As in (a), using the maximum method (MM). (d)-(f) As in (a)-(c), for N15 > 0.5. (g)-(i) As in (a)-(c), for N15 > 1.

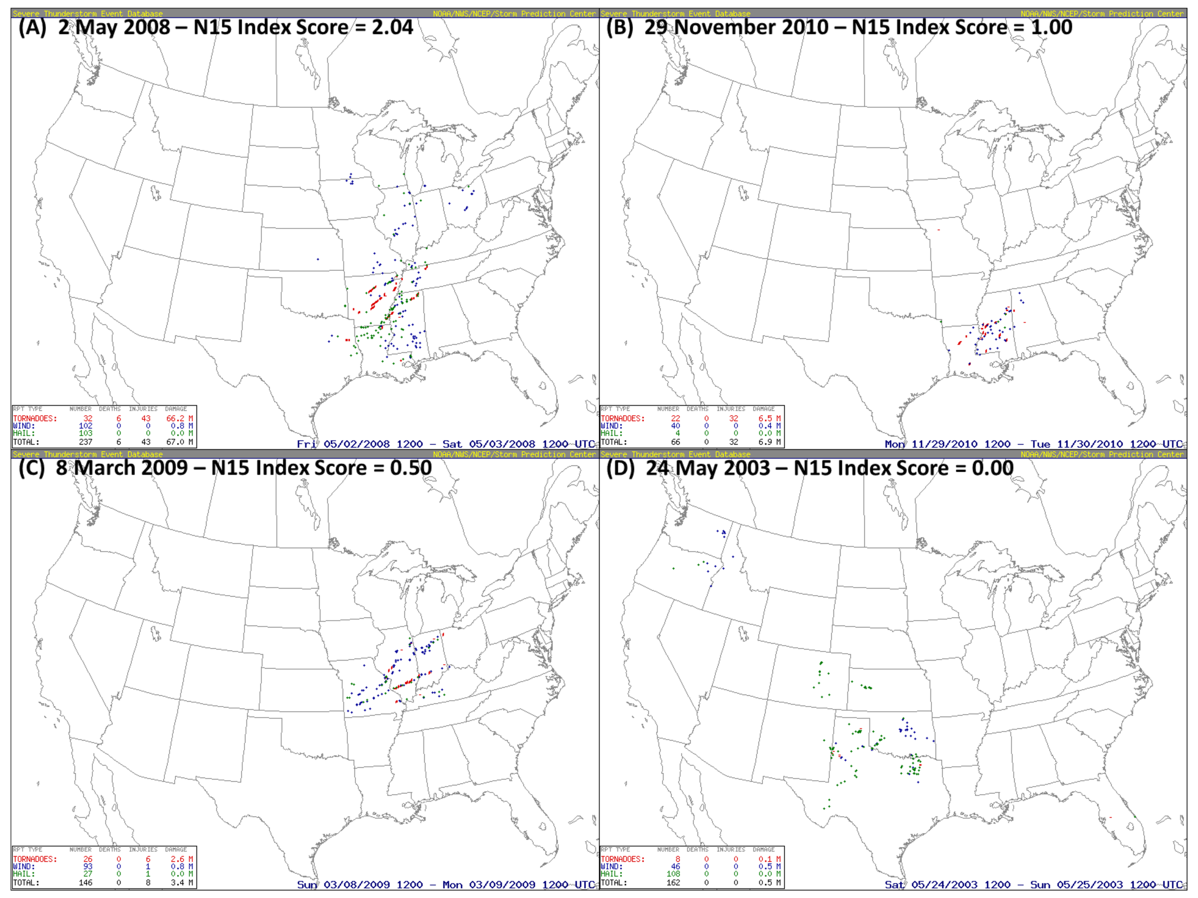

Figure 5: Examples of severe weather outbreaks and their rankings, with tornadoes (red), hail (green), and wind (blue) reports indicated for the appropriate 24-h period.

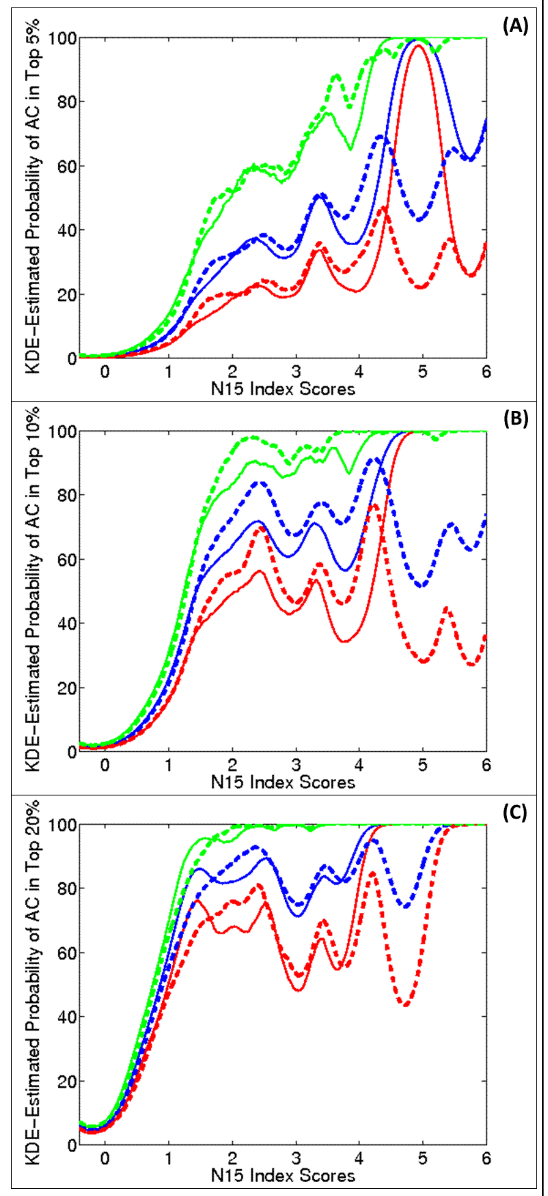

Figure 7: KDE-derived probabilities that the SCP areal coverage (KM) is in the top (a) 5%, (b) 10%, and (c) 20% of the 970 cases from 2003–2010, using NARR diagnoses (solid curves) and WRF simulations initialized at 0000 UTC on the nominal date of the outbreaks (dashed curves). Color-coding as in Fig. 6.

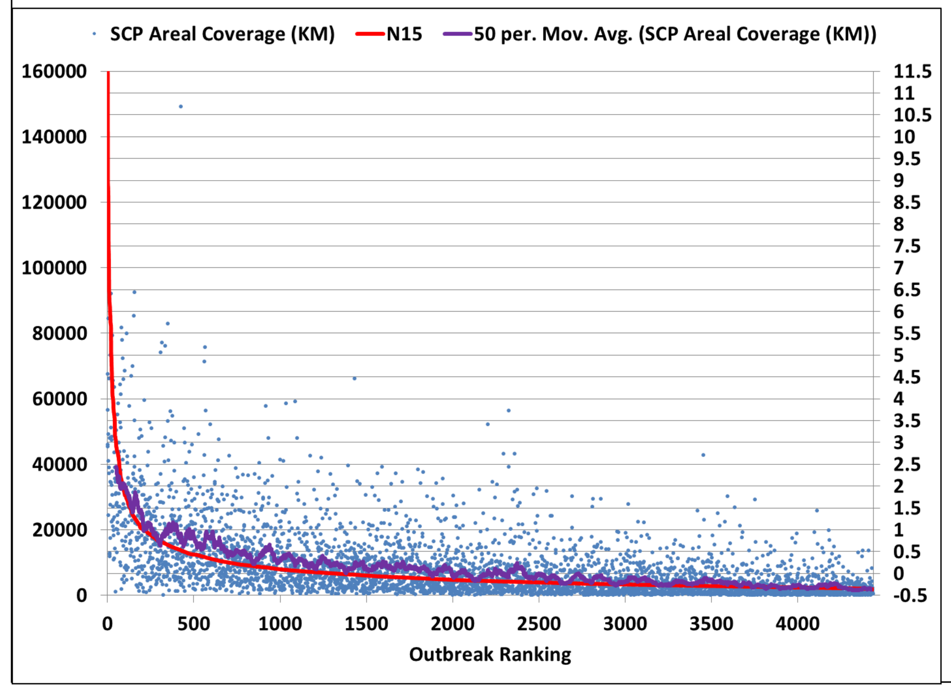

Figure 2 (left): The N15 scores (right *y*-axis) as a function of the outbreak's rank number (*x*-axis) for each of the 4437 cases considered from 1979–2010. The areal coverage of SCP using the KM (left *y*-axis and a 50-point moving average are also indicated.

Figure 3 (right): Relative frequency (*y*-axis) of cases exceeding N15 index scores (*x*-axis) as a function of increasing N15 score, for both the 1979-2010 dataset (blue) and 2003-2010 dataset (green).

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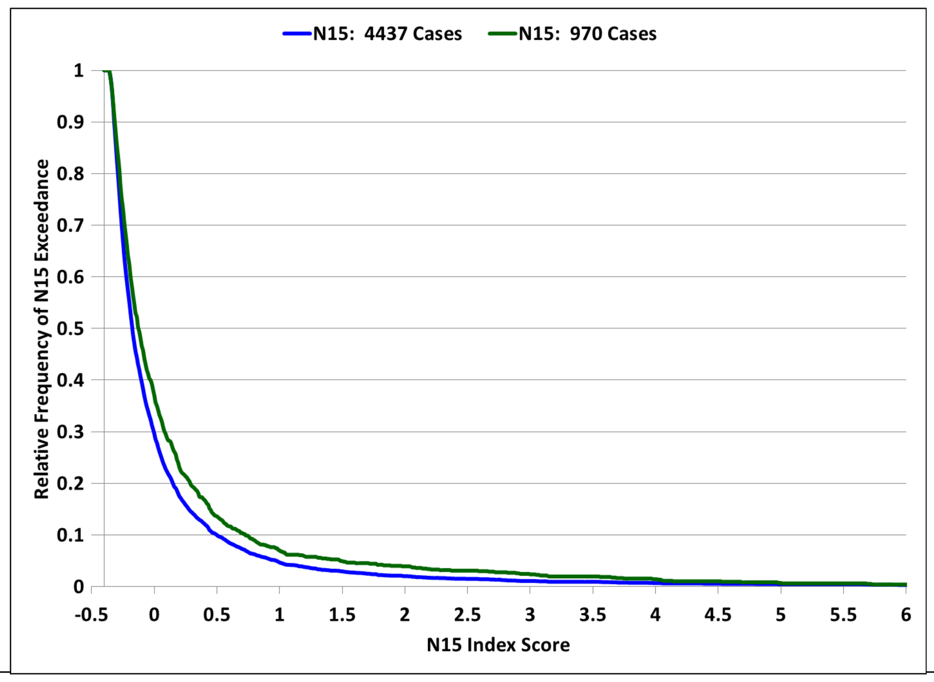

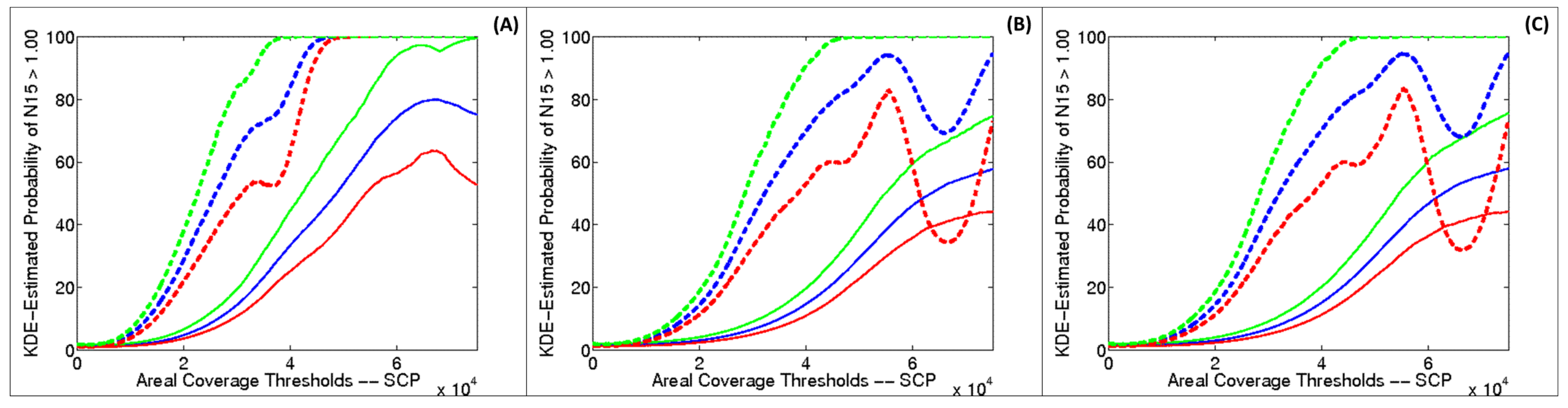

Figure 6: The 95% confidence interval (red and green curves) and median value (blue) of the KDE-estimated probabilities of an outbreak exceeding the N15 index score of 1 for a given value of areal coverage of SCP. Results shown are for NARR diagnoses (solid curves) and WRF forecasts initialized at 0000 UTC on the nominal day of the event (dashed curves), for 970 cases from 2003–2010, using the (a) KM, (b) IM, and (C) MM areal coverage methods.