P5.4

APPLICATION OF CLIMATE STATISTICS AND ENSEMBLE FORECASTS IN THE PREDICTION OF SEVERE WEATHER EPISODES

David R. Bright*
NOAA/NWS/NCEP/SPC, Norman OK

Richard H. Grumm
NOAA/NWS, State College, PA

1. INTRODUCTION

The Ensemble Prediction System (EPS) data from the National Centers for Environmental Prediction (NCEP) Short-Range Ensemble Forecast system (SREF; Du et al. 2004) are routinely used as guidance to help forecasters predict severe weather potential. This study focuses on the use of the SREF to help define the severe weather threat through climatological anomalies. The case studies presented herein represent two severe weather outbreaks that occurred in early April, 2006.

SREF products have demonstrated usefulness in quantifying uncertainty associated with severe weather outlooks at the Storm Prediction Center (SPC; Bright et al. 2004, 2005). Most of this work has focused primarily on severe weather parameter evaluation including raw probabilistic and joint probabilistic forecasts and calibrated guidance. However, the SPC to date has not assessed in detail the usefulness of climatological anomalies as an ensemble tool. Grumm and Hart (2001) demonstrate the usefulness of this approach in the prediction of winter storms, and this paper documents the early attempt to investigate the approach as a severe weather ensemble tool.

2. METHODS

SREF data were retrieved from the NCEP archive to produce the images used in this paper. Most of these products are available in real-time at the SPC and/or the Weather Forecast Office in State College, PA. When the SREF forecasts are assessed relative to seasonal climatology, the NCEP/NCAR Global Re-analysis (GR) data are used. All anomaly fields (i.e., "departure of" fields) are shown as the ensemble mean minus the GR mean value divided by the GR standard deviation, producing a standardized anomaly as described by Grumm and Hart (2001).

A second type of climatological anomaly is explored relative to severe events. In order to perform this analysis a severe event climatology is required; a rudimentary severe event climatology for early April is constructed as follows. First, the SPC severe weather report archive for 2005 and 2006 was parsed to extract all reports separated by $\geq$ 30 minutes and $\geq$ 60 km between 1 March and 30 April across the CONUS. These reports were interpolated to the time-matched SREF initial or 3h forecast grid, provided the grid existed in the SPC SREF archive and the report fell within 60 minutes of the grid valid time. The two case study days shown in section 3 were removed from the analysis to preserve independence. This approach yielded approximately 600 data points from which the severe event climatological mean and variance were computed. These values are relative to the severe event location and therefore applied uniformly across the domain.

3. RESULTS

3.1 2 April 2006

An outbreak of severe weather ahead of a strong cold front occurred over a large region of the central and eastern United States on 2 April 2006. Figure 1 is a plot of the 24h severe weather reports ending 12 UTC 3 April 2006). A preliminary total of 872 severe reports including 86 tornadoes was received by the SPC; 26 people lost their lives in this deadly outbreak.

All SREF figures are 24h forecasts initialized at 2100 UTC 1 April 2006 and valid at 2100 UTC 2 April 2006. The development of a strong surface cyclone over Missouri led to a surge of unseasonably high precipitable water (PW) ahead of the surface cold front (Fig. 2). The sea level pressure anomaly associated with this event is 2 to 3 standard deviations below normal near the low center over Iowa. Meanwhile, a large portion of the Mississippi Valley is 2 to 3 standard deviations above normal in the PW (Fig. 3). The 850 hPa U- and V-wind anomalies are also 2 to 3 standard deviations from normal on both sides of the cold front (not shown). North of the warm front, negative U-wind anomalies are also present. This event is also characterized by large, positive CAPE anomalies over the same general area where the PW is anomalously high (not shown). The SREF mean mass and wind departure fields indicate the potential for an anomalous event.

Having investigated the departure from seasonal climatology, the remaining analysis is relative to the severe event climatology. The PW anomaly is above normal across much of the warm sector, and exceeds one standard deviation in some places (Fig. 4). An analysis of most unstable CAPE (MUCAPE; Fig. 5) also indicates much of the warm sector is above normal, with a large region ahead of the cold front 1 to 3 standard deviations above severe event normal. The Significant Tornado Parameter (STP; Thompson et al. 2003) is designed to elucidate areas in which the large-scale environment is supportive of strong or violent tornadoes. The STP is above severe event normal from northern Louisiana to central Illinois, with a departure of 1.5 in northeast Arkansas (Fig. 6). Indeed, this event appears noteworthy relative to both the seasonal climatology *and the* severe event climatology.

* *Corresponding author address: David R. Bright, NOAA/NWS/NCEP Storm Prediction Center, 120 David L. Boren Blvd., Norman, OK 73072; E-mail: david.bright@noaa.gov.*

3.2 7 April 2006

A second severe weather outbreak in less than a week occurred 7 April 2006 with widespread severe weather from northern Louisiana through the Ohio Valley (Fig. 7). This event resulted in a preliminary total of 871 severe reports, including 91 tornadoes and 8 fatalities. As in the previous case, all figures are 24h SREF forecasts from 21 UTC 6 April 2006 valid at 21 UTC 7 April 2006.

The departure from seasonal normals of the PMSL and PW are slightly less than in the previous case (Figs. 8 and 9, respectively). The PW is notably less than in the previous case, with anomalies only around 1 standard deviation above normal from Louisiana to New England.

Examining the SREF forecast relative to the severe event climatology finds a portion of the southeast that is above normal in PW and MUCAPE (Figs. 10 and 11, respectively). As in the seasonal climatology, the severe event PW anomaly is only slightly positive (about 1/2 standard deviation above normal from extreme eastern Texas to the Tennessee border). The MUCAPE anomaly is a bit more notable and exceeds two standard deviations from northeast Texas to southwest Tennessee. However, the significant tornado anomaly is rather striking and exceeds two standard deviations above normal over northern Mississippi, northwest Alabama, and southwest Tennessee (Fig. 12).

4. SUMMARY

Two short cases were presented to highlight the SREF's ability to provide guidance in the prediction of severe weather. Both of the cases produced widespread severe weather, including strong and violent tornadoes. Although not shown in detail, both events were reasonably well forecast by the SREF. And although not really the subject of this paper, joint probability products (e.g., CAPE and shear) and parameter evaluation (e.g., significant tornado parameter) in ensemble space were quite useful (Weiss et al. 2006).

This short study focused on climatic anomaly evaluation and indicated that deviations from both seasonal and severe event climatology may be useful in severe weather forecasting. Grumm and Hart (2001) have demonstrated the usefulness of seasonal climate anomalies to elucidate the impact of winter storms. Not surprisingly, a similar approach was found to be promising here. Furthermore, the development of a rudimentary severe event climatology appears to have merit as well. Both outbreaks were notable departures from seasonal and severe event normals.

The development of anomalies based on higher resolution North American Regional Re-analysis data (NARR) is underway and should help refine aspects of the forecast. Further work needs to be done to investigate the merit of severe event normals, and more robust methods of constructing the severe event climatology are required. Application of the anomalies should aid in assessing predictability limits and/or "forecast confidence" as well.

The poster presentation will include additional examples and products, with supporting probabilistic and joint probabilistic guidance available.

5. ACKNOWLEDGEMENTS

Appreciation is extended to all those responsible for the short-range ensemble development and archive at the NCEP Environmental Modeling Center (EMC) and NCEP Central Operations (NCO). Many thanks to Steve Weiss of the SPC for his always helpful discussion and review.

6. REFERENCES

Bright, D.R., M.S. Wandishin, R.E. Jewell, and S.J. Weiss, 2005: A physically based parameter for lightning prediction and its calibration in ensemble forecasts. *Preprints*, Conf. on Meteor. Applications of Lightning Data, San Diego, CA, Amer. Meteor. Soc., CD-ROM (4.3).

Bright, D.R., M.S. Wandishin, S.J. Weiss, J.J. Levit, J.S. Kain, and D.J. Stensrud, 2004: Evaluation of short-range ensemble forcasts in predicting severe convective weather during the 2003 SPC/NSSL Spring Program. *Preprints*, 22nd Conf. Severe Local Storms, Hyannis, MA, Amer. Meteor. Soc., P15.5.

Du, J and co-authors: 2004: The NOAA/NWS/NCEP short range ensemble forecast (SREF) system: Evaluation of an initial condition verse model physics approach. *Preprints, 16th Conference on Numerical Prediction*, Seattle, WA, Amer. Meteor. Soc., CD-ROM, 21.3.

Grumm, R. and R. Hart, 2001: Standardized anomalies applied to significant cold season weather events: Preliminary findings. *Weather and Forecasting*, **16**, 736-754.

Thompson, R.L, R. Edwards, J.A. Hart, K.L. Elmore and P.M. Markowski, 2003: Close proximity soundings within supercell environments obtained from the Rapid Update Cycle. *Weather and Forecasting*, **18**, 1243-1261.

Weiss, S.J, D.R. Bright, J.S. Kain, J.J. Levit, M.E. Pyle, Z.I. Janjic, B.S. Ferrier, and J. Du, 2006: Complimentary use of short-range ensemble and 4.5 km WRF-NMM model guidance for severe weather forecasting at the Storm Prediction Center. Preprints, 23rd Conference on Severe Local Storms, St. Louis, MO, Amer. Meteor. Soc., CD-ROM, 8.5.

7. FIGURES

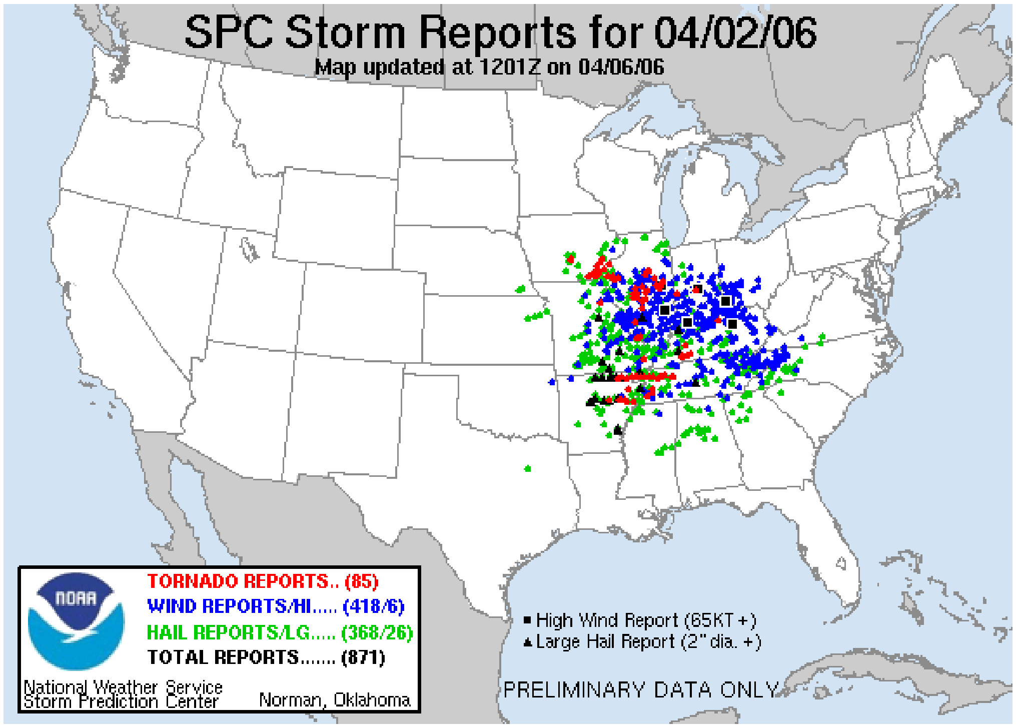

Figure 1. Storm Prediction Center reports of severe weather for 2 April 2006. Types of severe events are as shown in the key on each image.

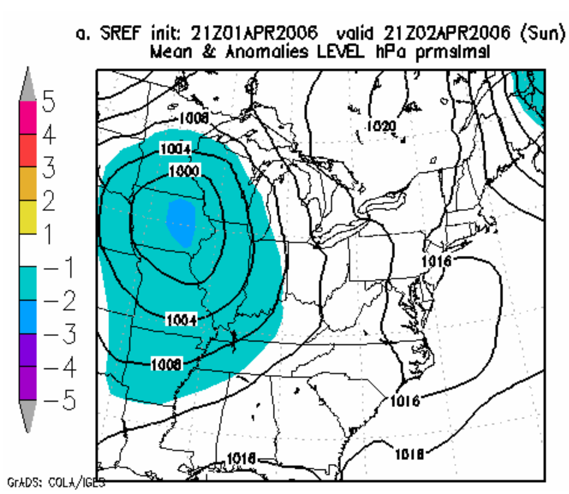

Figure 2. SREF forecasts initialized at 2100 UTC 1 April 2006 valid at 2100 UTC 2 April 2006 showing the ensemble mean MSLP (hPa; contours) and MSLP anomaly (standard deviations from normal; shaded).

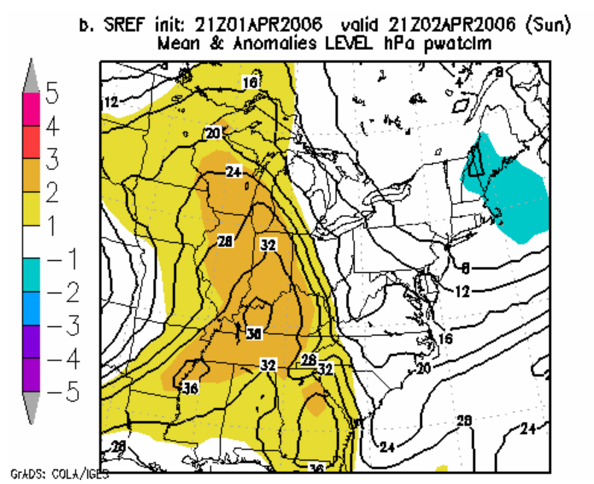

Figure 3. As in Fig. 2 but for precipitable water (PW) with the SREF mean (mm; contoured) and the PW anomaly (shaded).

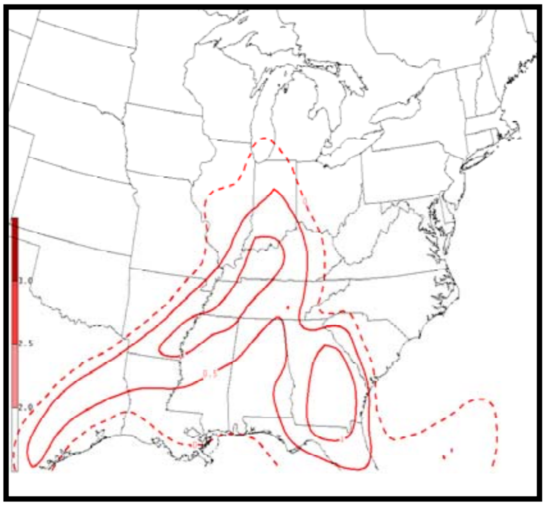

Figure 4. As in Fig. 2 except the PW anomaly relative to the severe event climatology.

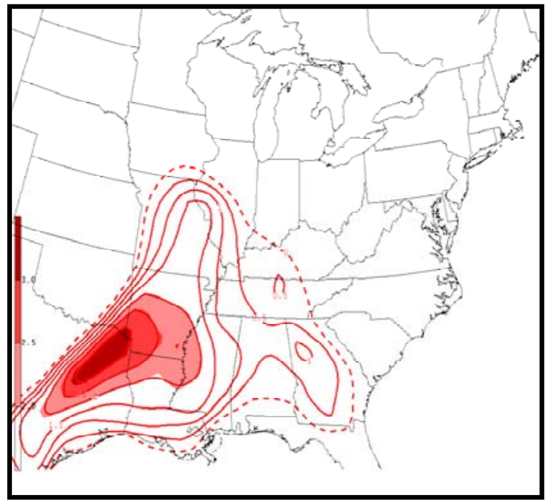

Figure 5. As in Fig. 2 except the MUCAPE anomaly relative to the severe event climatology.

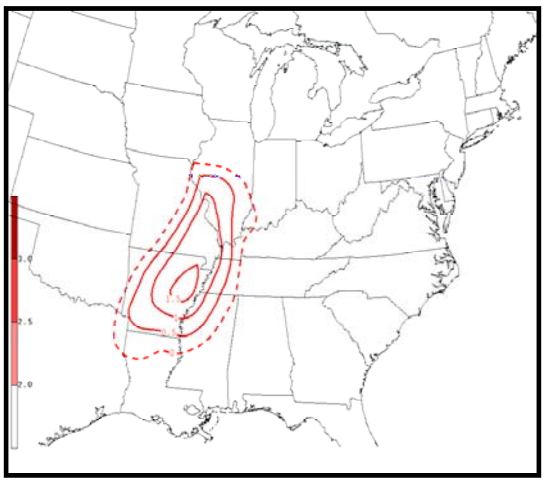

Figure 6. As in Fig. 2 except STP anomaly relative to the severe event climatology.

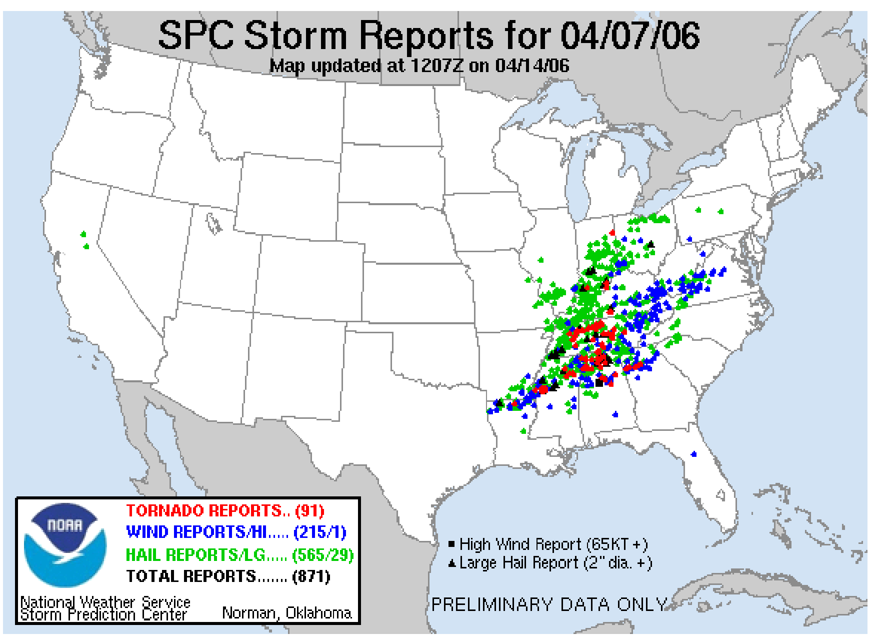

Figure 7. As in Figure 1 except valid for 24 hour period ending 1200 UTC 8 April 2006.

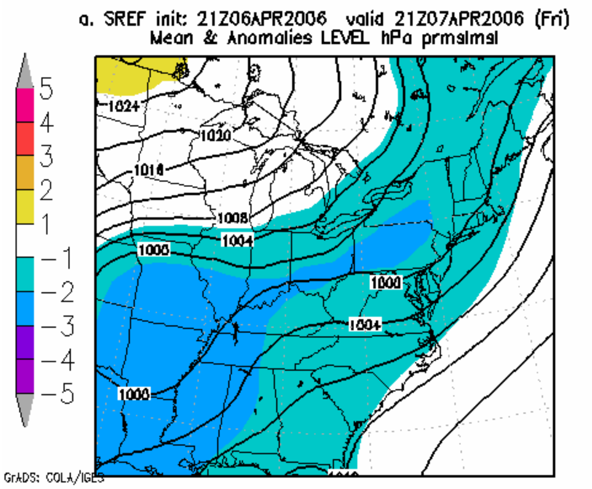

Figure 8. SREF forecasts initialized at 2100 UTC 6 April 2006 valid at 2100 UTC 7 April 2006 showing the ensemble mean MSLP (hPa; contours) and MSLP anomalies (standard deviations from normal; shaded).

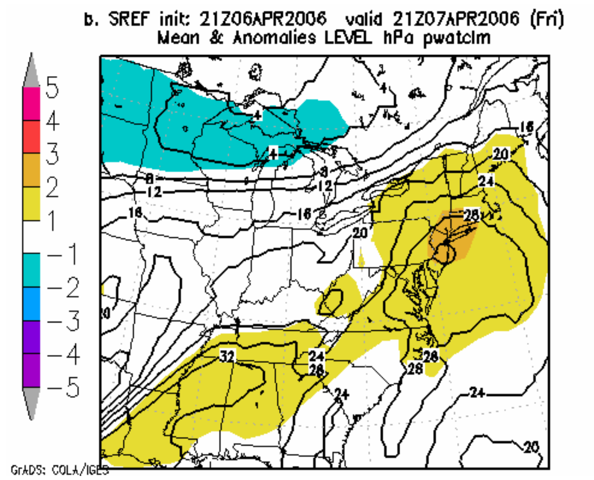

Figure 9. As in Fig. 8 but for precipitable water (PW) with the SREF mean (mm; contoured) and the PW anomalies (shaded).

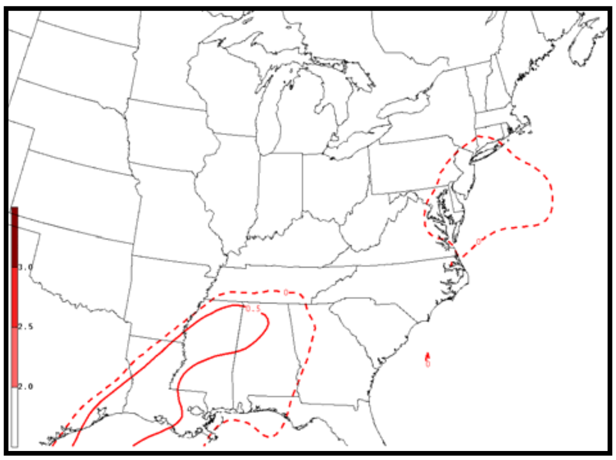

Figure 10. As in Fig. 8 except the PW anomaly relative to the severe event climatology.

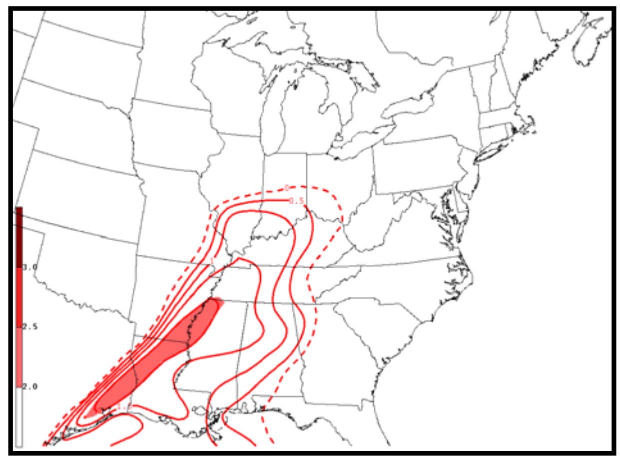

Figure 11. As in Fig. 8 except the MUCAPE anomaly relative to the severe event climatology.

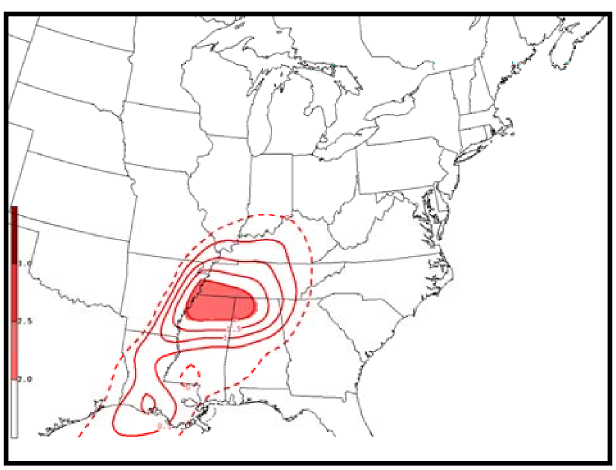

Figure 12. As in Fig. 8 except the STP anomaly relative to the severe event climatology.