Parameter Assessment for a Marginal, High-Shear, Low-CAPE (HSLC) Cold Season Tornado Event in Indiana

Owen Rahman, Robin Tanamachi

PURDUE UNIVERSITY | Department of Earth, Atmospheric, and Planetary Sciences

OVERVIEW

On 31 December 2018, a quasi-linear convective system (QLCS) moved through southern Indiana and produced an EF1 tornado in northern Spencer County. Relatively low CAPE and higher 0-3 km bulk shear values were calculated, making this case an HSLC event. Testing HSLC parameters for tornado potential, SHERBE did not indicate tornado potential while SHERBS3 did. The strong low-level jet seen in this case was the likely reason for the missed detection by SHERBE.

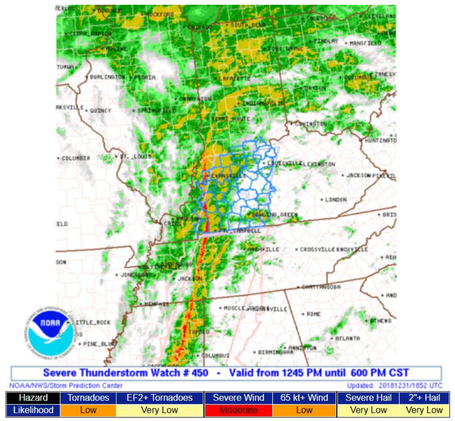


Fig 1. Severe Thunderstorm Watch 450 released by the Storm Prediction Center on 31 December 2018. The watch is overlaid with a reflectivity mosaic.

CASE BREAKDOWN

The severe weather event of 31 December 2018 brought several key atmospheric ingredients (Johns and Doswell 1992) together:

- Moisture: Surface temperature 17.8°C, surface dew point 17.2°C
- Instability: Most Unstable CAPE 100-200 J kg $^{-1}$
- Lift: An advancing QLCS from a strong cold front
- Shear: 0-1 km shear 28 m s $^{-1}$, 0-3 km shear 33 m s $^{-1}$, 0-6 km shear 38 m s $^{-1}$

PARAMETER EVALUATION

SHERB* parameters are used operationally to assess tornado potential in HSLC scenarios (Sherburn and Parker 2014). Using an averaged Rapid Refresh model sounding, pulled from KOWB and KHNB airport locations, shown in Fig 3 below, SHERBE and SHERBS3 parameters were calculated (Table 1). These locations were chosen due to proximity to the eventual tornado event, providing a representative snapshot of preceding atmospheric conditions. Fig 2 provides Rapid Refresh model simulated reflectivity for a spatial representation of the event.

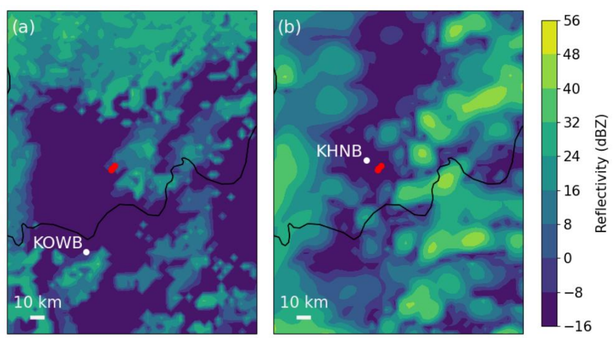


Fig 2. Rapid Refresh model simulated reflectivity for (a) 18Z with KOWB (Owensboro, Kentucky Regional Airport AWOS) highlighted in white and (b), 19Z with KHNB (Huntingburg, Indiana Regional Airport ASOS) highlighted in white. The tornado track is highlighted in red, and the Indiana-Kentucky state border is outlined in black.

The only difference between the SHERBE and SHERBS3 calculation is the consideration of either Effective Shear (Thompson et al. 2004) or 0-3 km shear magnitude (Eqns. 1 and 2). Since the base effective shear level was already within the low-level jet, the effective shear value was much lower than the 0-3 km shear magnitude, well below 1 (Table 1). It is important to note that each parameter is normalized, so a value above 1 indicates significant tornado potential.

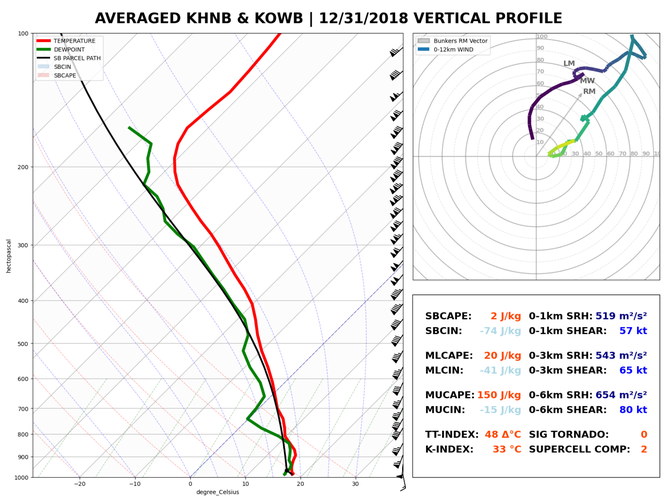


Fig 3. An averaged BUFKIT sounding pulled from Rapid Refresh model data from 18Z at KOWB and 19Z at KHNB.

Table 1. The SHERBE and SHERBS3 parameter terms from Sherburn and Parker (2014), with calculated values for this case.

SHERB* Parameter Term:	Term Full Name:	Value:
ESHR	Effective Shear	0.142 m/s
LLLR	Low-Level (0-3 km) Lapse Rate	4.56 K/km
LR75	700-500 Hectopascal Lapse Rate	5.91 K/km
S3MG	0-3 km Shear Magnitude	34.47 m/s
SHERBE	Severe Hazards in Environments with Reduced Buoyancy Parameter Using Effective Shear	0.005
SHERBS3	Severe Hazards in Environments with Reduced Buoyancy Parameter Using 0-3 km Shear	1.227

$$\mathrm{SHERBE} = \left(\mathrm{ESHR}/27\ \mathrm{m\ s^{-1}}\right) \times \left(\mathrm{LLLR}/5.2\ \mathrm{K\ km^{-1}}\right) \times \left(\mathrm{LR75}/5.6\ \mathrm{K\ km^{-1}}\right). \quad (1)$$

$$\mathrm{SHERBS3} = \left(\mathrm{S3MG}/26\ \mathrm{m\ s^{-1}}\right) \times \left(\mathrm{LLLR}/5.2\ \mathrm{K\ km^{-1}}\right) \times \left(\mathrm{LR75}/5.6\ \mathrm{K\ km^{-1}}\right). \quad (2)$$

CONCLUSIONS

While the SHERBE and SHERBS3 parameters are generally good indicators of HSLC tornado potential, conflicting results were obtained for this case. Forecasters in affected areas correctly described a marginal tornado potential, so it is important to use all available resources to forecast severe weather events.

ACKNOWLEDGEMENTS

A special thanks to Jacob Bruss for supplying a source code for Fig 3. The Rapid Refresh model soundings for Fig 3 were sourced from BUFKIT (Mahoney and Niziol 1997). Fig. 3 graphics were made using Python packages Matplotlib, MetPy, and CartoPy.

REFERENCES

Johns, R. H., and C. A. Doswell, 1992: Severe local storms forecasting. Weather and Forecasting, 7, 588–612, https://doi.org/10.1175/1520-0434(1992)007<0588:slsf>2.0.co;2.

Mahoney, E. A., and T. A. Niziol, 1997: BUFKIT: A software application toolkit for predicting lake effect snow. Preprints, 13th International Conf. on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, Long Beach, California, American Meteorological Society, 388–391.

Sherburn, K. D., and M. D. Parker, 2014: Climatology and Ingredients of Significant Severe Convection in High-Shear, Low-CAPE Environments. Weather and Forecasting, 29, 854–877, https://doi.org/10.1175/WAF-D-13-00041.1.

Thompson, R. L., Mead, C. M., & Edwards, R. (2004). Effective bulk shear in supercell thunderstorm environments, Paper presented at 22nd Conference on Severe Local Storms, American Meteorological Society, Hyannis, MA.