TWISTEX 2008: In Situ and Mobile Mesonet Observations of Tornadoes

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Overview

- In May 2008, the Tactical Weather Instrumented Sampling in/near Tornadoes Experiment (TWISTEX) collected four thermodynamic and kinematic datasets of tornadic circulations.
- Three of these were obtained unintentionally in circulations well removed from the intense low-level mesocyclone. The remaining intercept was conducted as planned on a developing tornado.
- We compare the observational datasets with laboratory and numerical simulations.

Instrumentation

- Two Hardened In situ Tornado Pressure Recorder (HITPR) probes (Fig. 1a) (10 measurements per second) and one photogrammetric probe (Fig. 1b) (Samaras, 22nd SLS).
- Three vehicles with mesonet instrumentation (one measurement every 2 seconds) to sample the Rear Flank Downdraft (RFD) (Fig. 1c & 1d).
- Mesonet sensors measured temperature, dew point, pressure, and winds which underwent quality control inspection.
- Time-stamped GPS and video verified location and visual details pertaining to each event.

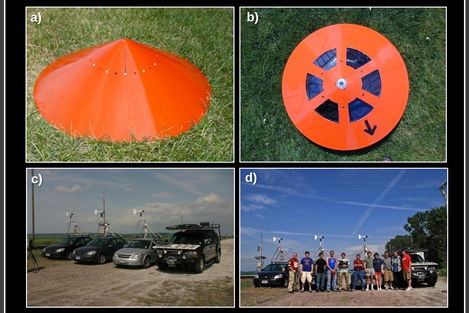

Figure 1. a) HITPR probe, b) photogrammetric probe, c) mobile mesonet stations, and d) TWISTEX personnel with mobile mesonet stations.

May 10th, 2008

- Two mobile mesonet stations intercepted a weak tornadic circulation 4 miles N of Broken Bow, OK (Fig. 4), measuring pressure deficits of 2.5 and 4 mb, followed by gusts of 75 and 100 kts 10 seconds later (Fig. 2a).
- Why the lag in when gusts occurred? Wind direction was highly turbulent during this time, due to effects from nearby trees (Fig. 2b).

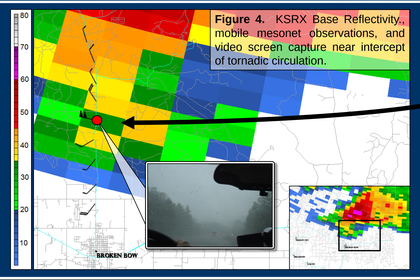

Figure 4. KSRX Base Reflectivity., mobile mesonet observations, and video screen capture near intercept of tornadic circulation.

May 29th, 2008 – Case 1

- In situ instruments intercepted a mature tornado 5 miles NW of Tipton, KS (Fig. 6). One mobile mesonet was near the tornadic circulation; another was 1 km S.
- Pressure deficits of 5, 7, and 15 mb were observed (Fig. 3c), agreeing with lab and numerical simulations (Fig. 2a & 2b).
- Winds were sustained > 40 kts, with max gust of 85 kts observed by one mesonet (Fig. 2e). Wind direction shifted from WSW to NNW (Fig. 2f). (Additional analysis in Lee et al., 24th SLS).

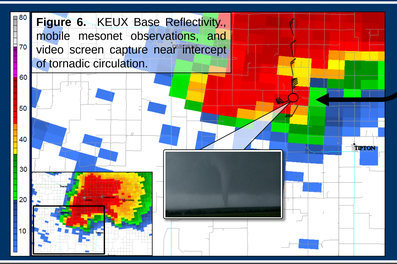

Figure 6. KEUX Base Reflectivity., mobile mesonet observations, and video screen capture near intercept of tornadic circulation.

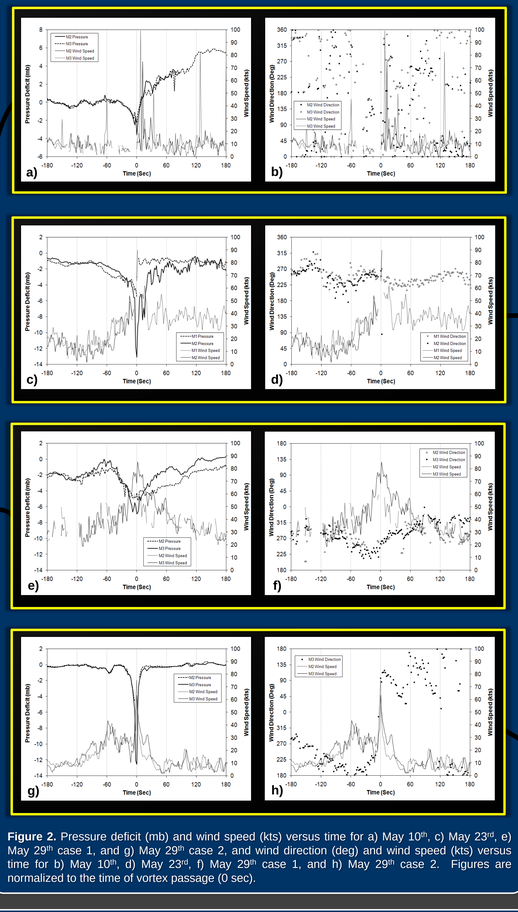

Figure 2. Pressure deficit (mb) and wind speed (kts) versus time for a) May 10th, c) May 23rd, e) May 29th case 1, and g) May 29th case 2, and wind direction (deg) and wind speed (kts) versus time for b) May 10th, d) May 23rd, f) May 29th case 1, and h) May 29th case 2. Figures are normalized to the time of vortex passage (0 sec).

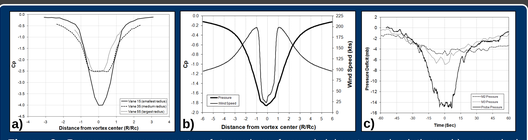

Figure 3. Pressure measurements of tornadoes from a) laboratory simulations, b) numerical simulations, and c) probe and mobile mesonet observations from May 29th Case 1.

May 23rd, 2008

- One mesonet intercepted satellite tornado 2 miles N of Quinter, KS (Fig. 5) with pressure deficit of 13 mb (Fig. 2c), coincident with peak westerly gust of 90 kts (Fig. 2d).
- Spotters reported a satellite vortex passed near M2. Pressure and wind speed measurements strongly support this observation (Additional analysis in Finley and Lee, 24th SLS.)

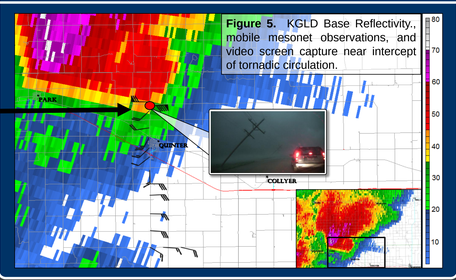

Figure 5. KGLD Base Reflectivity., mobile mesonet observations, and video screen capture near intercept of tornadic circulation.

May 29th, 2008 – Case 2

- Two mesonets intercepted weak anticyclonic tornado 8 miles N of Beloit, KS (Fig. 7).
- A rapid pressure drop of 13 mb (Fig. 2g) and max wind gust of 75 kts were measured.
- Interestingly, wind direction shifted from W to E (Fig 2h) in a northerly propagating tornado, indicating anticyclonic circulation, confirmed by spotters and video.

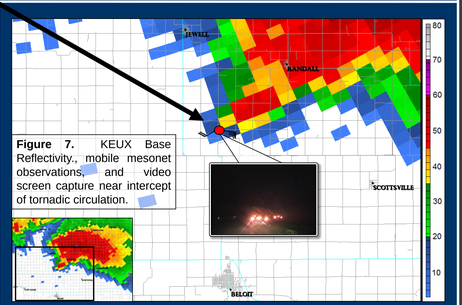

Figure 7. KEUX Base Reflectivity., mobile mesonet observations, and video screen capture near intercept of tornadic circulation.

Tornado Simulations

- Laboratory and numerical simulations were performed to compare with observations (Fig. 8).
- Profiles of surface pressure coefficient (Cp) (Fig. 3) show large pressure deficits coincident with center of vortex in each simulation. Flattening of profiles with medium and large core radii is due to central downdraft at vortex axis.
- Minimum in winds exist at center of vortex, with maximum in core region. Winds exponentially decrease with increasing distance from core (Fig. 3).

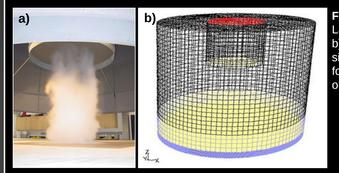

Figure 8. a) ISU WiST Lab Tornado Simulator & b) Fluent numerical simulation domain used for comparison to observational datasets.

Conclusions

- While 3 of 4 datasets were obtained unintentionally, they do add to the small collection of measurements obtained from in and near tornadoes.
- Observations show rapid pressure drop nearly coincident with maximum wind gust.
- General characteristics of observations compare well with lab and numerical simulations (Fig. 3).
- Efforts will continue in future TWISTEX field projects to collect measurements of tornadic flow field near the surface.

Acknowledgements

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