# Probabilistic Tornado Warning Plumes

## *AMS - 27th Conference on Severe Local Storms*

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**Motivation:** In 2012 the National Weather Service (NWS) office in Kansas City/Pleasant Hill, Missouri participated in the Impact-Based Warning project. A review of the project was conducted where NWS forecasters were asked to set aside the current NWS text warning system and brainstorm how severe weather threats could best be conveyed to customers. One of the suggestions was to create a grid of probabilities for severe weather threat in the path of the storm, which is also an ambition of the "Forecasting A Continuum of Environmental Threats" (FACETS) project at the National Severe Storms Laboratory (NSSL). Although the tools to do this directly are not currently available to NWS meteorologists, there is enough information in NWS tornado warning text to make some general assumptions regarding threat levels. Specifically, using the forecaster defined initial storm location and motion in the NWS warning text (right), threat levels downstream can be determined.

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PRECAUTIONARY/PREPAREDNESS ACTIONS...

TORNADOES ARE DIFFICULT TO SEE AND CONFIRM AT NIGHT. TAKE COVER NOW.

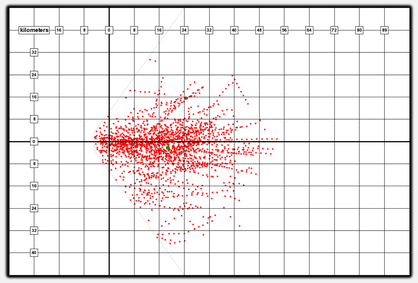
&&

LAT...LON 3772 8679 3766 8664 3762 8664 3760 8662
      3755 8665 3755 8667 3754 8666 3733 8680
      3733 8680 3736 8687
TIME...MOT...LOC 0035Z 200DEG 41KT 3738 8682

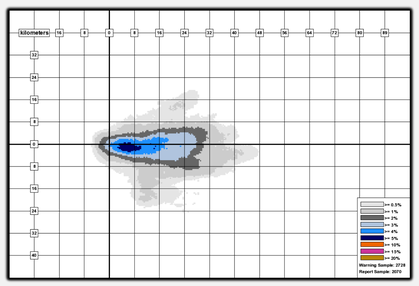
TORNADO...RADAR INDICATED
HAIL...0.00IN

$$
```

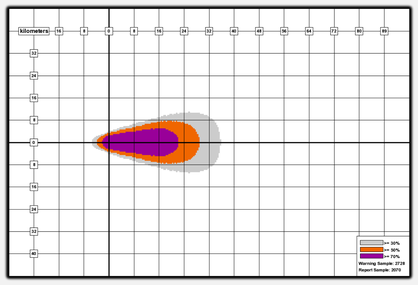
**Methodology/Climatology:** Tornado warnings/reports from 2008-2013 are normalized so that all storm motion is from left to right and share a common origin point. The warnings are divided into bins based on storm speed and warning time length. A gridded field of probabilities is produced from the reports, then using regression equations and smoothing a plume is calculated.




*(a) Scatter plot of tornado reports relative to initial storm location for tornado warnings. Green dot represents mean location of reports. Storm Speed: 13 m $s^{-1}$ Duration: 45 minutes.*

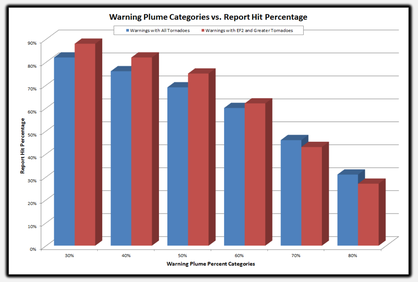



*(b) Gridded field of probabilities of tornado reports relative to initial storm location for tornado warnings using report data from scatter plot (a). Storm Speed: 13 m $s^{-1}$ Duration: 45 minutes.*

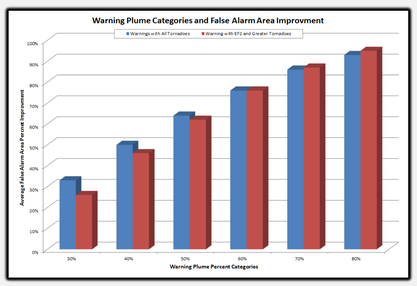



*(c) Probabilities plume for tornado reports relative to initial storm location for tornado warnings applying regression techniques and smoothing to probabilities in (b). Storm Speed: 13 m $s^{-1}$ Duration: 45 minutes.*

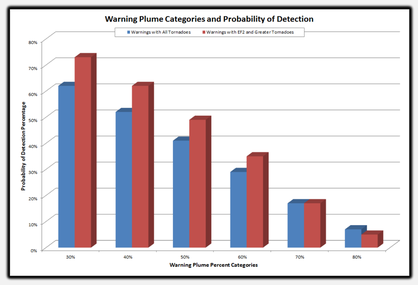
**Verification:** Statistical analysis for tornado warning plumes based on methodology/climatology (2008-2013) to the left. Plume verification statistics are calculate for only warning polygons and reports in warning polygons. Hit percentage, false alarm area percent improvement, and probability of detection are calculated for each plume category against verified warning polygons.




*(d) Bar graph of warning plume percent categories vs. the percentage that the plume verified with at least one report. Blue represents all tornadoes. Red represents EF2 and greater tornadoes.*

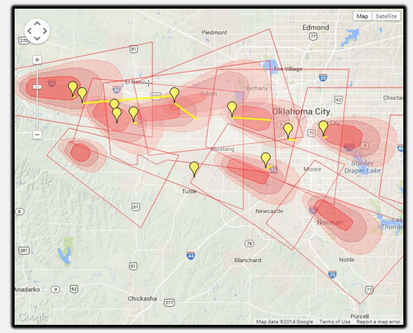



*(e) Bar graph comparison of the average false alarm area percent improvement of warning plumes over warning polygons for each warning plume percent category. Blue represents all tornadoes. Red represents EF2 and greater tornadoes.*

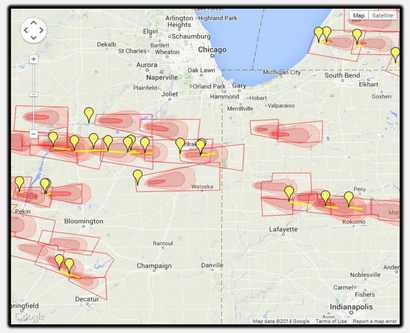



*(f) Bar graph comparison of probability of detection values for each warning plume percent category. Blue represents all tornadoes. Red represents EF2 and greater tornadoes.*

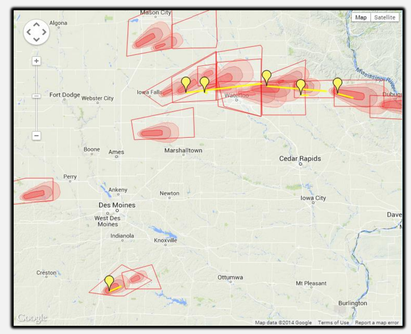
**Examples:** Tornado warning polygons and plumes for real-world examples. Each map is shown for an 8-hour period beginning at the time indicated. Tornado warning polygons and plumes are in differing shades of red. Tornado reports are signified by yellow markers with yellow lines indicating tornado path.



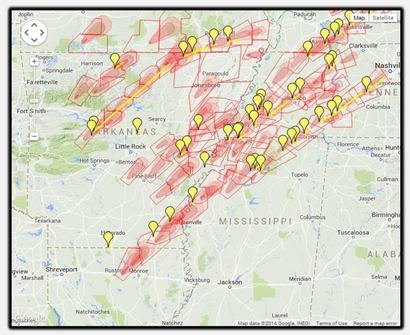

*(g) Tornado warnings/plumes in red. Tornado reports in yellow 1800 UTC 31 May 2013*




*(h) Tornado warnings/plumes in red. Tornado reports in yellow. 0000 UTC 06 Jun 2010*




*(i) Tornado warnings/plumes in red. Tornado reports in yellow. 1900 UTC 25 May 2008*




*(j) Tornado warnings/plumes in red. Tornado reports in yellow. 1900 UTC 05 Feb 2008*

**Conclusions:**

A climatology of reports downstream from the initial storm location for warnings exhibits a plume-shaped distribution.

For warning polygons that had tornado reports in them, about 82% of the lowest threshold warning plume (i.e. 30%) also had a tornado report inside the plume. This number increases to 88% when the warnings and reports are filtered to contain only EF2 or greater tornadoes.

There is a significant improvement in false alarm area with the warning plumes, however this is offset in the lower probability of detection values for the warning plumes.

The success/failure of the warning plumes is contingent upon the placement of the origin storm location in the NWS warning text.

**References:**

FACETS - Forecasting A Continuum of Environmental Threats. National Severe Storms Laboratory (NSSL). http://nssl.noaa.gov/projects/facets/

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