# Analysis of Convectively Generated Cold Pools and Fronts from Mesonet Data

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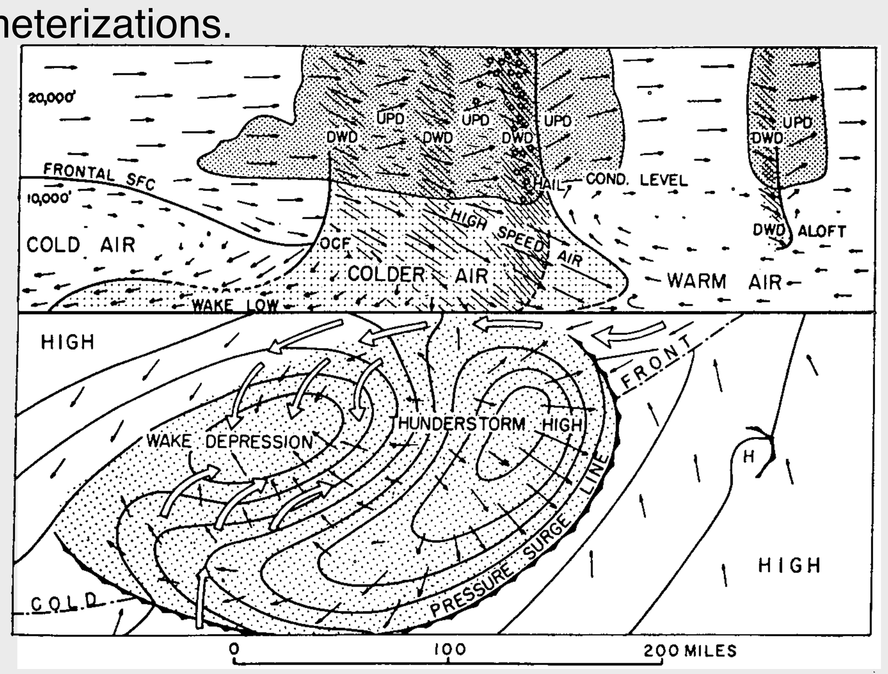
## Motivation

Because convective cloud systems generally have strong interactions with boundary layer circulations and thermodynamics, the boundary layer wind and thermodynamic fields contain a great deal of information about convective cloud systems and their interactions with the boundary layer. We are in the process of "retrieving" this information from 15 years of 5-minute Oklahoma Mesonet data and hourly Arkansas Basin River Forecast Center (ABRFC) gridded precipitation data.

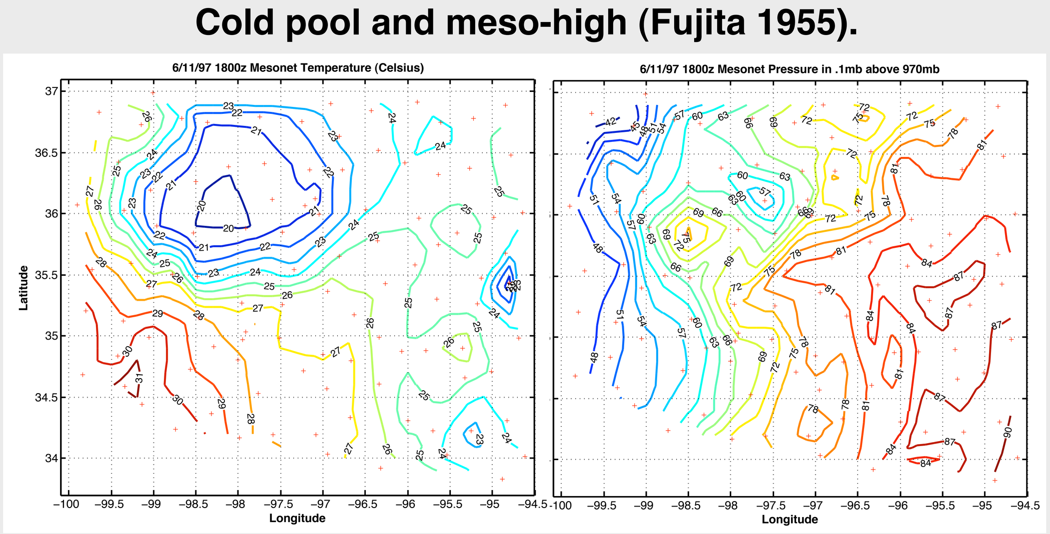
Sun and Krueger (2012) have already demonstrated that estimates of cloud base updraft and downdraft mass fluxes can be retrieved from the surface divergence field. We also investigated a method to estimate rain evaporation in convective systems from the cold pool hydrostatic surface pressure anomaly (Fujita 1959).

We have implemented an objective method to locate fronts using mesonet station time series, and applied the method to 4 summer months of 5-minute data from the Oklahoma Mesonet as well as the period coinciding with the MC3E field campaign. Our method is similar to that used by Engerer, Stensrud, and Coniglio (2008). These fronts are then used with surface divergence to locate cold pool boundaries.

Datasets of observed cold pool properties can be used to evaluate convective microphysics parameterizations and cold pool parameterizations used in large-scale cumulus parameterizations.

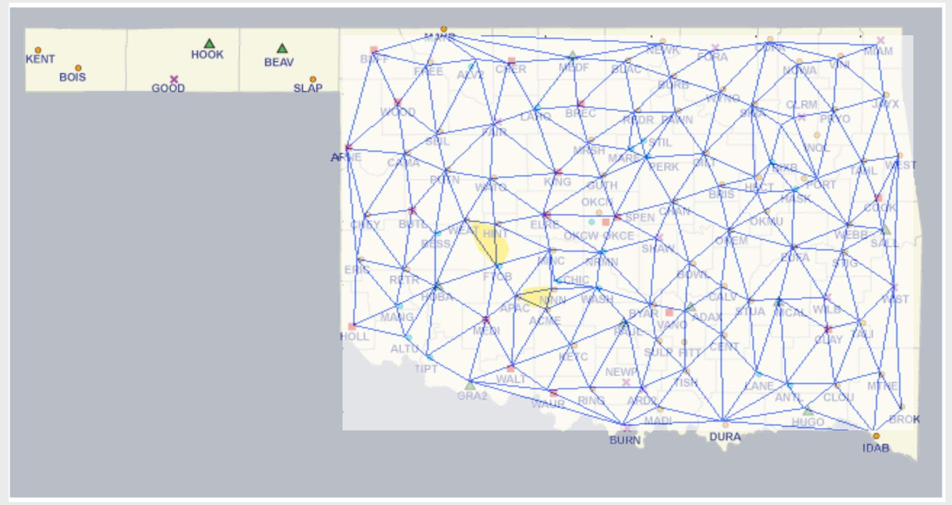



Cold pool and meso-high (Fujita 1955).



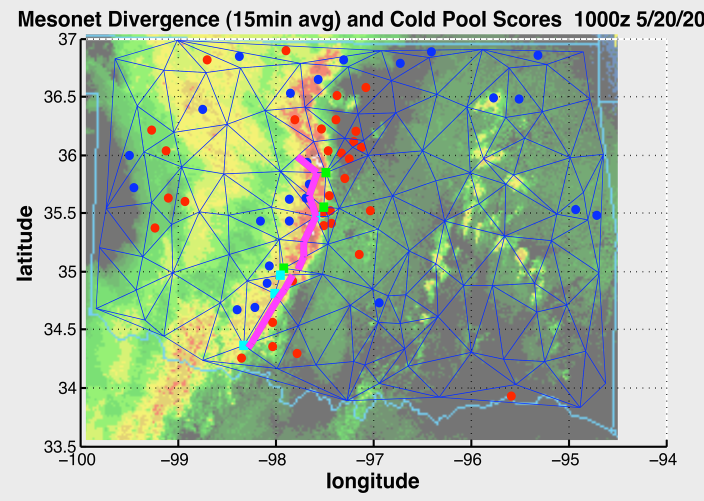

Cold pool and meso-high observed by the Oklahoma Mesonet.

## Method



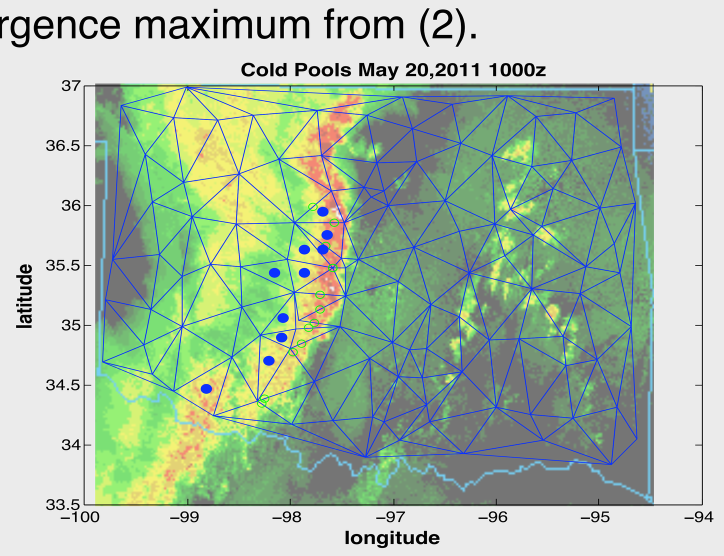
Oklahoma Mesonet stations are at analysis triangle vertices.

To locate a front, we first calculate a "cold pool score", which (currently) combines two indicators of frontal passages: surface pressure rise and surface temperature drop, over 30-minute time intervals. A **frontal passage** occurs at a station if (1) the cold pool score exceeds a threshold, and (2) the cold pool score has reached its largest value during the 6-hour interval centered on this time. If a front eventually reaches all three stations that define a mesonet triangle, the front can be tracked as it traverses the triangle.



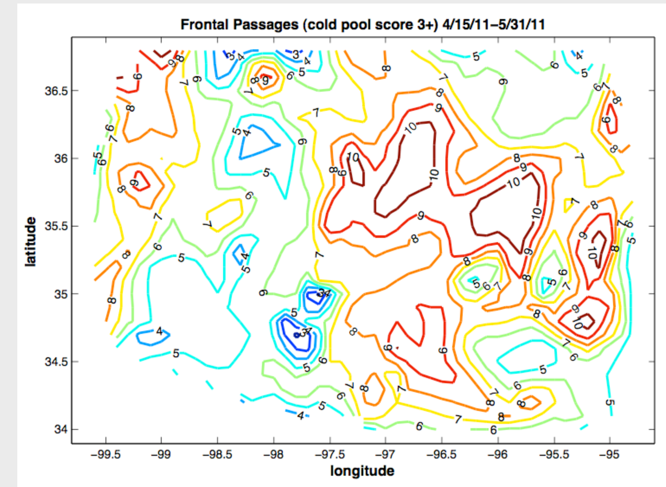

Example of frontal analysis based on mesonet station time series. Red dots indicate triangles with strong convergence. Dark blue dots indicate triangles with strong divergence. (Radar images from the UCAR image archive.)

A **cold pool** occurs at a triangle if (1) a frontal passage occurred at the triangle, and (2) the divergence maximum during a 3-hour interval centered on the frontal passage is above $1 \times 10^{-4}$ $s^{-1}$. Given that (1) and (2) occur, a triangle is part of a cold pool as long as the divergence is at least half the divergence maximum from (2).

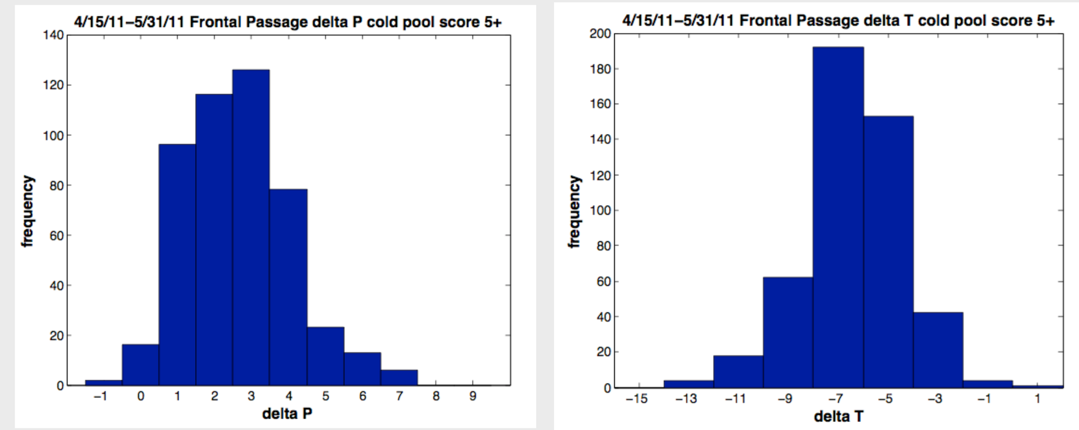



Example of cold pool analysis. Solid circles are cold pools (colors are different pools). Open circles mark the front.

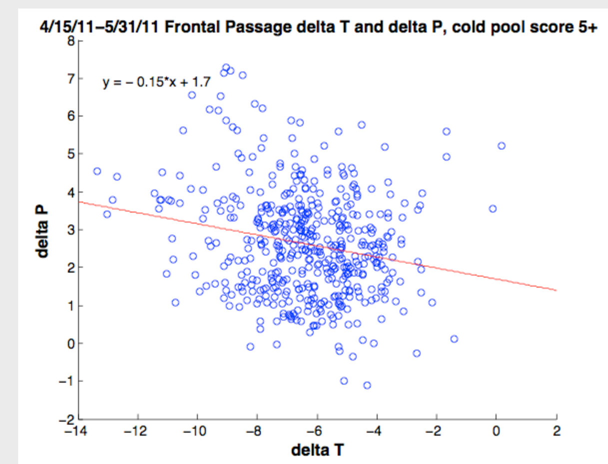
## Results



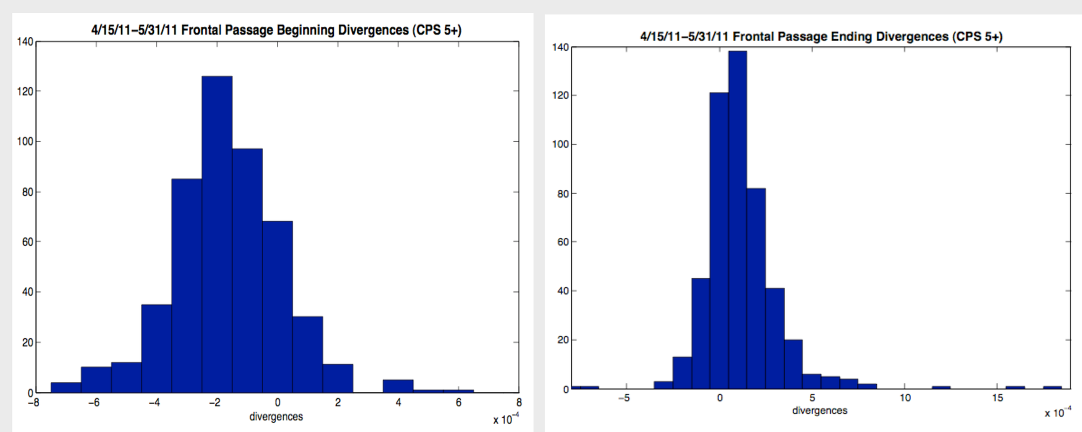

Number of frontal passages (cold pool score > 3) during 4/15/11-5/31/11




Histograms of pressure and temperature changes during frontal passages (maximum change between 2 hr after and 0.5 hr before frontal passage.




Temperature versus pressure changes during frontal passages (maximum change between 2 hr after and 0.5 hr before frontal passage).



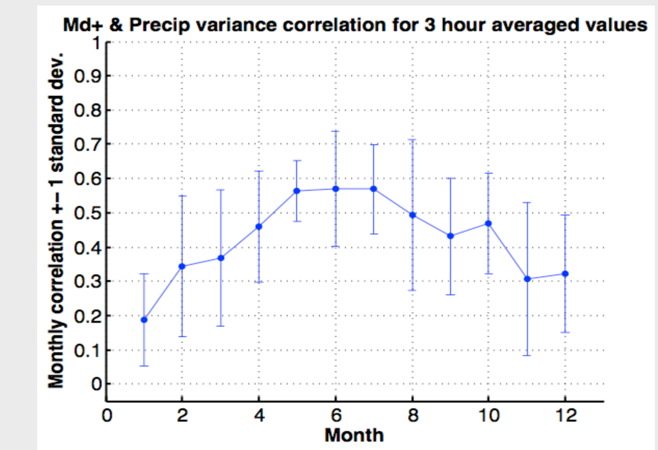

Histograms of divergence before (left) and after (right) frontal passages.

Analyzing the entire 1997-2011 Mesonet period has begun. Initial results have been found for the average updraft (Mu) and downdraft (Md) mass fluxes, as well as those for strong updraft (Mu+) and downdraft (Md+) regions (convergence, divergence > $1 \times 10^{-4}$ $s^{-1}$). Seasonal correlations between these values and precipitation have been calculated. An alternative measure, using precipitation variances across the Mesonet instead of total precipitation was also explored.

## Results

| Average Correlation | Mu Md | Mu+ Md+ | Mu Precip | Md Precip | Mu+ Precip | Md+ Precip |
|---|---|---|---|---|---|---|
| MAM | 0.15 | 0.57 | 0.37 | 0.33 | 0.43 | 0.48 |
| JJA | 0.37 | 0.73 | 0.50 | 0.42 | 0.55 | 0.58 |
| SON | 0.12 | 0.56 | 0.31 | 0.28 | 0.35 | 0.41 |
| DJF | 0.15 | 0.56 | 0.17 | 0.18 | 0.21 | 0.27 |

Average seasonal correlations for 3-hr-averaged Mu, Md, Mu+, Md+, and mesonet station precipitation for 1997-2011.




Monthly correlations for 3-hr-averaged Md+ and mesonet station precipitation variance for 1997-2011. Correlations are similar for precipitation and precipitation variance.

## Summary

Frontal passages are characterized by strong surface convergence ahead of the front, and strong surface divergence behind the front. The number of frontal passages during June-August 1997 (not shown) and April 15 - May 31, 2011 varied substantially across the mesonet. There was only a weak correlation between temperature drop and pressure rise. This indicates that the vertical structure of the temperature perturbation in the cold pools varies from case to case. A seasonal pattern in the correlation between updrafts/downdrafts and precipitation represents the heightened influence of convective precipitation, centered in the summer months.

## References

Engerer, N. A., D. J. Stensrud, and M. C. Coniglio, 2008: Surface characteristics of cold pools. *Mon. Wea. Rev.*, **136,** 4839-4849.

Fujita, T. T., 1959: Precipitation and cold air production in mesoscale thunderstorm systems. *J. Meteor.*, **16,** 454–466.

Sun, R., and S. K. Krueger, 2012: Mesoanalysis of the interactions of precipitating convection and the boundary layer. *J. Adv. Model. Earth Syst.*, (accepted).

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