Spatial Assessment of Mesoscale Pressure Perturbations using the US Transportable Array

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American Meteorological Society
16th Conference on Mesoscale Processes
Boston, MA
August 4, 2015

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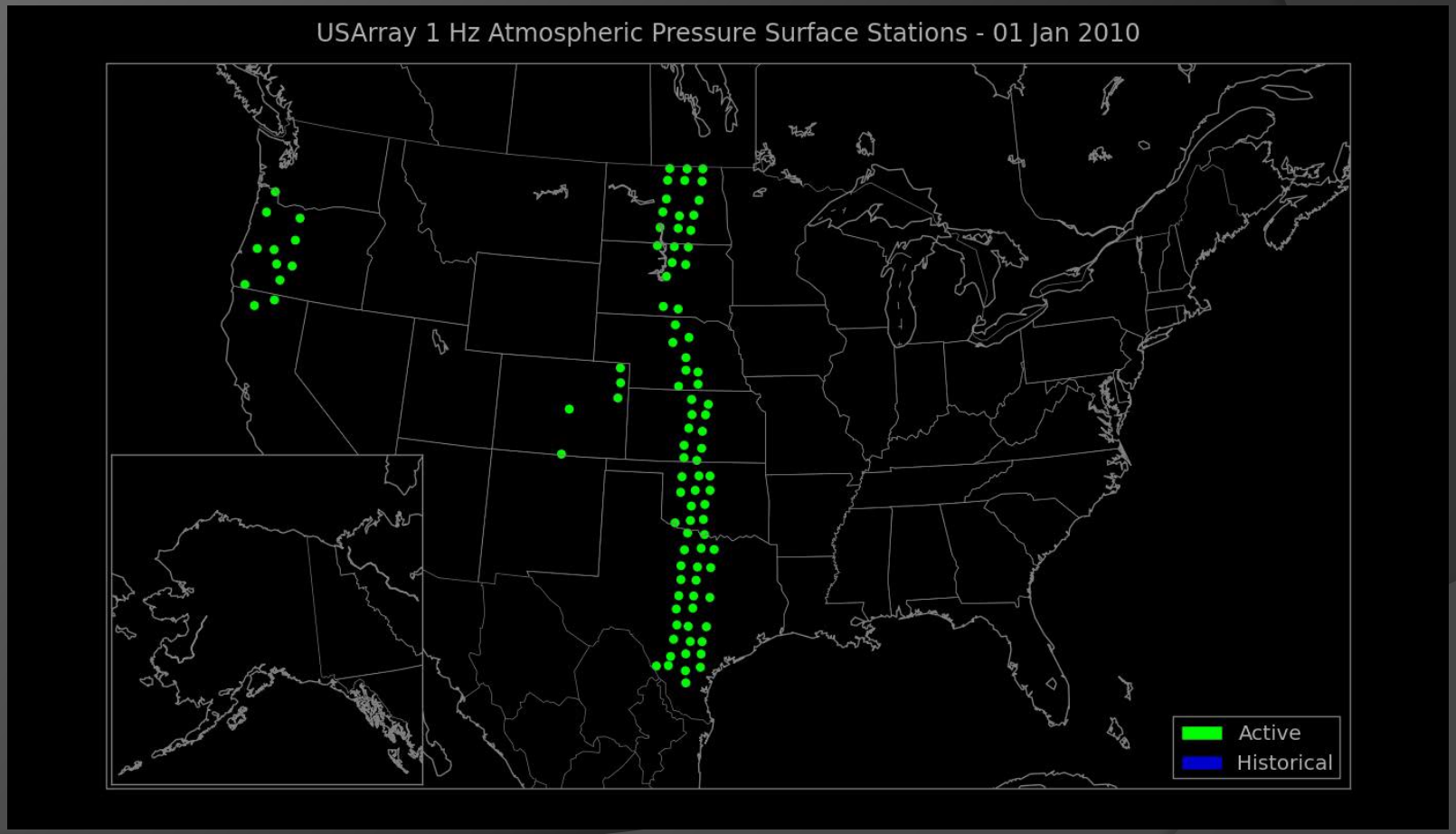
NSF

Earthscope US Transportable Array (USArray TA)

- "Rolling" deployment of ~400 surface stations across CONUS and Alaska for earth mapping and seismic-related research
- 2010: Barometric pressure sensors added (1 and 40 Hz sampling)

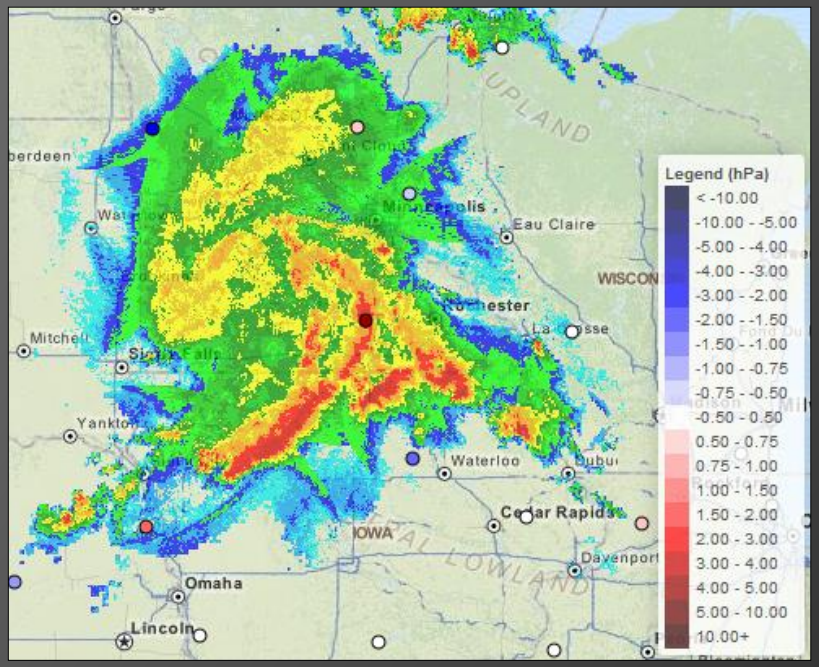


Project Motivation and Objectives

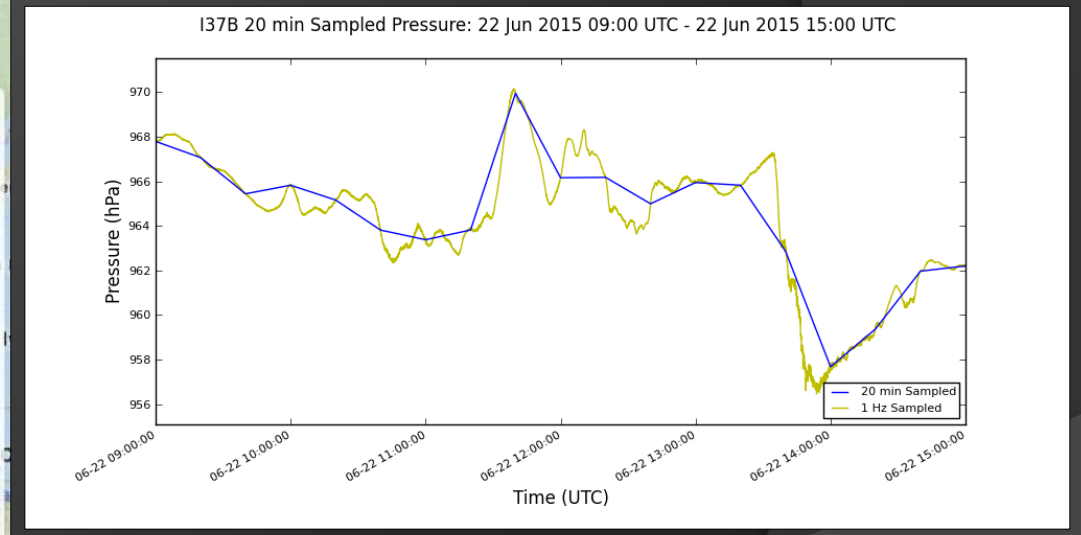
- USArray TA provides unique dataset to study mesoscale surface pressure fluctuations from convection, gravity waves, etc.

21-22 June 2015 Overnight Midwest Derecho

Mesoscale Pressure Perturbations: 1140 UTC 22 June 2015



I37B 1 Hz and 20 min-sampled Pressure Time Series



http://meso1.chpc.utah.edu/usarray/cgi-bin/usarray_pres_perturbation_archive.cgi?yr=2015&mo=06&dy=22

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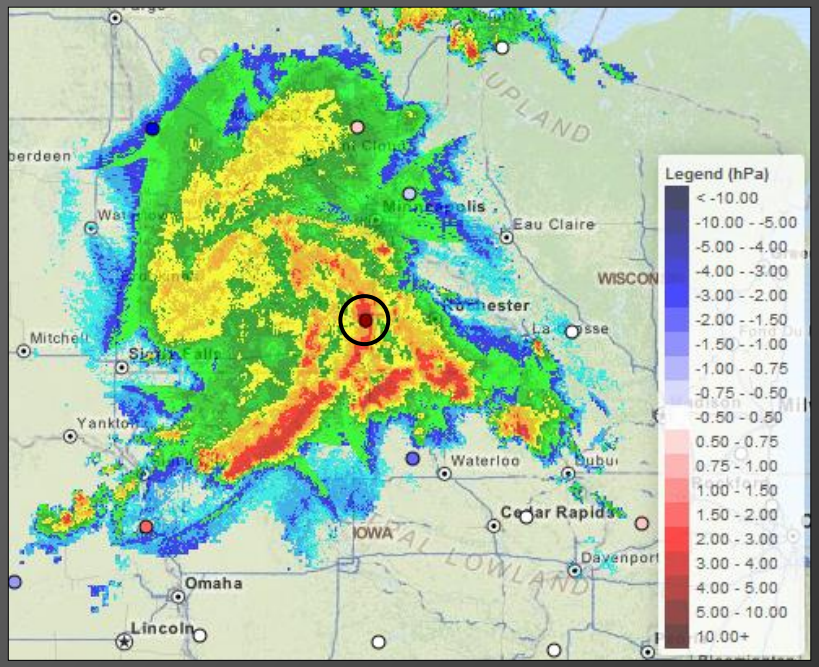

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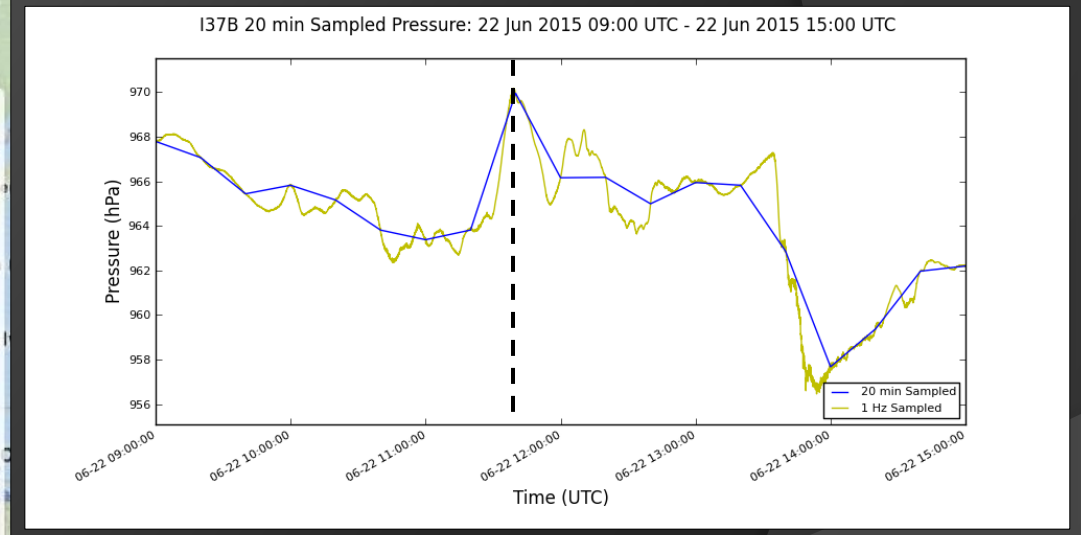

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Project Motivation and Objectives

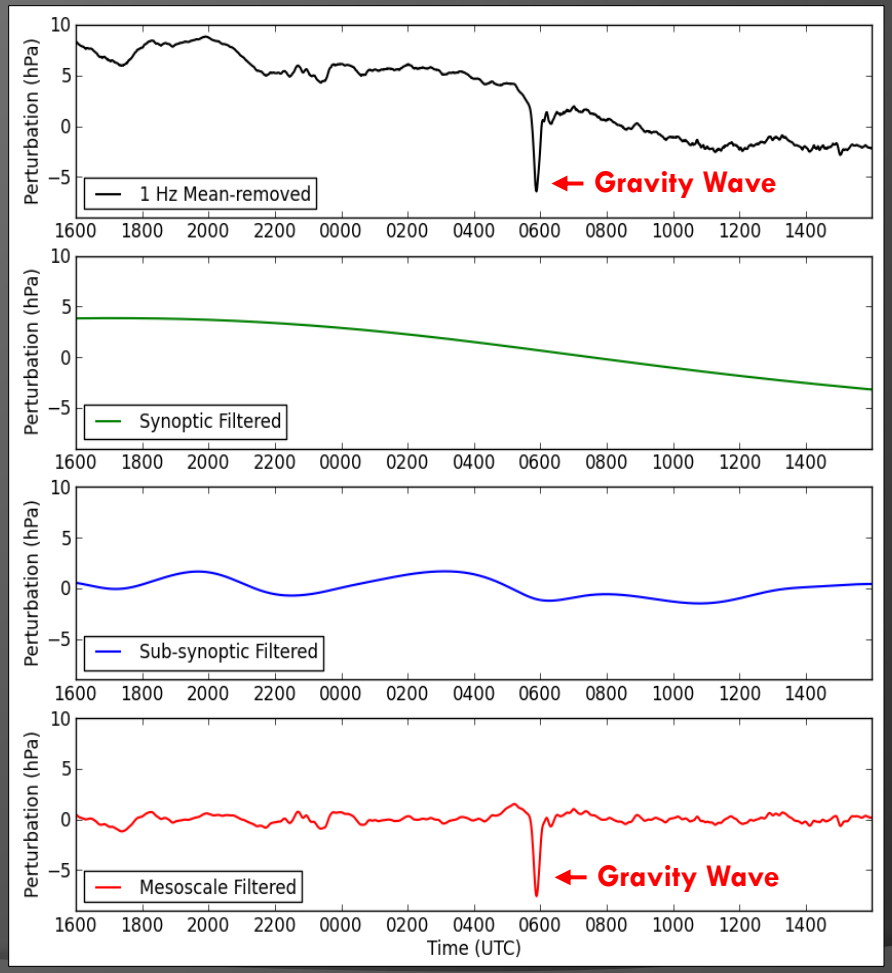
- Additional unique characteristics:
  - Cartesian-based deployment (~70 km spacing)
  - Uniformity (same setup/equipment for each station)
  - Reliability for 1 Jan 2010 – 30 Jun 2015 (1047 stations):
    - Median station availability percentage: **99.8%**
    - Median station availability post-QC: **99.7%**

- **Goal:** assess and describe pressure signatures/perturbations at multiple scales of atmospheric phenomena
  - Individual stations: time series analysis
  - Spatial assessment: observations combined with gridded datasets via numerical models

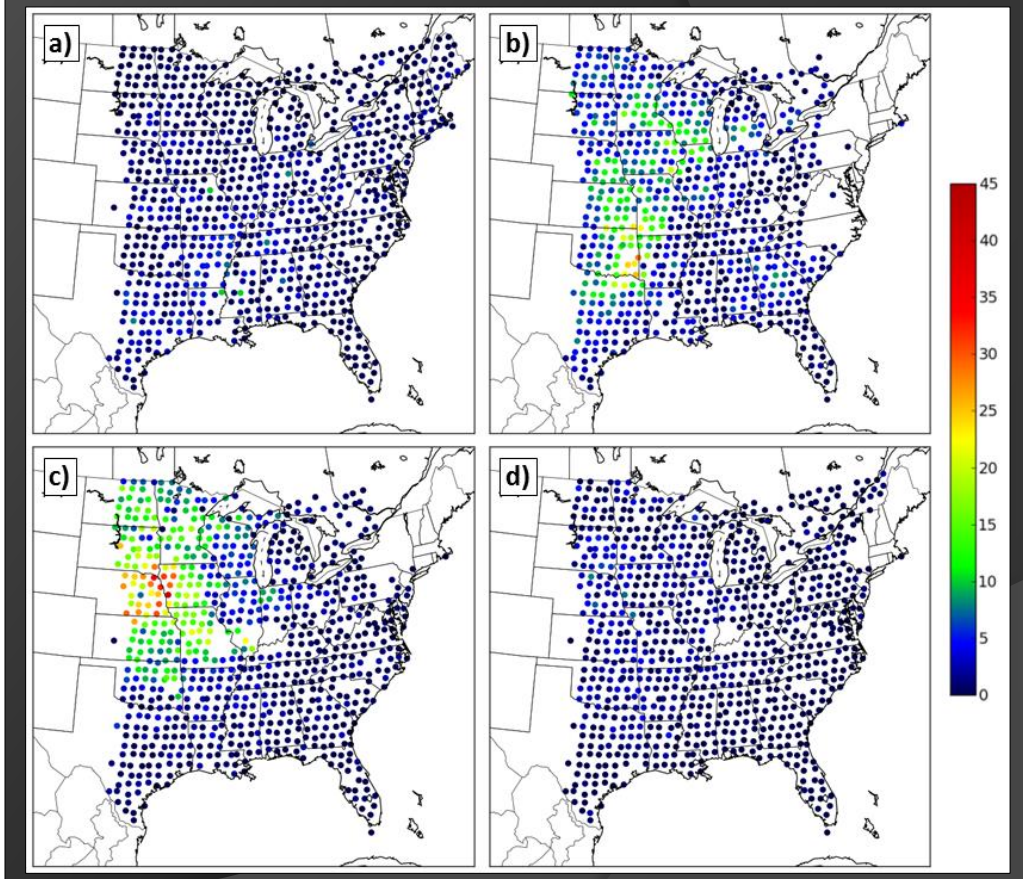
Time Series Analyses

Jacques, A. A., J. D. Horel, E. T. Crosman, and F. L. Vernon, 2015: Central and Eastern United States Surface Pressure Variations Derived from the USArray Network. *Monthly Weather Review*, **143**, 1472-1493, doi:10.1175/MWR-D-14-00274.1

24 h Station Time Series

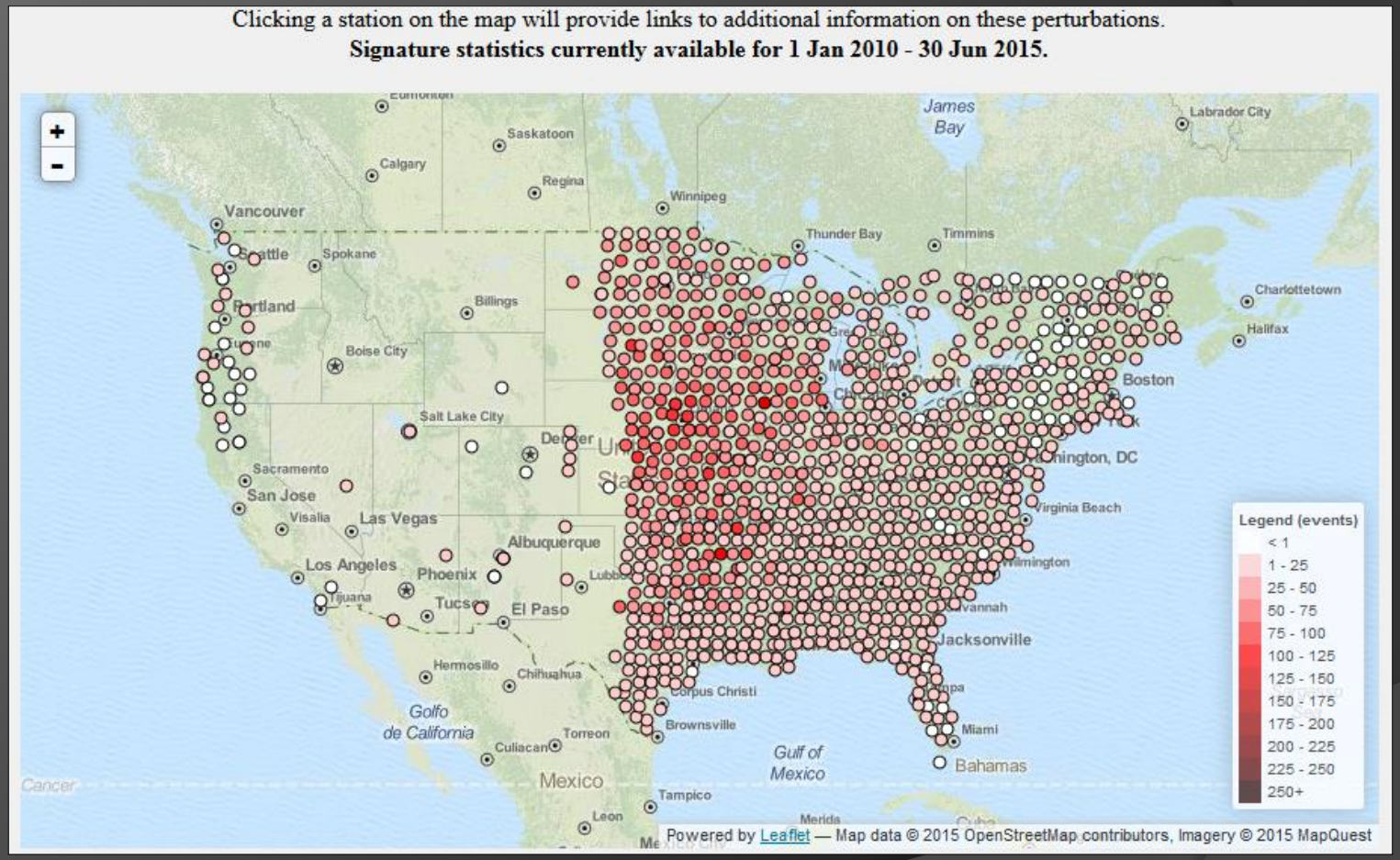


Seasonal Large (≥ 3 hPa) Mesoscale Pressure Signatures



Time Series Analyses

- Case studies perused further via developed web products (http://meso1.chpc.utah.edu/usarray)



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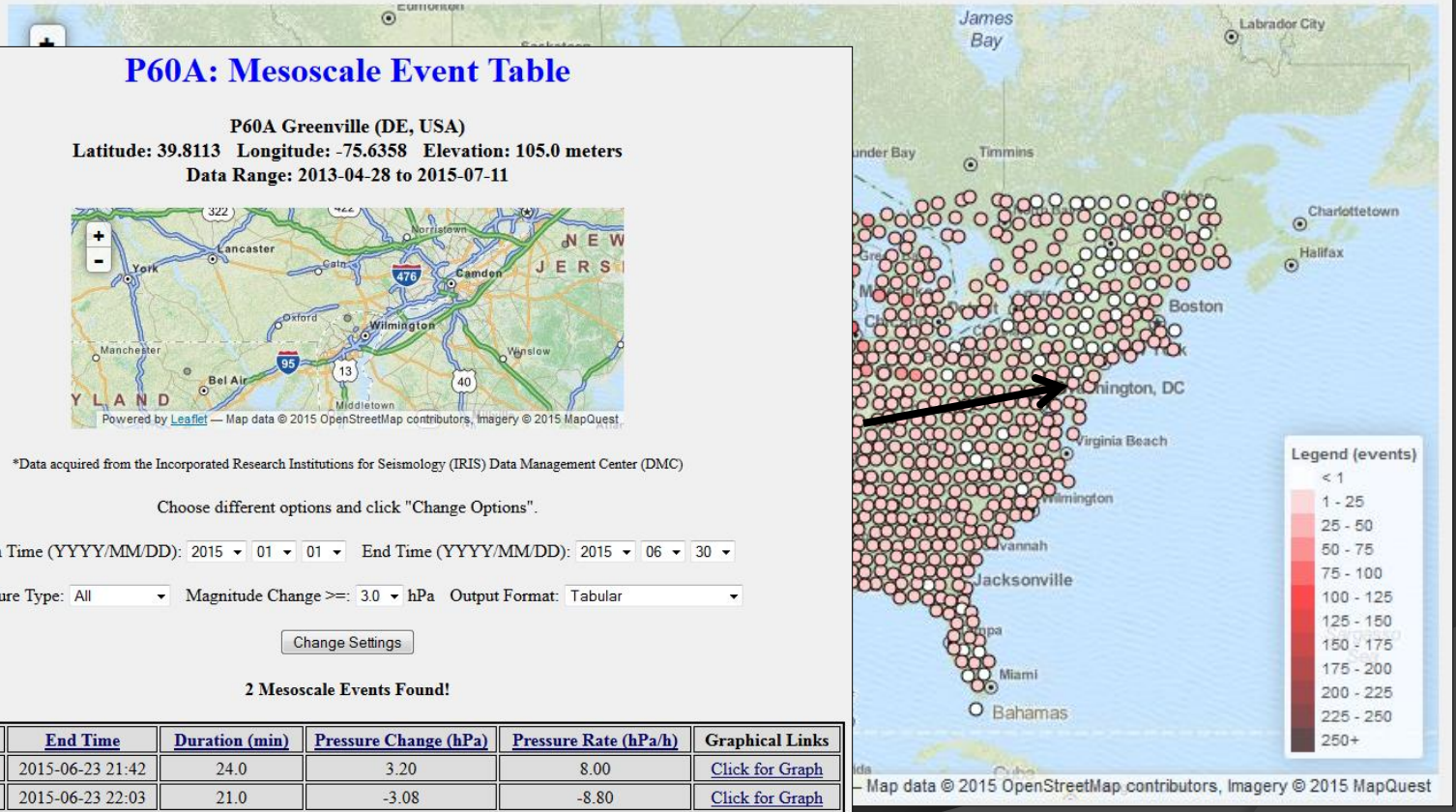
Clicking a station on the map will provide links to additional information on these perturbations.

Signature statistics currently available for 1 Jan 2010 - 30 Jun 2015.



P60A: Mesoscale Event Table

P60A Greenville (DE, USA)
Latitude: 39.8113 Longitude: -75.6358 Elevation: 105.0 meters
Data Range: 2013-04-28 to 2015-07-11

*Data acquired from the Incorporated Research Institutions for Seismology (IRIS) Data Management Center (DMC)

Choose different options and click "Change Options".

Begin Time (YYYY/MM/DD): 2015 01 01 End Time (YYYY/MM/DD): 2015 06 30

Signature Type: All Magnitude Change >=: 3.0 hPa Output Format: Tabular

Change Settings

2 Mesoscale Events Found!

Begin Time	End Time	Duration (min)	Pressure Change (hPa)	Pressure Rate (hPa/h)	Graphical Links
2015-06-23 21:18	2015-06-23 21:42	24.0	3.20	8.00	Click for Graph
2015-06-23 21:42	2015-06-23 22:03	21.0	-3.08	-8.80	Click for Graph

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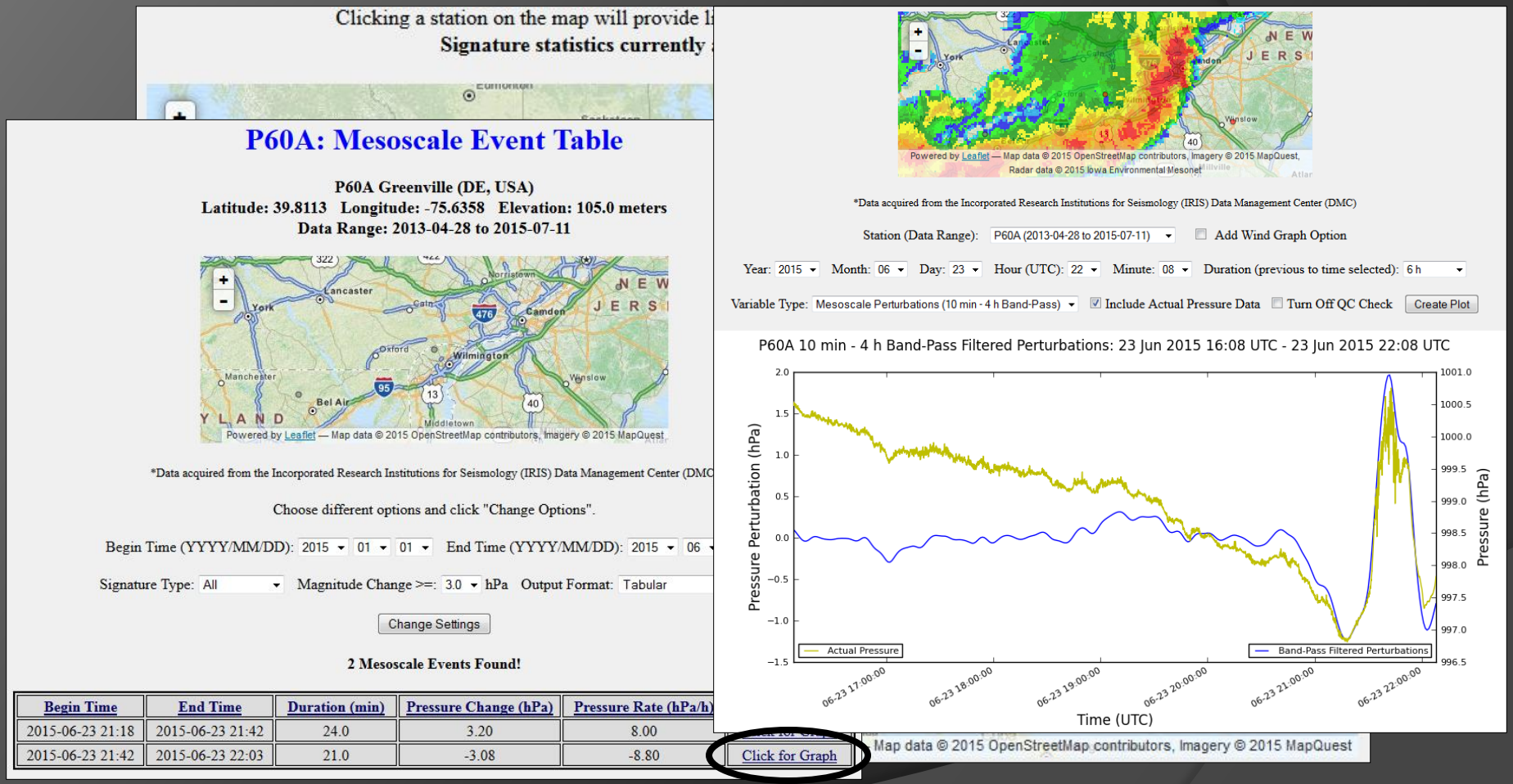
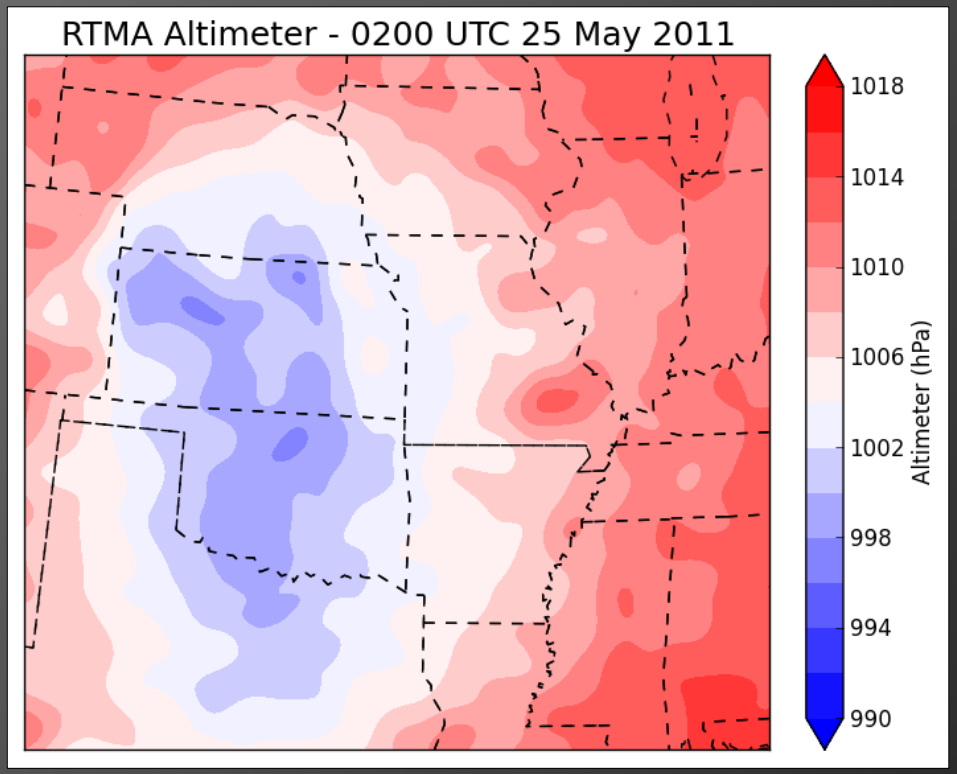
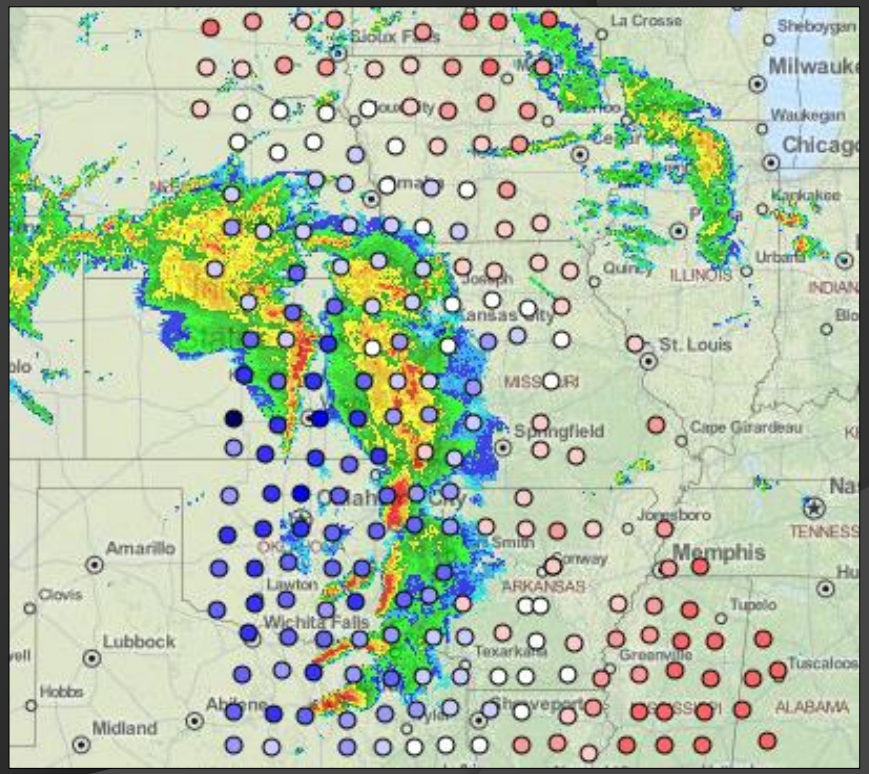


Mesoscale Pressure Perturbation Spatial Analyses

- Potential to utilize USArray TA with gridded datasets
  - USArray TA: higher temporal, lower spatial resolution
  - Grids: lower temporal, higher spatial resolution

RTMA Analysis and USArray TA Altimeter: 0200 UTC 25 May 2011





UU2DVAR Introduction

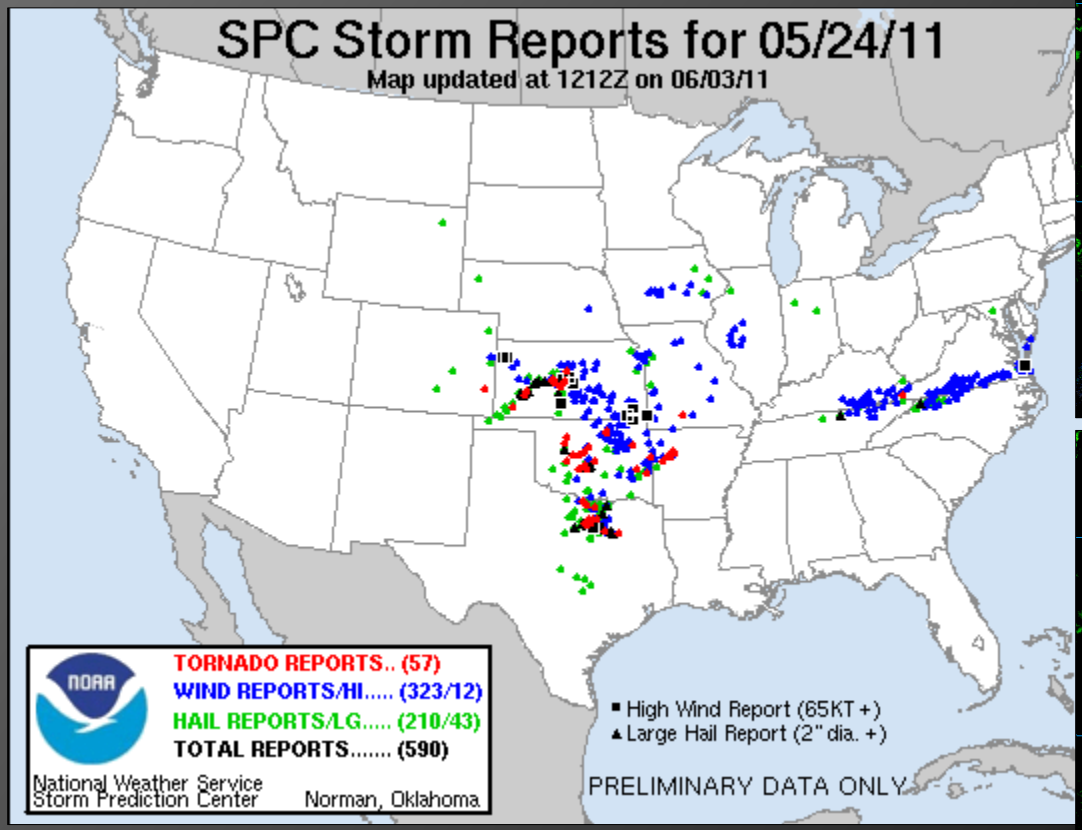
- University of Utah Two-Dimensional Variational Analysis (Tyndall and Horel 2013)
- Background grids courtesy NCEP RTMA
- USArray TA data functions as "independent observation dataset"
- Observation and background error covariances assumed
- Analysis produced using variational approach to "map" observation innovations (differences between observations and background)
- More on UU2DVAR: http://meso1.chpc.utah.edu/uu2dvar/

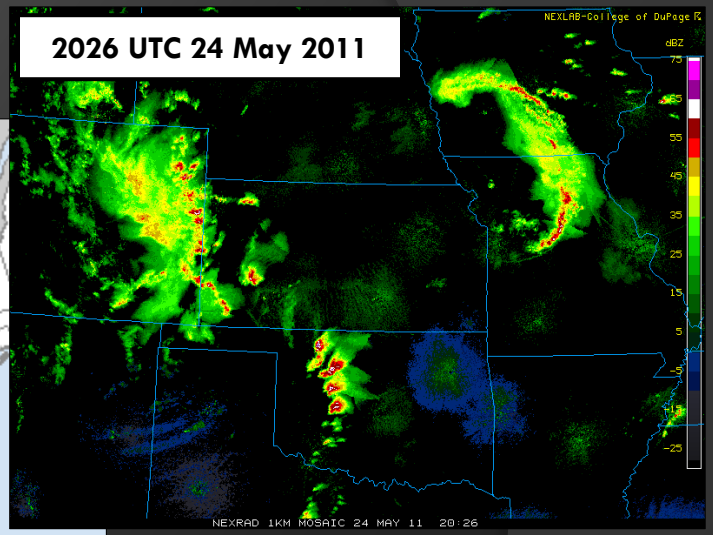
Five Minute Pressure Analyses

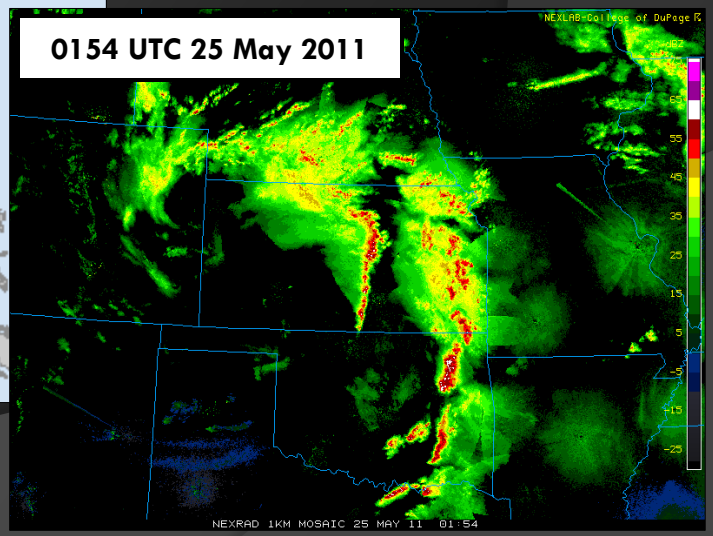
- Hourly surface pressure background interpolated every 5 minutes to take advantage of TA temporal frequency
- Background and observations converted to 1 hr pressure tendency to eliminate background/observation elevation discrepancies
- UU2DVAR analysis grids generated every 5 minutes
- Analysis grids converted back to sea level using background terrain

Case – Severe Weather Outbreak 24 May 2011

- 57 tornado reports including EF5 which resulted in 9 fatalities
- Several convective modes (linear systems, supercells, etc.)

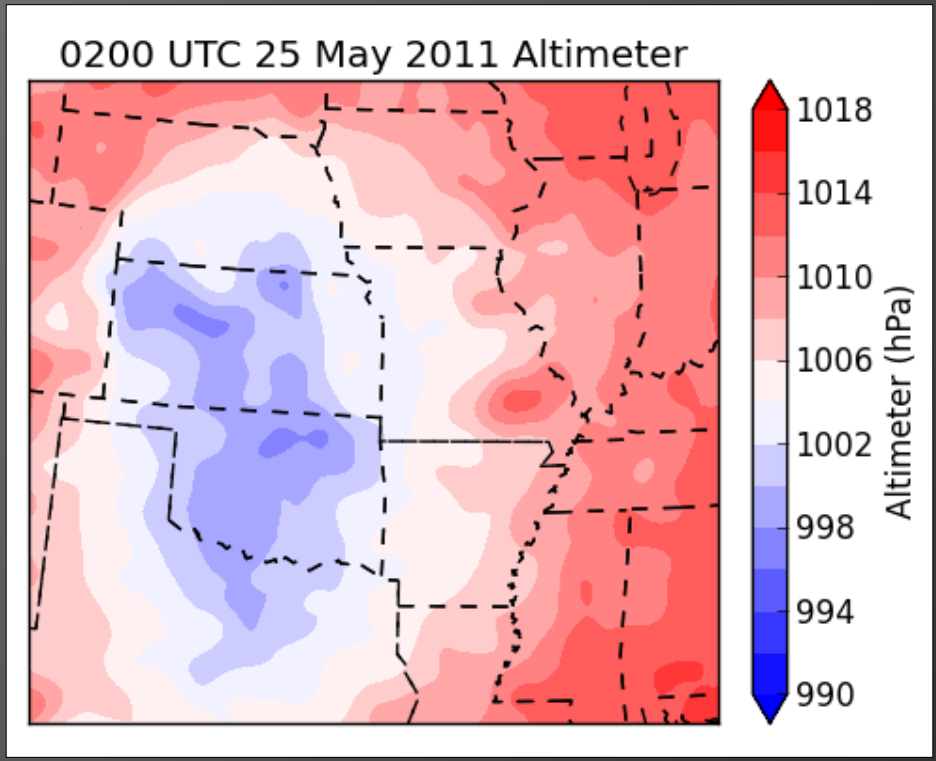


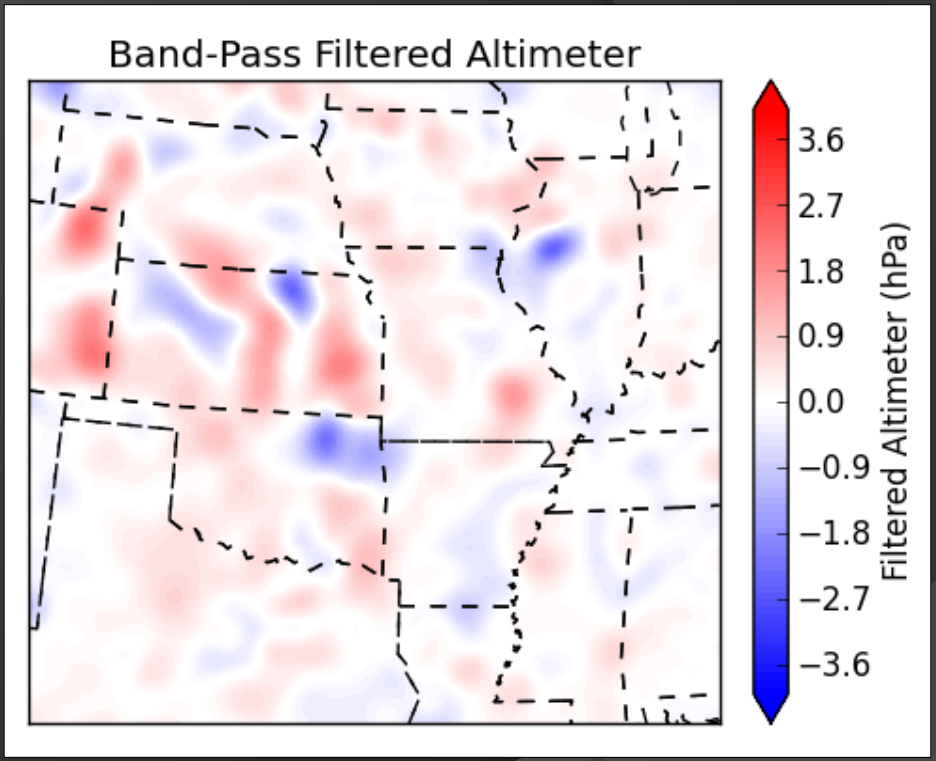




Case – Severe Weather Outbreak 24 May 2011

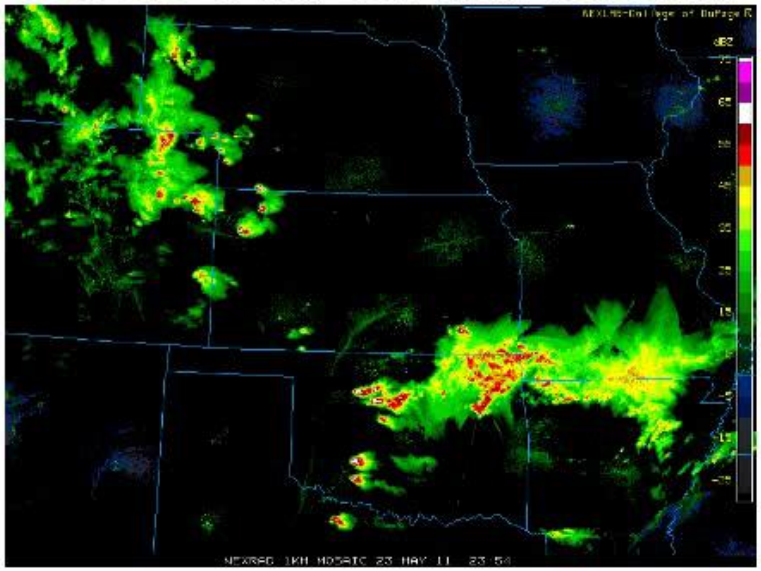
- Analysis grids temporally band-pass filtered (10 min – 8 h) to isolate mesoscale pressure perturbations



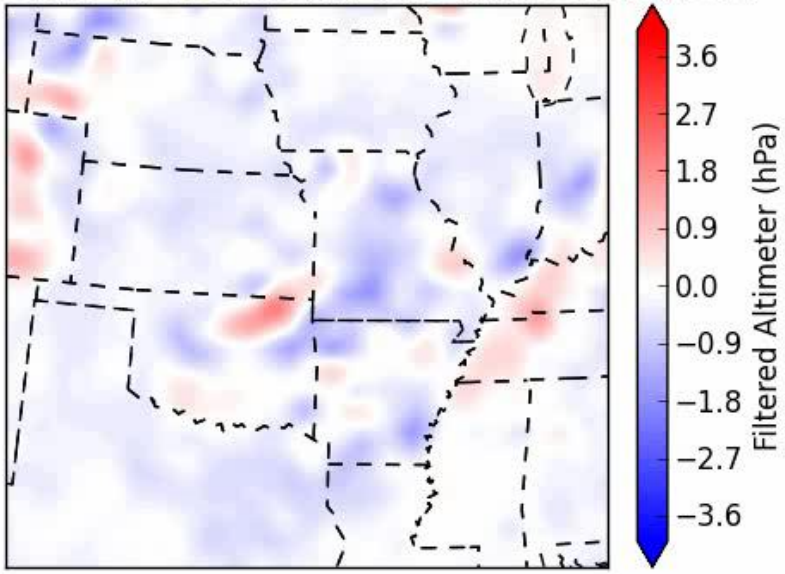


Case – Severe Weather Outbreak 24 May 2011

0000 UTC 24 May 2011 Radar Reflectivity

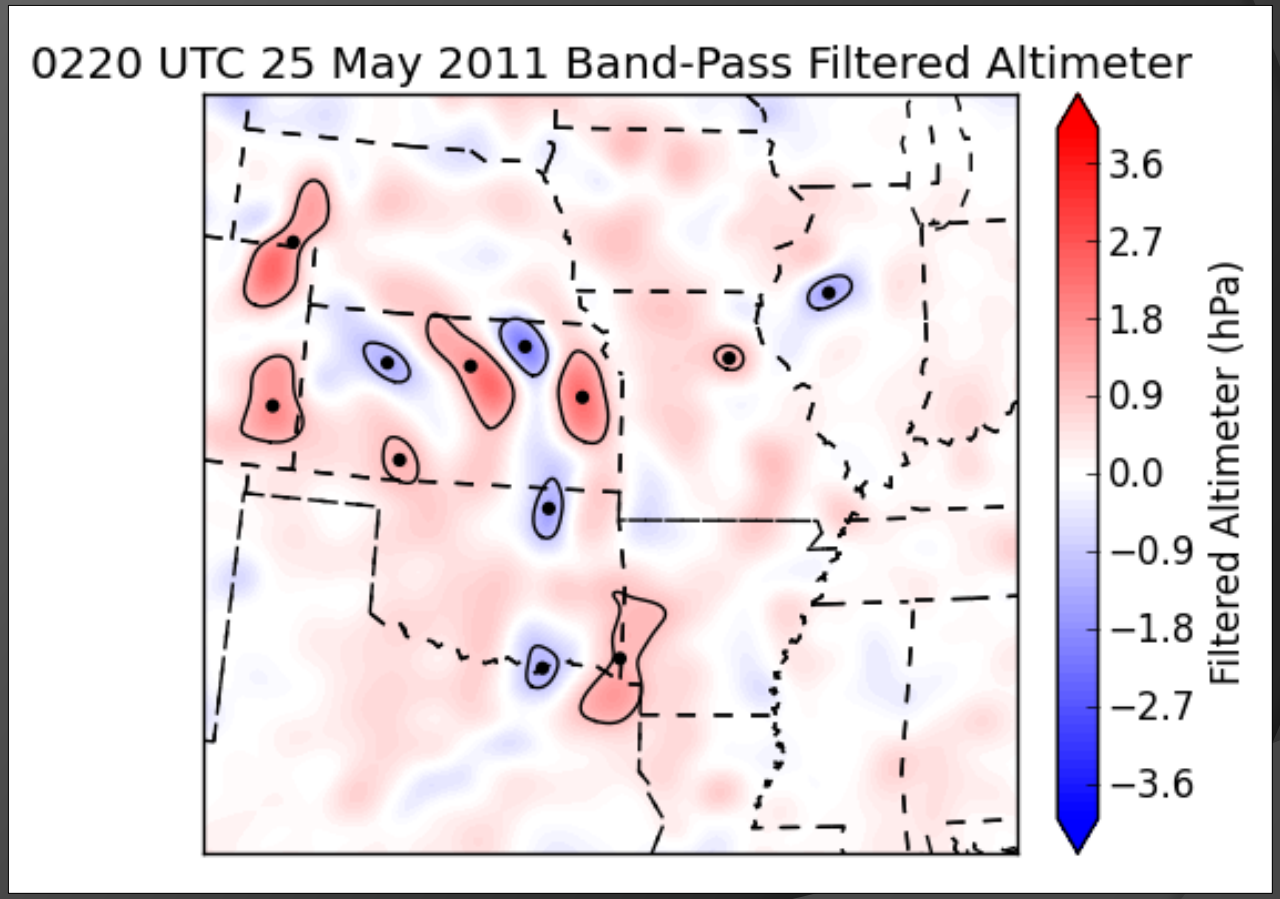


0000 UTC 24 May 2011 Band-Pass Filtered Altimeter



Perturbation Identification Methodology

- Centroid-based technique being developed to identify individual large (≥1 hPa) mesoscale pressure perturbations



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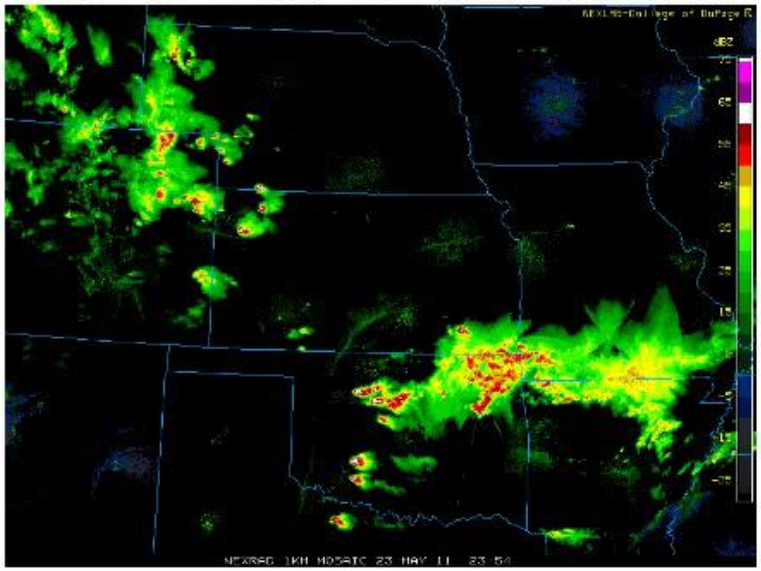

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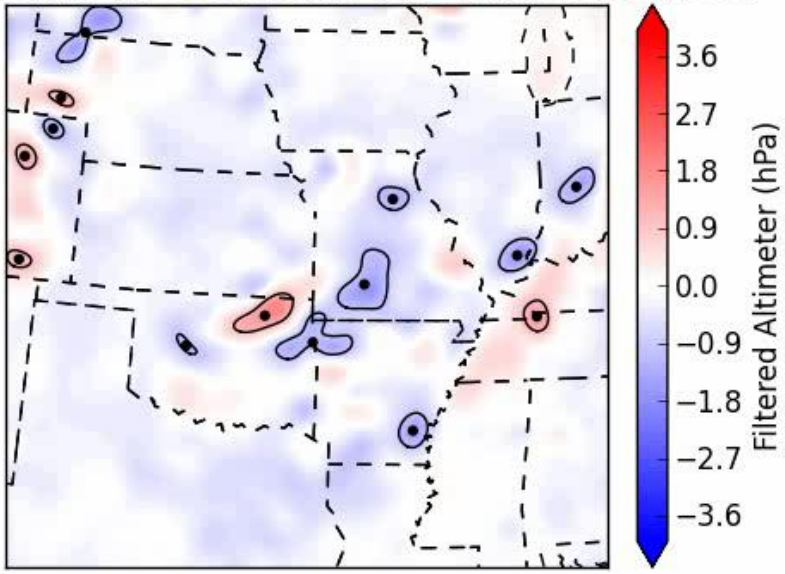

Future Work

- Refine/expand perturbation identification methods
- Determine additional perturbation characteristics (e.g. propagation speed)
- Expand spatial analysis dataset beyond shown case examples
- Archives of 1 Hz observations remain accessible at http://meso1.chpc.utah.edu/usarray/
- Real-time and archive 5-min averaged TA observations remain available through MesoWest (http://mesowest.utah.edu)

Acknowledgements and References

This research is funded by National Science Foundation Grant Number 1252315. We would like to thank Dr. Frank Vernon of Scripps Institution of Oceanography, the USArray Array Network Facility (ANF), and the Incorporated Research Institutions for Seismology (IRIS) for providing access to live data streams for the USArray project. We would also like to acknowledge the Center for High Performance Computing (CHPC) at the University of Utah.

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Tyndall, D., and J. Horel, 2013: Impacts of mesonet observations on meteorological surface analyses. *Wea. Forecasting*, **28**, 254-269, doi:10.1175/WAF-D-12-00027.1