Using Python to Store, Display, and Analyze Pressure Observations from Earthscope's USArray Network

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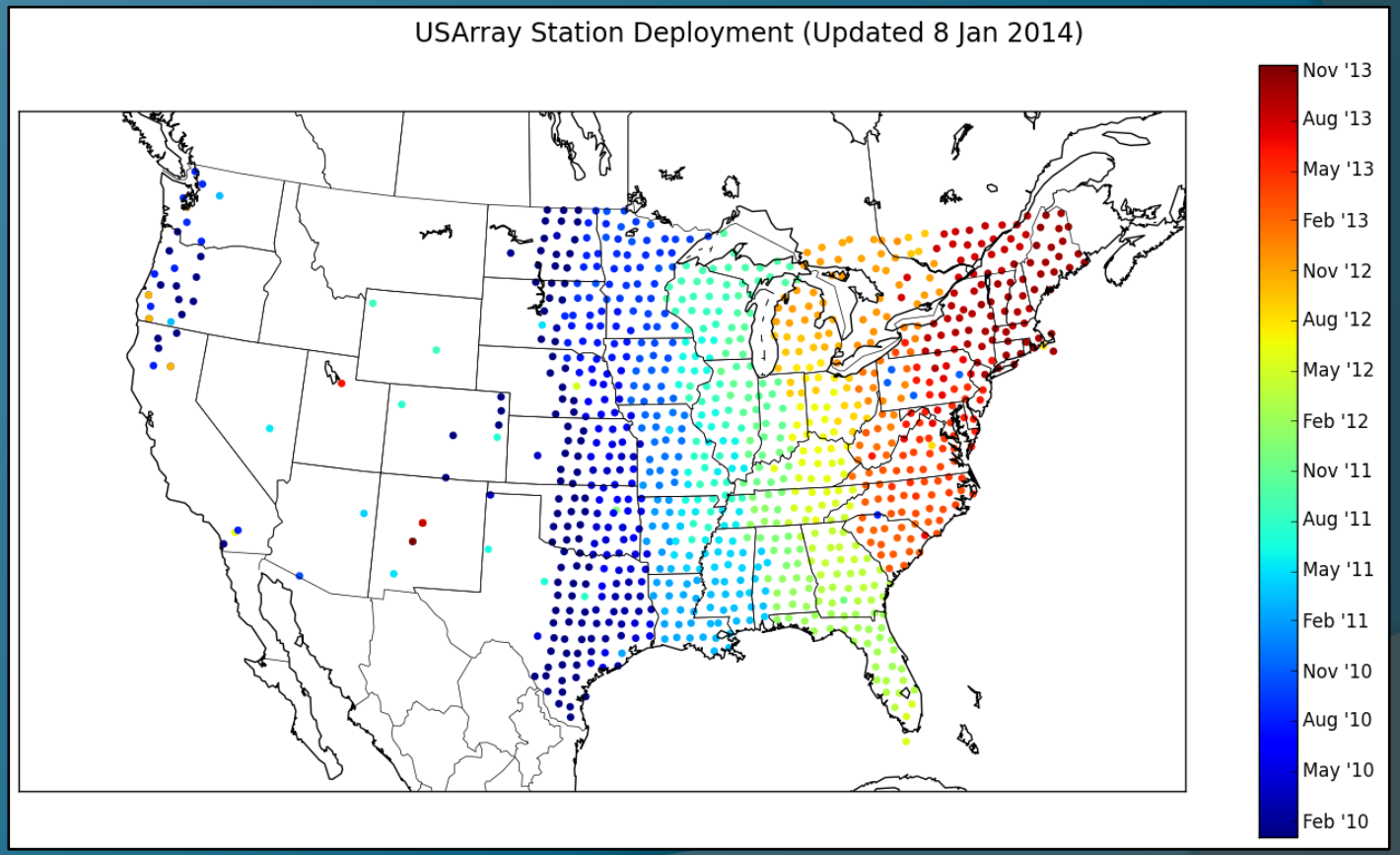
What is the US Transportable Array (USArray)?

- EarthScope-funded project of ~400 seismic stations traversing across the CONUS in an effort to catalogue and study seismic activity
- Stations outfitted with microbarometers in 2010 (1 Hz reporting frequency)



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Project Objectives

- Improve access for the atmospheric science community to both real-time and archived pressure observations through displays and other web-based products at varying sample intervals (1-second, 5-minute, etc.)

- Develop and analyze climatologies at each observing site of pressure perturbations and signatures in terms of frequency and amplitude

- Examine pressure perturbations and perturbation gradients in the context of local, mesoscale, and synoptic-scale flows (waves, terrain-flow interactions, thermally-forced systems, etc.)

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Motivation for Use of Python

- USArray pressure dataset provides a unique opportunity to catalogue meteorological events at multiple spatial and temporal scales
    - Semi-regular station spacing (~70 km between locations)
    - 1 Hz temporal resolution
    - Station deployment ~1.5-2 years

- Python chosen due to its numerous advantages in the following areas…
    - Storage and querying of large arrays of data
    - Object-oriented nature for fast manipulating
    - Time series filtering procedures
    - Leveraging of interactive web displays

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Python for USArray Data Storage

- Dataset produces a number of challenges due to its large size, spatial irregularities (non-gridded), and temporal irregularities

- PyTables chosen as mechanism to store observations in two "databases" based on station and time in compressed HDF5 format

- Database #1: Individual station tables of all observations
    - Level-7 Zlib compression
    - New data appended on a daily basis
    - Statistics from 1 Jan 2010 – 31 Dec 2013
        - Total observations: 46,086,051,637
        - Disk Space Used: 58 GB
        - ~1.26 bytes per observation (time, station, value)

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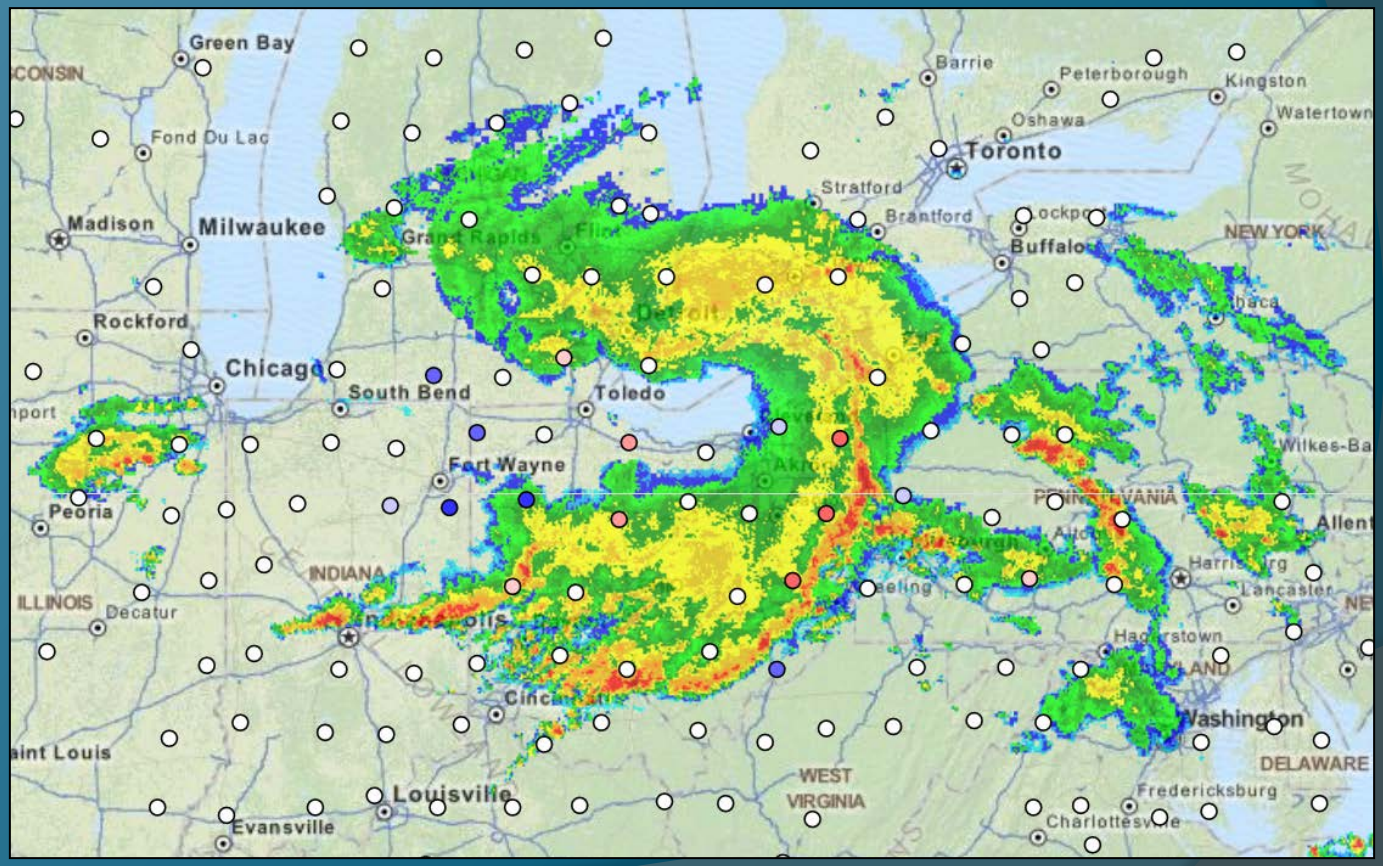
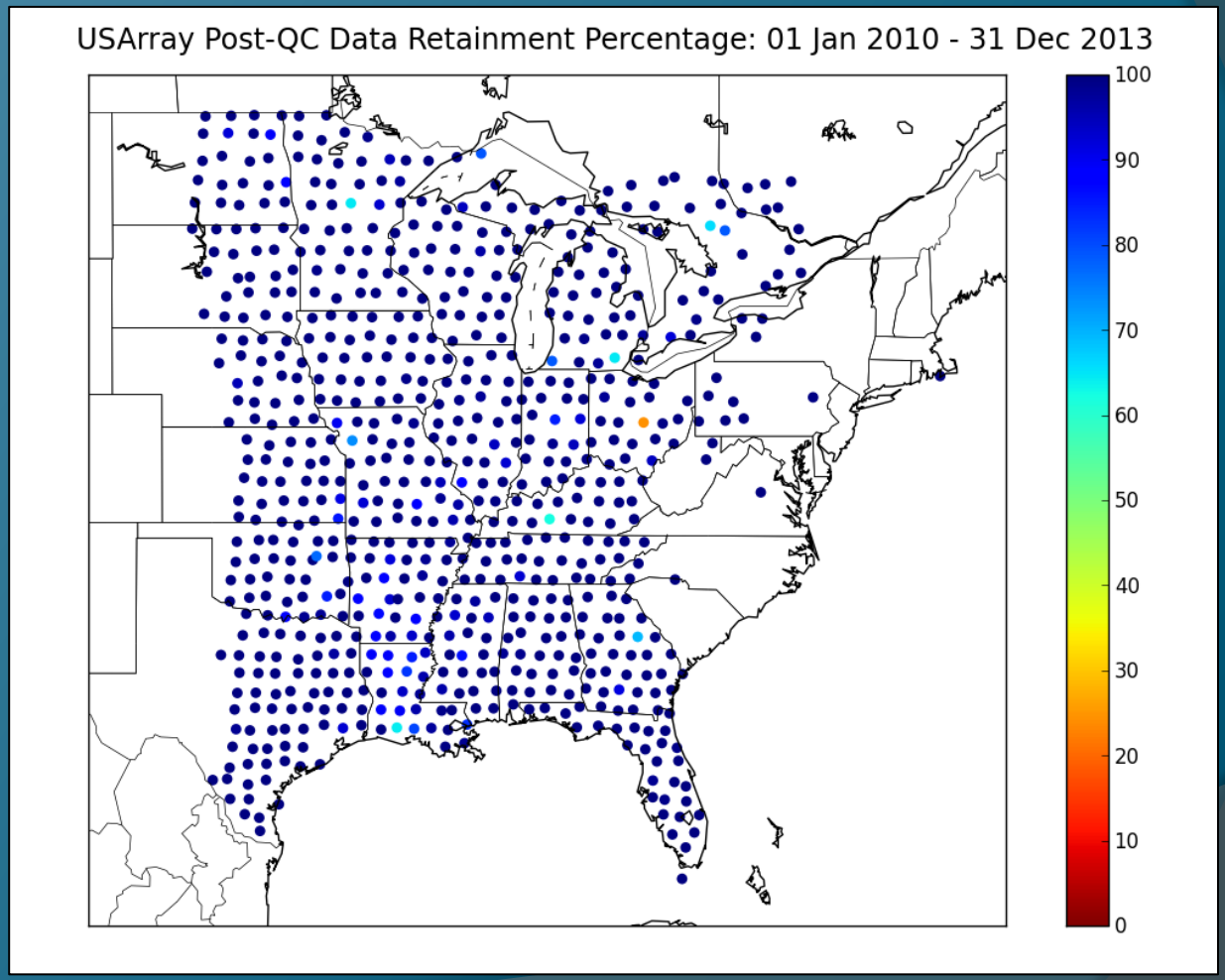
Python for USArray Data Storage

- Database #2: Daily files of all active USArray Stations
  - Nested tables used to store data in pseudo-gridded format
  - Supplemental metadata schema used to leverage dataset onto maps



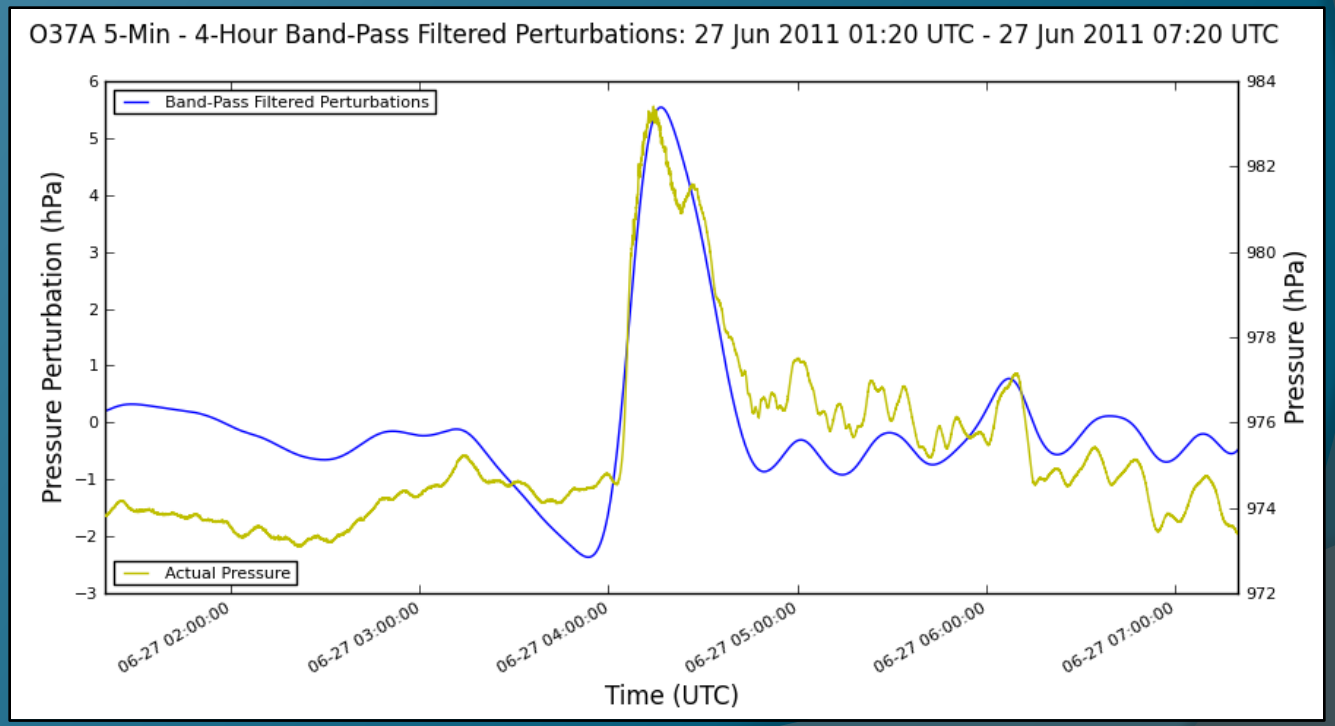
Python for USArray Data Analysis

- Quality Control: the ability of NumPy to efficiently parse large data arrays aided significantly in identifying missing/spurious data periods



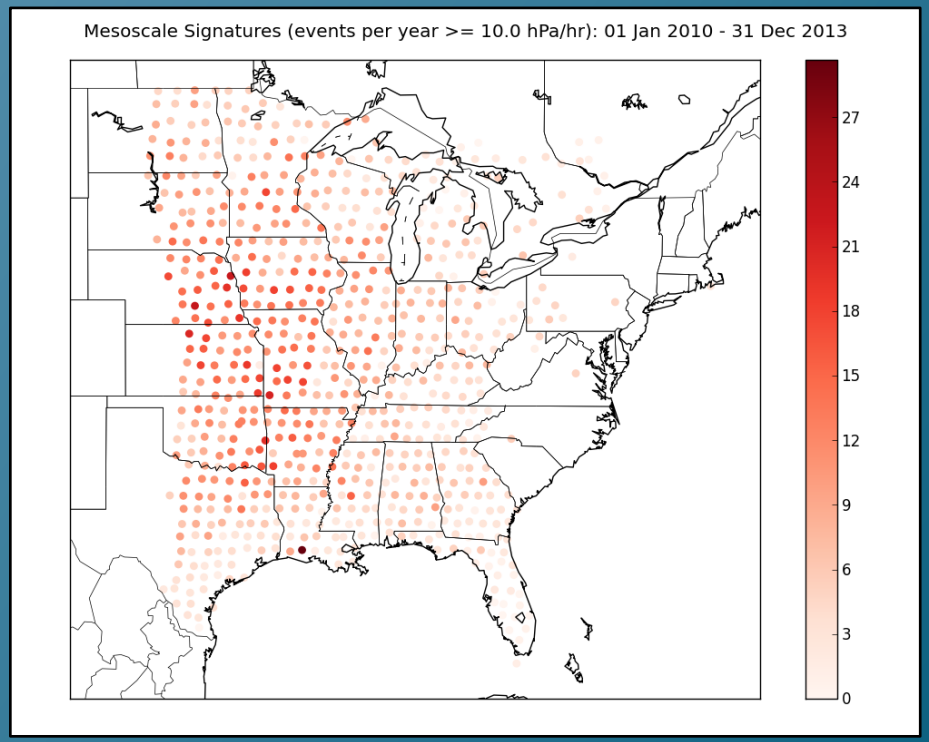
Python for USArray Data Analysis

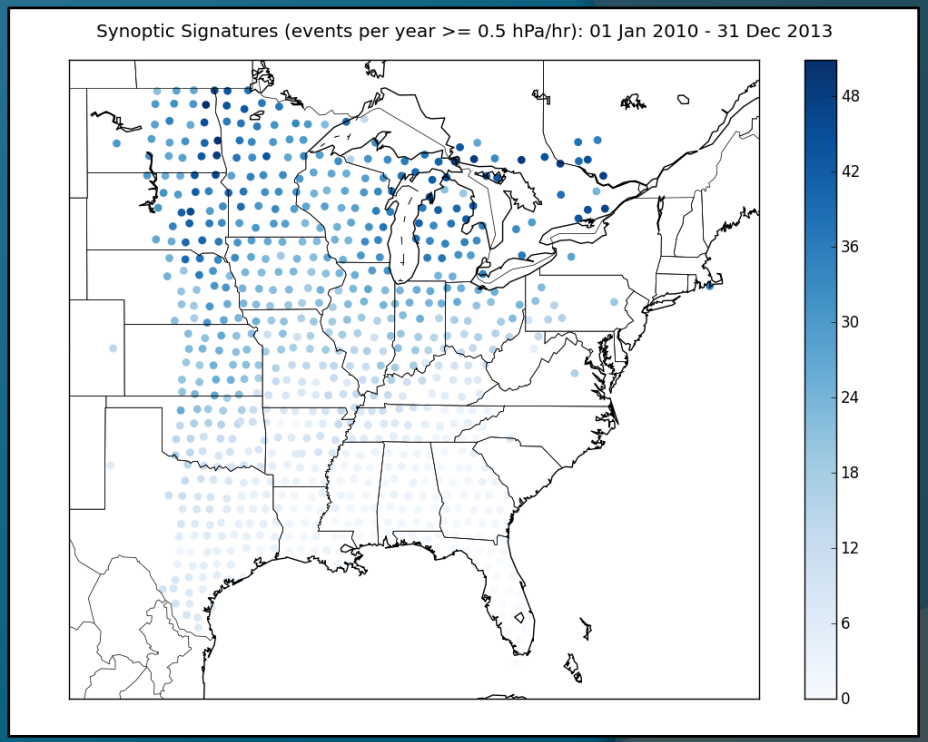
- Mesoscale/Synoptic Pressure Signature Identification Algorithms
  - SciPy Butterworth filtering techniques applied to generate perturbation time series from the original time series data
  - Large pressure signatures identified using local min/max functions



Python for USArray Data Analysis

- Descriptive quantities of the pressure signature fields stored in HDF5 PyTables file for fast querying based on user-defined preferences





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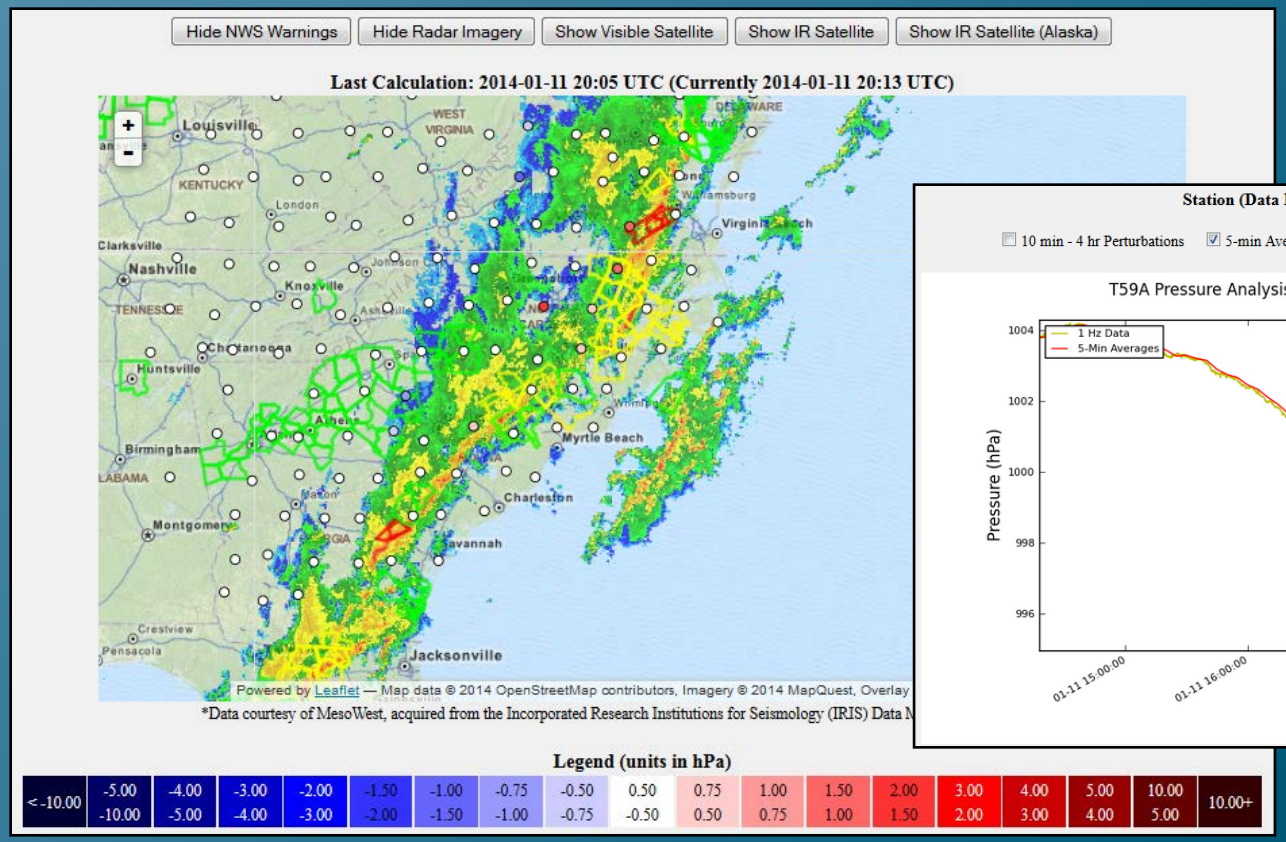
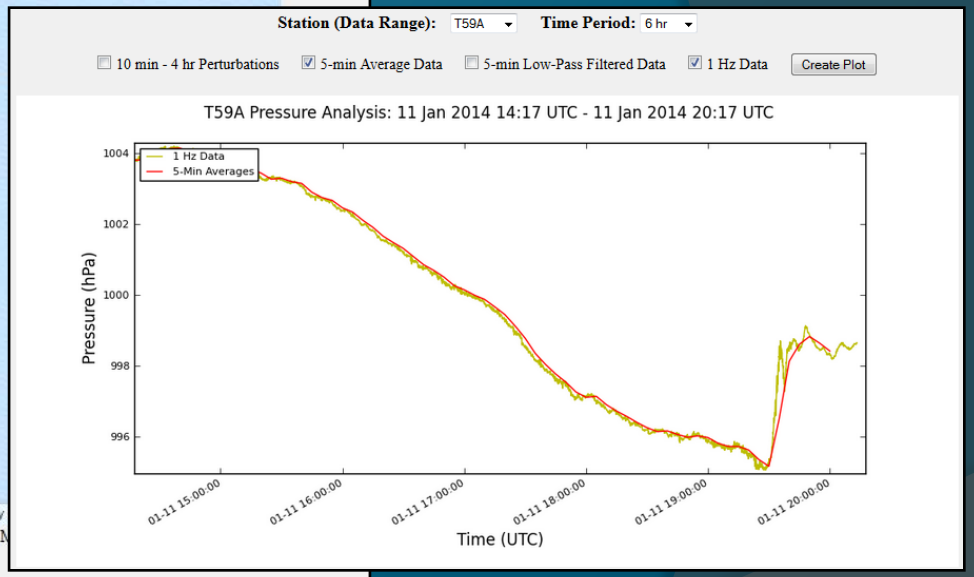
Python for USArray Web Displays

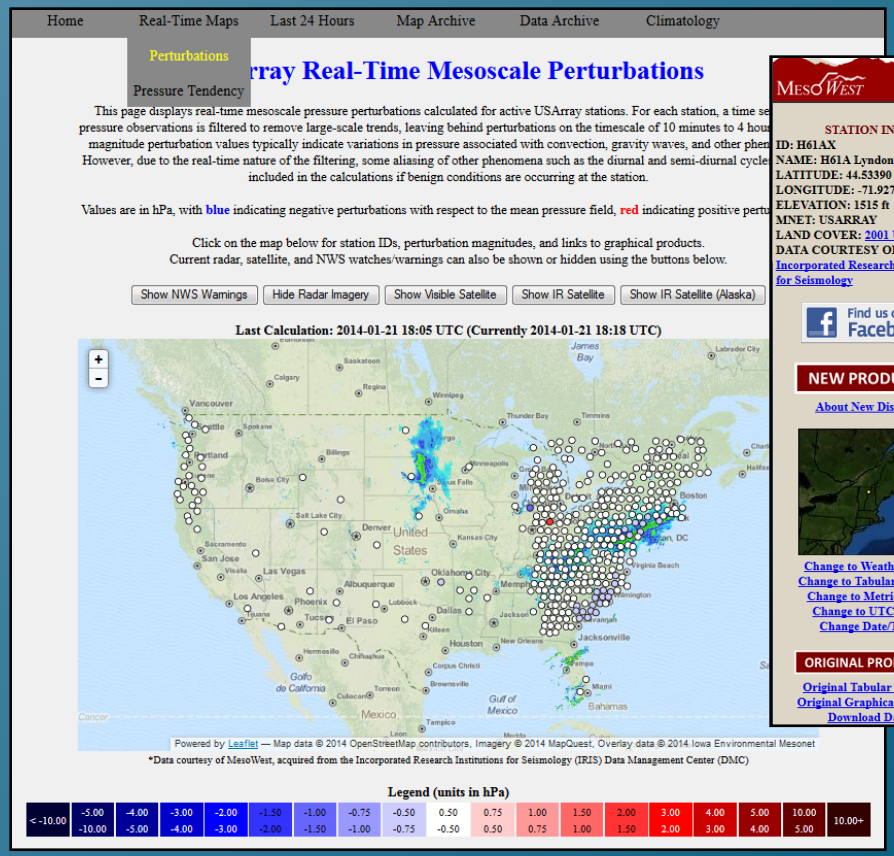
- Website (http://meso1.chpc.utah.edu/usarray) uses Python in conjunction with JQuery and Leaflet to generate interactive maps and plots

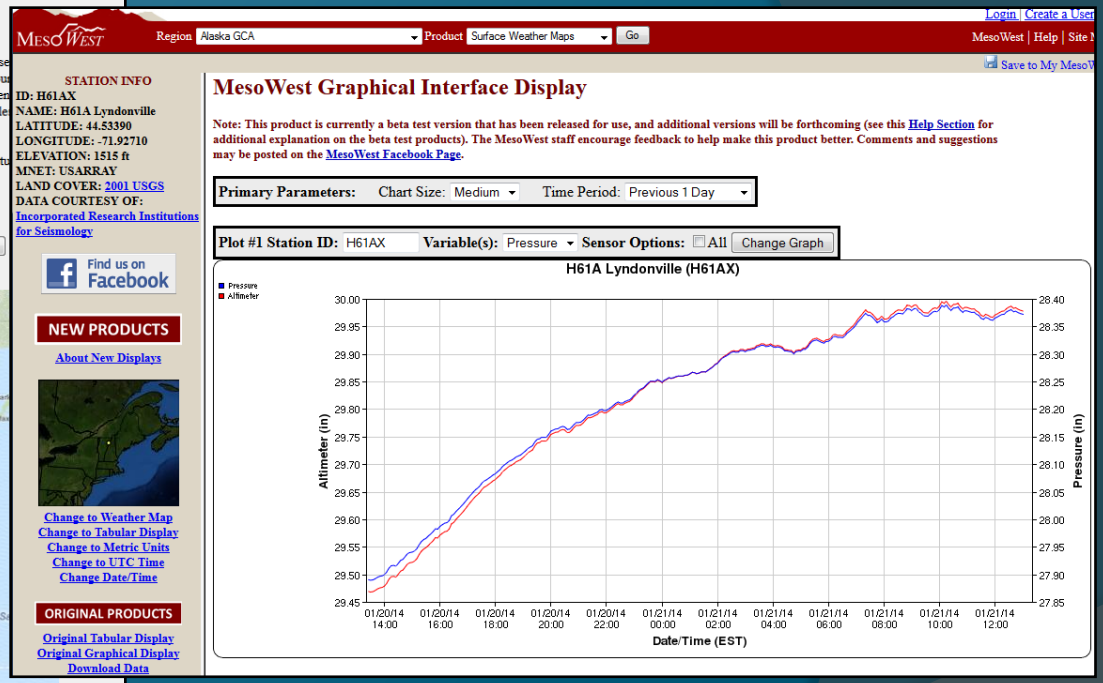




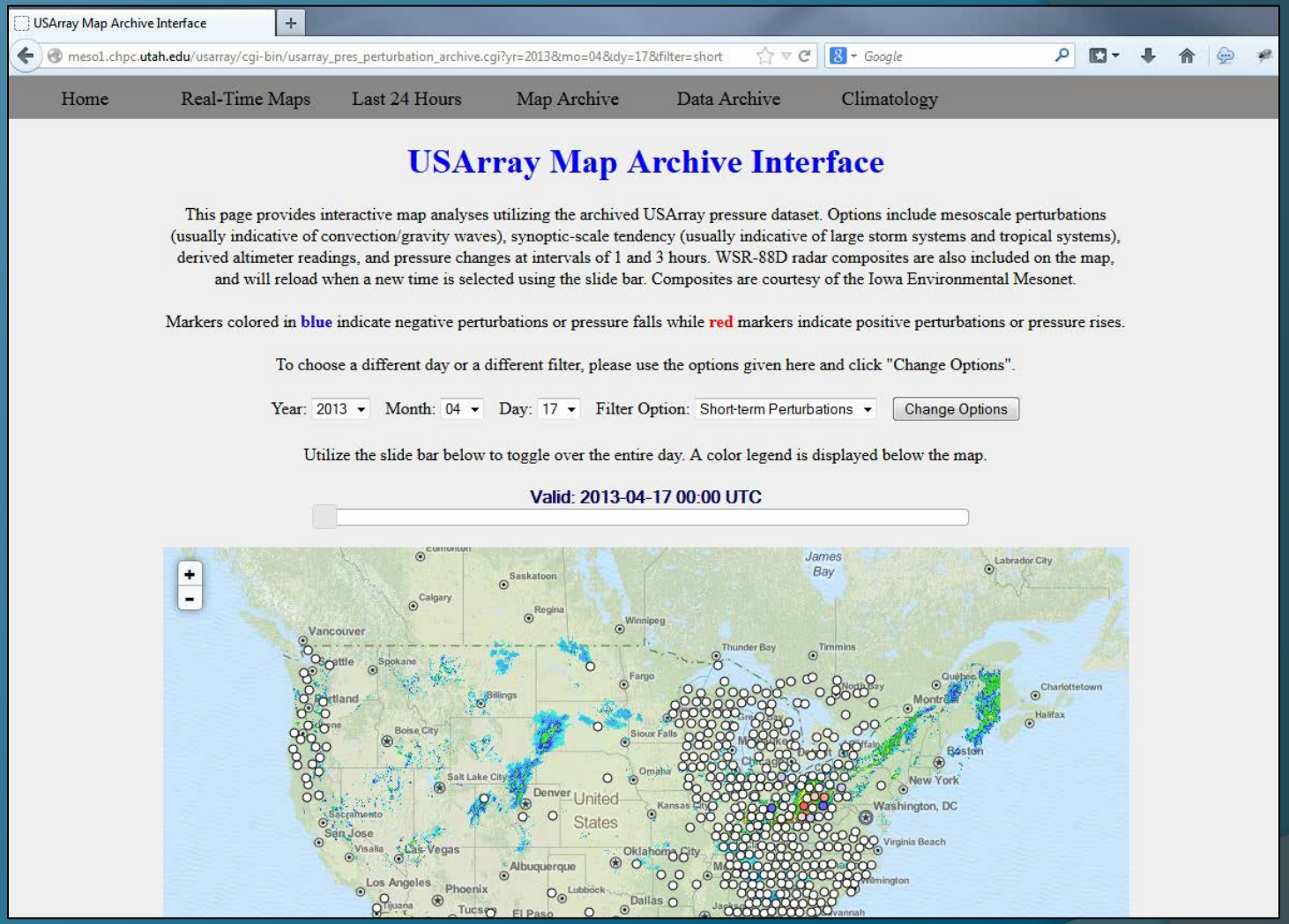
Python for USArray Web Displays

- Real-time displays utilize 5-minute observations courtesy of MesoWest (http://mesowest.utah.edu). MesoWest data is also forwarded onto MADIS.



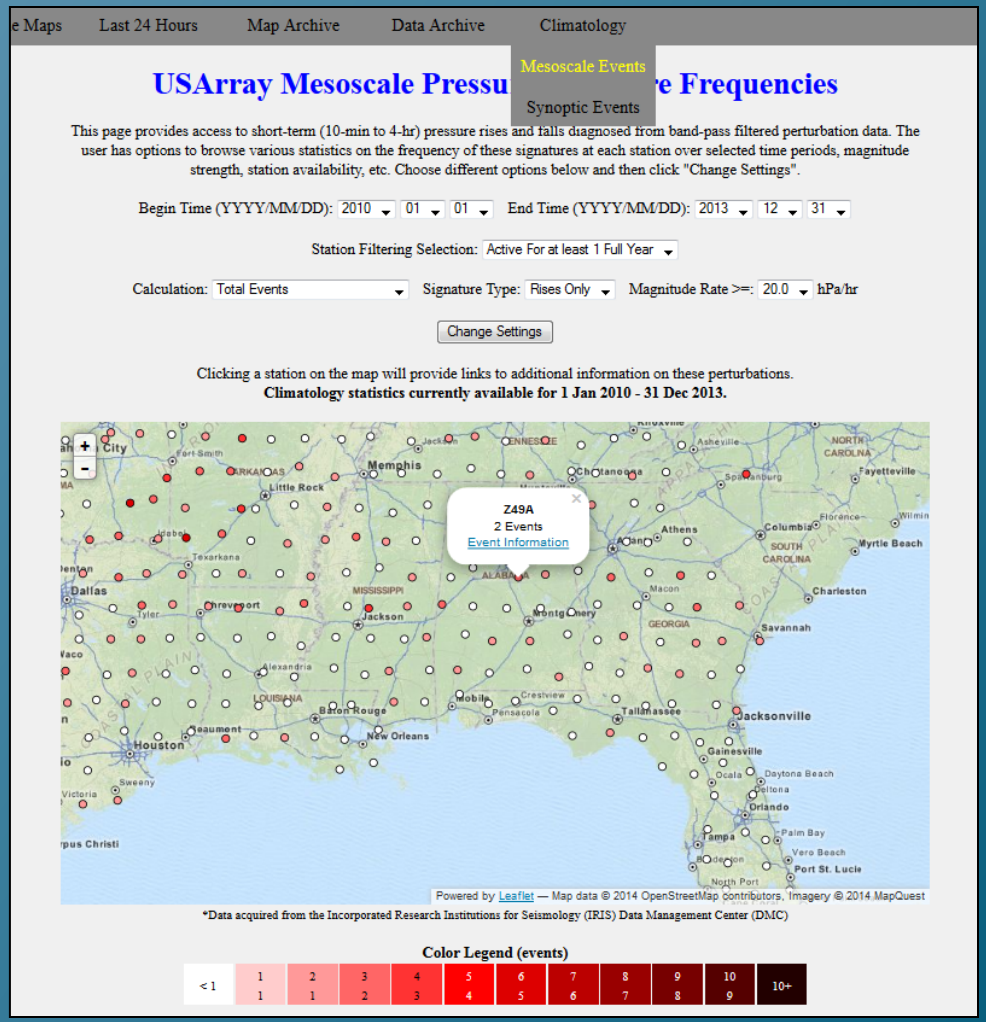


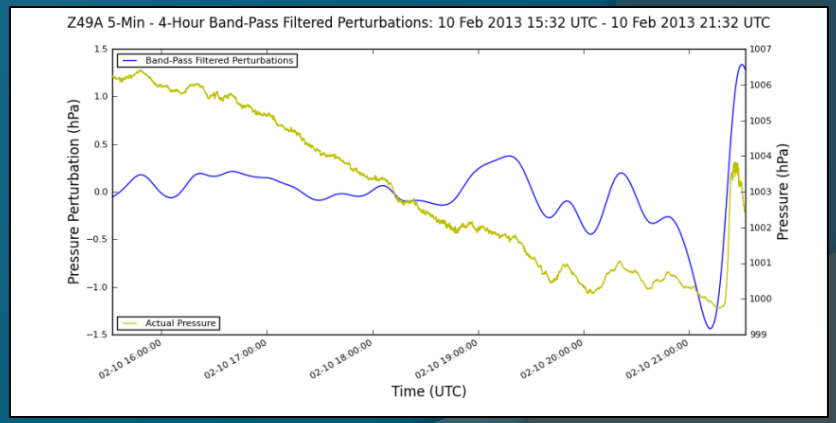
Python for USArray Web Displays



http://meso1.chpc.utah.edu/usarray

Python for USArray Web Displays





http://meso1.chpc.utah.edu/usarray

Future Tasks

- Continue developing climatologies of pressure perturbations and signatures for all USArray stations using Python storage/analysis techniques
- Explore wavelet analyses of time series using PyWavelets
- Develop algorithms to calculate pressure perturbation gradients
- Develop climatologies of the above pressure perturbation gradients for each USArray station in the database

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Acknowledgements and References

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Additional work on this project can be found in tomorrow's poster session…

Jacques, Alexander A. and J. Horel, 2014: Pressure Signatures of Extreme Weather Events Deduced from Earthscope's USArray Network
26th Conf. Weather Analysis and Forecasting - Poster #108

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