Southwest U.S. Seismo-Acoustic Network: An Autonomous Data Aggregation, Detection, Localization and Ground-Truth Bulletin for the Infrasound Community

SUSSAN
Southwestern U.S. Seismo-Acoustic Network

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Abstract

The Southwest U.S. Seismo-Acoustic Network (SUSSAN) is a collaborative project designed to produce infrasound event detection bulletins for the infrasound community for research purposes. We are aggregating a large, unique, near real-time data set with available ground truth information from seismo-acoustic arrays across New Mexico, Utah, Nevada, California, Texas and Hawaii. The data are processed in near real-time (~ every 20 minutes) with detections being made on individual arrays and locations determined for networks of arrays. The detection and location data are then combined with any available ground truth information and compiled into a bulletin that will be released to the general public directly and eventually through the IRIS infrasound event bulletin.

We use the open source Earthworm seismic data aggregation software to acquire waveform data either directly from the station operator or via the Incorporated Research Institutions for Seismology Data Management Center (IRIS DMC), if available. The data are processed using InfraMonitor, a powerful infrasound event detection and localization software program developed by Stephen Arrowsmith at Los Alamos National Laboratory (LANL). Our goal with this program is to provide the infrasound community with an event database that can be used collaboratively to study various natural and man-made sources. We encourage participation in this program directly or by making infrasound array data available through the IRIS DMC or other means.

Introduction

SUSSAN includes infrasound data from Southern Methodist University (SMU), The University of California San Diego (UCSD), the University of Utah (UU), Los Alamos National Labs (LANL) and Sandia National Labs (SNL). Figure 1 shows a map of the Southwestern United States and the location of each array. The arrays from the University of Utah make up the backbone of the network.

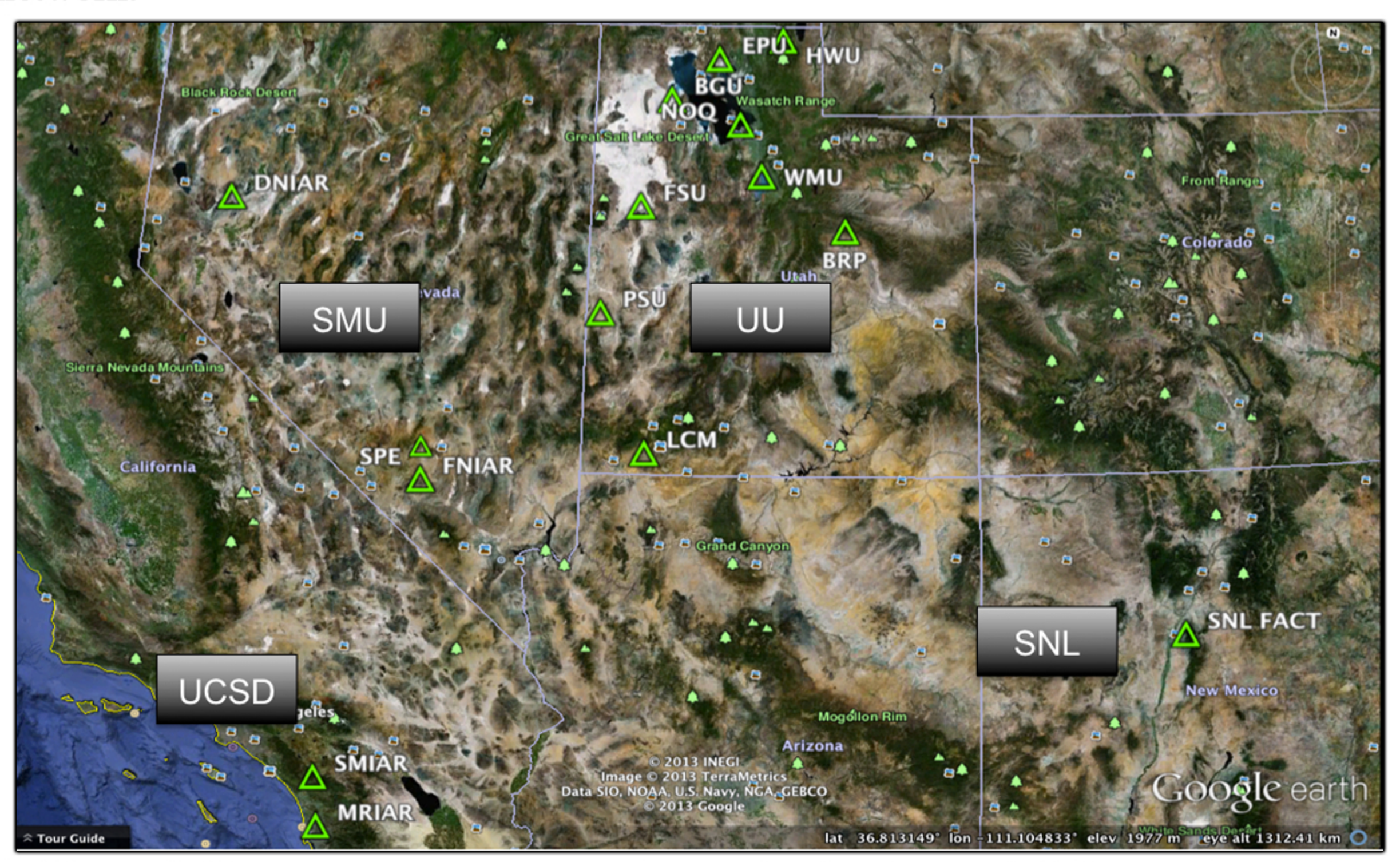
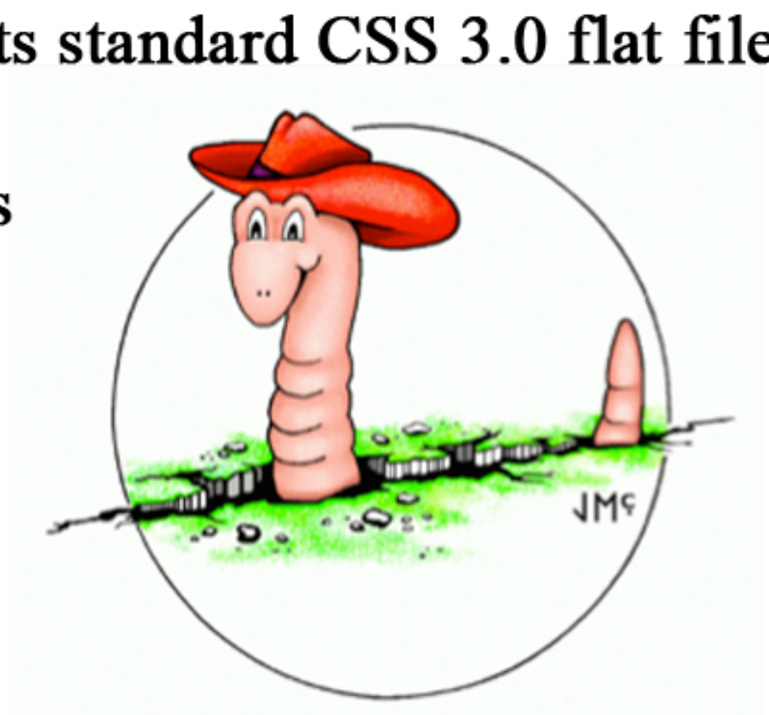
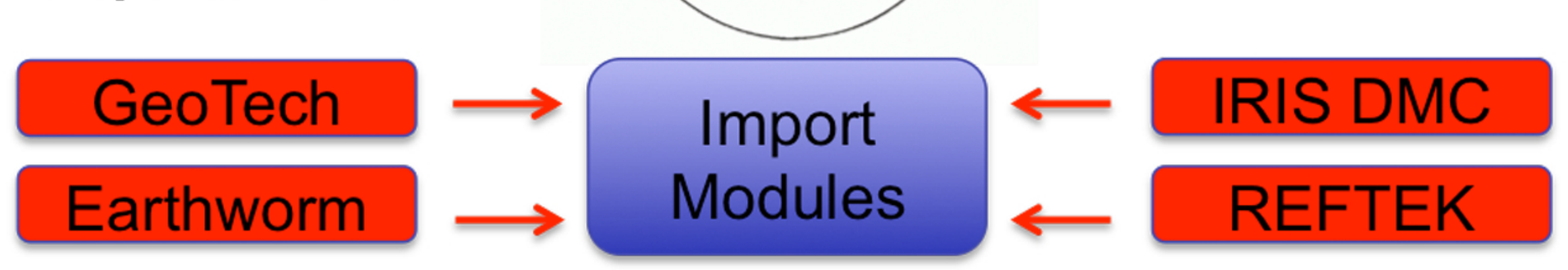


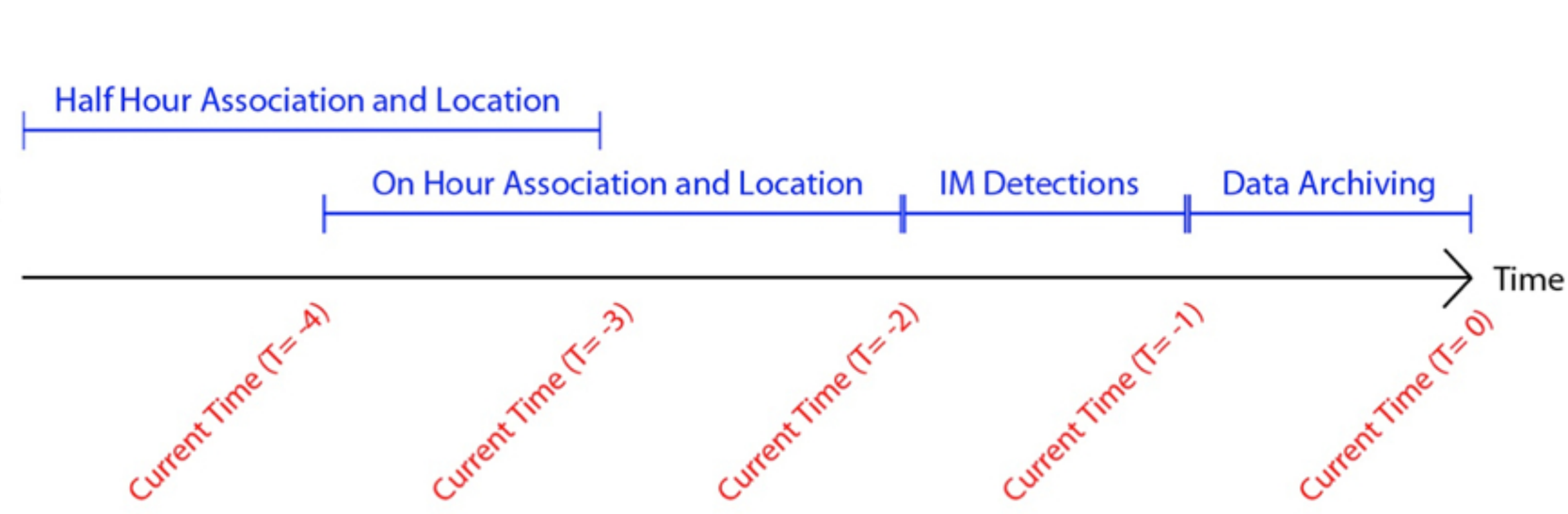
Figure 1. Map of the arrays that make up the Southwest U.S. Seismo-Acoustic Network.

The backbone of SUSSAN is the Earthworm seismic acquisition system, currently maintained by Instrumental Software Technologies, Inc. (ISTI). Earthworm is open-source software that enables us to download and archive data in real-time from multiple data sources. Earthworm has several options for data export to the file system such (SUDS, SAC, AH, SEISAN, GSE, mini-SEED, and WFDISC). We save the imported data as individual SAC files split by the hour. The version of InfraMonitor (version 3) that we are currently using supports standard CSS 3.0 flat files (wfdisc, site and binary) as well as SAC files instead of binary files. We use the SAC output option primarily because InfraMonitor accepts SAC files and the WFDISC output option in earthworm is available only in Linux and we are operating on a Mac. The SAC files are written every ten minutes and are complete and ready for processing at ten minutes after the hour.

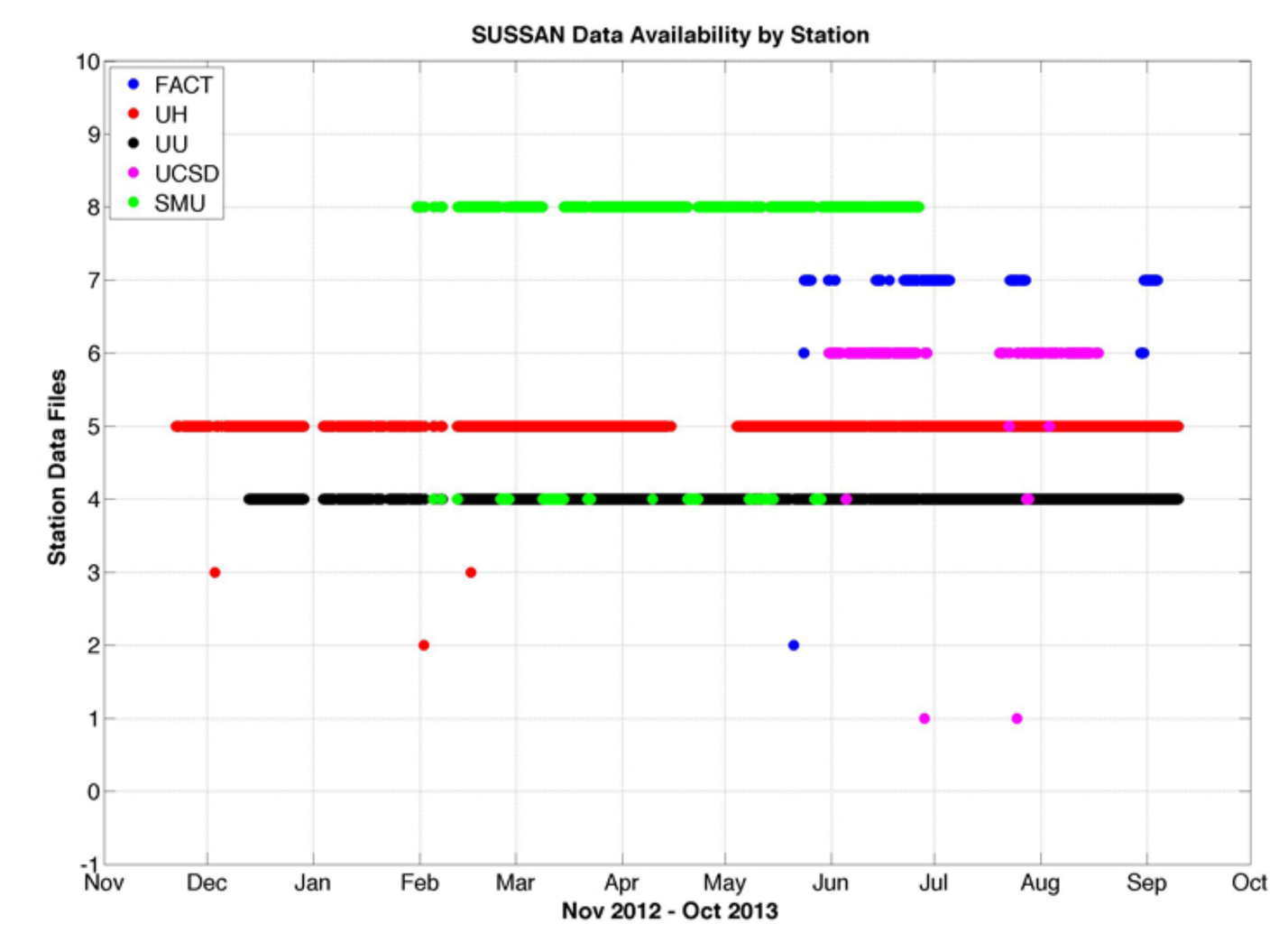




Processing of the infrasound data was split into two parts. The first part is running each array's sensor data through the signal detector. Each file was automatically imported into InfraMonitor and broadband filtered between 1 and 5 Hz. The detector was set to this frequency band in an attempt to capture the most sources, but we were primarily looking for impulsive events at higher frequencies. The events are written out to an hourly detection file that contains the information necessary for association. Association takes place over a 30-minute moving window that incorporates two hours of detection data to account for the travel time from one side of the association grid to the other.



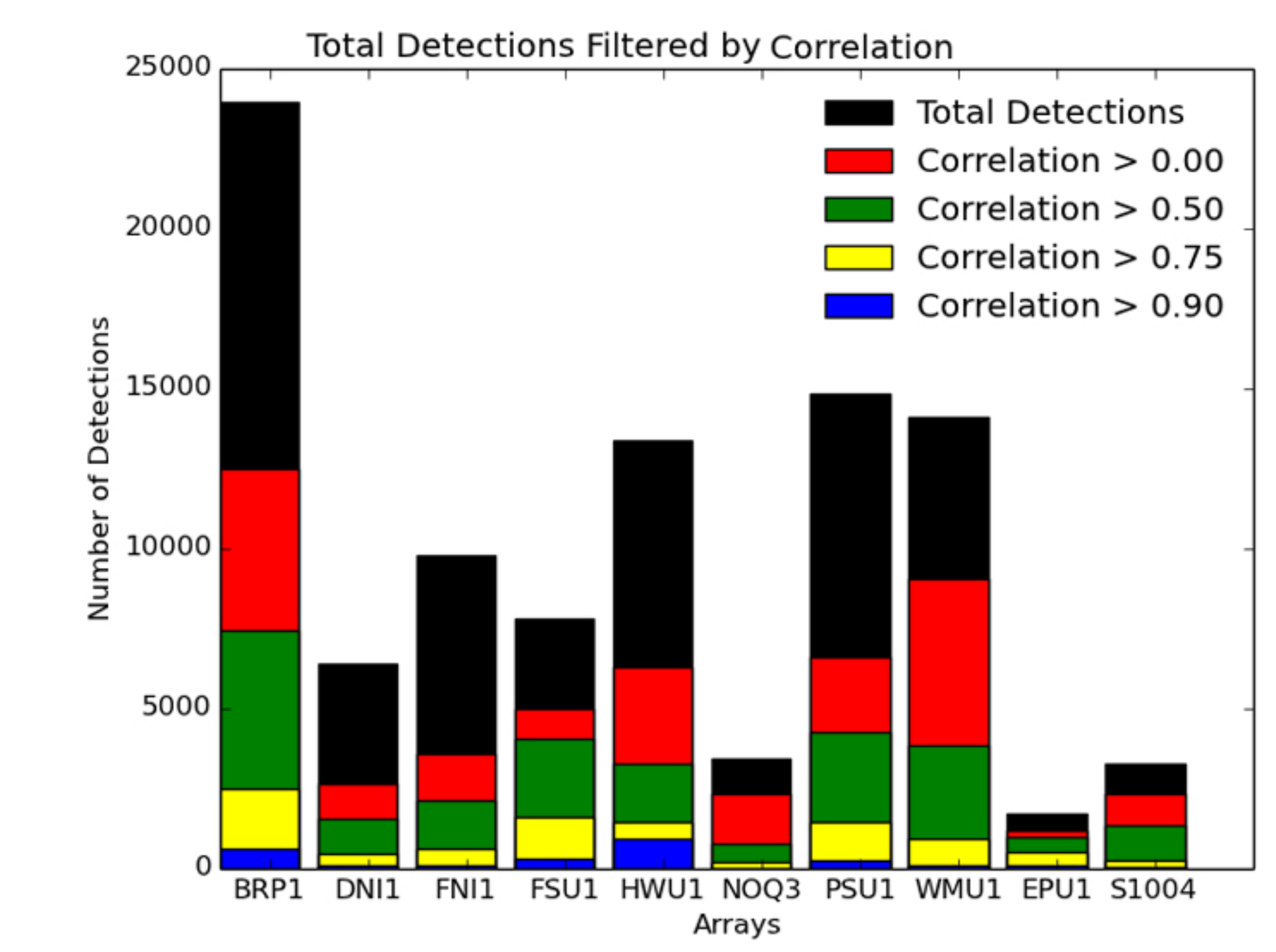
Data Statistics



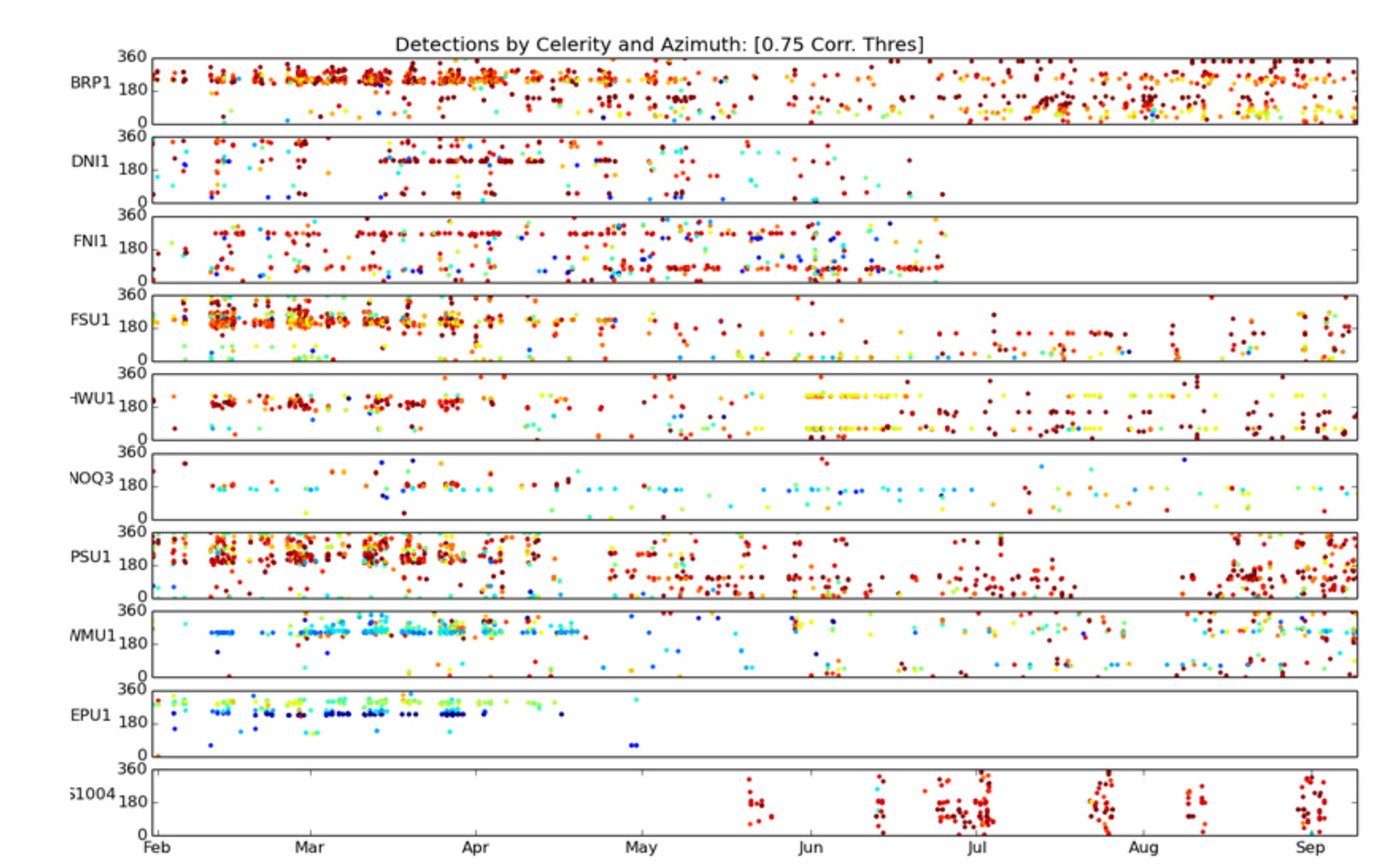
Array network uptime for all SUSSAN arrays as well as a test array in Hawaii via the IRIS real-time feed. The arrays came online at different times. Some arrays had connectivity issues.

The results presented here are from February - September 2013. This includes data for 10 Arrays with 98, 733 total detections made. To make the data set more manageable we filtered the data by reasonable average propagation speeds of 0.22 - 0.36 km/s at various correlation levels.

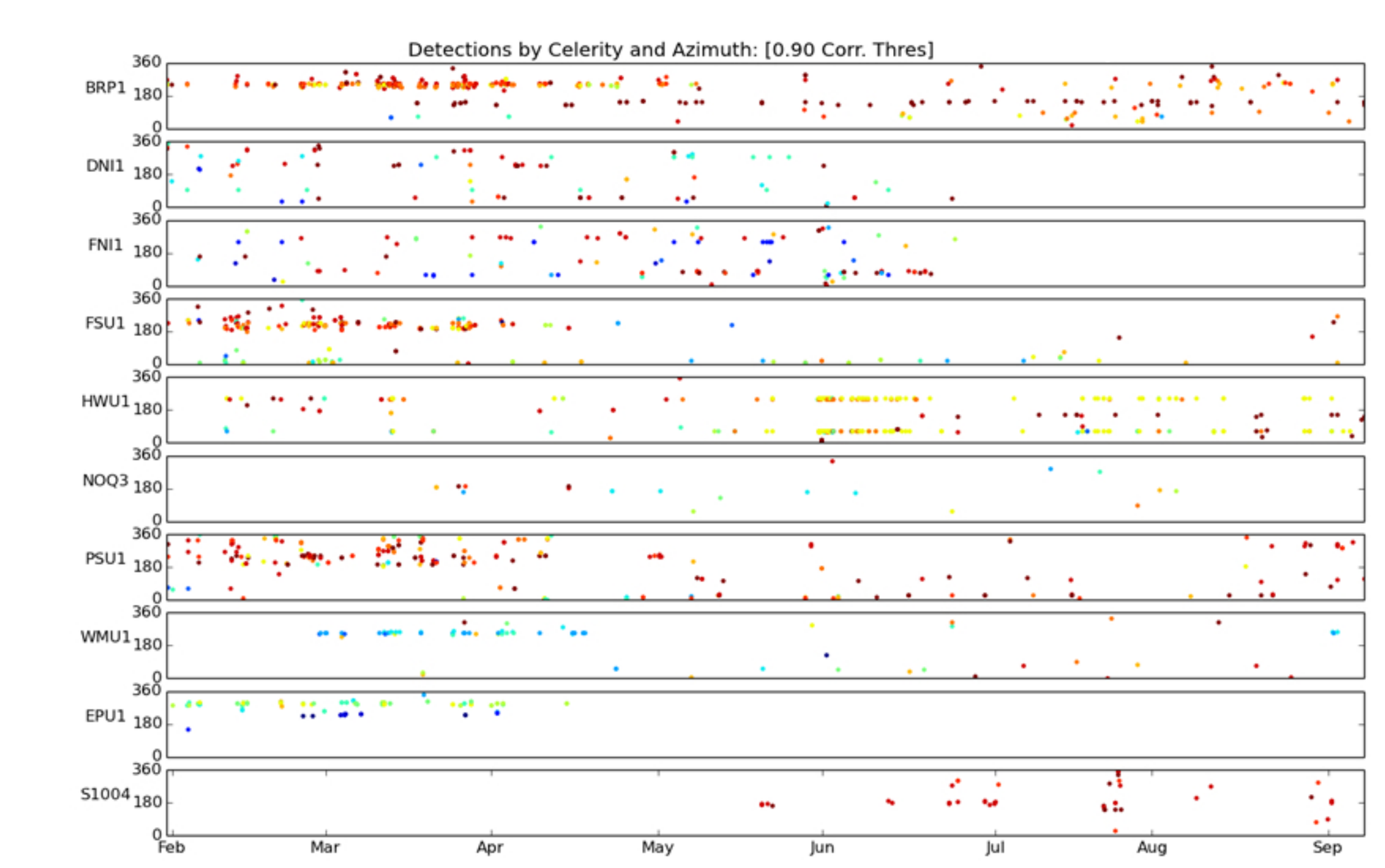
Correlation	Number of Detections
0.00	51, 550
0.50	29,730
0.75	10,019
0.90	2,613



Raw Detections

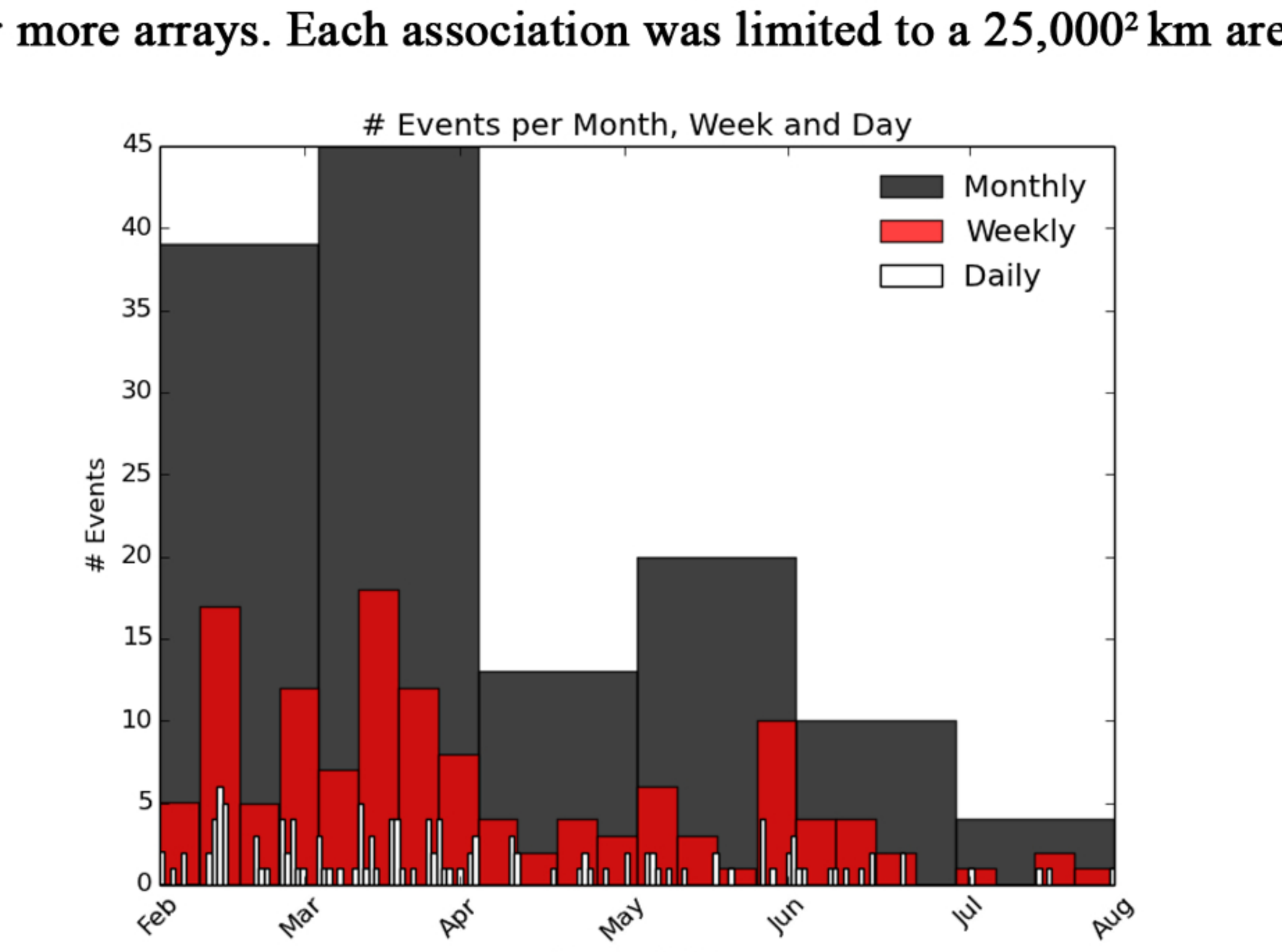


The figures above and to the right show detections by hour and azimuth and filtered by correlation threshold and average propagation speeds between 0.22 and 0.36 km/s.

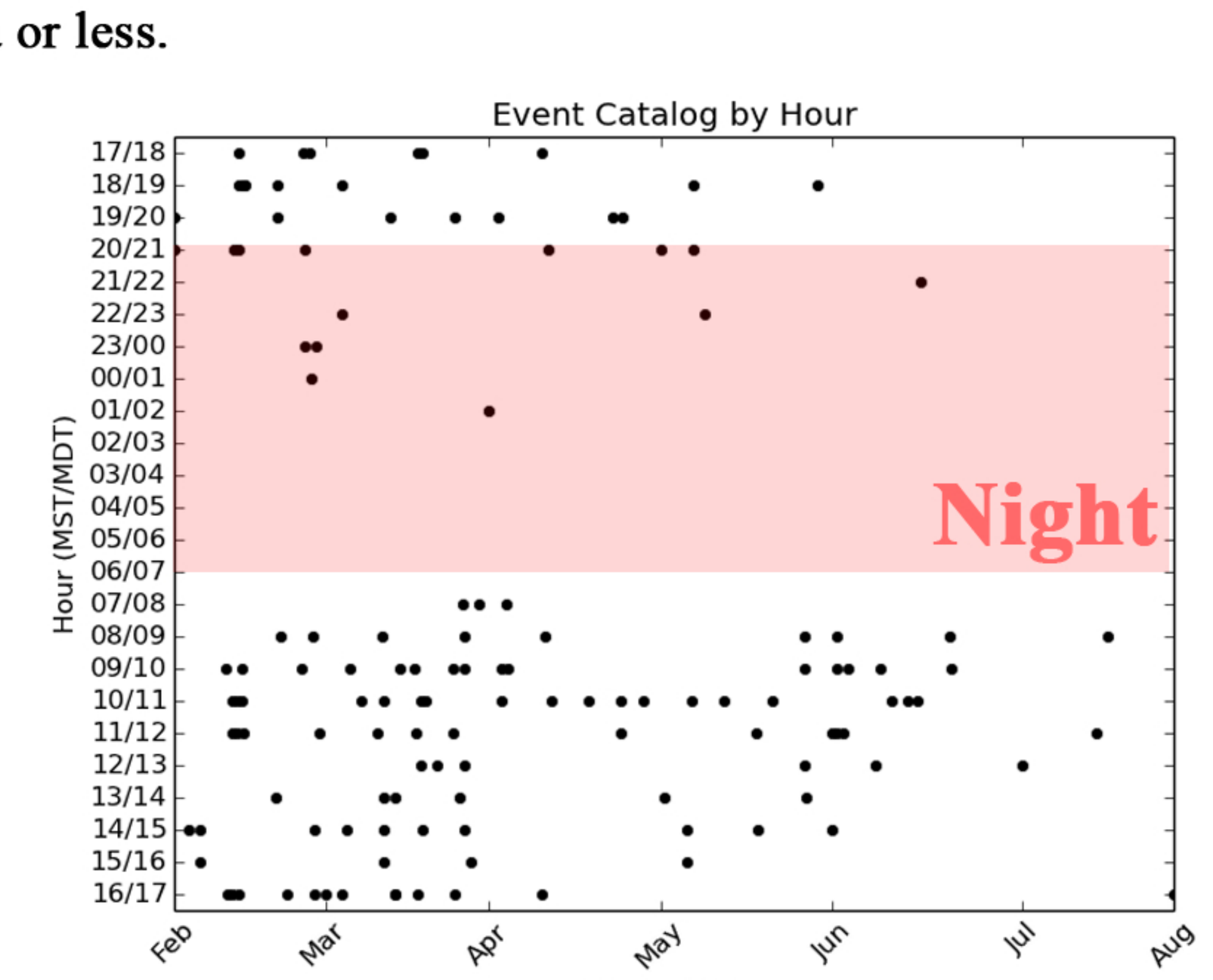


Associations

All of the detections with valid propagation speeds were passed to the association module. Associations were made with four or more arrays. Each association was limited to a 25,000² km area or less.



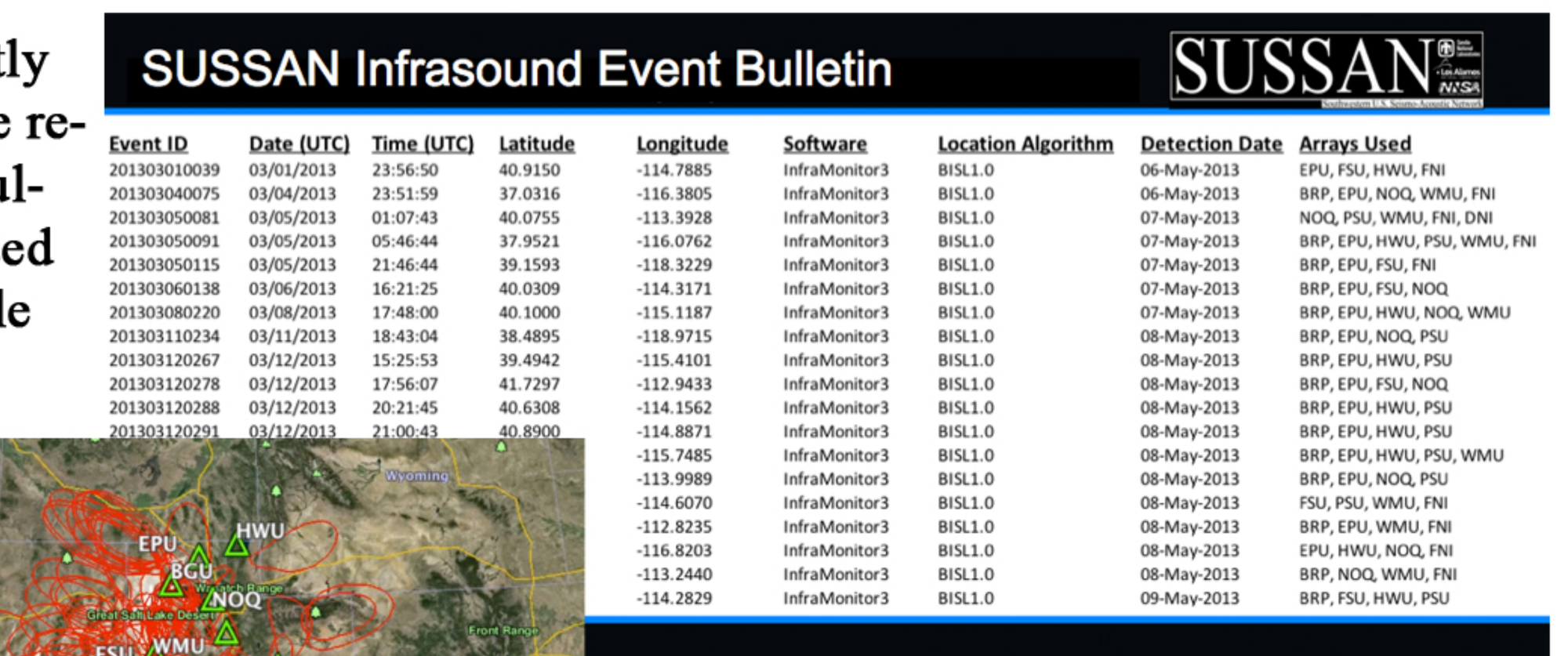
The figure above shows associated events per month (black), week (red) and day (white). For the study period InfraMonitor associated 133 events. The majority of associated events occur earlier in the study period

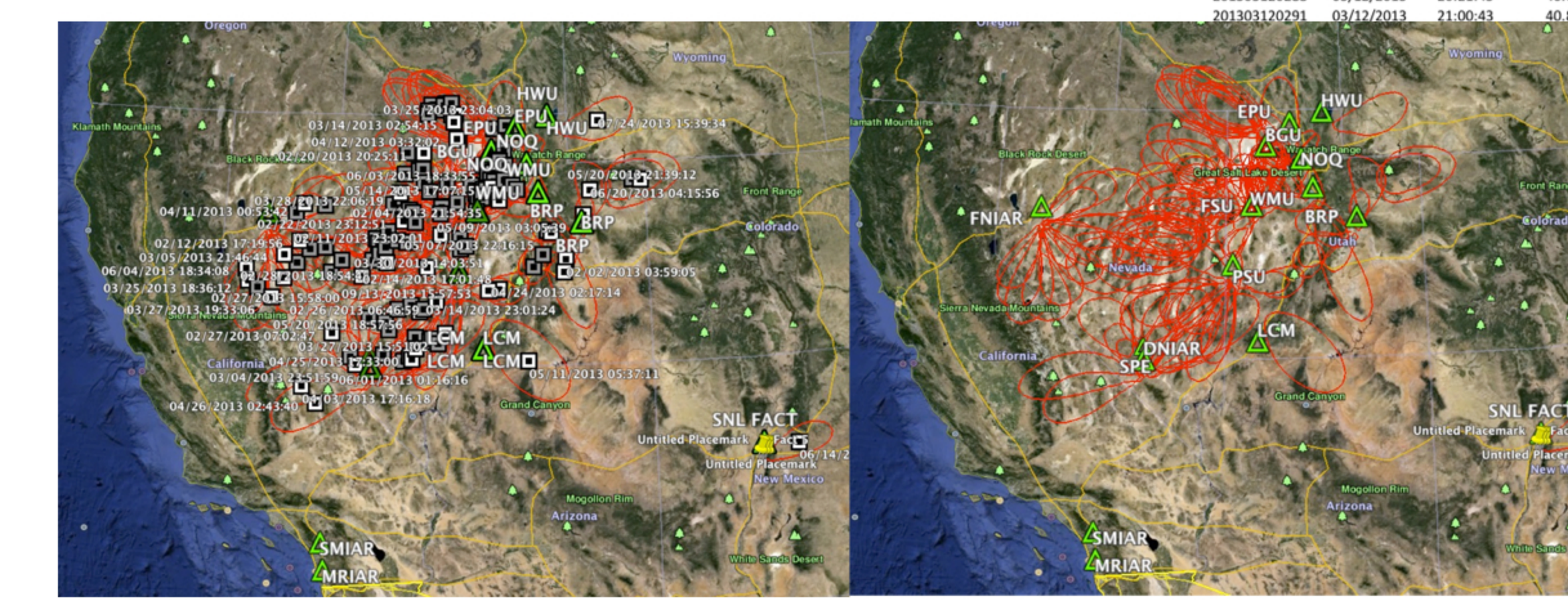


The figure above shows all 133 associated events. Most of the associated events occured during daylight hours.

Data Products

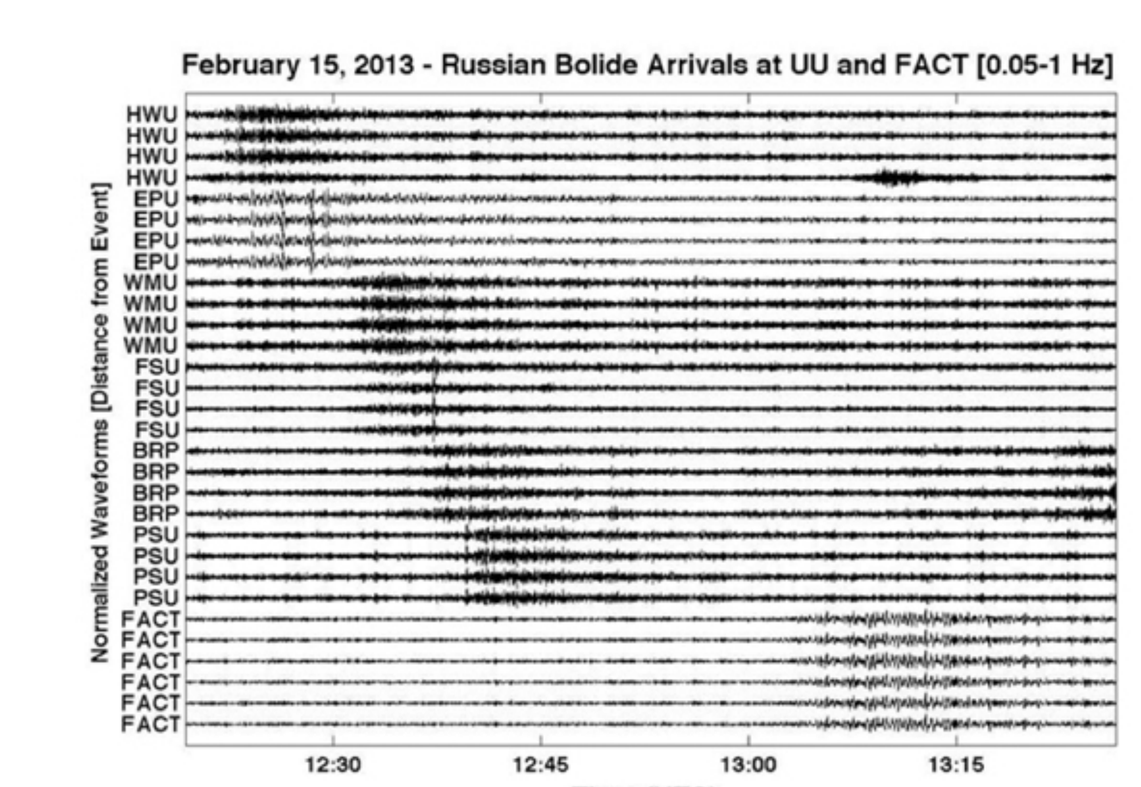
From the automated processing routines that are currently in place we have a flexible set of data products from the results. The figure at right shows an example html web bulliten with latitude, longitude, time, date, and stations used in the association. Below are two examples of the google maps and kml output files.

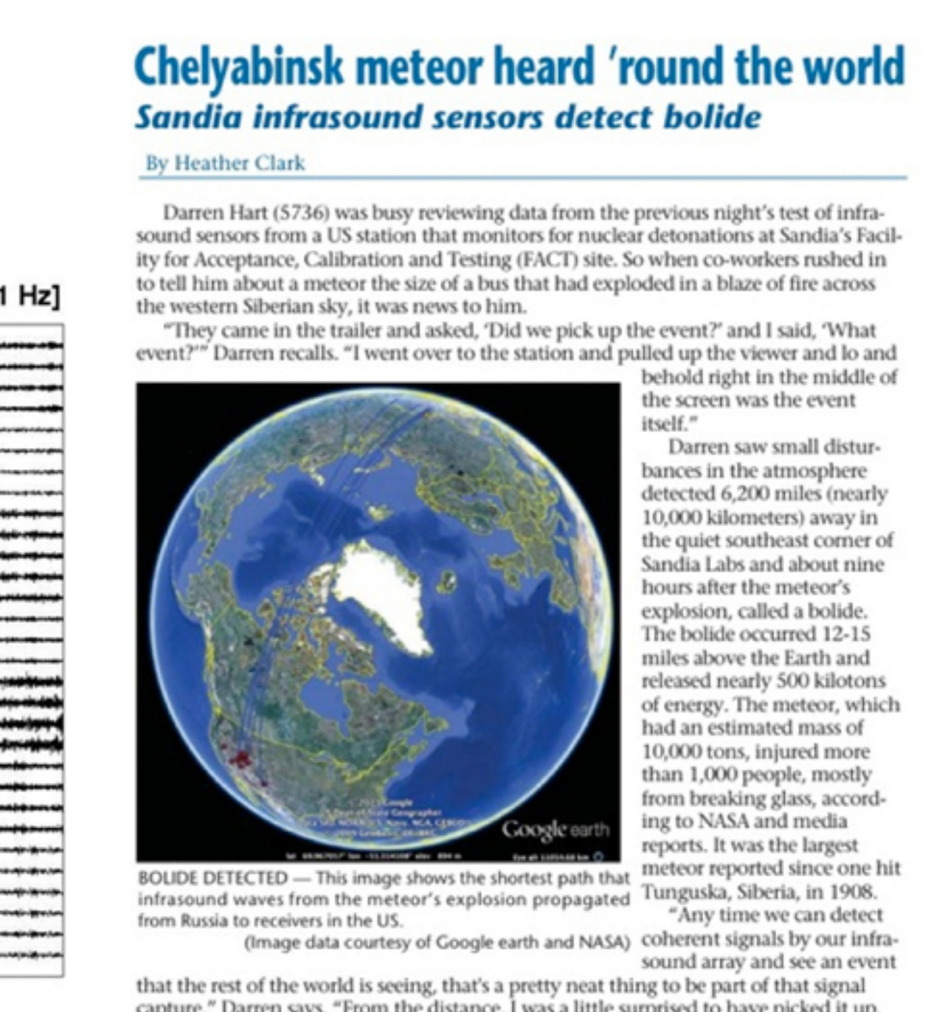


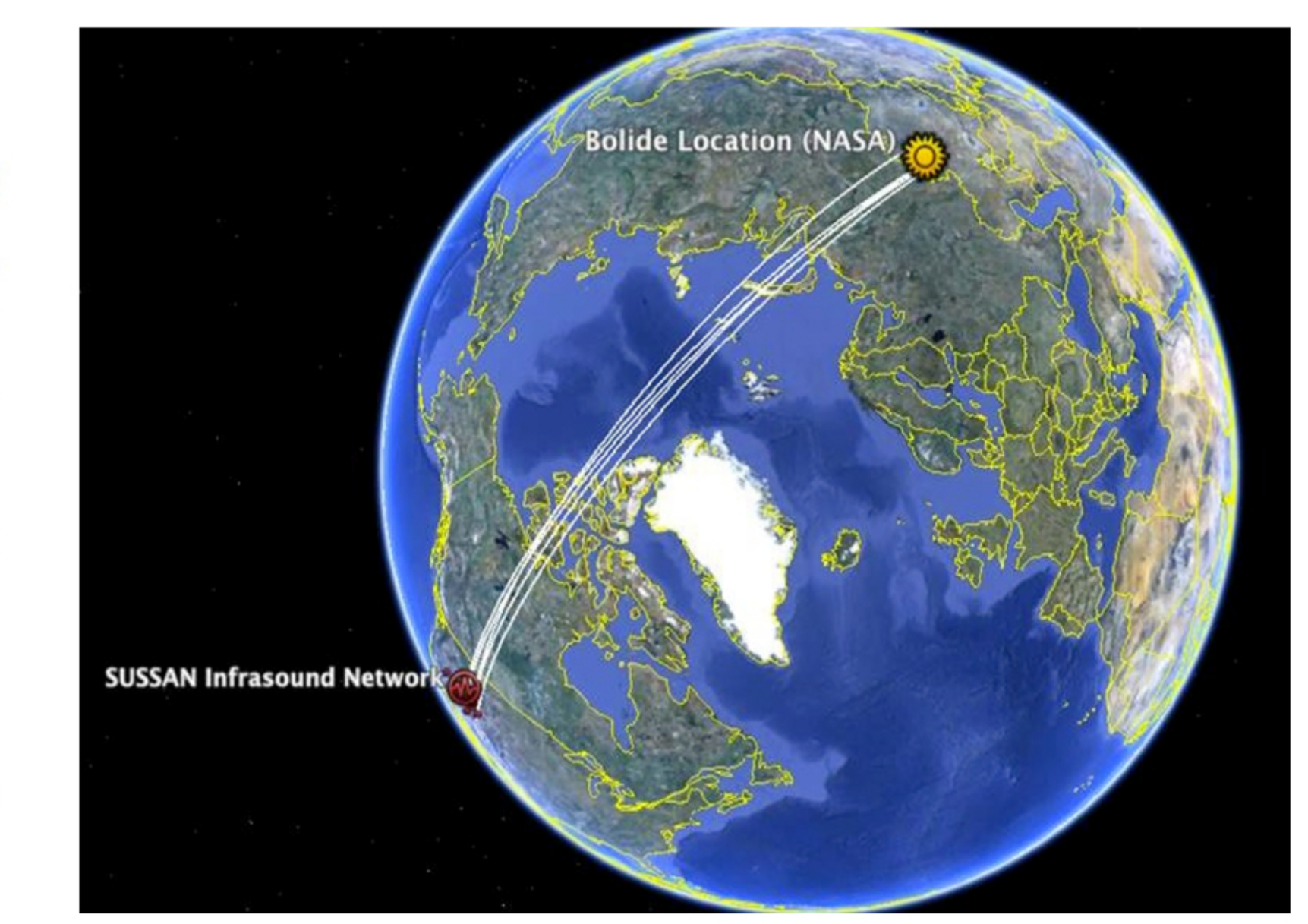


Notabile Events

The SUSSAN network detected the Russian Meteor event on Feburary 13, 2013. We used arrays in Utah and New Mexico to calculate back-azimuth's, which projected directly over NASA's satelite location.

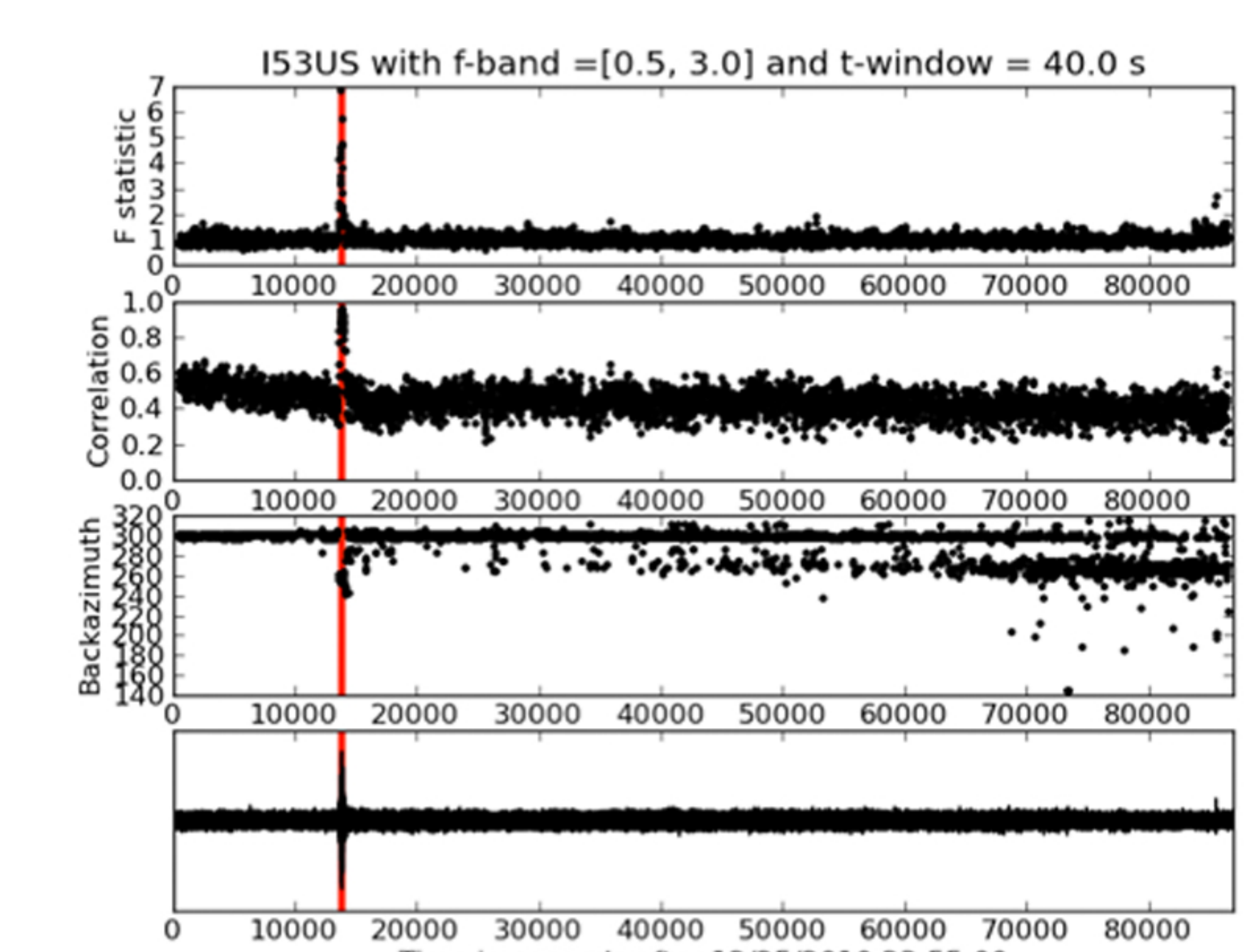






Future Work

SUSSAN has been funded for a second year, where we will be expanding from the Southwest U.S. to the global IMS infrasound network. To accomplish this we will be using an upgraded version of InfraMonitor called InfraPy. InfraPy is a faster, more reliable implementation written completely in python. This highlly adaptible framework will enable the near real-time data ingest from the IMS newwork. The figure below shows two of the new modules in InfraPy using IMS data.



Acknowledgements

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