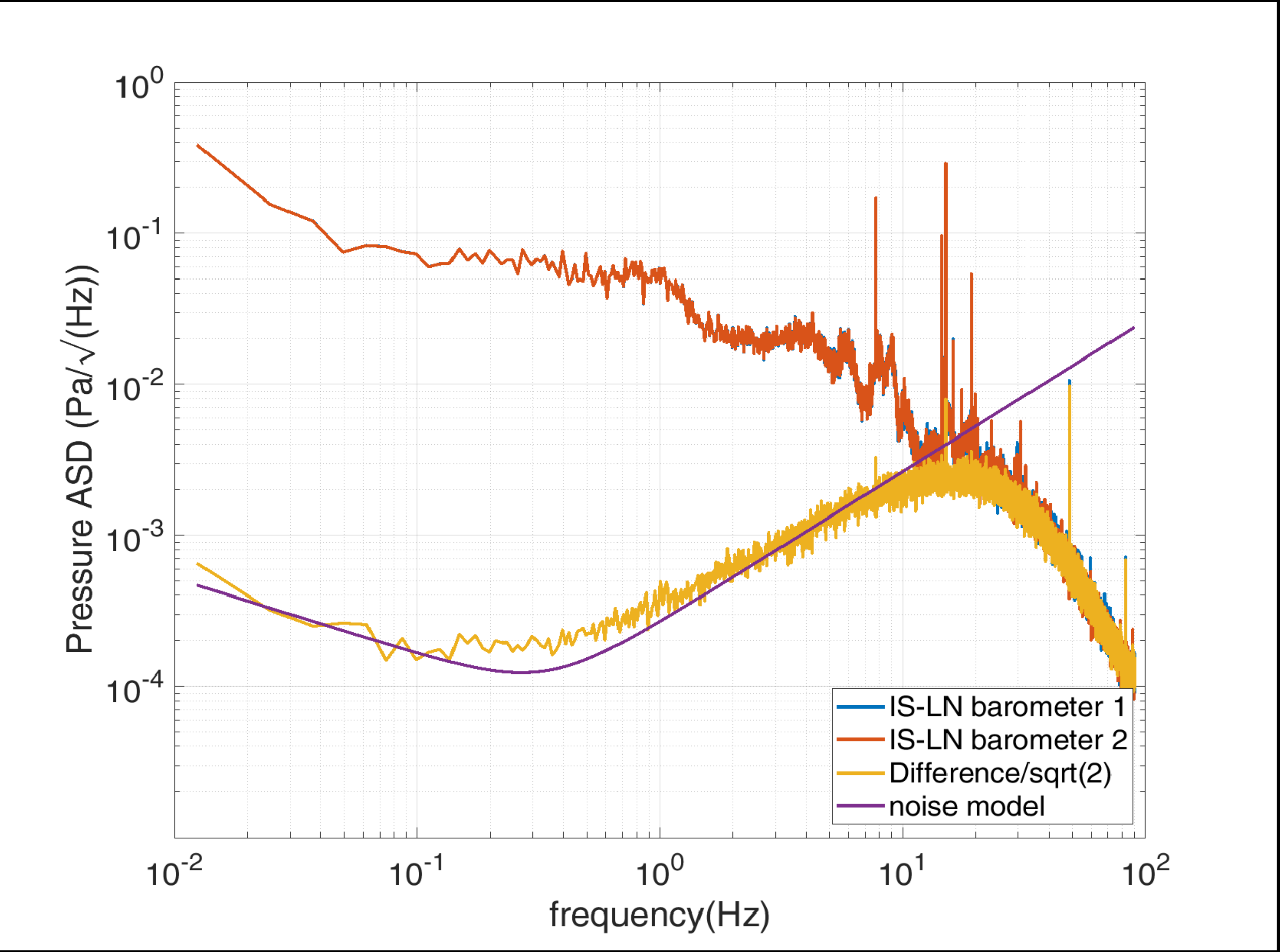
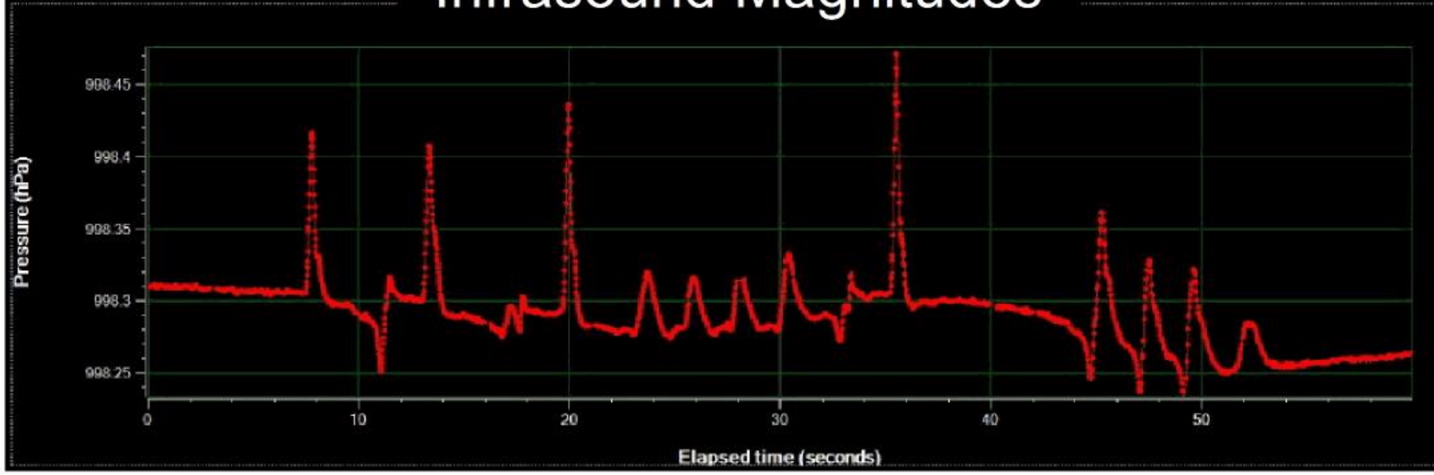
Atmospheric Measurements

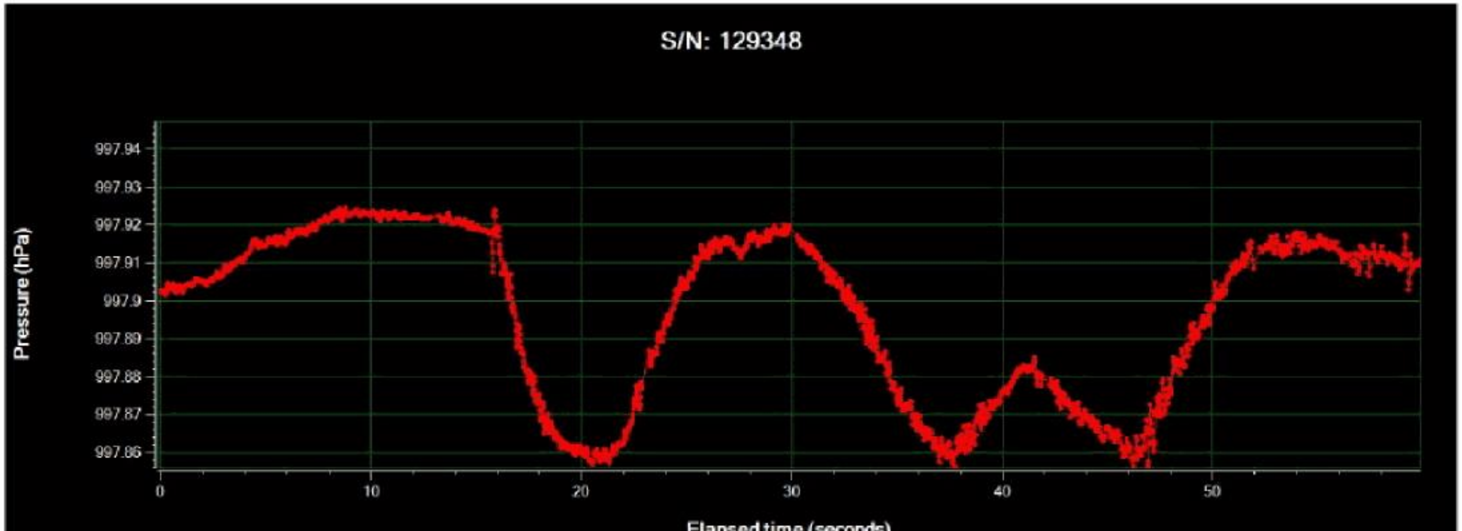
Sensor Noise Floor



- Infrasound Magnitudes -

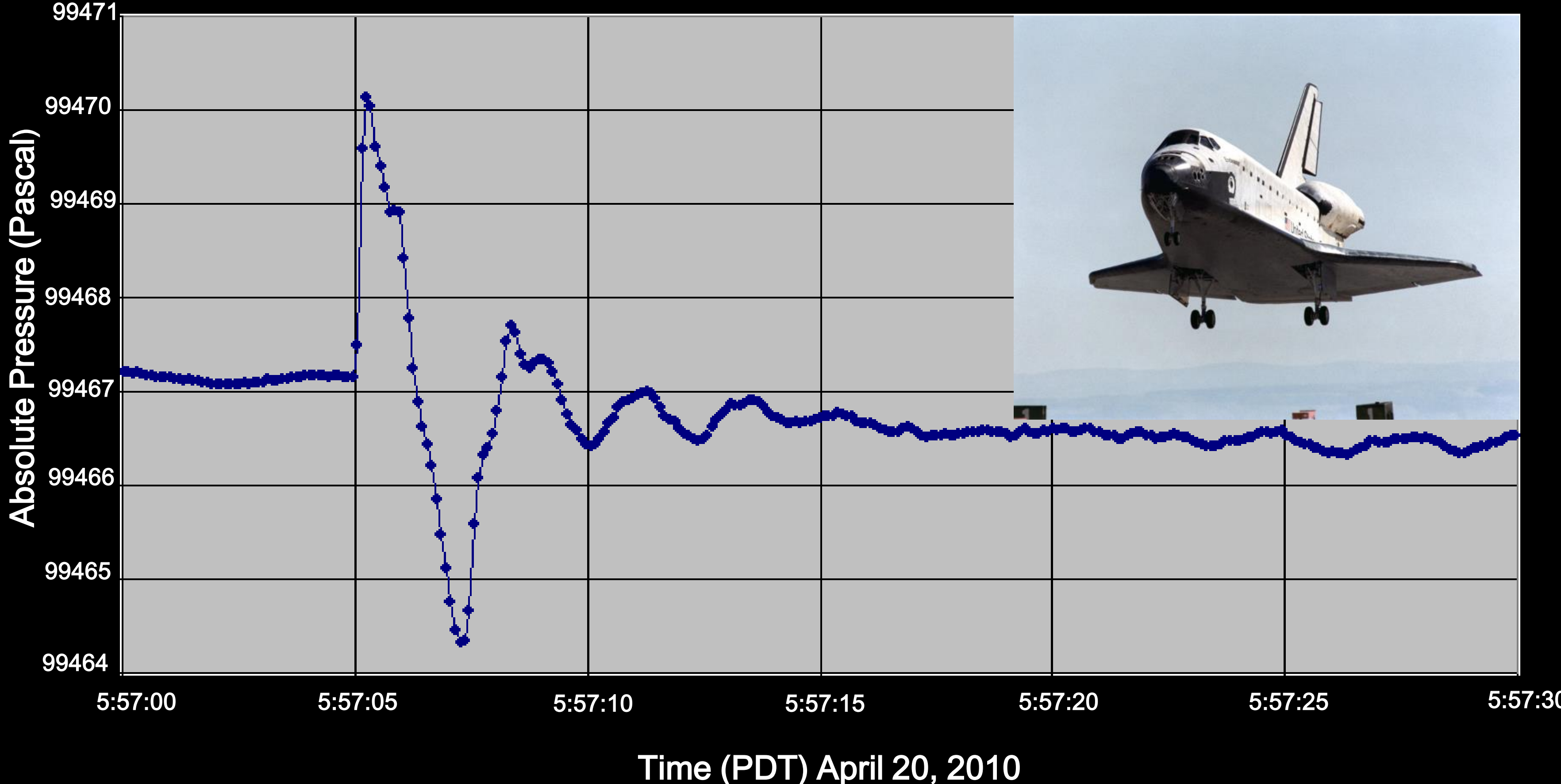


- Doors Opening & Closing - 10 Pa Magnitude -

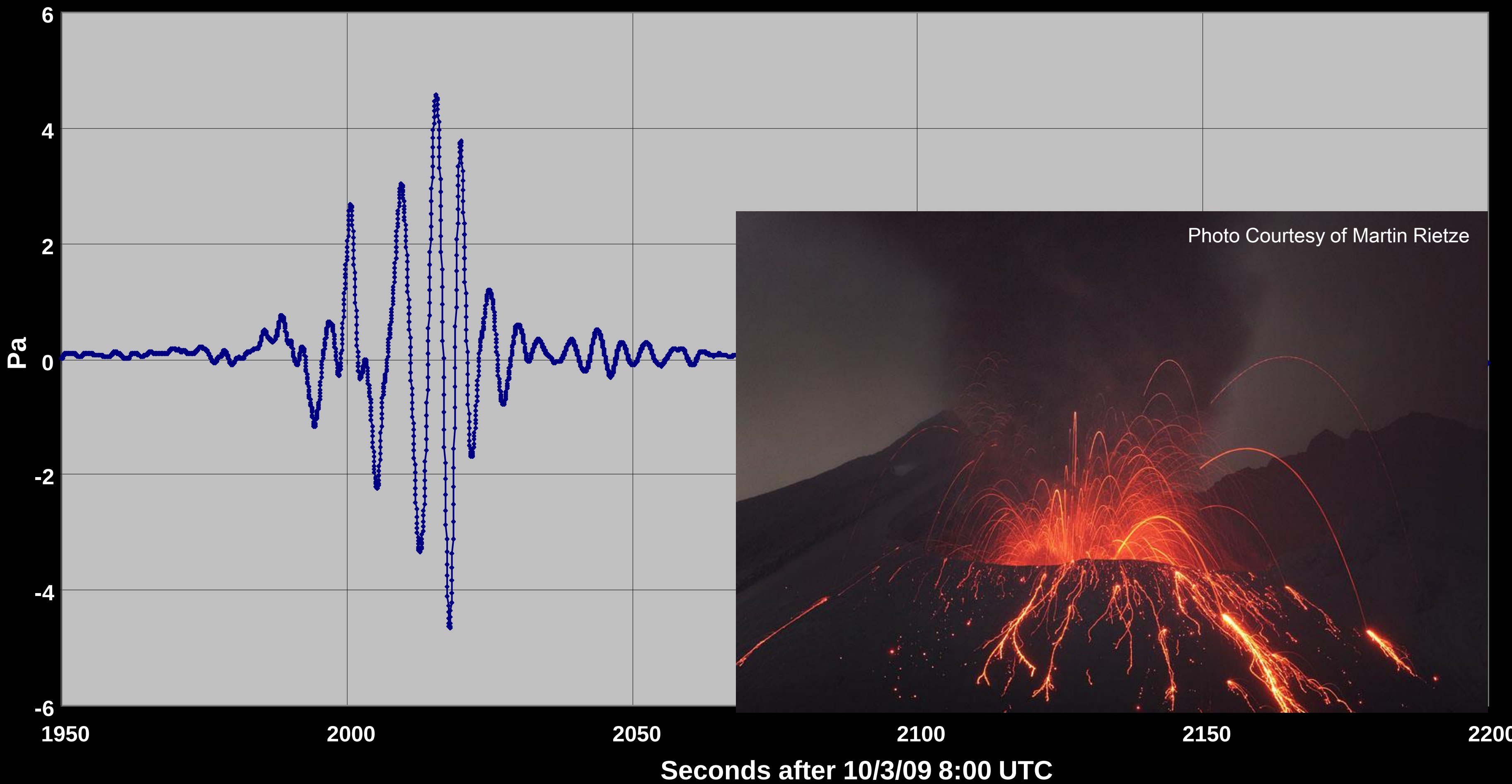


- Spelling UW - 5 Pa Magnitude = 0.5 m Altitude Change -

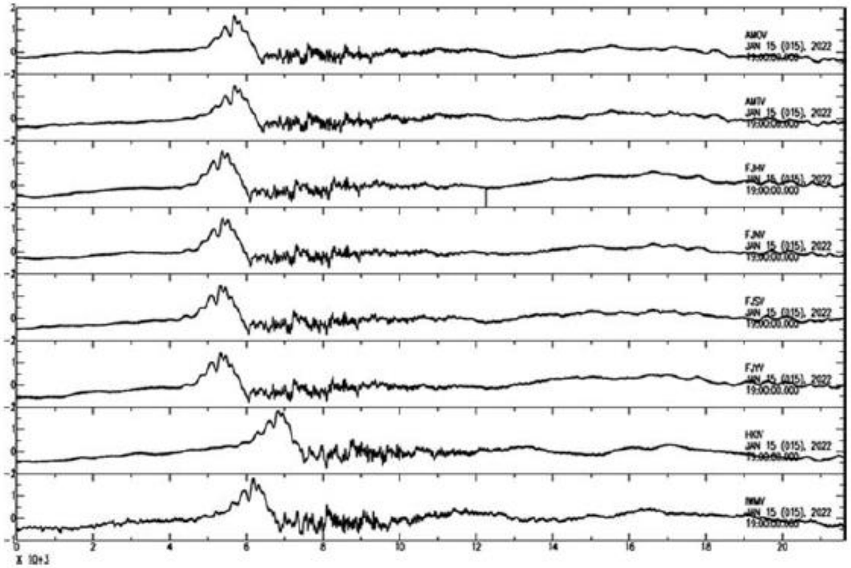
Space Shuttle Pressure Signature



Sakurajima Eruption Measured 1000 km Away at Nuclear Test Monitoring Site

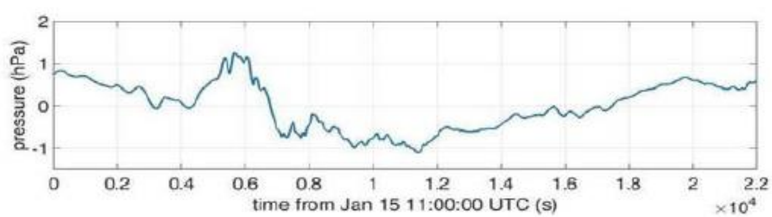


Tonga eruption generated infrasound signals measured on the Japanese Volcano Monitoring Network (V-Net).



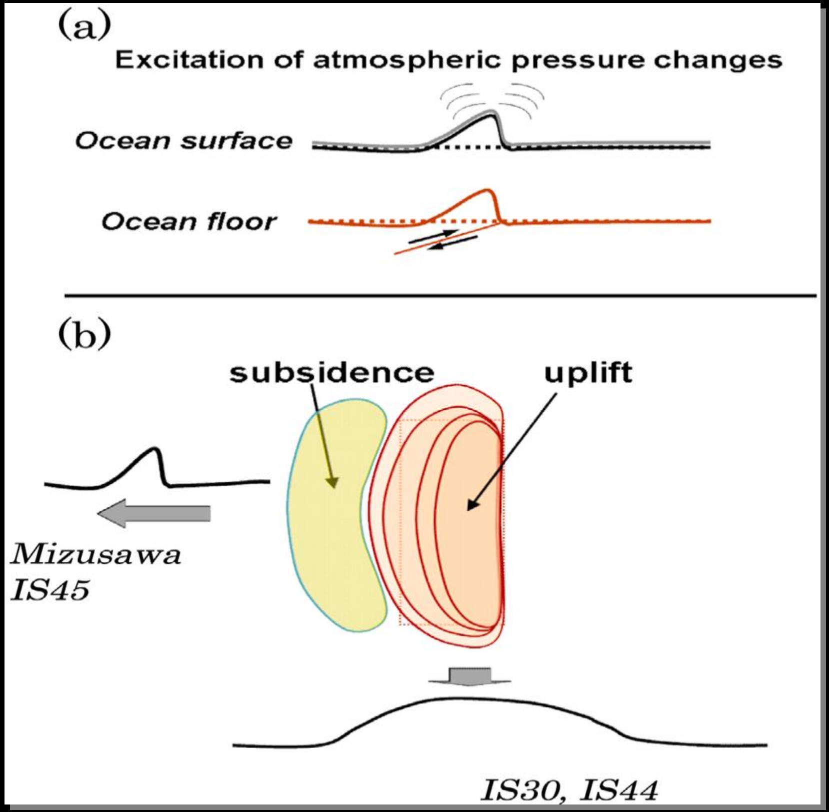
Distance Tonga to Japan = 5,034 miles (8,020 Km)

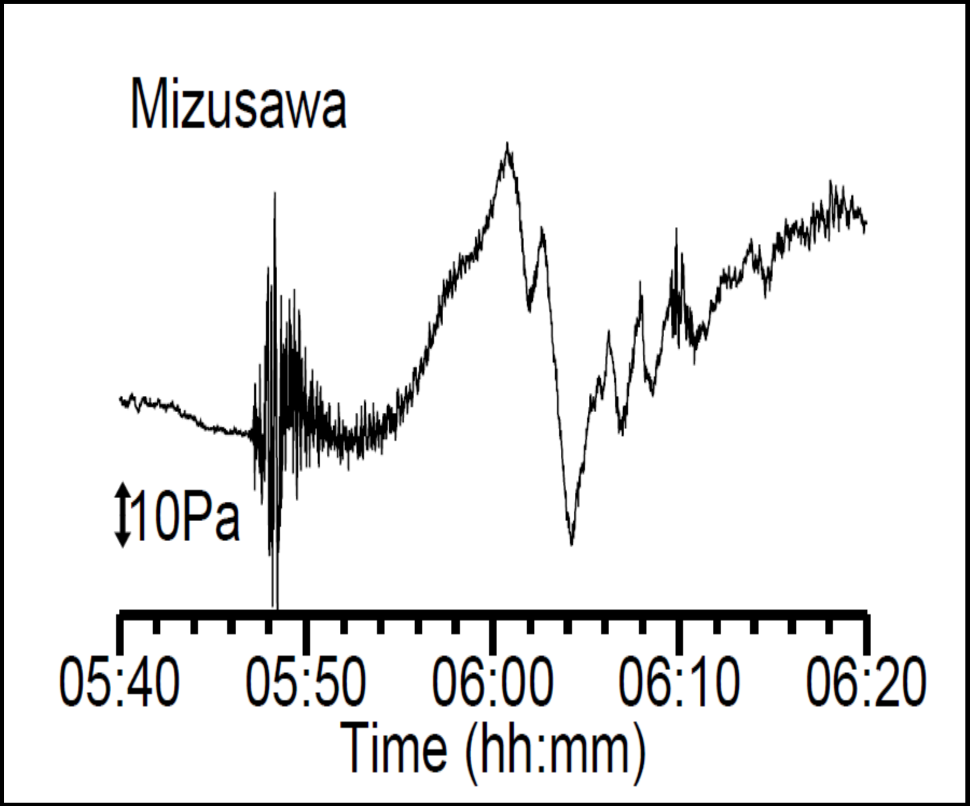
Tonga Eruption Measured in Seattle



Distance Tonga to Seattle = 5,777 miles (9,189 Km)

Infrasound Detection of Tsunamis

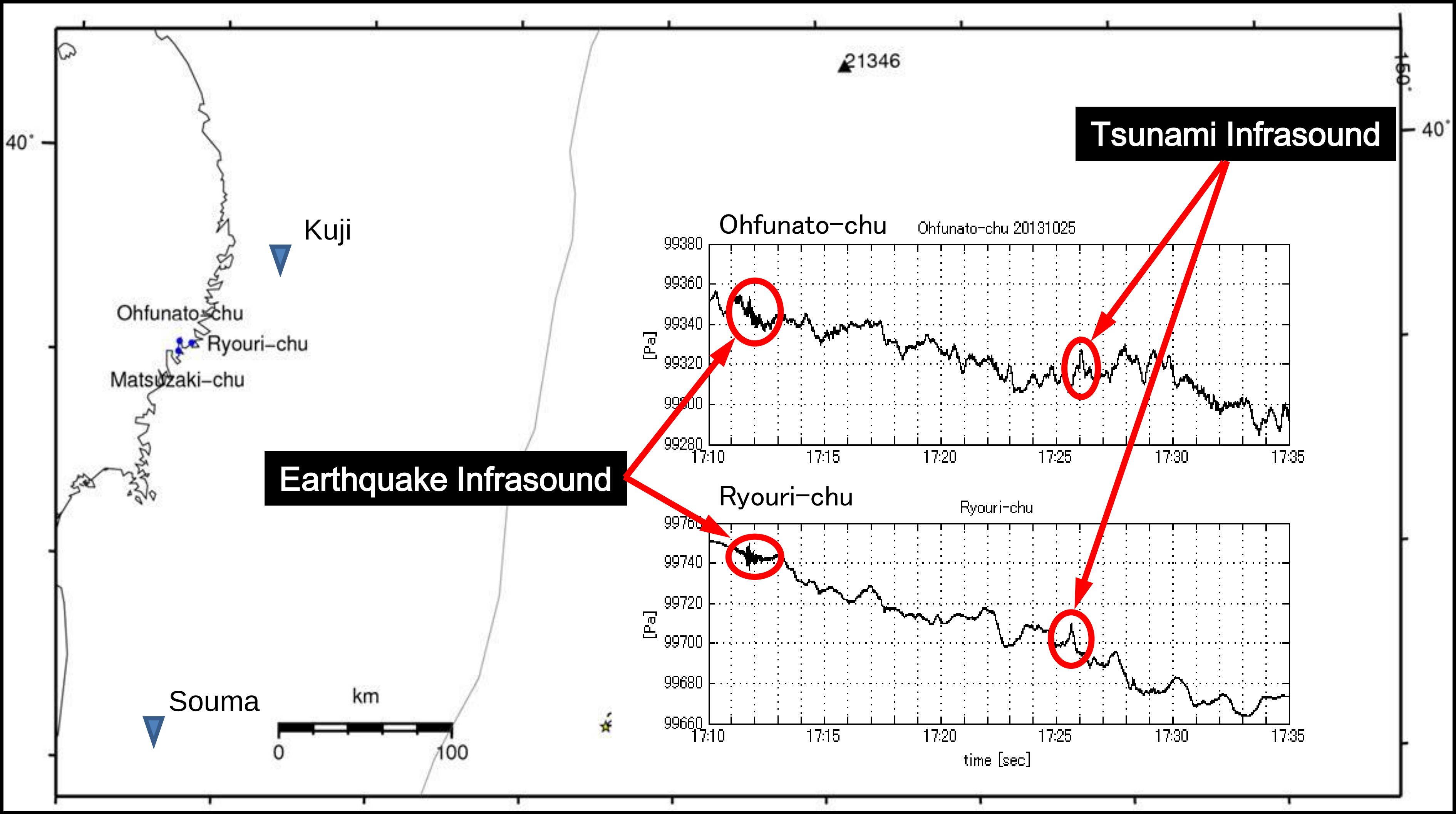




Plot courtesy of Dr. Nobuo Arai

Prototype Tsunami Infrasound Warning Systems with Nano Baro Sensors Deployed at Ohfunato (Tohoku region)

Infrasound signals associated with the outer-rise earthquake of Oct. 25, 2013 were detected.

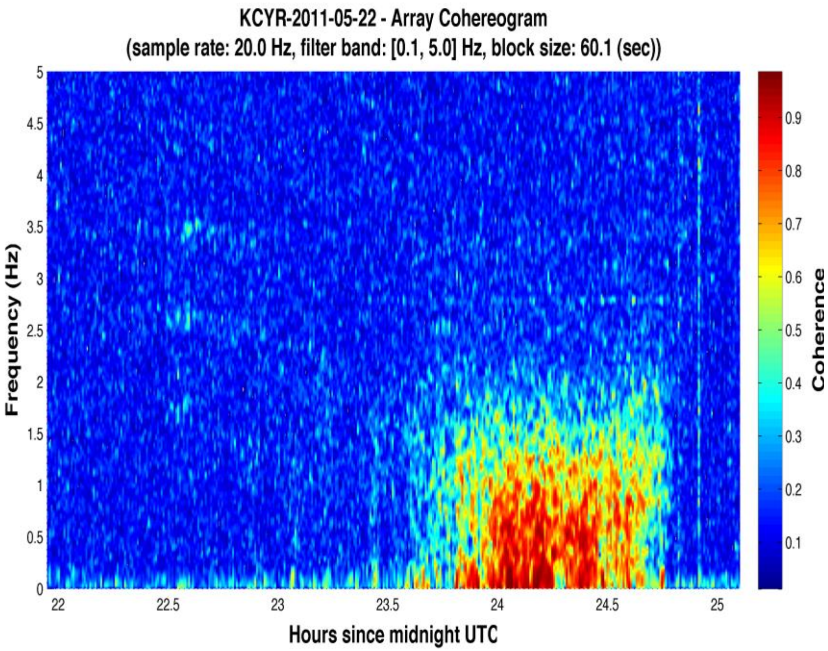


Outer-rise earthquake (*Mw=7.1*) 2013/10/25 17:10 (UTC) , 10/26 02:10 (JST)

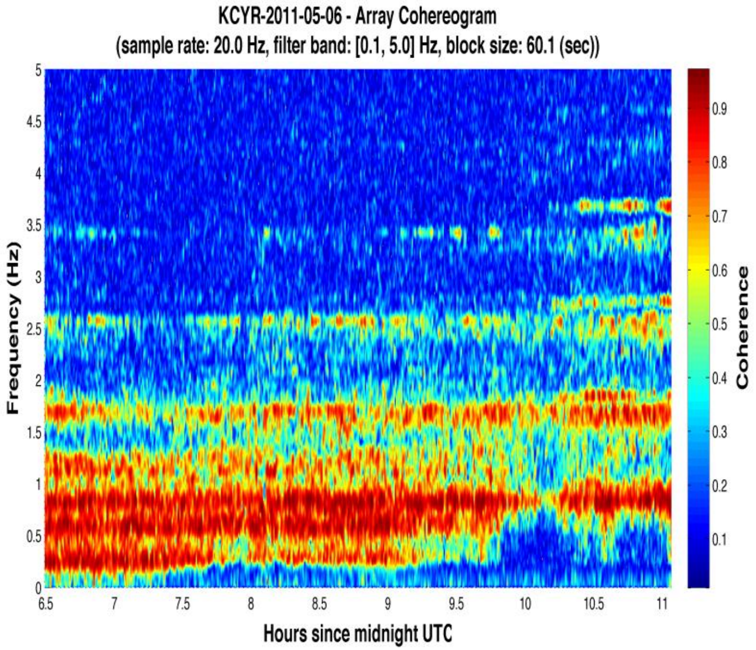
Observed tsunamis : Kuji 18:23 (UTC) 40 cm & Souma 18:38 (UTC) 40 cm

Tornado detection with Nano Baro

- UMass - CASA radar network in Oklahoma
  - The main objectives of CASA's Oklahoma radar network was tornado early detection
  - It had been shown (e.g., Bedard) that tornadoes produce infrasound (~1Hz sound waves)
  - We deployed infrasound arrays at two of the Oklahoma radar sites
- Results (presented at AMS in New Orleans and the EGU in Vienna)
  - Verified the ability of the Paroscientific barometers to detect distant tornadoes
  - Verified the ability of the Paroscientific barometers to detect wind turbine infrasound emissions



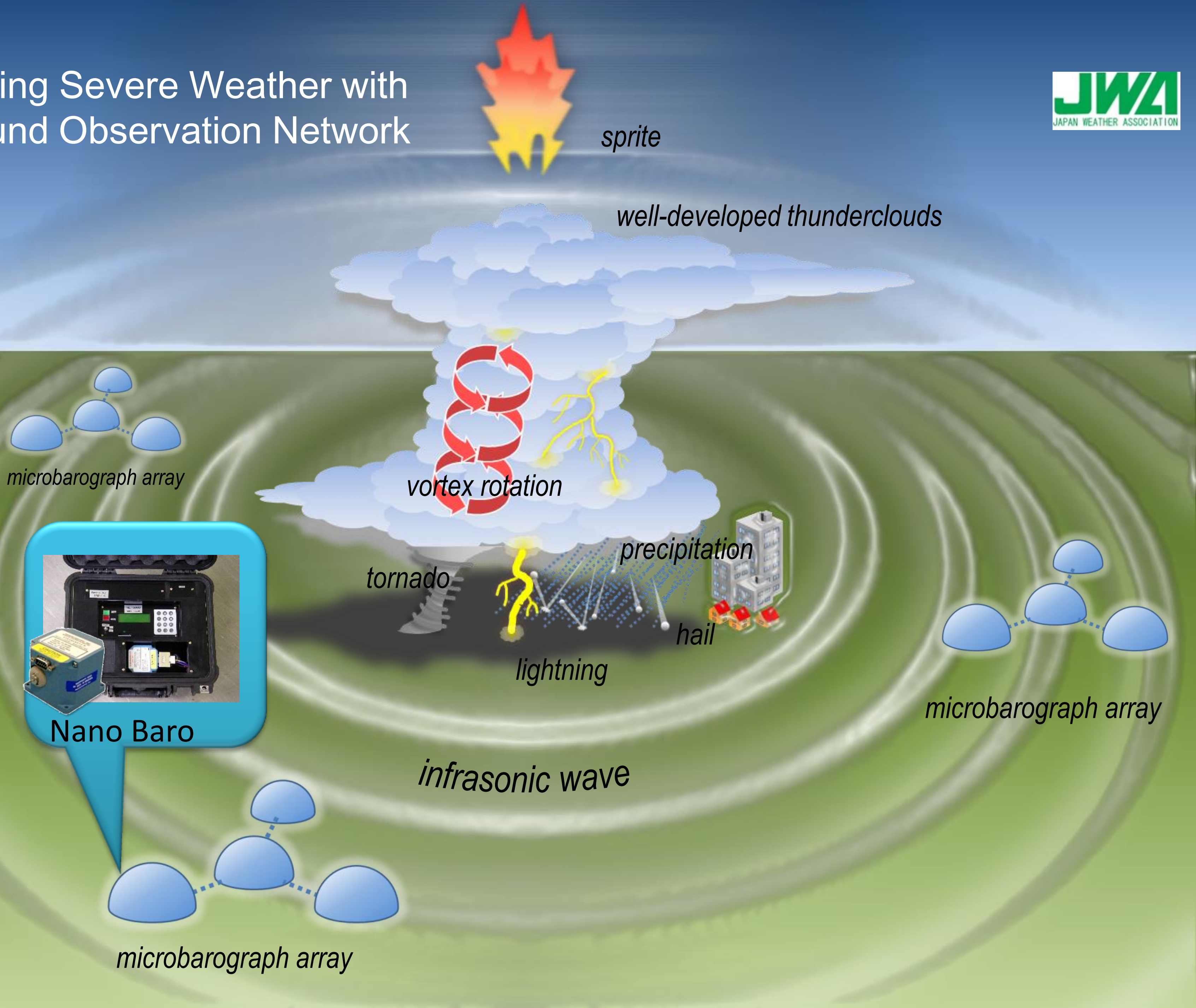
Infrasound signature from a tornado



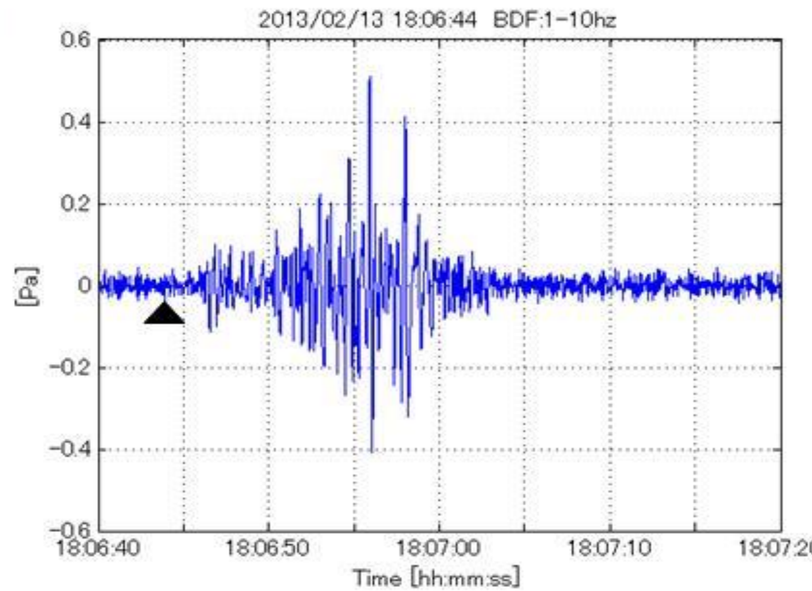
Infrasound signature from a windfarm

Courtesy of David Pepyne

Monitoring Severe Weather with Infrasound Observation Network

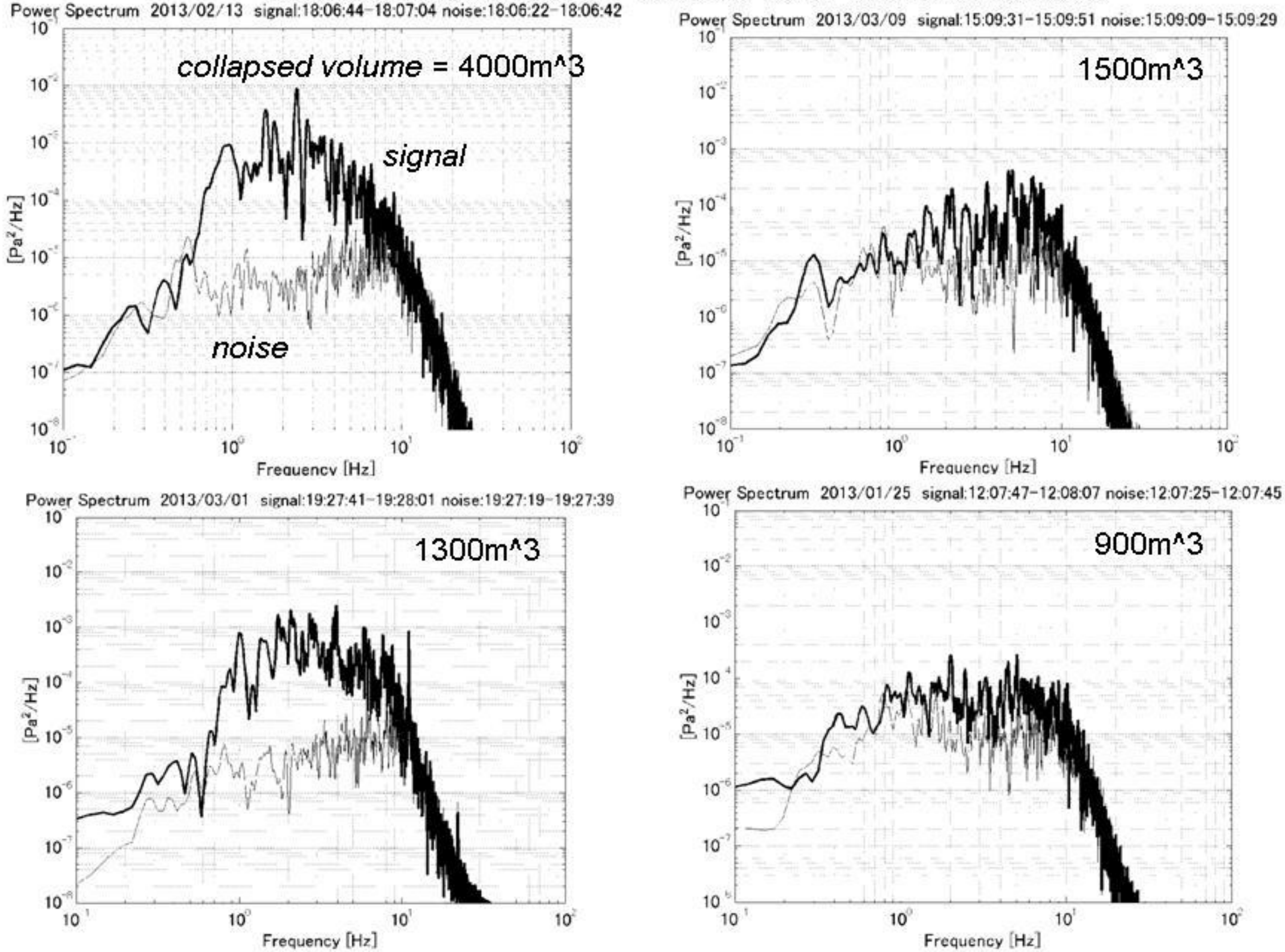


System for Monitoring the Acoustic Signals of Snow Avalanches

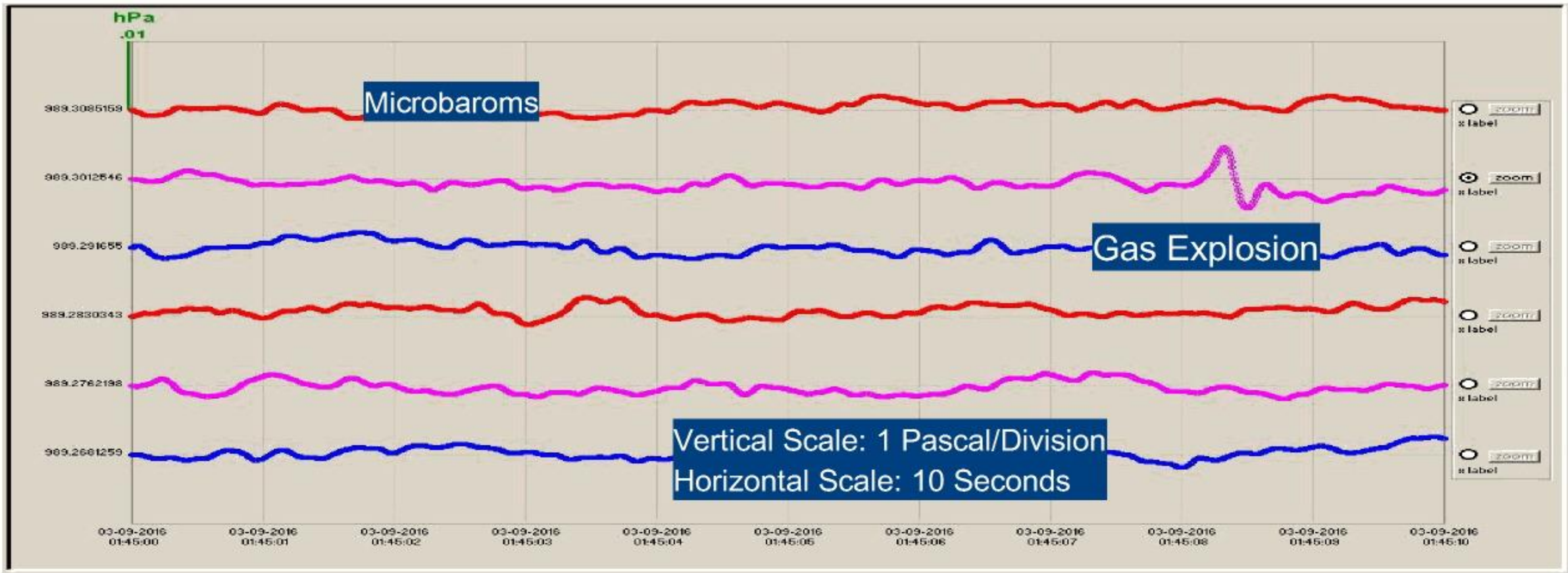


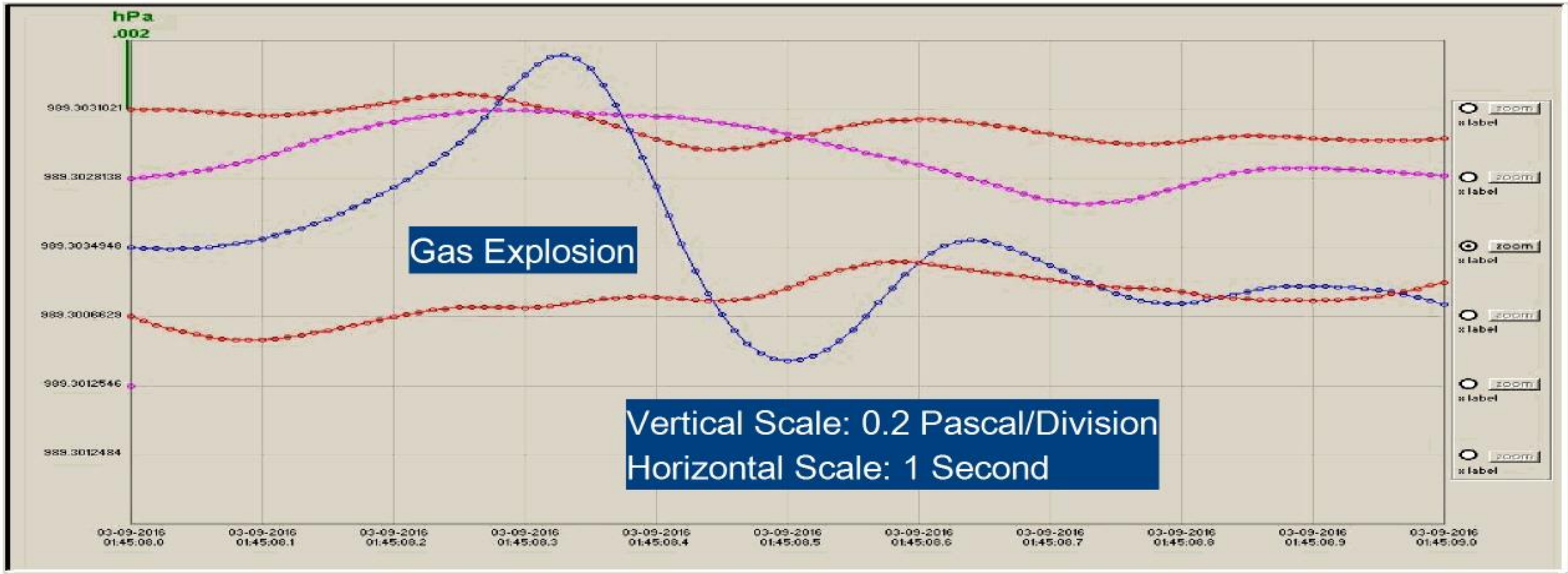
6000-16B (Paroscientific)

The power spectrum of the infrasound signals associated with the snow avalanches

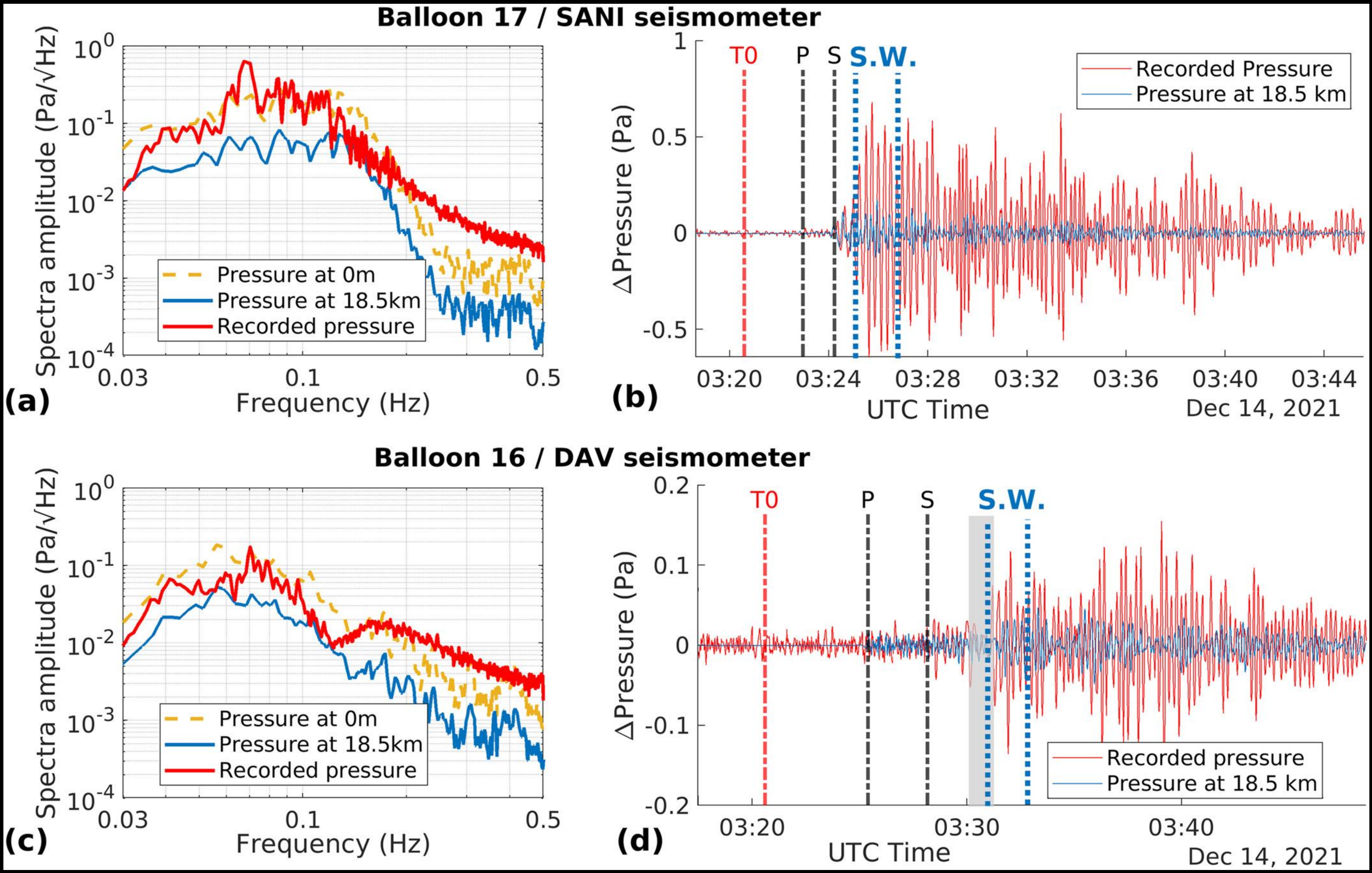


Seattle Gas Explosion – March 10, 2016





Infrasound From Large Earthquakes Recorded on a Network of Balloons in the Stratosphere



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GPS Meteorology

GPS Determination of Precipitable Water Vapor

- Measure Total Delay = Ionospheric + Neutral Delays
- Ionospheric Delay (frequency dependent) determined by comparing L1 & L2 GPS signals
- Neutral Delay=Wet Delay + Hydrostatic Delay (Barometric Pressure, Temperature, Humidity dependent)
- Calculate Precipitable Water Vapor from Wet Delay

GPS-MET and Nano Baro for Flood Forecasting

- Improved flood forecasting benefits from a radar network coupled with a hydrologic model
- A key variable for precipitation forecasting is atmospheric water content
- High spatial-temporal resolution estimates of atmospheric water content can be made with GPS-meteorology

Courtesy of David Pepyne

Drivers become stranded in high waters across North Texas

Street flooding North of DFW, Jan. 2012

Dallas Floodway

Atmospheric Tides at Harvard Vault

Andreas Muschinski analyzed a 15-day long series of pressure data acquired with a Paroscientific Barometer at the Harvard Vault.

The solar atmospheric tides can be clearly seen in the frequency spectrum of the pressure fluctuations. The dominant mechanism for solar tides is thermal expansion due to solar radiation.

The observed amplitudes are:

12 hour tide amplitude--100 Pa

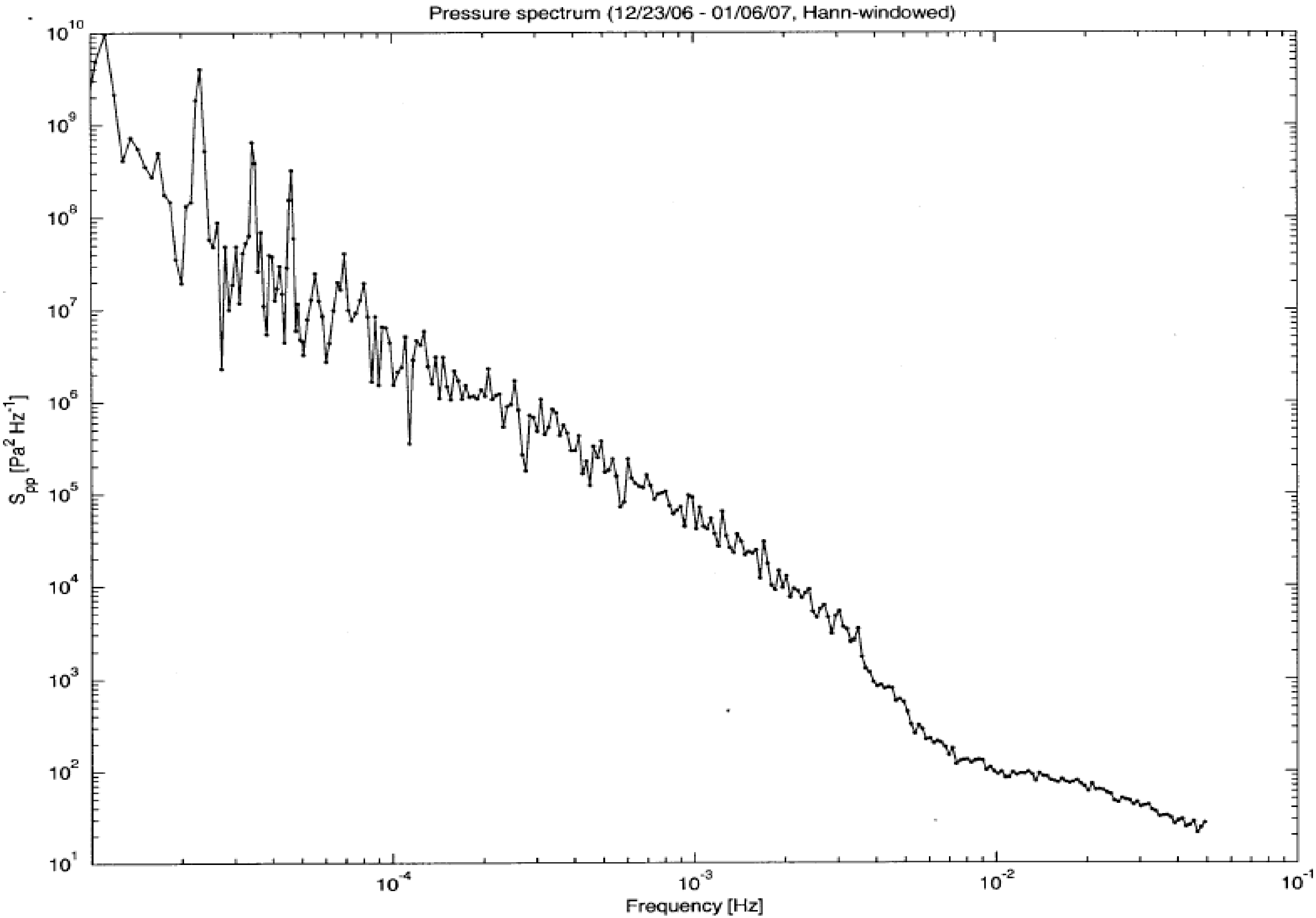
8 hour tide amplitude--40 Pa

6 hour tide amplitude-----30 Pa

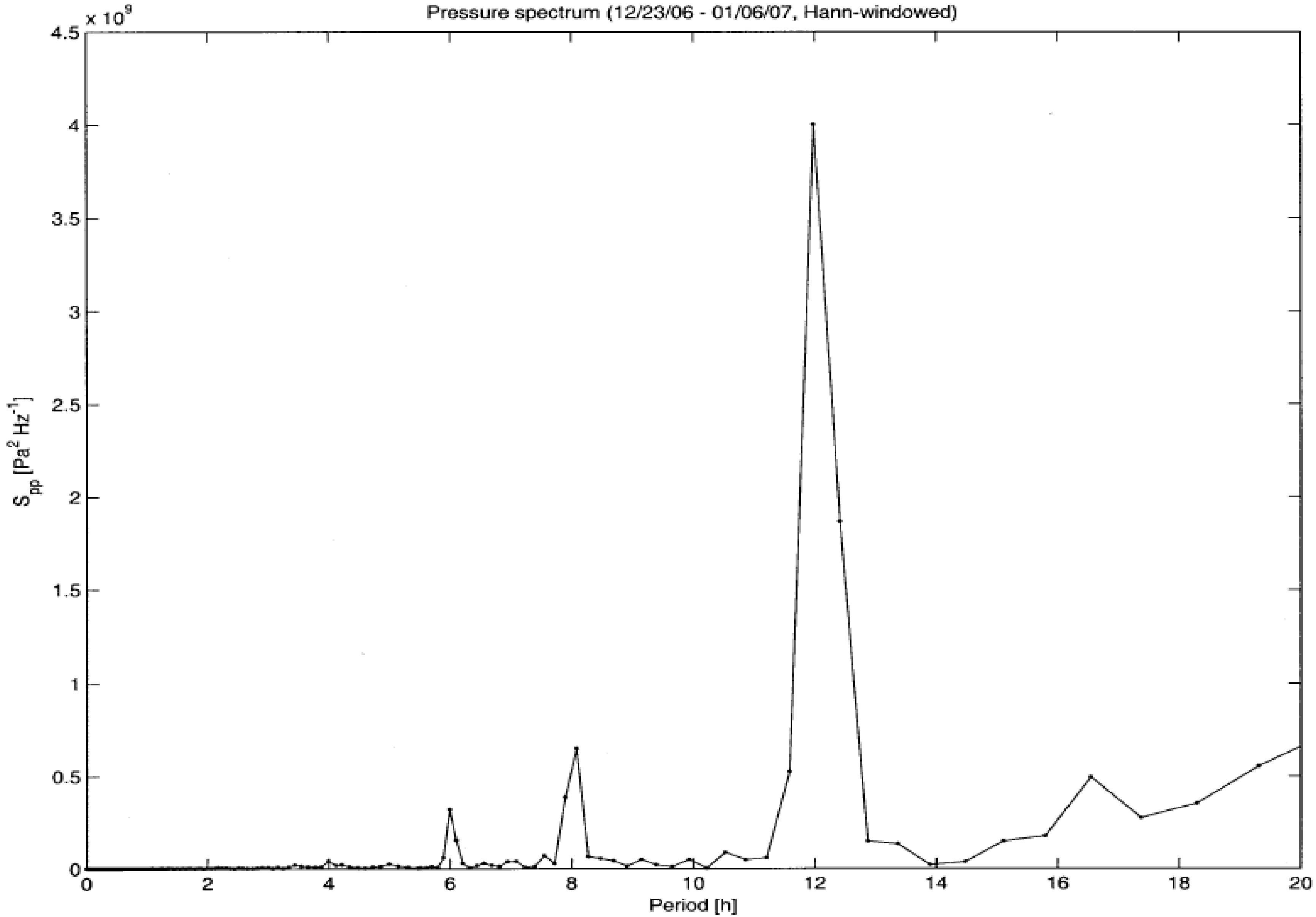
4 hour tide amplitude----8 Pa

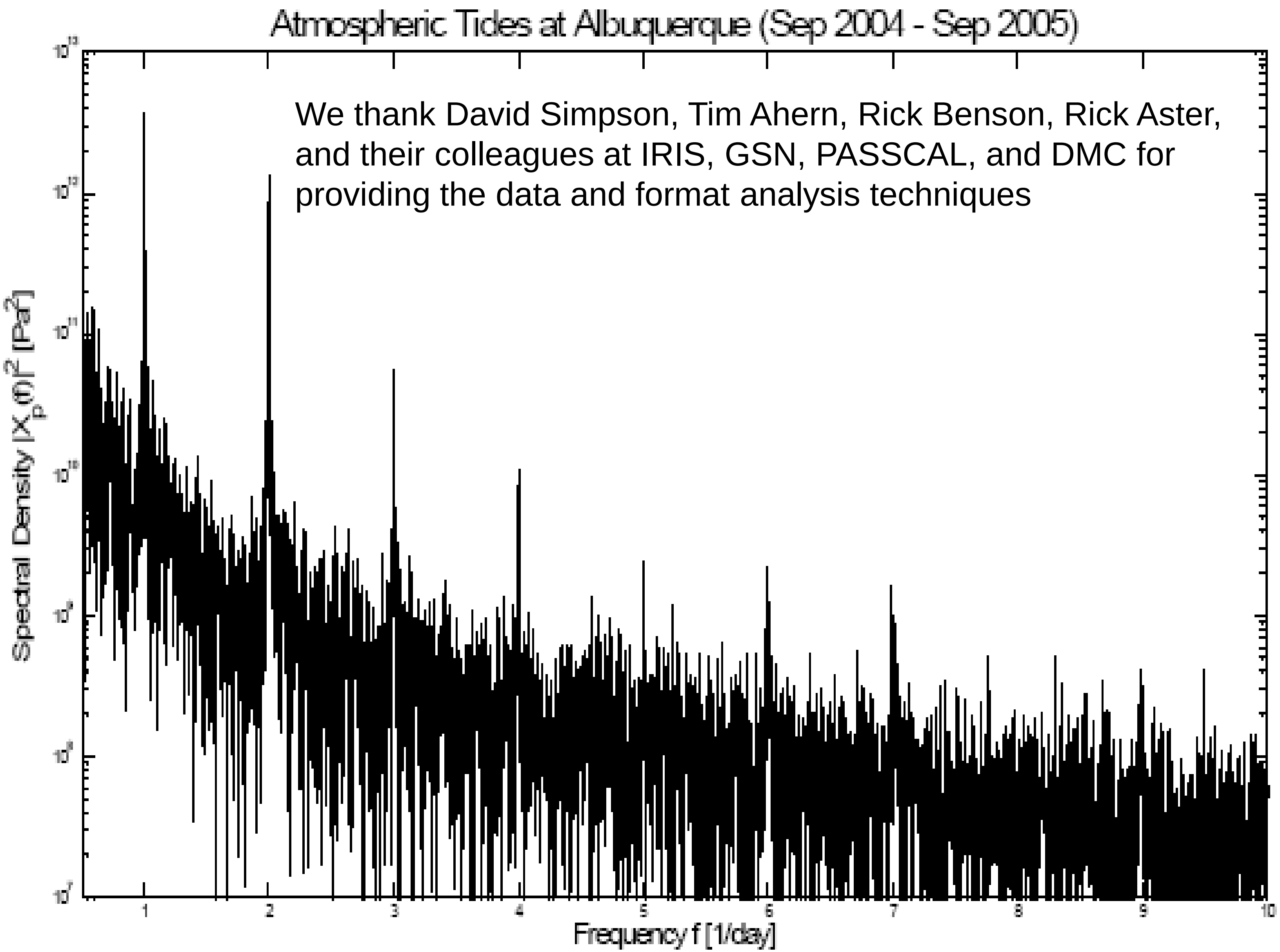
We thank Robert Busby and John Collins of IRIS for conducting the tests and providing the data, Harvard University for use of their facility, equipment and seismic data, and Quanterra, Inc. for their collection, integration and installation assistance.

Atmospheric Tides at Harvard Vault



Atmospheric Tides at Harvard Vault





We thank David Simpson, Tim Ahern, Rick Benson, Rick Aster, and their colleagues at IRIS, GSN, PASSCAL, and DMC for providing the data and format analysis techniques

The Quartz Sensors Have:

- Digital outputs.
- High absolute accuracy.
- Minimum size, weight, & power consumption.
- Low noise floor (high resolution over a broad spectrum).
- High reliability and insensitivity to environmental factors.
- Measurements from a fraction of a second to giga-seconds.