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Underground Seismic Measurements

First Steps at Homestake

Instrumental Signals

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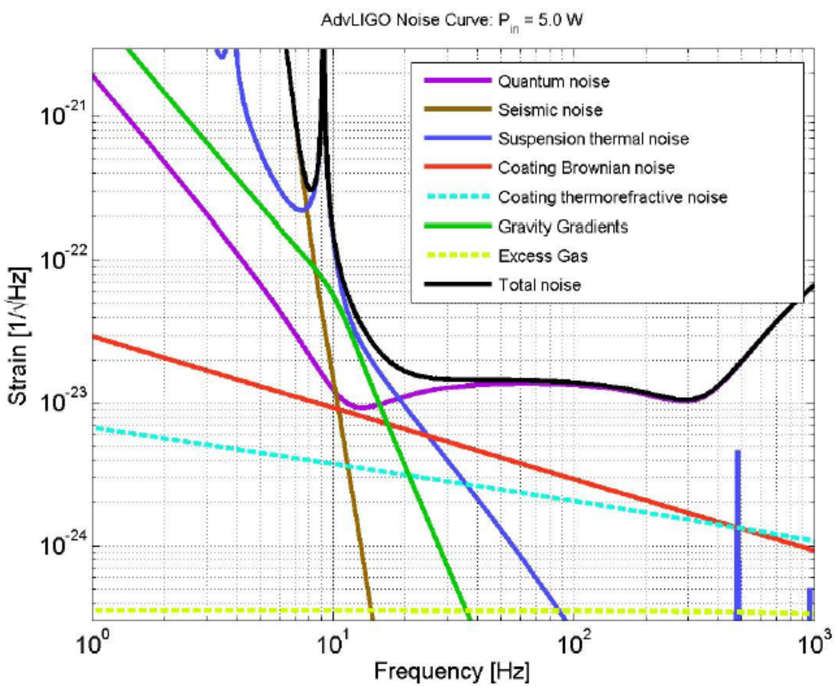

Question:

Do we need to improve isolation indefinitely?

Answer:

No, we just need to establish a sufficiently simple measurement point for the noise (or its parameterization). Isolation is old school.

Strategies

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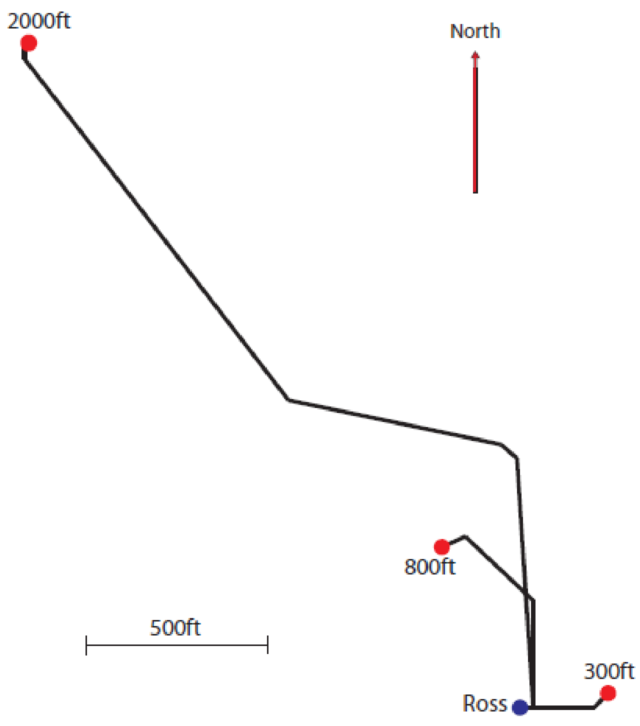
1. Go to a place with weak seismic noise! (no doubt)
2. Go underground! (atmosphere and shaking buildings)
3. Go to a place with homogeneous rock? (pro: only need to understand wave field; cons: coherence scales determined by seismic wave length)
4. Go to a place with hard rock? (pro: weak seismic noise; cons: large wave length)

The 99% Commitment

We will subtract 99% of the GGN in third-generation detectors.

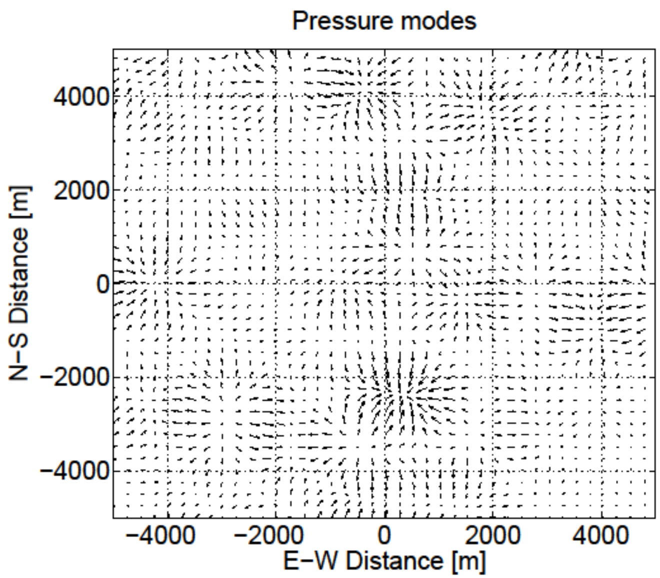
1. We need to calibrate the strainmeters / dilatometers / seismometers with higher accuracy / precision than 99% (includes dependence on temperature, pressure, …)
2. We need to measure the seismic field with higher accuracy / precision than 99% (STS-2 and T240 cannot)
3. We need to understand the seismic signal better than 99% (analyze different modes)
4. We need to model GGN with input from seismic measurements better than 99%

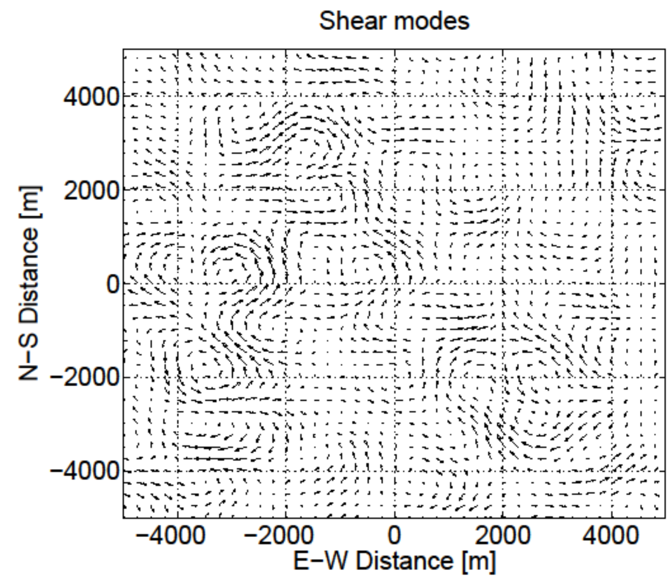
How to Predict GG Signals



- New instruments (e.g. optical strain meters)
- Large seismic 4D network (=3D array)
- Go underground or design your soil

Rock Displacement



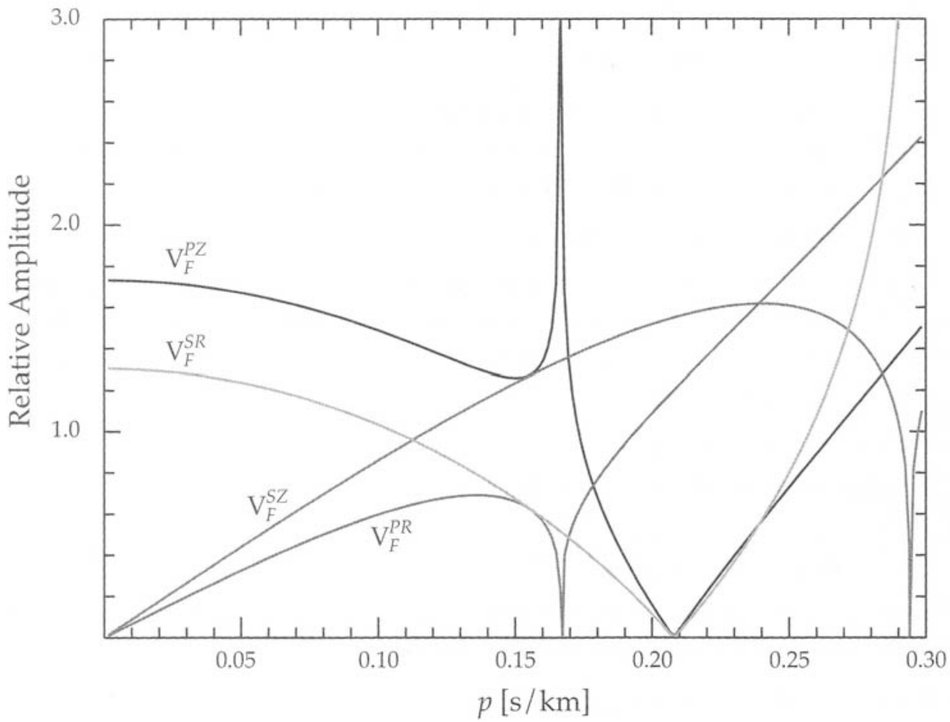


$\lambda = 2000\text{m}$ $\lambda = 1800\text{m}$

- Longitudinal waves (pressure mode) cause density fluctuations
- Homogeneous rock: minimal volume of correlated fluctuations is of the order $(\lambda / 2)^3$

Coupling to Seismic Wave

Body-wave displacement inside body relative to surface



Shear waves polarized horizontally with respect to surface:

$$V^{SH} = \frac{1}{2}$$

The Former Homestake Mine

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Design of Measurement

- Connect seismometer to hard rock
- Isolate from sound and air current
- Place seismometers on tiles
- Cover the ground around the instrument

Quiz

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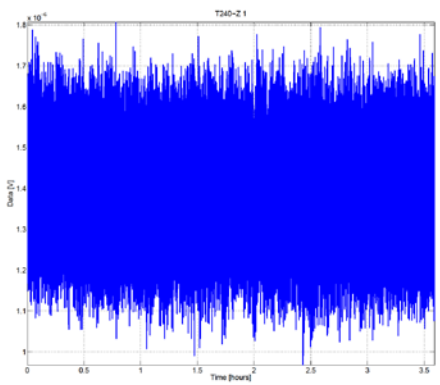
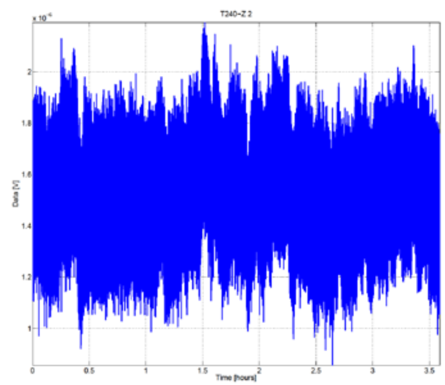
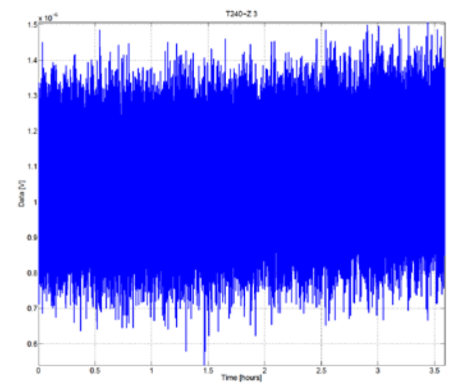
3.5h of data from 3 different T240. One is without tile, box and cover. Which one is it?



A



B



C

Seismic Noise at Homestake

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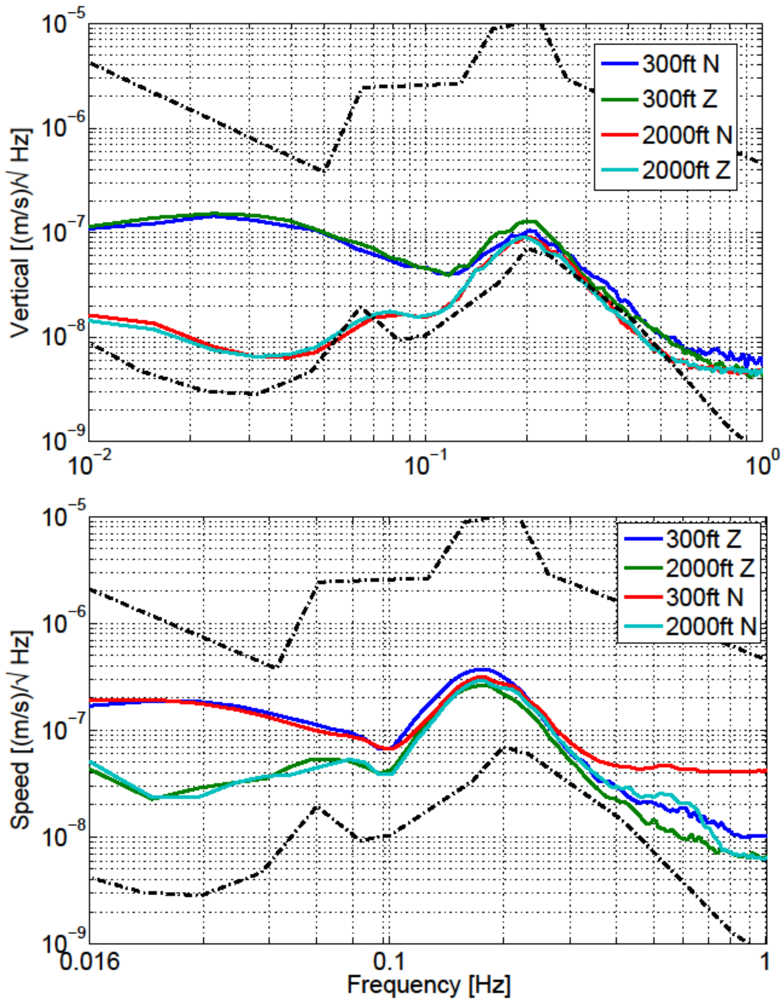

Quiet-time spectra at 2000ft depth are close to global low-noise model (may also be true for surface seismicity at Homestake)

Average spectra depend on

1. Oceanic weather (microseisms)
2. Human activity (tilts at surface, weaker effect at 2000ft)

Underground Weather (-2000ft)

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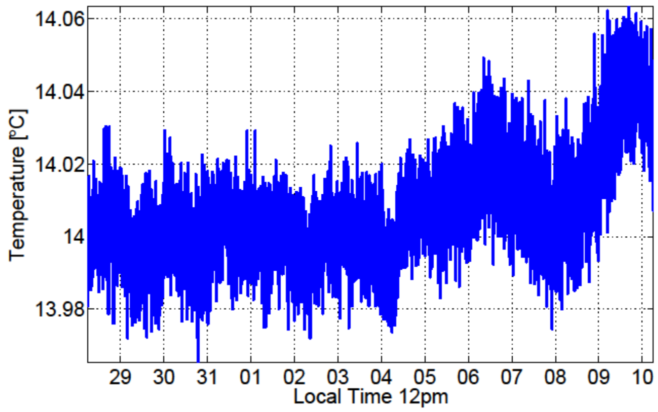

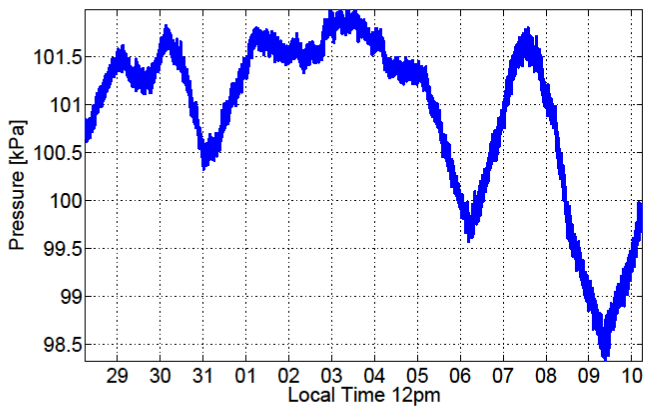

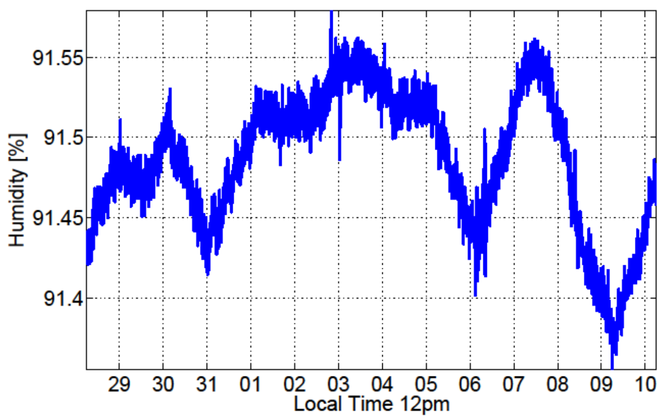

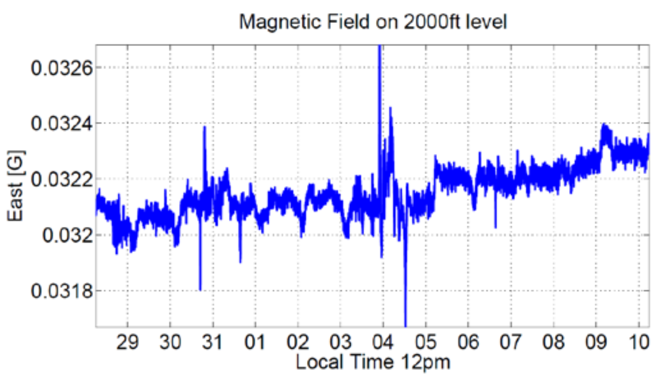

Rock Homogeneity at Homestake?

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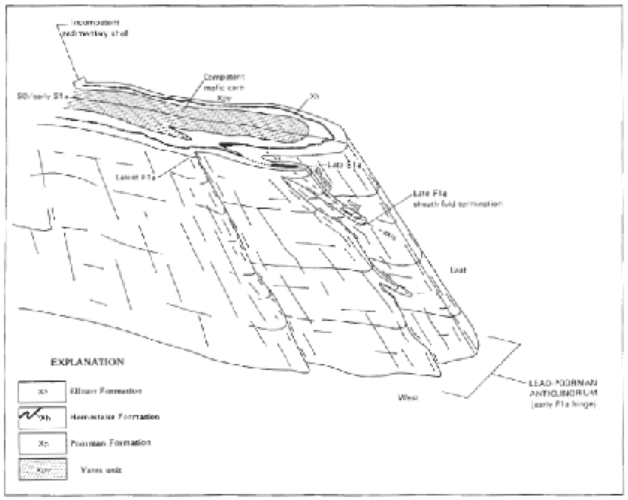

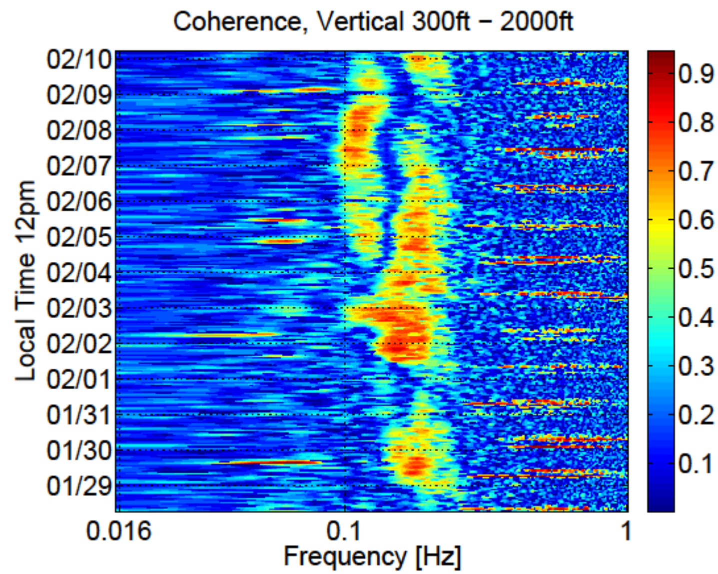

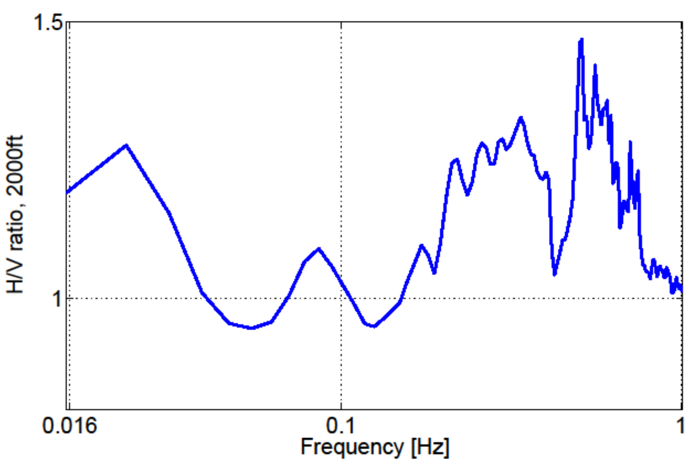

H/V ratio suggests that rock inhomogeneities are significant.

Need to test: characteristic frequencies may related to source of microseisms.

More Spectra

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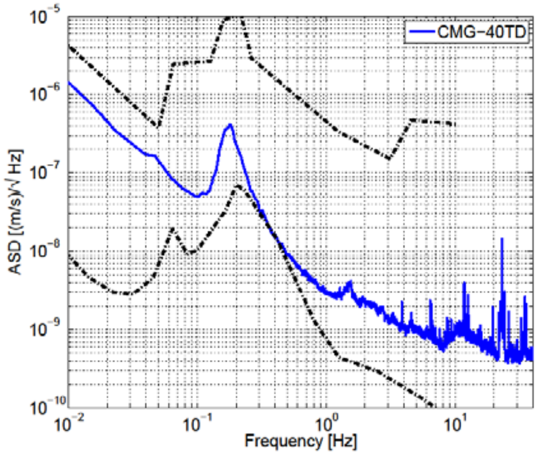
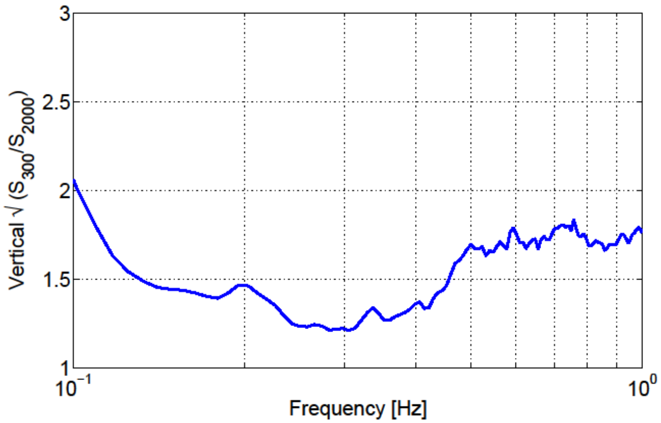
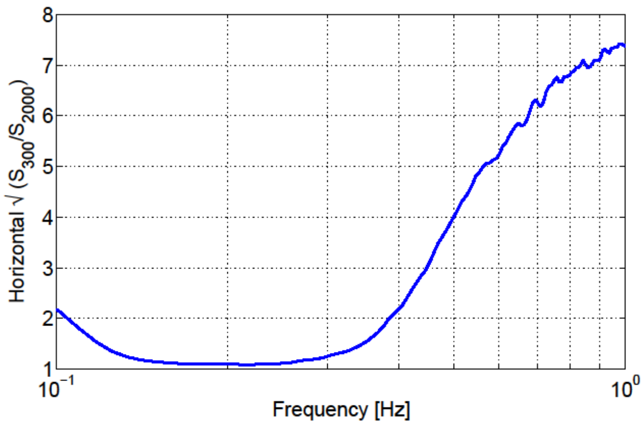
Warm Data



Ratio of 300-Z over 2000-Z

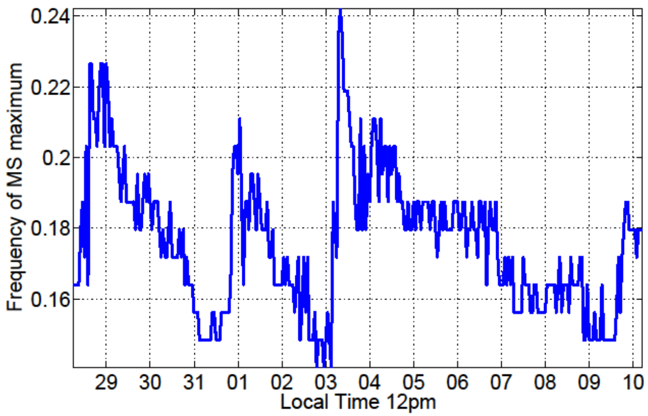


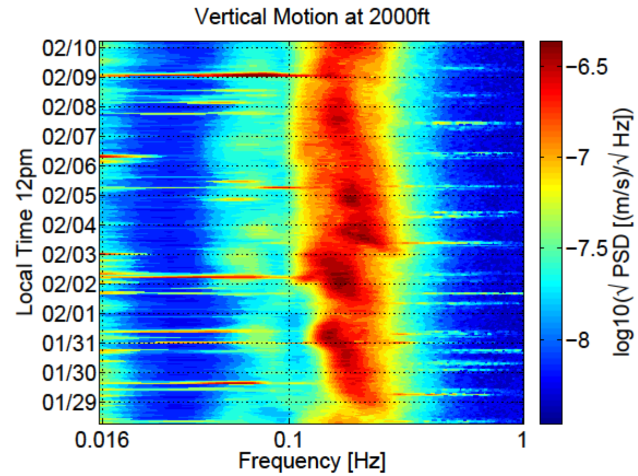
Ratio of 300-H over 2000-H

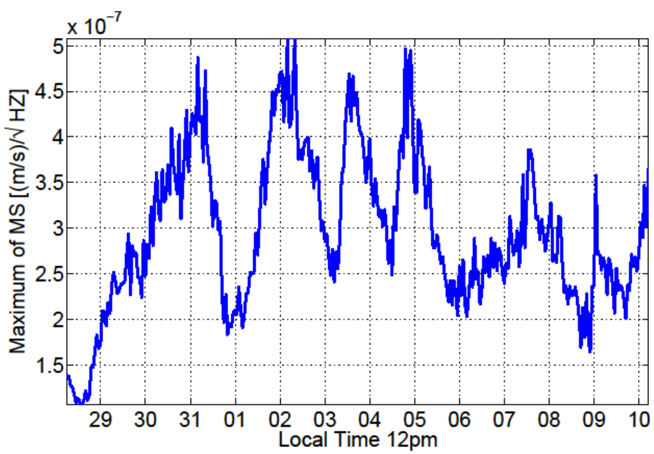


- Small contribution of Rayleigh waves to surface displacement
- Strong tilt noise at f>0.4Hz in horizontal channels at 300ft, presumably no Love waves

More Science







- Frequency: jumps to high value and then decreases linearly within time T
- Power: increases within shorter time T – dT, then decreases rapidly

- Higher frequencies: still oceanic microseisms? Conversion of tides to higher frequencies?

Summer Plans

1. Three stations on the 4100ft separated by 200m
2. One new station on the 2000ft (fault will separate this station from the old one)
3. New timing system
4. Finite element simulation to derive a first (Homestake) GGN prediction
5. Support from one or two summer students

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