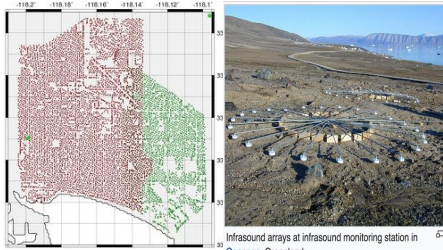


EAS 4801 - Planetary Sound Lec #10: Recording devices (Cont)

Dr. Zhigang Peng
01/27/2020
Spring 2020

Streckeisen STS-2 Broadband Sensor



Infrasound arrays at infrasound monitoring station in Qaanaaq, Greenland

Exam this wed. 12:20-1:10 pm

- 30 multiple choices (30 points)
- 3 simple answer/definitions (30 points)
- 2 simple calculations (20 points)
- 2 graphics (20 points)

https://www.iris.edu/hq/internship/news/applications_summer_2020



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Home News Applications Summer 2020

Applications now being accepted for Summer 2020

The IRIS Undergraduate Internship Program is pleased to announce that it is now accepting applications for the summer of 2020. If you are an undergraduate math, physics, geoscience or computer science student interested in exploring Earth and developing new skills, please consider applying! The deadline for applications is February 15th. Our program has proven to be a successful stepping stone for careers in oil & gas industry, academia, federal and state governments, and in a variety other geo-technical fields.

November 11th, 2019

IRIS Undergraduate Interns...

- Build lasting connections with like-minded students interested in using their quantitative skills to better understand Earth
- Are funded to travel to their mentor's institution and conduct independent research
- Receive a weekly stipend of \$600 - \$800 for subsistence for 8 to 11 weeks
- Have fun while learning critical skills that have led over 78% of alumni to pursue geoscience careers in federal and state governments, academia, industry, and as independent consultants
- Receive full funding to present their independent research at the Fall American Geophysical Union conference
- Are diverse in gender, race and ethnicity, age, disability status, and academic standing... YOU could be next!

How to access scientific data

<http://ds.iris.edu/mda/>

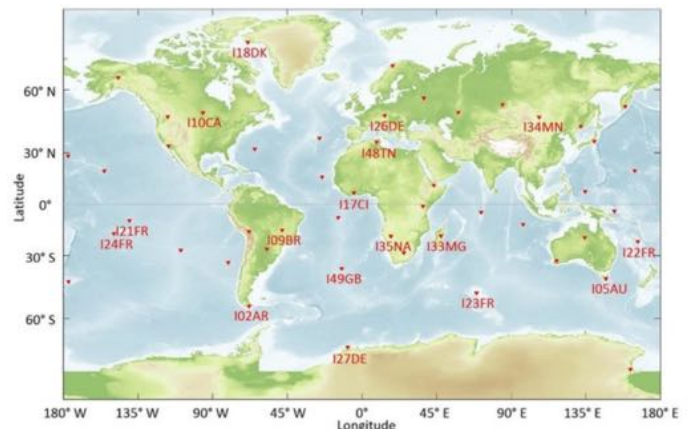
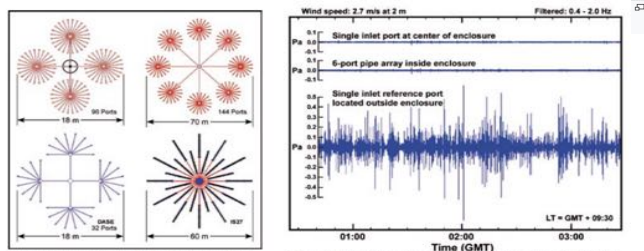
http://ds.iris.edu/wilber3/find_event



Infrasound Monitoring

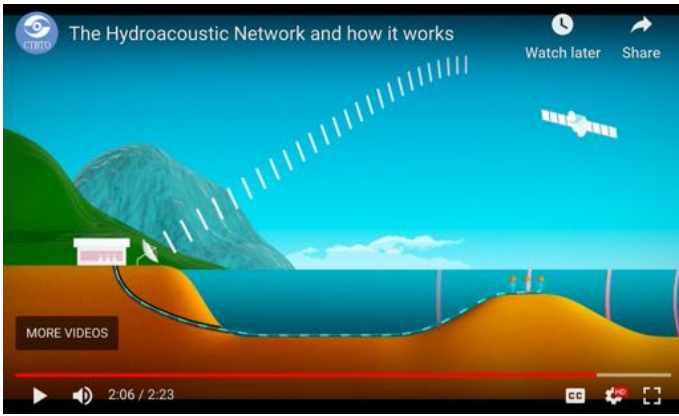
The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) Preparatory Commission uses infrasound as one of its monitoring technologies, along with seismic, hydroacoustic, and atmospheric radionuclide monitoring. The loudest infrasound recorded to date by the monitoring system was generated by the 2013 Chelyabinsk meteor.

<https://en.wikipedia.org/wiki/Infrasound>

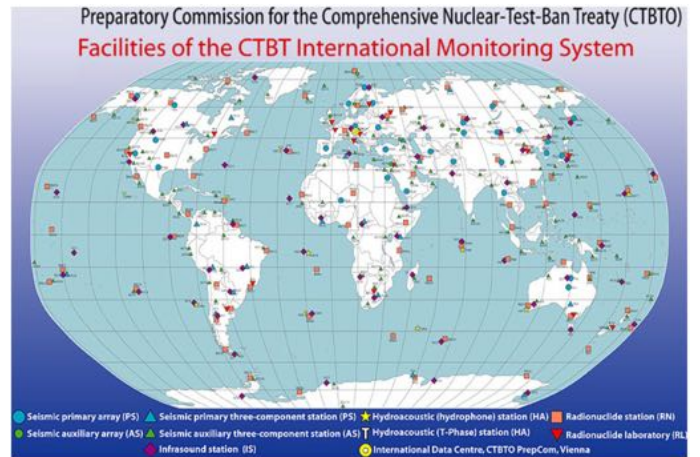


<https://www.ctbto.org/verification-regime/monitoring-technologies-how-they-work/infrasound-monitoring/>

https://www.ctbto.org/fileadmin/content/reference/outreach/ctbto_spectrum_10/p18_19_Recent_developments_in_IS_monitoring_technology.pdf



<https://www.ctbto.org/verification-regime/monitoring-technologies-how-they-work/hydroacoustic-monitoring/>



Geophone: a device that converts ground motion into voltage

Geophones

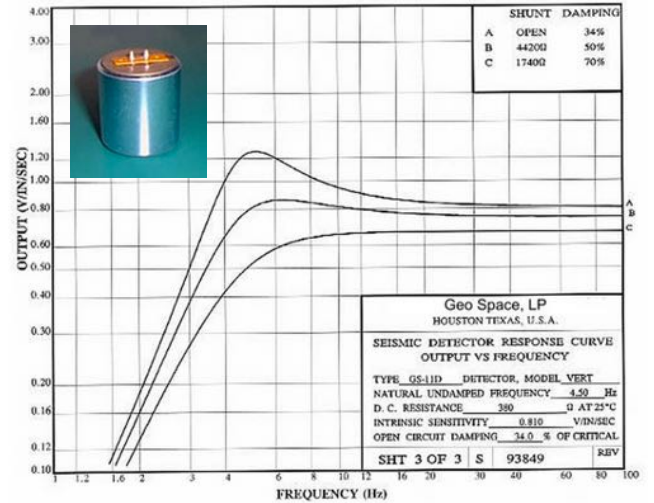
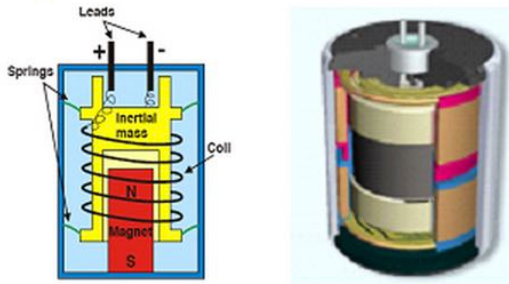
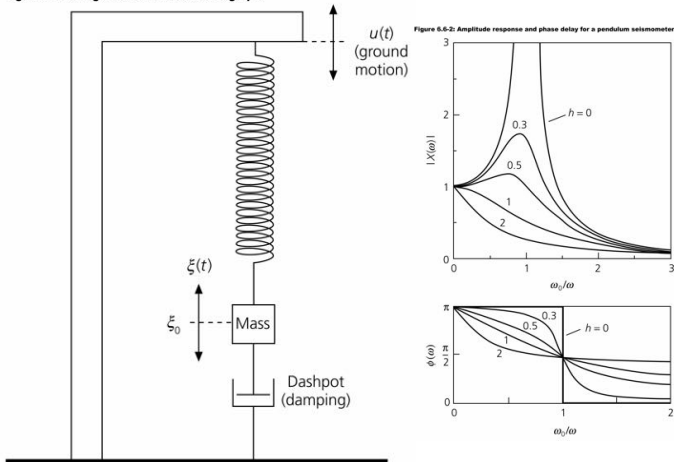


Figure 6.6-1: Diagram of a vertical seismograph.



damped harmonic oscillator composed of a spring and dashpot

Newton's Law: $F = ma$

Case for no damping:

$$m \frac{d^2 u(t)}{dt^2} + k u(t) = 0 \quad \text{where } k \text{ is the spring constant.}$$

Solution is perpetual harmonic oscillation:

$$u(t) = Ae^{i\omega_0 t} + Be^{-i\omega_0 t} \quad \text{or} \quad u(t) = A_0 \cos(\omega_0 t)$$

(A and B are constants)

The mass moves back and forth with a natural frequency $\omega_0 = (k/m)^{1/2}$

Once the motion is started, the oscillation continues forever.

Figure 6.6-5: Illustration of an electromagnetic seismograph.

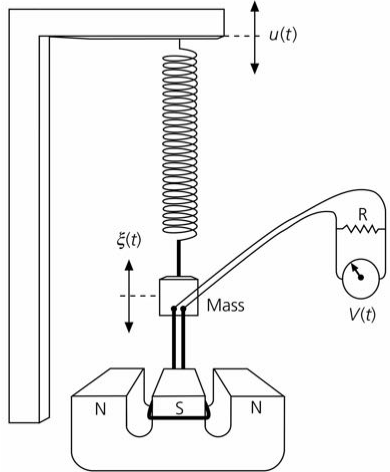
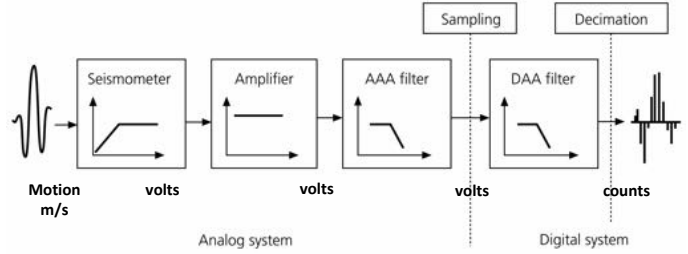


Figure 6.6-12: Diagram showing the analog-to-digital (ADC) process.



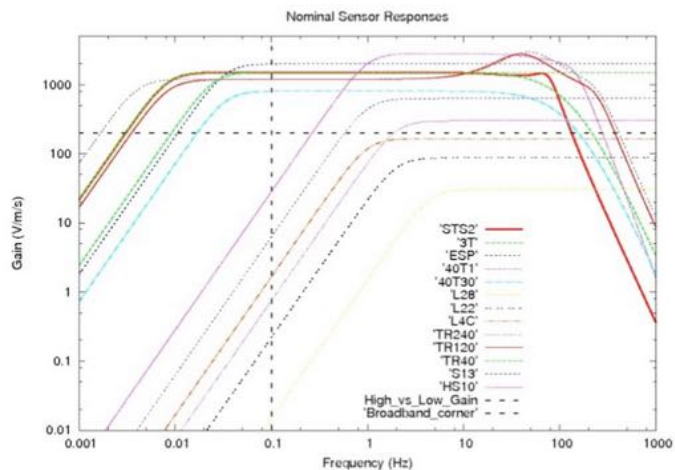
AAA: Analog Anti-Aliasing Filter
DAA: Digital Anti-Aliasing Filter

Broadband Seismometers

Streckeisen STS-2 Broadband Sensor
Home • Instrumentation • Sensors • Broadband.



Typical seismic deployment



<https://www.passcal.nmt.edu/content/instrumentation/sensors/sensor-comparison-chart>

Traditional Land Deployment



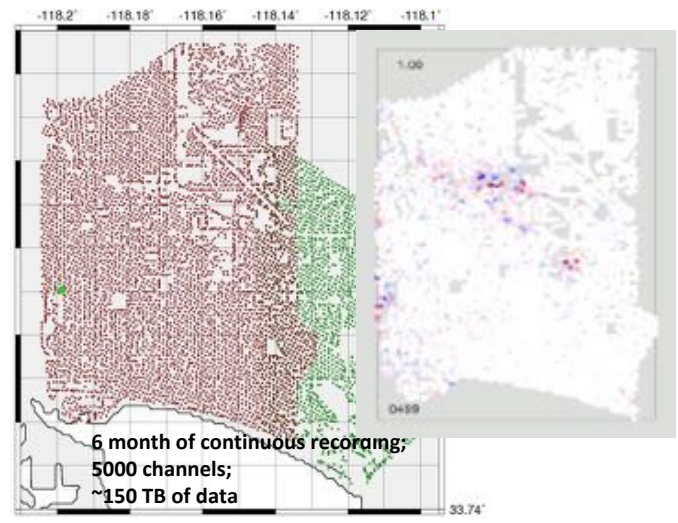
Figure 1. Seismic field technician with 20+ Kg cable. Carrying this heavy weight on rough terrain is hazardous, even with experienced personnel.

New types of sensor/recording system

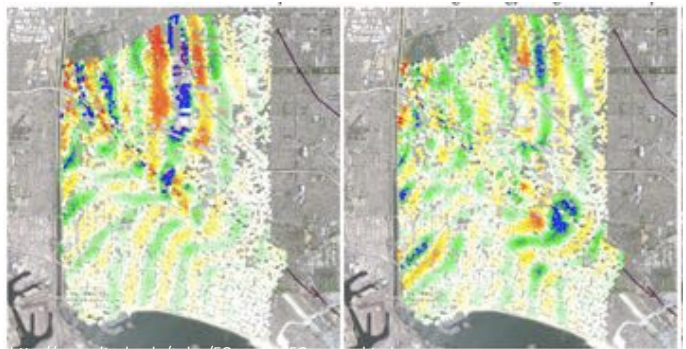


Typical Node specifications

Sensory Data Channels: 3	Total Harmonic Distortion: 0.0002% @ 12 dB Gain, -3 dB Full Scale	Sensor Impedance: 50 Ohms
ADC Resolution: 24 bits	Equipment Input Noise: 0.25 μ Vrms @ 0 dB	Sensor Step Response: 100 ns
Sample Interval: 0.5, 1, 2, 4 milliseconds	0.2 μVrms @ 12 dB	Sensor DC Resistance: 100 Ohms
Pre-amplifier Gain: 0 dB to 36 dB in 6 dB steps	0.1 μVrms @ 24 dB	Power: 3.2 Watts, Orthogonal Configuration
Anti-alias Filter: 206.3 Hz @ 2ms (80.0% of Nyquist)	2500 mV peak @ 0 dB	50 Hz - 70% damped
DC Blocking Filter: 1 Hz to 60 Hz, 1 Hz increments, 8 dB/Octave, or DDT	Full Scale Input Signal: 2500 mV peak @ 0 dB	2 V/V @ 178.7 V/m/s
Operating Temperature Range: -40°C to +60°C	625 mV peak @ 12 dB	5 Hz - 70% damped
Operating Life: 33 days (continuous @ 20°C @ 2ms)	156 mV peak @ 24 dB	1.95 V/V @ 178.7 V/m/s
	Gain Accuracy: 0.500%	Battery: Type: Rechargeable Li-Ion
	Dynamic Range: 127 dB @ 0 dB Pre-amplifier Gain	Charging Temperature Range: +5°C to +40°C
	Common Mode Rejection Ratio: >110 dB	Recharge Time: <4 hours
	DC Offset: <10% of input noise with DC Blocking Filter Hz	Physical: Weight: 6.2 to 2.8 kg, including spike
	Timing Accuracy: \pm 50 microseconds GPS Disciplined	Dimensions: 4.6 in (11.7 cm) diameter by 6.4 in (16.3 cm) high



<http://www.gps.caltech.edu/~clay/LB3D/Survey.html>

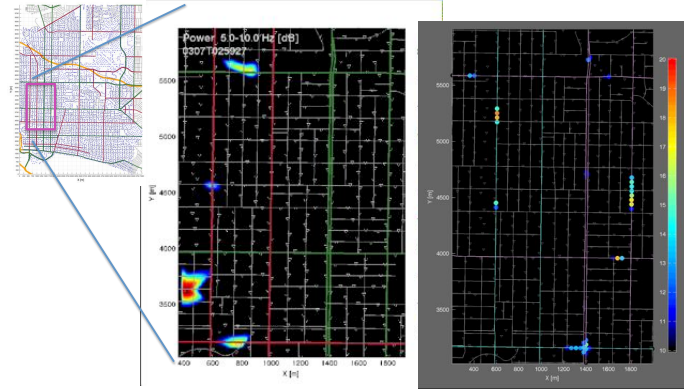


Cable free, fast deployment system



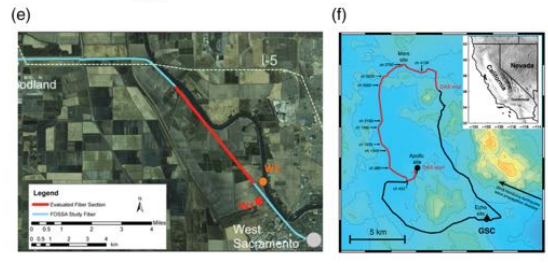
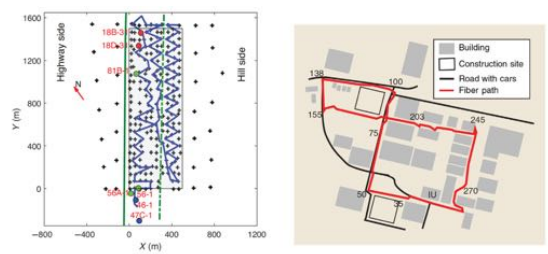
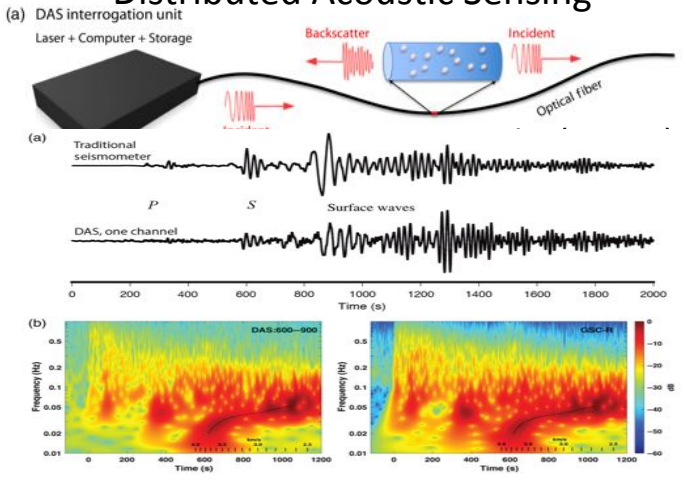
Noise Tracking of Cars/Trains/Airplanes

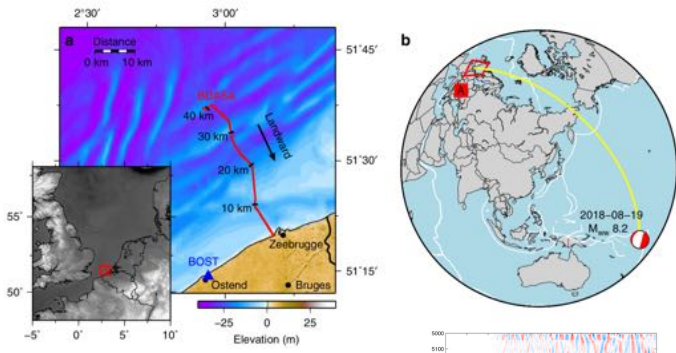
5200 element Long Beach array (Dan Hollis)



Riahi, Gerstoft, The seismic traffic footprint: Tracking trains, aircraft, and cars seismically, GRL 2015 22

Distributed Acoustic Sensing





Williams et al. (Nature Comm., 2019)

Dark fiber refers to unused fiber-optic cable. Often times companies lay more lines than what's needed in order to curb costs of having to do it again and again.

