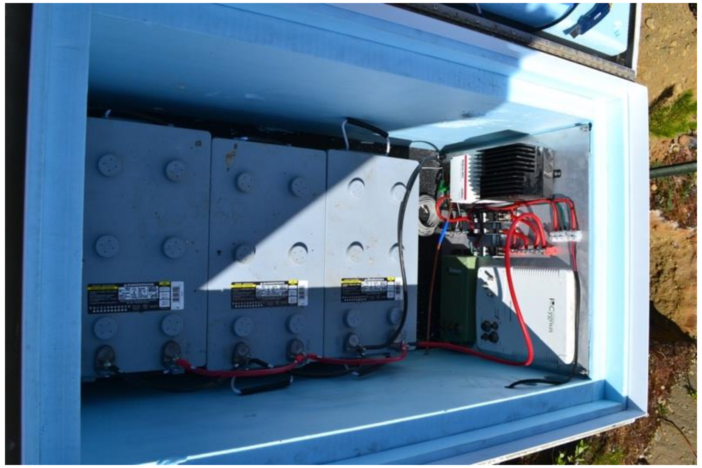
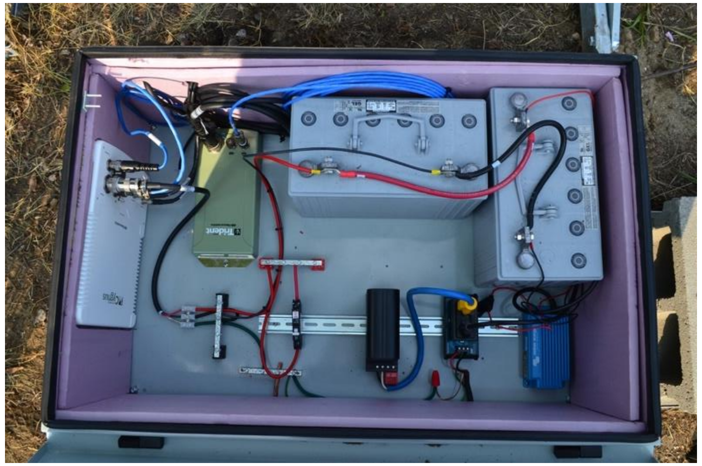
Lecture 1: Broadband OBS instrumentation and (meta)data

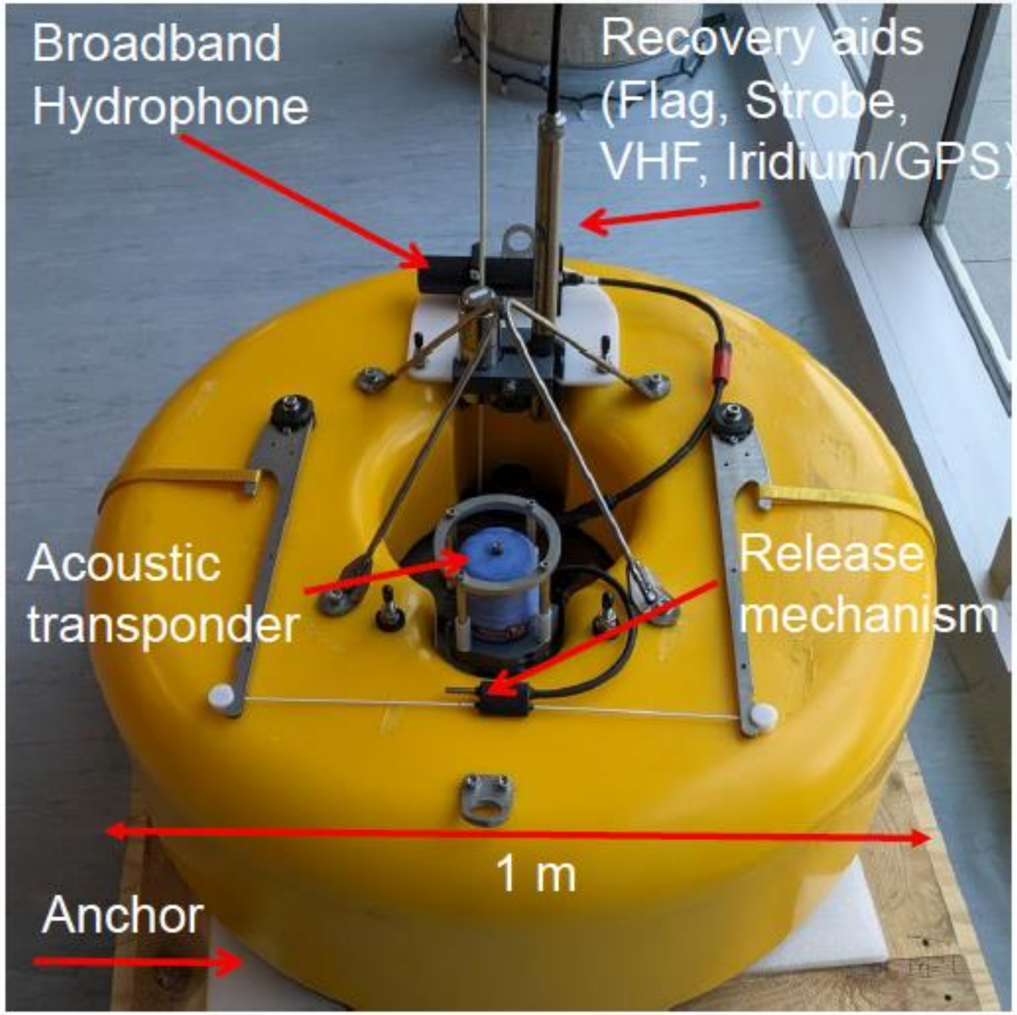
OBS training workshop, VUW, April 14-16, 2025

Anatomy of a Seismograph: Remote Field Site



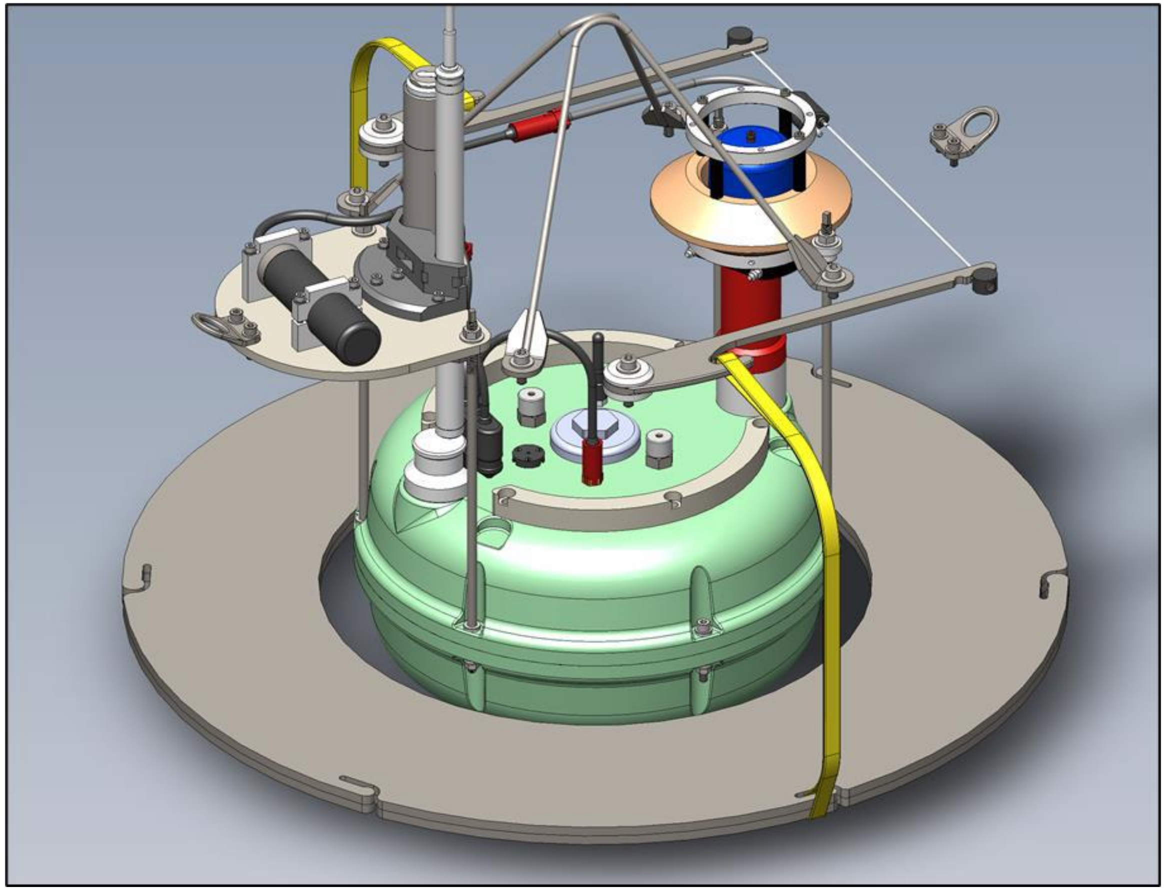


Anatomy of a Seismograph: Aquarius OBS

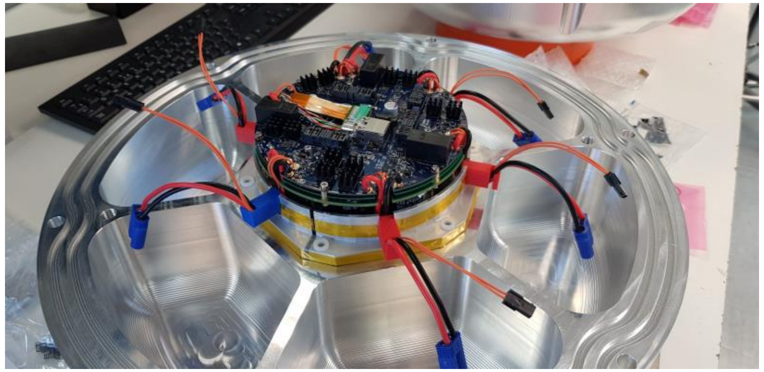


Specification	Number	Impact
Max deployment (months)	18	Long-term deployments for earthquake monitoring
Clock drift (ms/day)	<0.5	Precise time-keeping over long deployments
Seismometer bandwidth	120s – 100 Hz	Joint use for passive and active source
Dynamic range	24-bit	Records brand range of signal amplitudes
Hydrophone bandwitdh	100s – 8 kHz	Acoustic monitoring and compliance
Communication	Acoustic modem	Real-time data to surface from SF instruments
Buoyancy	Syntactic foam	Unsinkable once anchor is released, even if instrument is flooded

Anatomy of a Seismograph: Aquarius cutaway



Rechargeable lithium batteries provide autonomy for 12-18 months



Fast charging: 1 hour per month of deployment

Aquarius OBS: Recorded Data Channels

Optimal sampling rates determined to maximize battery life

Primary sensors

Sensor	Sampling rate (Hz)
3-axis Seismometer	250
Centering position (x3)	5
Hydrophone	100
External pressure	5

Secondary sensors

Sensor	Sampling rate (Hz)
Battery voltage	5
Power consumption (W)	1
Internal temperature	5
Internal pressure	5
Internal humidity	5
External temperature	1

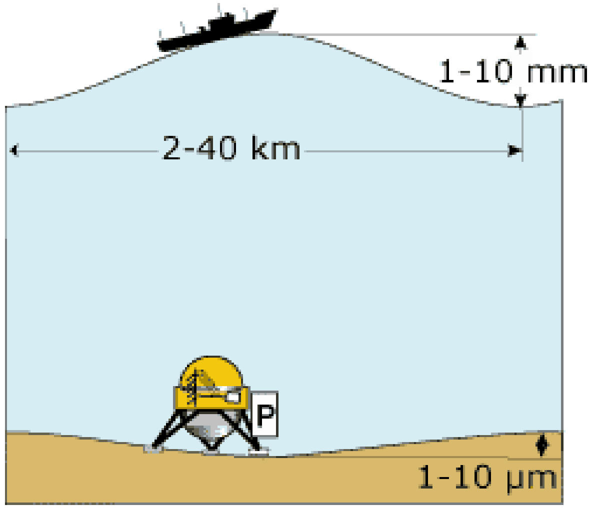
Aquarius OBS: Seismometer

- Guralp 3-component digital feedback with velocity response.
- Weak motion (high gain) 120 sec to 100 Hz flat response
  - Can adjust measurement bandwidth digitally (e.g., short period for shallow water, longer period for deeper water).
- The basic concept is a sensor beam suspended by the electrical balance in a capacitive field.
- Re-centers automatically
- Goes into lockdown if the motion too strong.
- Works in any orientation, no need for mechanical levelling (NOT GIMBALED)

Aquarius OBS: Hydrophone

An ultra low frequency hydrophone featuring a pressure compensated design, capable of operating at full ocean depth. Used in ASW industry and for noise measurements.

Differential Pressure measurement for seafloor compliance and correction (Tutorial this PM)



Cartoon representation of a compliance measurement (not to scale!), with typical signal wavelengths and amplitudes.

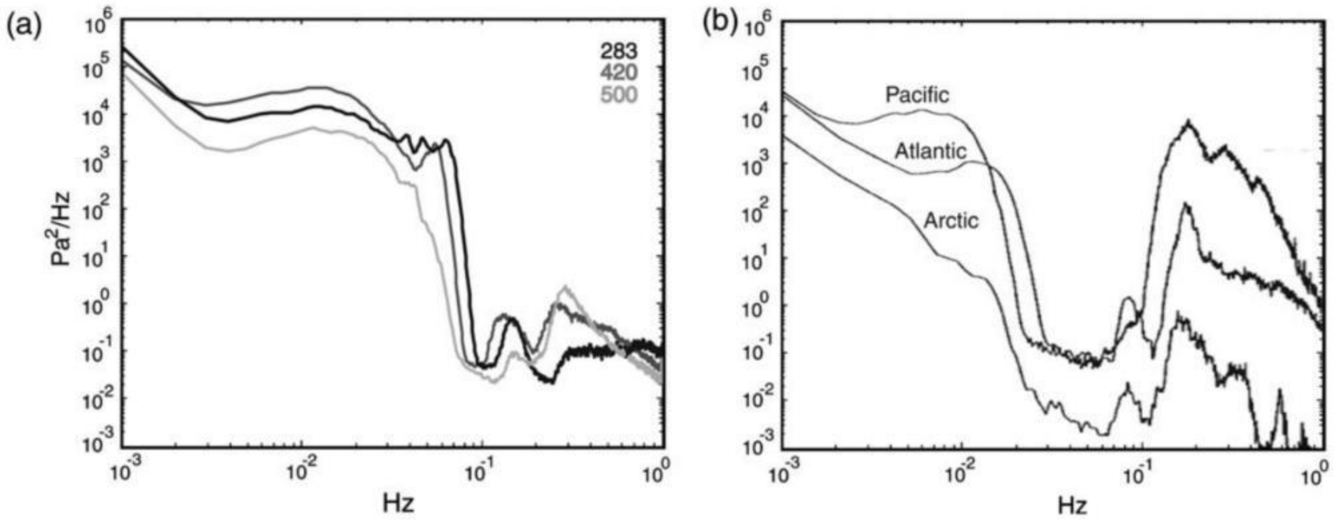


Figure 2. (a) The spectra of pressure at the three offshore San Diego sites corresponding to the acceleration spectra in Figure 1b. (b) Pressure spectra from three deep-water sites in the Pacific, North Atlantic, and Arctic oceans. The infragravity wave signal is lower in the Atlantic compared with the Pacific (Webb *et al.*, 1991). The Arctic is considerably quieter, both in the infragravity wave band (<0.03 Hz) and in the microseism peaks (0.05 to 0.1 and 0.1 to 5 Hz) because the ice cover greatly attenuates infragravity waves and prevents the propagation of the swell and wind-driven waves that are the source for the microseisms (Webb and Schultz, 1992). The multiple peaks in the microseism band at 0.15, 0.6, 0.9 Hz in the Arctic data are associated with different Rayleigh wave modes.

Aquarius OBS: Hydrophone

Can increase sampling rate to 1 kHz

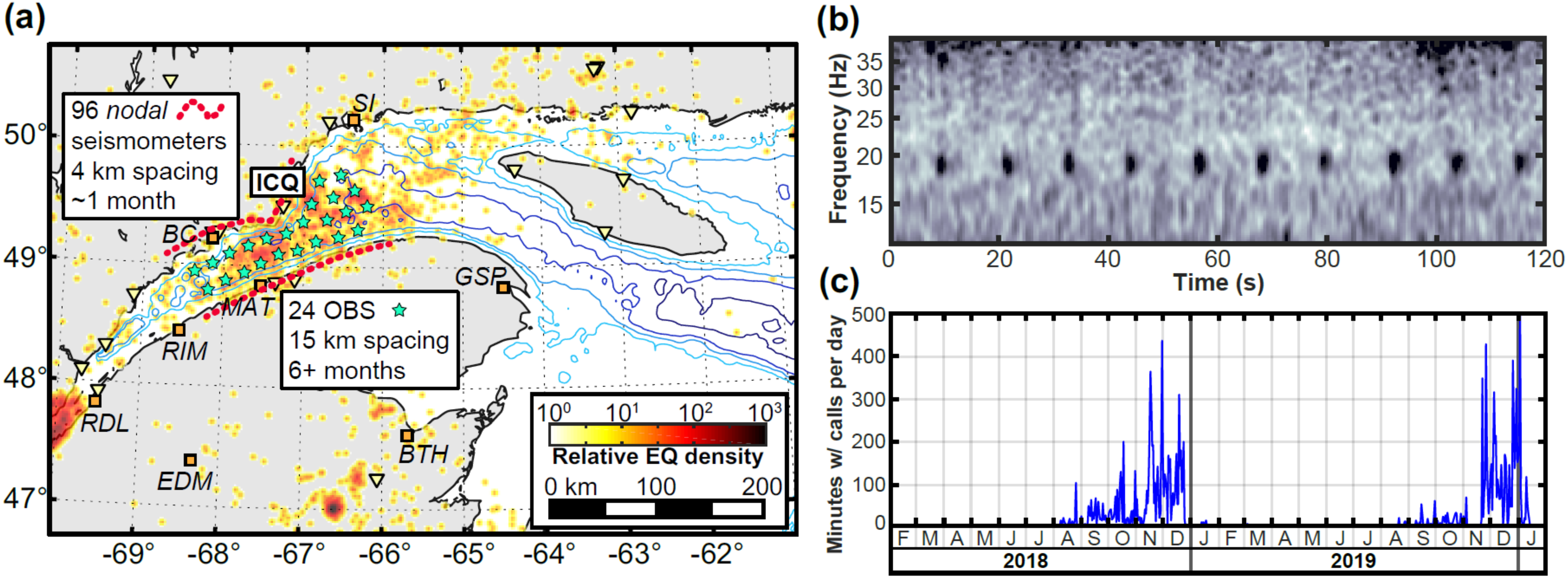
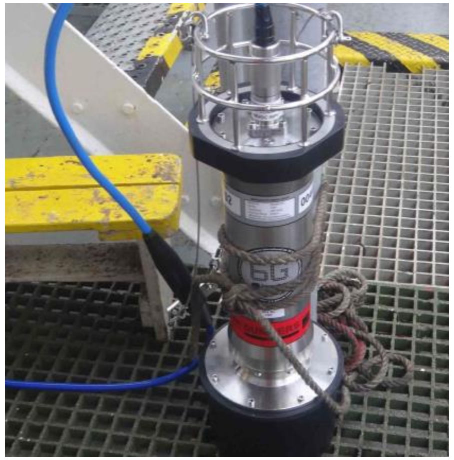
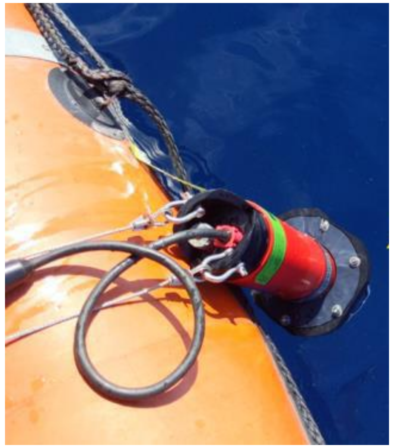


Figure 1. (a) Map of the proposed OBS network shown with relative earthquake (EQ) density from the *Earthquakes Canada* catalog and bathymetry, which is contoured at 100 m intervals. Yellow triangles indicate network land seismometers. Cities and large towns are marked with orange rectangles and labelled with short-forms BC = Baie-Comeau, BTH = Bathurst, EDM = Edmundston, GSP = Gaspé, MAT = Matane, RDL = Rivière-du-Loup, RIM = Rimouski, SI = Sept-Îles. (b) Characteristic spectrogram of a 20 Hz fin whale call sequence as recorded on land seismometer ICQ, whose position is indicated in (a). (c) Two-year catalog of fin whale calls per day recorded at seismometer ICQ.

Aquarius OBS: Topside Acoustic Modems

	Gyro USBL	Directional dunker	Omni-directional Dunker
Water depth range	7 km	6+ km	<3 km
Deployment options	Rigid pole only (side-along or through-hull)	Rigid pole OR Cable hang	Rigid pole OR Cable hang
Command PC	Dedicated Marine PC	Deck unit	Deck unit
Weight in air	56 kg	28 kg	7 kg
Range accuracy	0.1%	Good but worse – no heave/pitch/roll corrections	



Aquarius OBS: Deck unit

Acoustic modem for use on vessel / buoy / wave glider

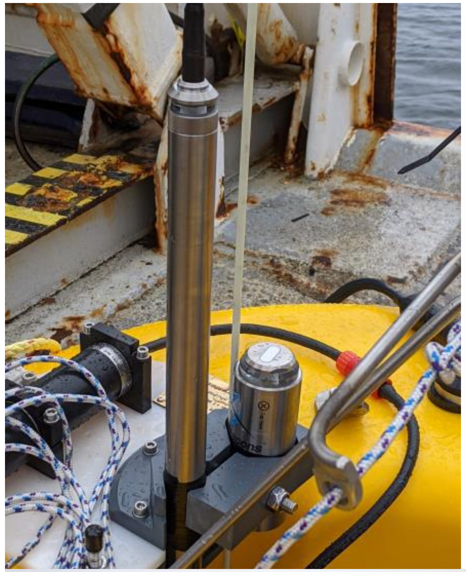
Pressure vessel with acoustic modem

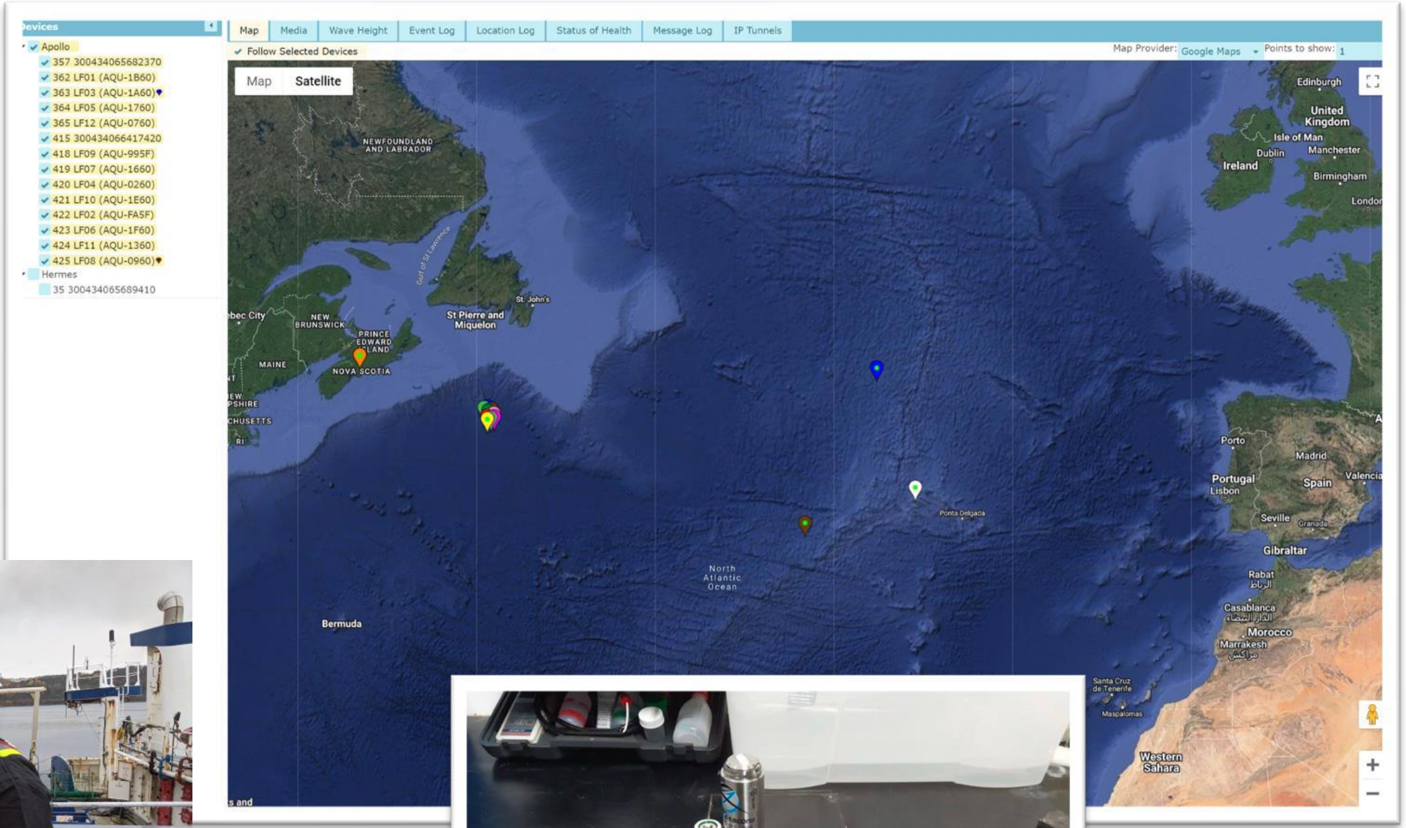
No need to remove buoyancy

Deck Unit

Single Ethernet cable to pressure vessel: Data, Power, Configuration

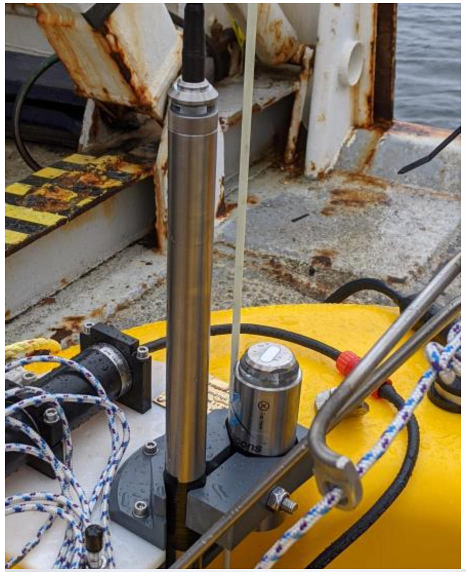
Aquarius OBS: Recovery devices

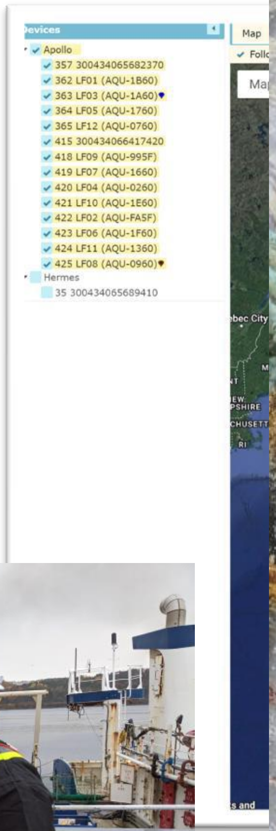




- GPS beacon activates on surfacing
- Position updates sent by iridium satellite
- Update frequency and flasher commands can be sent by satellite
- Can track for ~1 year with daily updates

Aquarius OB





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ELVES: Earthquakes and Locking inVEstigation of Subduction

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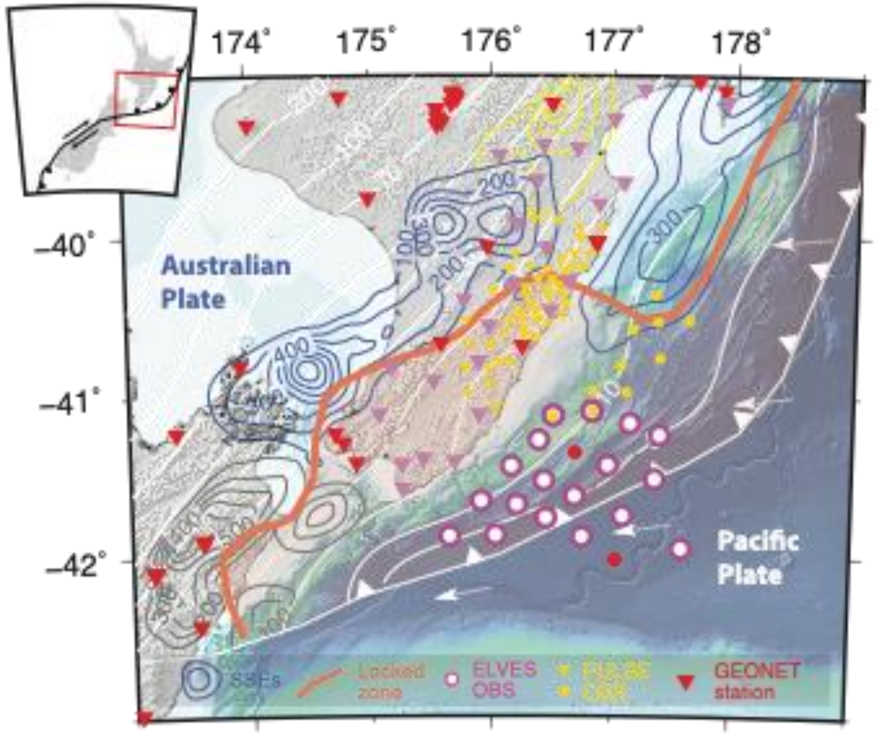
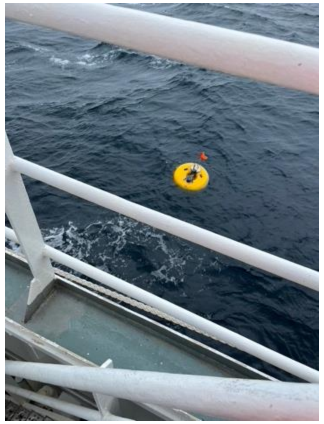
Samuel Clouston, Quan Zhang, David Hobbis, Daniel Murray

GNS SCIENCE TE PŪ AO
VICTORIA UNIVERSITY OF WELLINGTON TE HERENGA WAKA
uOttawa
DALHOUSIE UNIVERSITY
NFSI
Toka Tū Ake EQC

TAN2501 Science party





Seismic Data: SCNL

- Can you identify these examples?
  - NZ.TSZ.10.HHZ
  - CN.HAL..HNN
  - II.FFC.00.LH1
  - 7D.J55A..BDH
  - 3O.EL23A..CH3

Seismic Data: SCNL

- A unique means of referring to a digitized signal, which represents the type and configuration of ground motion (or other) data being collected
  - Station (S)
  - Channel (C)
  - Network (N)
  - Location (L)
- *This should really be NSLC, based on seismic data file naming convention…*

Station (S)

- **1-5 characters long**
- Tied to a specific latitude/longitude/elevation
  - International standards dictate if the site moves by more than 10 meters it must receive a new name

Channel (C)

- **3 characters long**
- Each character has a specific meaning and can only be selected for a certain subset
- **[Band Code][Instrument Code][Orientation Code]**

[Band Code]	[Instrument Code]	[Orientation Code]
Set by the sampling rate (e.g., C, H, B, L, S, E)	Reflects the type of instrument (e.g., H, N, D)	Dependent upon the instrument (e.g., Z, N, E, 1, 2, 3)

Band Code

Band code	Band type	Sample rate (Hz)	Corner period (sec)
F, G, D, C, E	…	≥ 250 to < 5000	Varies
E	Extremely Short Period	≥ 80 to < 250	< 10 sec
S	Short Period	≥ 10 to < 80	< 10 sec
H	High Broad Band	≥ 80 to < 250	≥ 10 sec
B	Broad Band	≥ 10 to < 80	≥ 10 sec
M,L,V, U, R, P, T, Q	Mid to Extremely Long Period	< 10 to < 0.000001	
A	Administrative Channel	variable	NA

Instrument Code

Instrument Code	Seismometer Type
H	High Gain Seismometer
L	Low Gain Seismometer
G	Gravimeter
M	Mass Position Seismometer
N *	Accelerometer

Many other instrument Types are available:
Tiltmeter, Creep, Magnetometer, Humidity, Rotation, Temperature,…

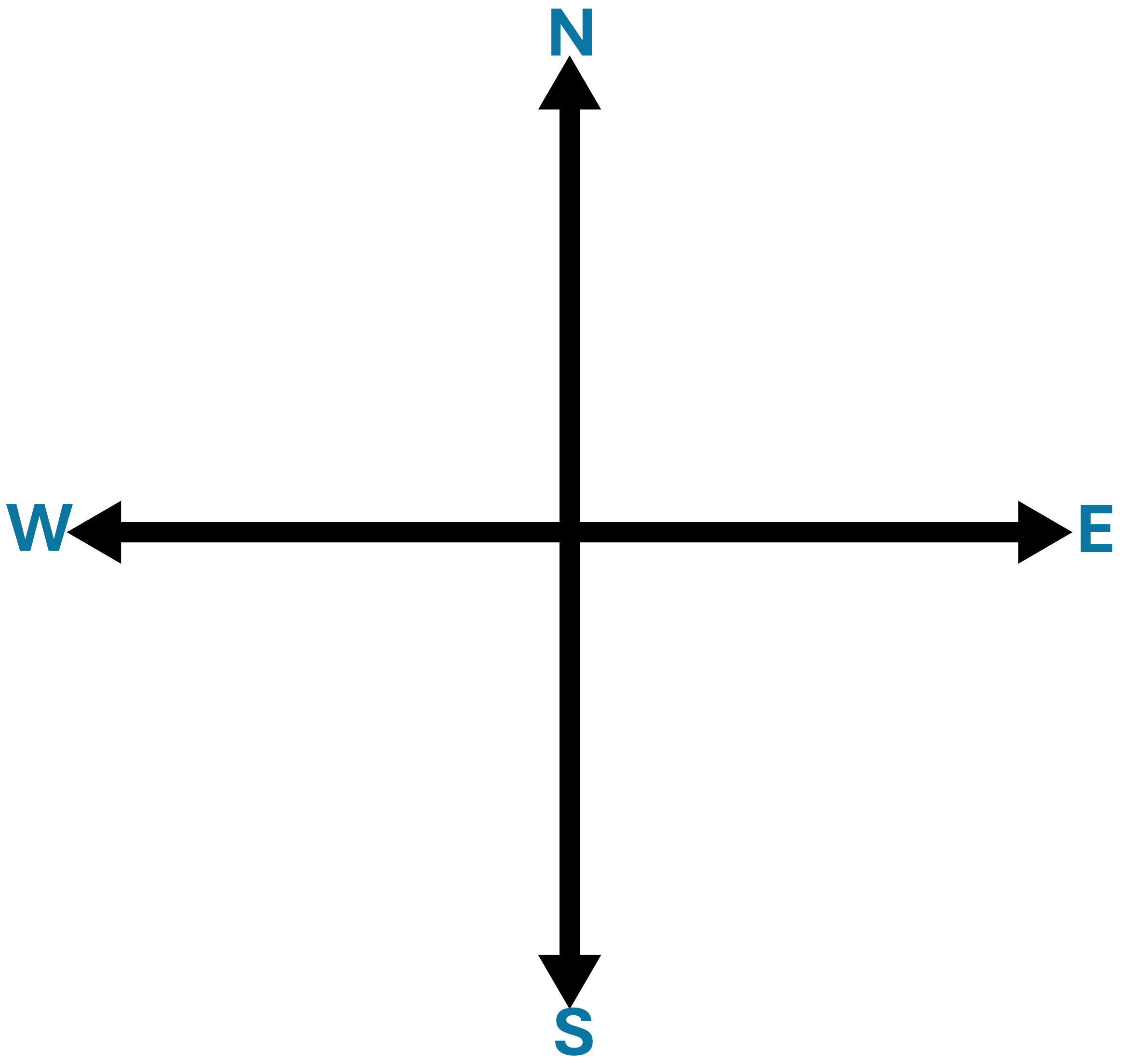
Ex: **Pressure (D)**. Several orientation codes to choose from

- F (infrasound)
- **H (hydrophone)**

Orientation Code (Seismometer)

Orientation Code	Orientation of components (typically 1 or 3)
Z N E	Traditional (Vertical, North-South, East-West)
A B C	Triaxial (Along the edges of a cube turned up on a corner)
T R	For formed beams (Transverse, Radial)
1 2 3	Orthogonal components but non-traditional orientations
U V W	Optional components
R T Z	Derived coordinates (example)

Component Rotation



KBS: Ny-Alesund, Spitzbergen

Δ = 100º
Az = 349º
Baz = 77º
Travel Times: Pdiff 13.8), PP (17.8), SKS (24.3), SS (32.2), Surface Waves (~46)

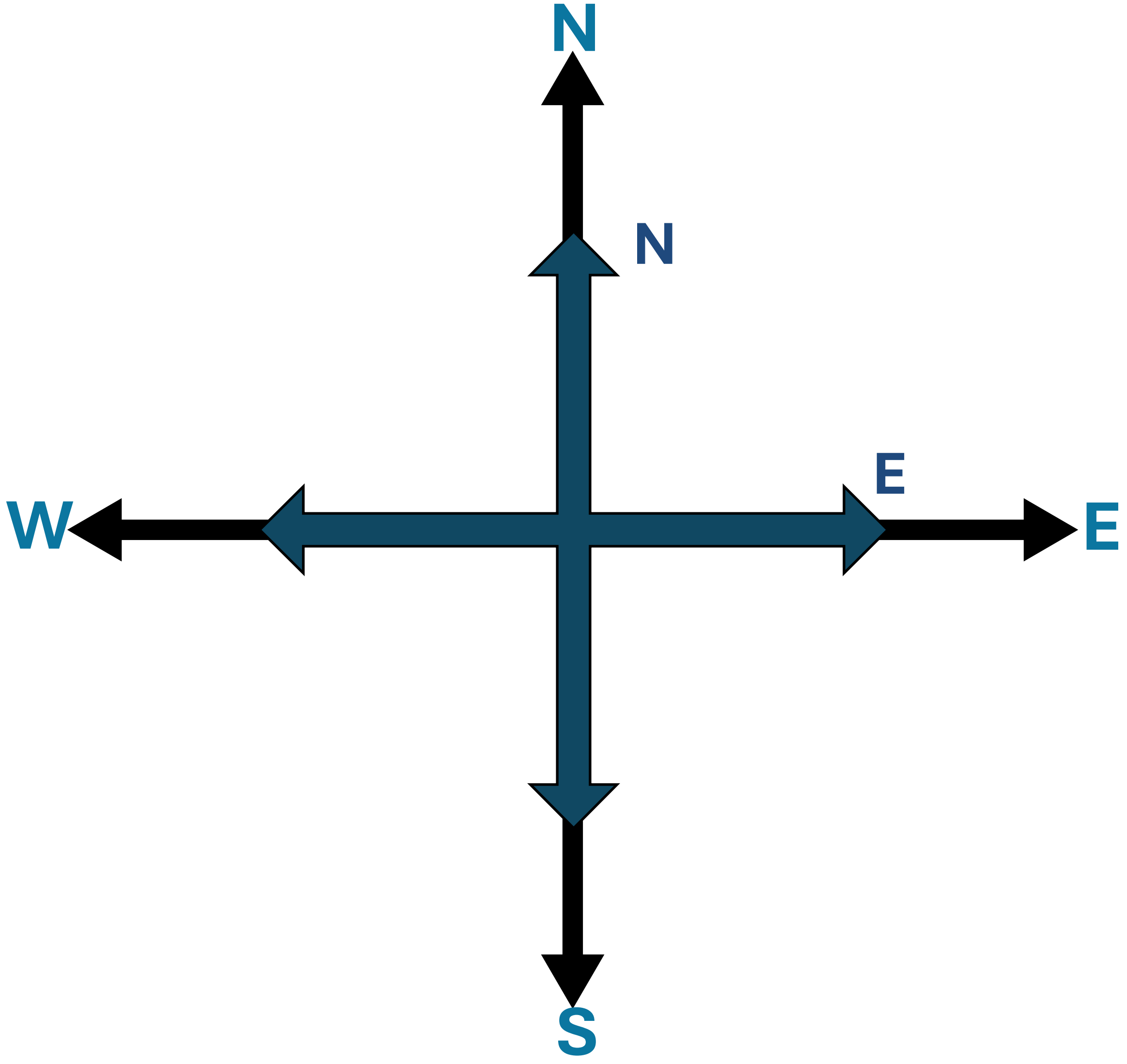
KONO: Kongsberg, Norway

Δ = 105º
Az = 330º
Baz = 79º

KBL: Kabul, Afghanistan

Δ = 61º
Az = 316º
Baz = 124º
Travel Times: P (10), PP (12.4), S (18.5), SS (22.5), Surface (~28.3)

Component Rotation



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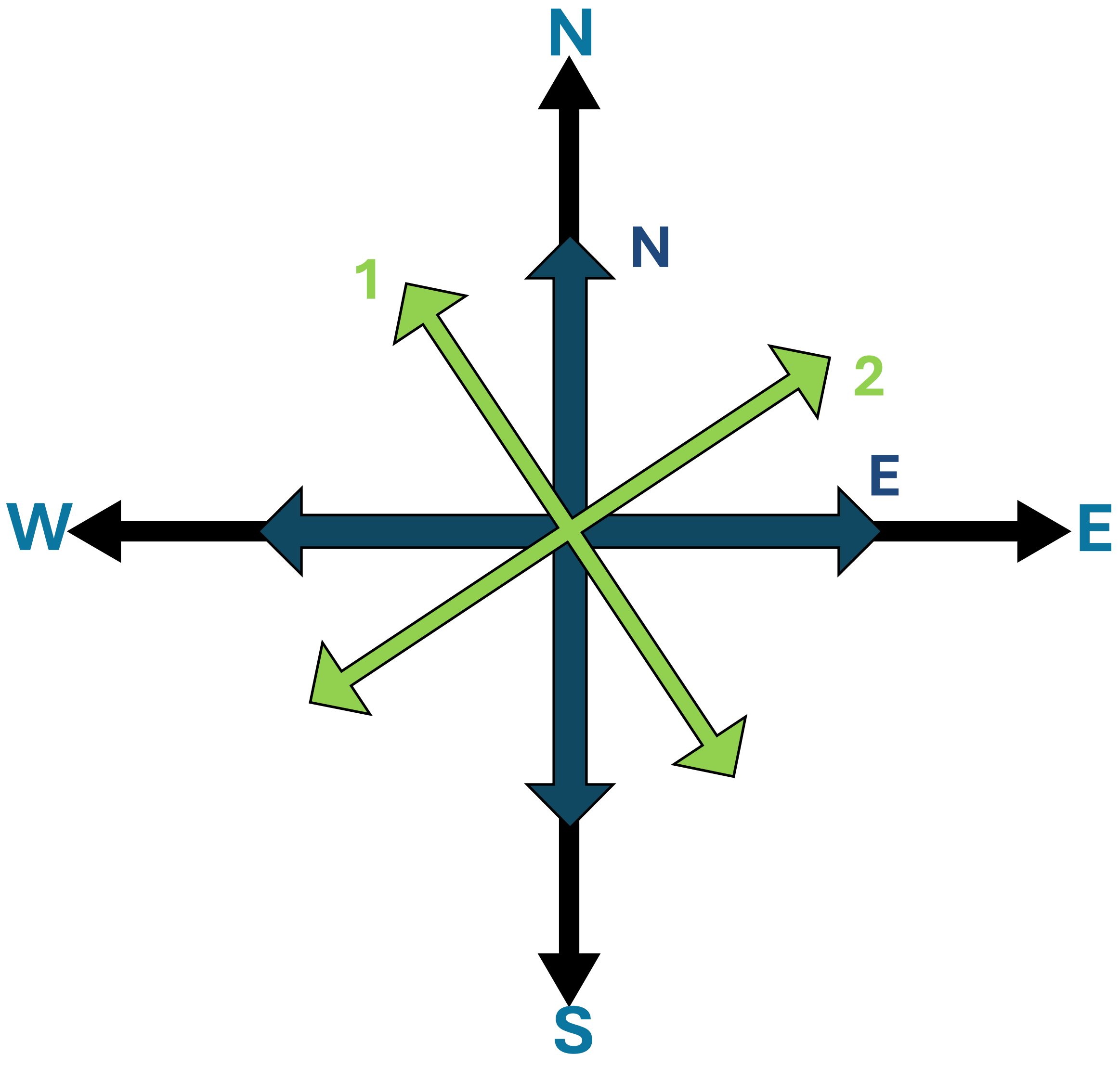

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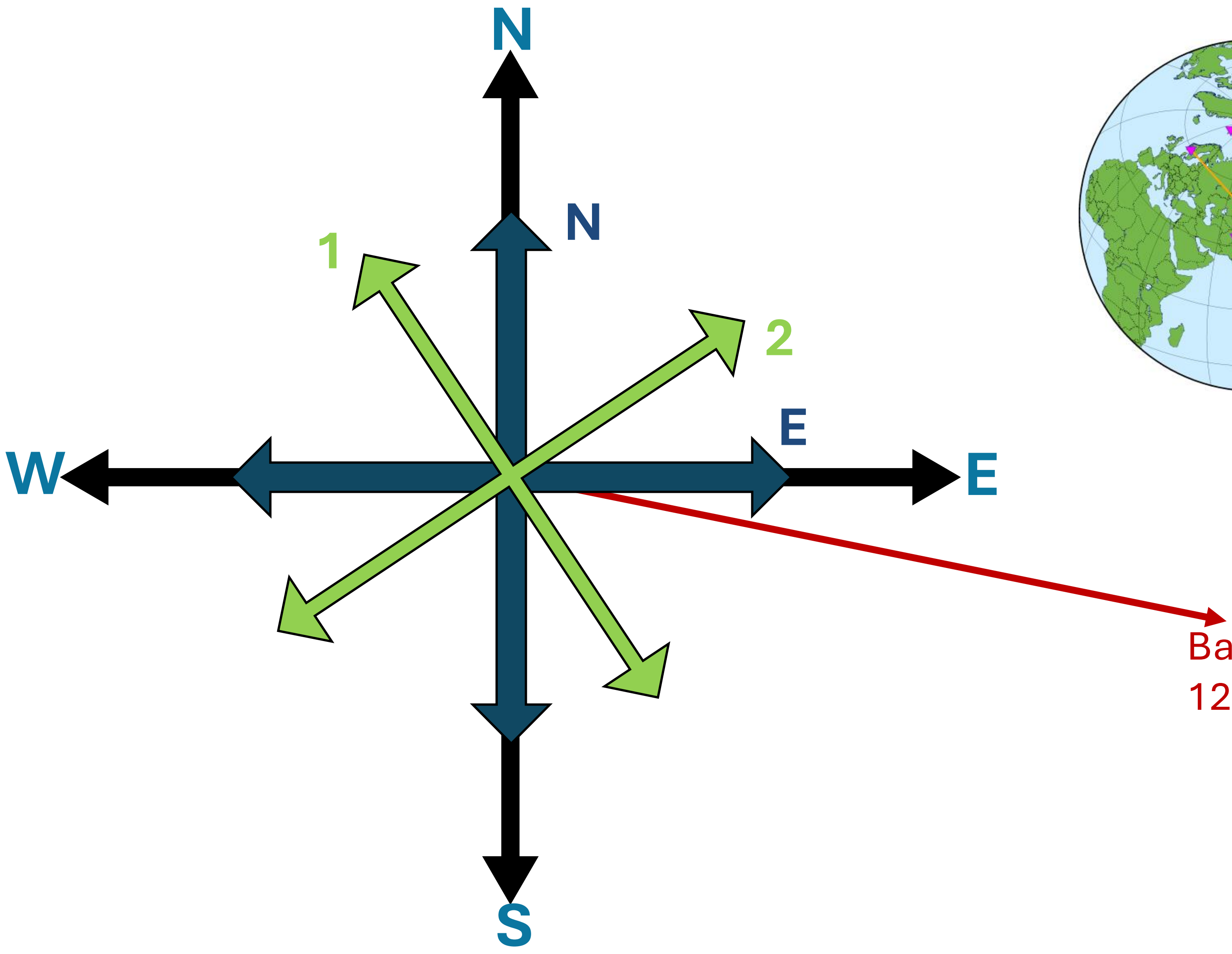

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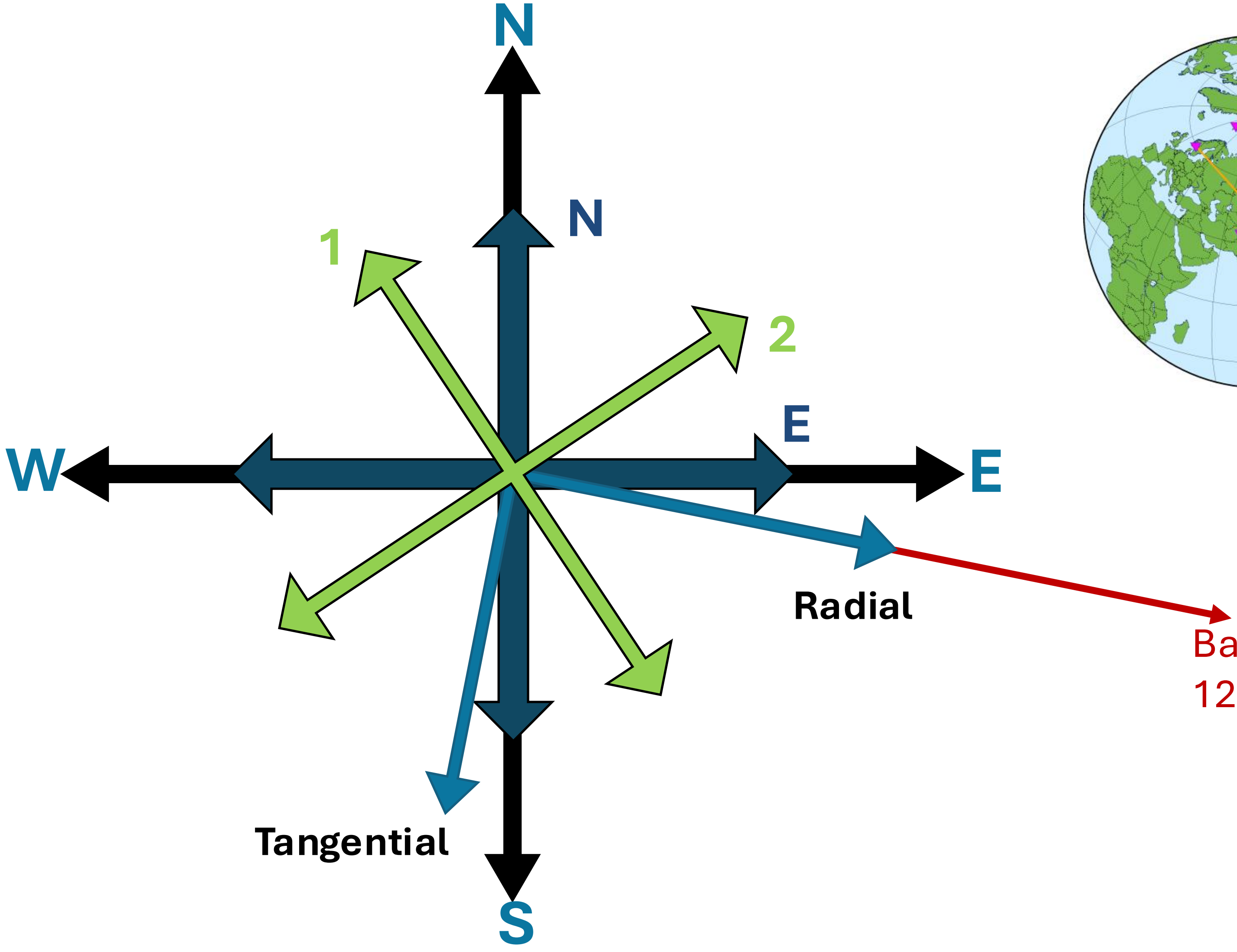

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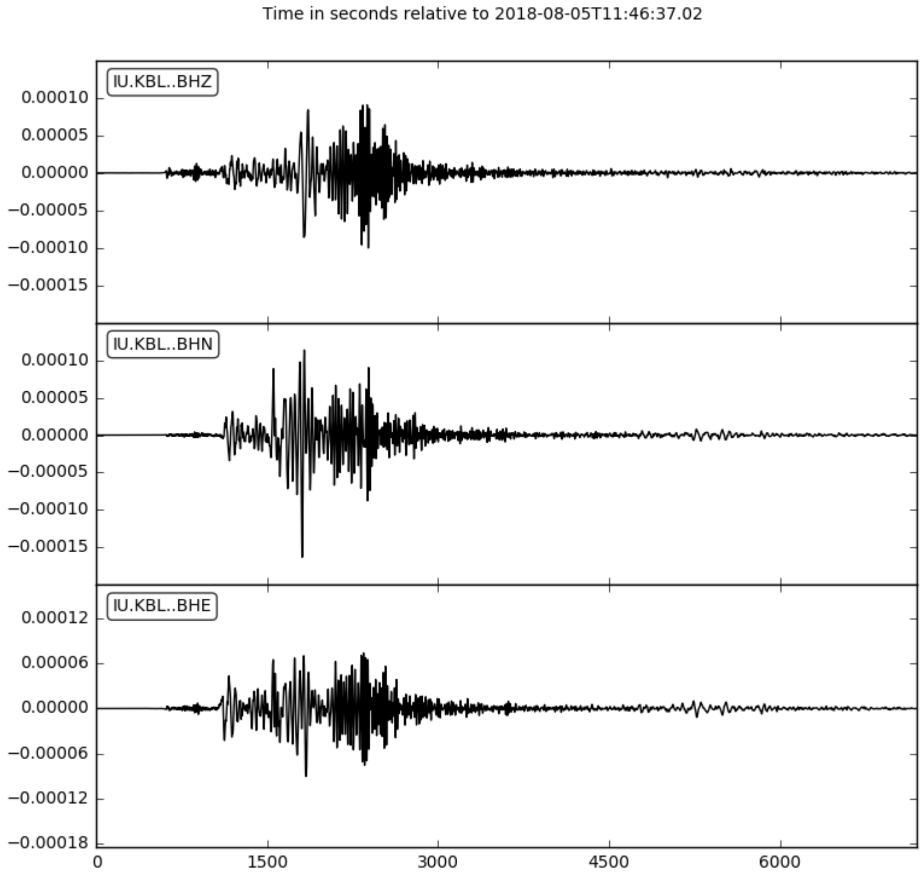
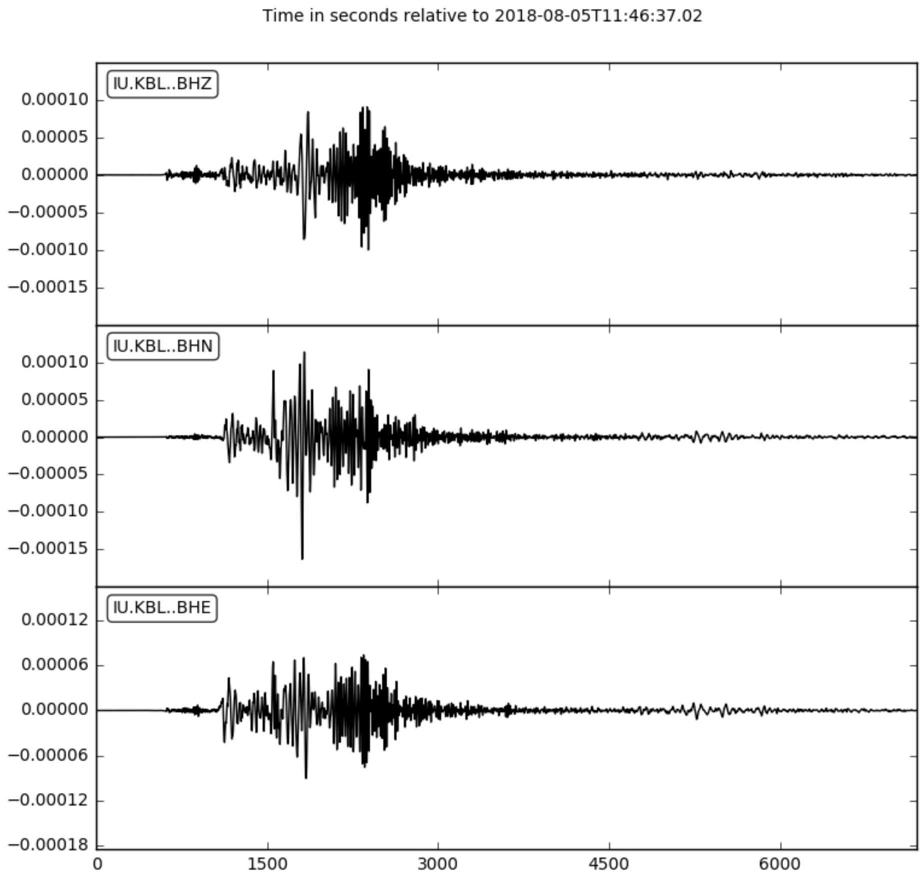
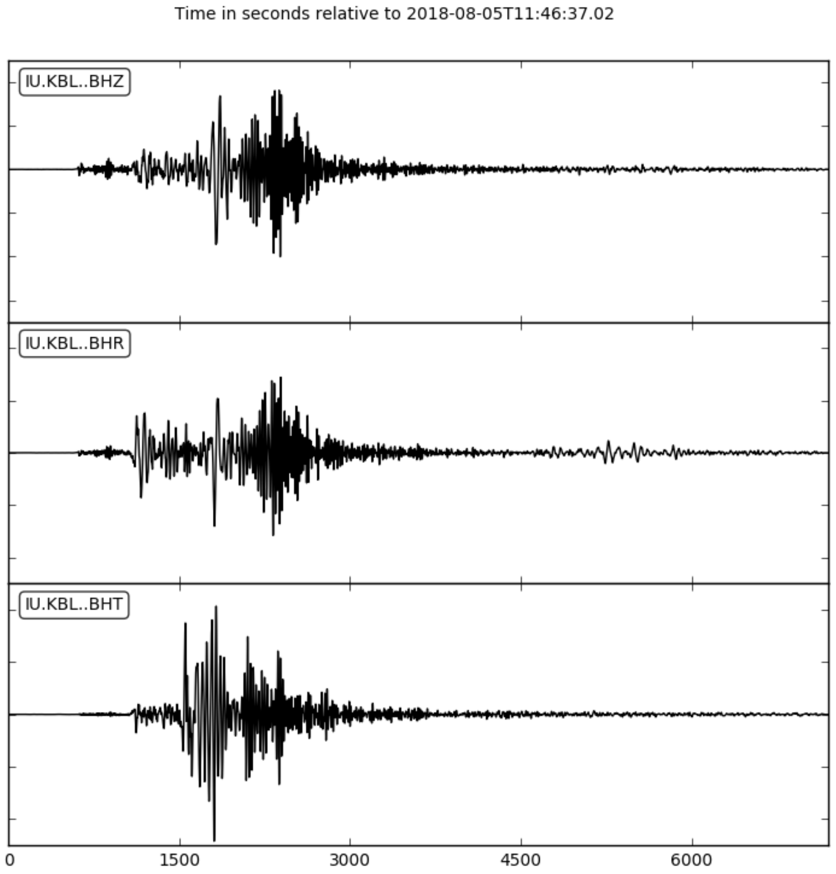
Rotation: KBL NE -> RT

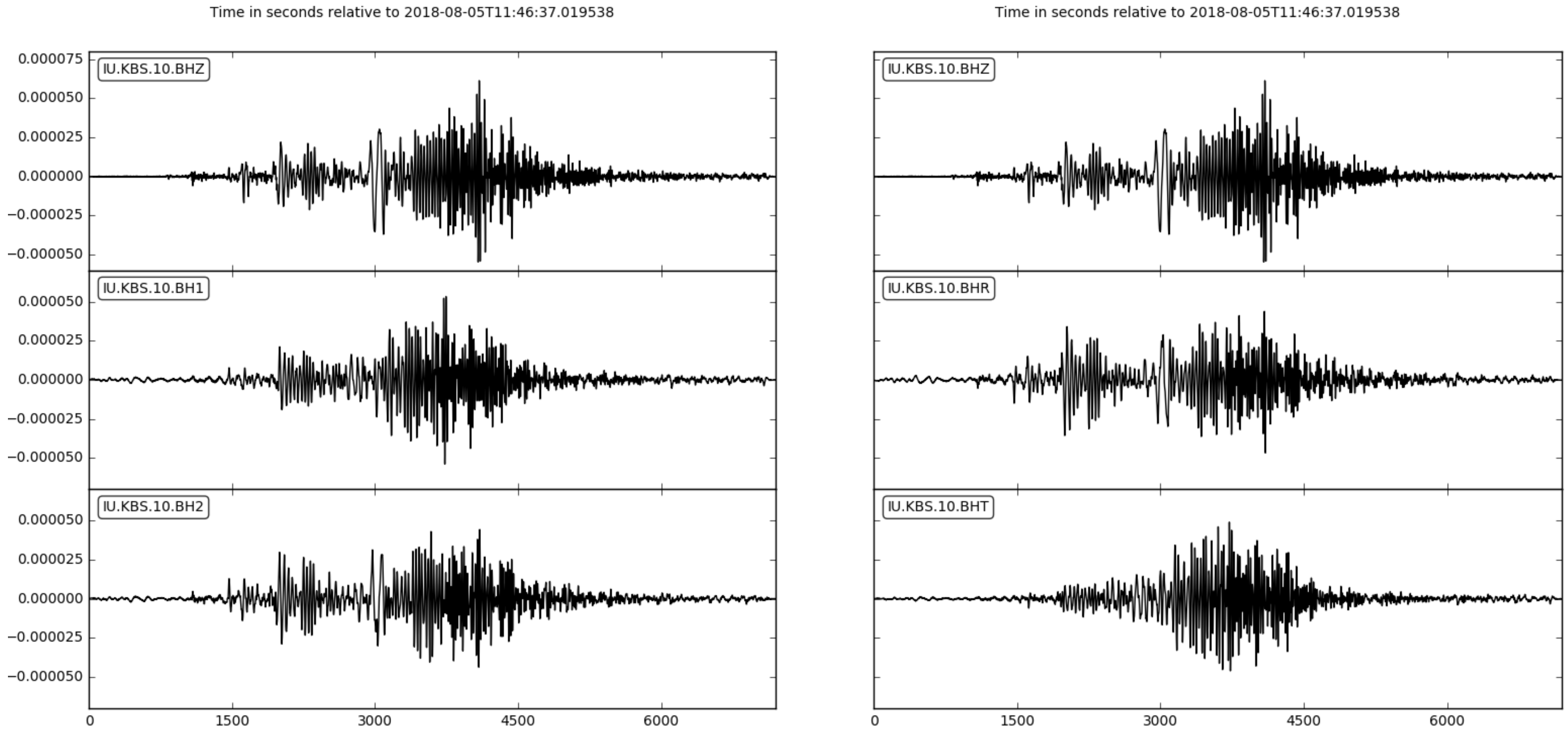


Rotation: KBL NE -> RT





Rotation: KBS 12 -> NE -> RT



Tutorial 1: Determine the orientation of horizontal components

Network (N)

- **1-2 characters in length**
- Identifies the network/owner of the data. Codes are assigned by the FDSN to provide uniqueness to seismic data
- Temporary Networks: X?, Y?, Z? #?
  - Stations are deployed for a fixed, typically short (<2-3 years) duration
  - E.g., regionally specific research networks, aftershock deployments, etc.
- Permanent Networks: all others
  - Although stations may be decommissioned, typically stations stay in the region of focus
  - E.g., national networks, global networks

Location (L)

- **2 characters**
- code used to uniquely identify different data streams (instruments) at a single station.
- These IDs are commonly used to logically separate multiple instruments or sensor sets at a single station
- Typically numeric, though not required
- Smallest number denotes “best” sensor (usually)

Example: IU.JOHN.00.BH1

IU : JOHN (1998-07-24 - 2599-12-31)

Network	IU Map DOI
Station	JOHN Map
Site Name	Johnston Island, USA
Start	1998-07-24T00:00:00 (205)
End	2599-12-31T23:59:59 (365)
Data Center	IRISDMC A
Latitude	16.7329
Longitude	-169.5292
Elevation (m)	2.0

Instruments

2021-05-29T00:00:00 (149) - 2599-12-31T23:59:59 (365)	
Location Code	Instruments / Channels
00	Streckeisen STS-2 Standard-gain BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A
20	Kinemetrics FBA ES-T EpiSensor Accelerometer HN1 100.0Hz IRISDMC A | HN2 100.0Hz IRISDMC A | HNZ 100.0Hz IRISDMC A LN1 1.0Hz IRISDMC A | LN2 1.0Hz IRISDMC A | LNZ 1.0Hz IRISDMC A
2012-10-29T00:00:00 (303) - 2599-12-31T23:59:59 (365)	
Location Code	Instruments / Channels
00	Streckeisen STS-2 Standard-gain VMU 0.1Hz IRISDMC A | VMV 0.1Hz IRISDMC A | VMW 0.1Hz IRISDMC A
31	CI/PAS pressure sensor LDO 1.0Hz IRISDMC A

Example: NZ.WEL.10.?H?

WEL

Station Details

Name	Wellington
Network	NZ
Start of operation	Sat Jan 1 1916 11:30 AM
End of operation	-

Sensors

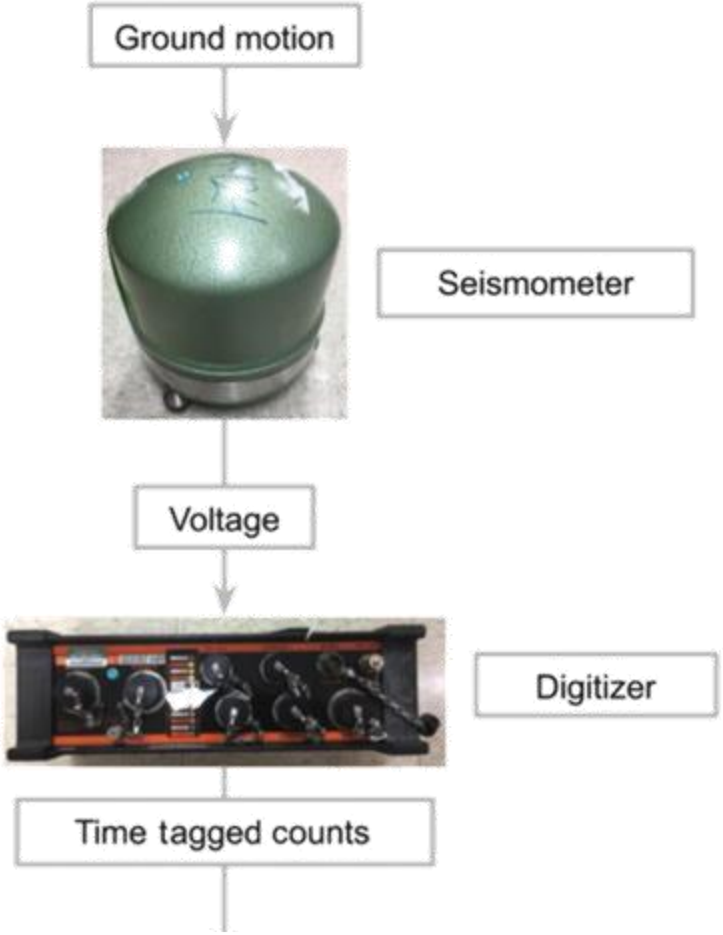
Location	**10**
Sensor Type	Broadband Seismometer
Model	CMG-3ESP
Make	Guralp
Channels	HHE,HHN,HHZ,LHE,LHN,LHZ
Start of operation	Thu Dec 18 2008 2:15 PM
End of operation	-

Station Location

Longitude: 174.768, Latitude: -41.284
Elevation: 138 m a.s.l.

Map showing location of station WEL

Recording ground motions from the ground

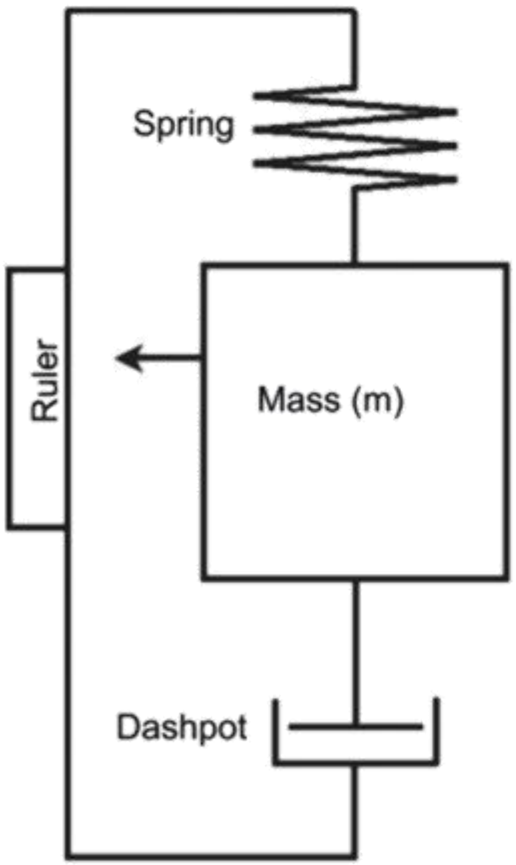


- Purpose:
  - Capture motions in the ground and convert them to a digital data
  - Seismometer converts ground motion voltage
  - Digitizer provides accurate time stamp to data sampled at a regular interval
  - Data is assembled in a buffer, then streamed to a datacentre or archived locally

Recording ground motions from the ground

- There are 4 complications arising when recording seismic data
    1. Recording the ground motion while also being on the ground
    2. Huge bandwidth of interest
    3. Huge dynamic range required
    4. Any instrument designed to handle (3) becomes highly sensitive to non-seismic noise sources (e.g., temperature, pressure, and magnetic field changes)

Recording ground motions from the ground



- Simple mechanical system where the instrument records the motion of the frame of a seismometer relative to a stationary mass
- i.e., the mass (m) is stationary and the instrument frame moves wrt to it
- Mass is connected to the frame with a spring (k) and dashpot (D) with a restoring force proportional to velocity

$$\ddot{x}(t)m + D\dot{x}(t) + kx(t) = -\ddot{u}(t), \qquad H(\omega) = \frac{-\omega^2}{\omega^2 + \frac{m}{D} i\omega + \frac{k}{m}},$$

Bandwidth

- Seismologists typically interested in frequencies spanning a broad range:
  - High frequencies typically of 200 Hz
  - Low frequencies down to 1.157×10^{-5} Hz (86,430 s)
- 24 octaves of bandwidth! (human ear is roughly 10 octaves).
- Manufacturers must shape the response so the instrument noise is below the Earth's background noise level.
- "passband" of the instrument is the frequency range over which the instrument has a "flat" response to ground motion.

Dynamic Range

- Interested in signals spanning a broad range in amplitudes.
- From the minimum Earth noise to the strong shaking occurring proximal to a large earthquake:
  - 10^{-9} m/s^2 to 2-3 g
- i.e., we would like the instrument to capture signals spanning 10 orders of magnitude or >100 dB of dynamic range.

Dynamic Range

- It is impractical to have a single instrument for the entire dynamic range of signals. The duties are split to two or more specifically designed sensors, often co-located
- Strong Motion:
  - Measures acceleration
  - Designed to stay on scale for nearby large magnitude earthquake
  - Clip level often exceeding 2 or 3 g
- Weak Motion:
  - Measures velocity
  - Designed to be on scale for small ground motions (small magnitude local events or distant large events)
  - Clip level is low, but has a high resolution for low amplitudes signals

Strong Motion Seismometers

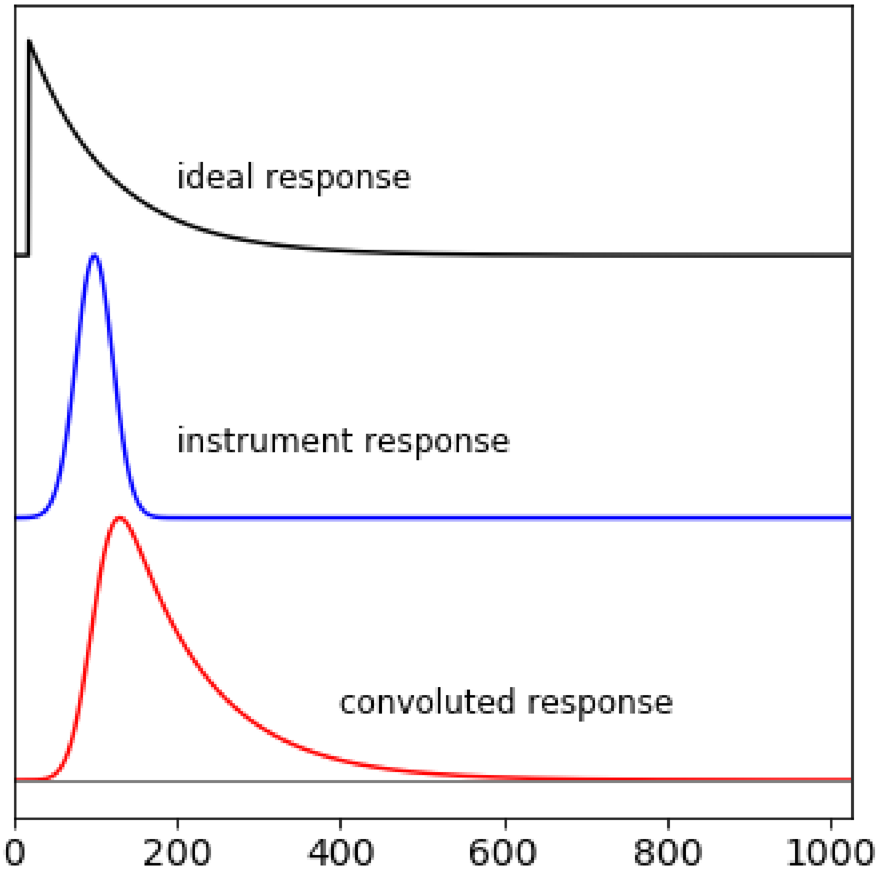
Weak Motion Seismometers



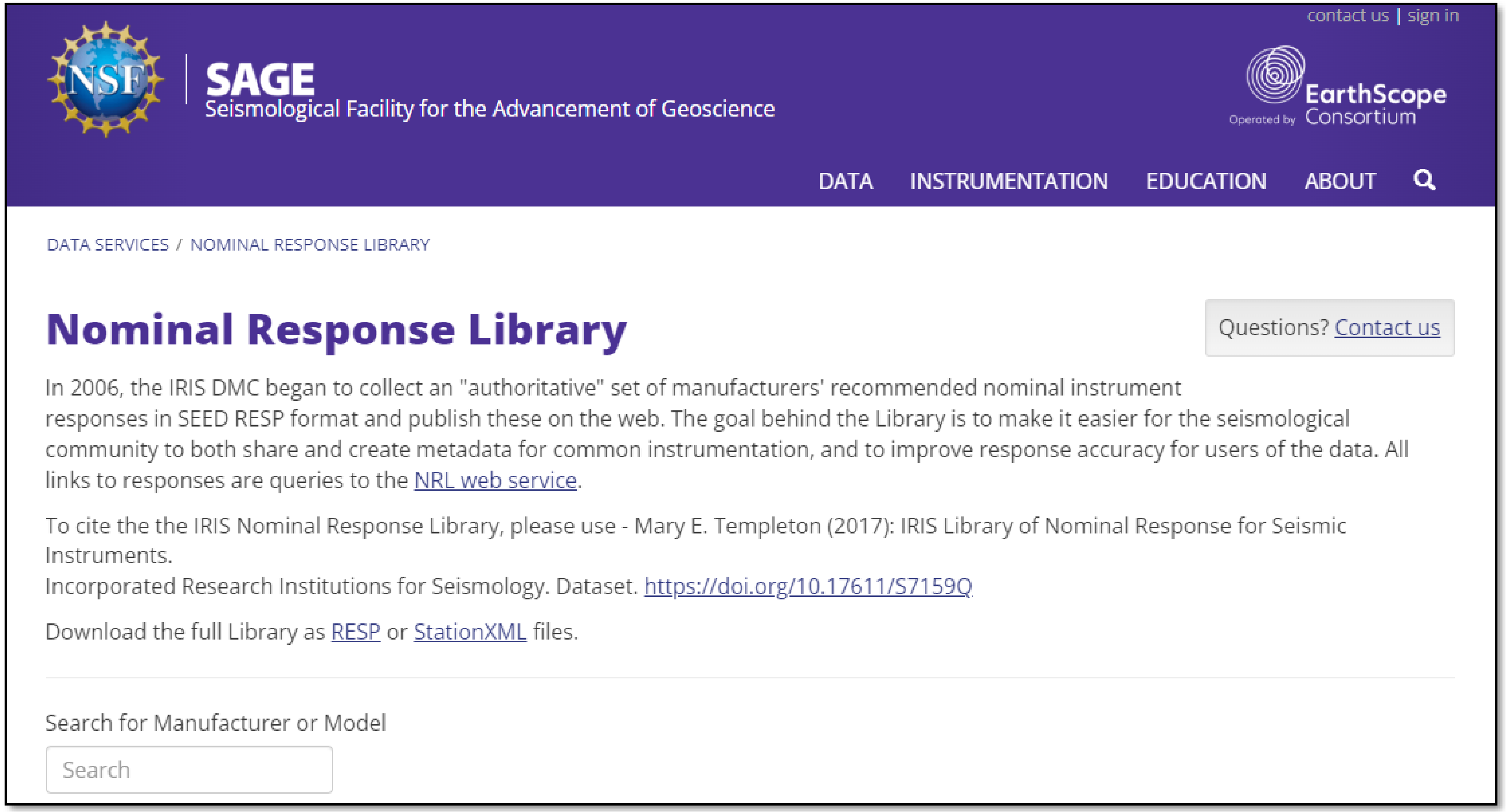



Instrument Response

- The signal we record is a convolution of the true ground motion plus some function imparted from the sensor itself
  - This is called the *instrument response function*
- Knowing the instrument response enables us to convert from counts (i.e., uV/m/s) to a more useful unit representative of the processes we are interested in
  - Displacement (m)
  - Velocity (m/s)
  - Acceleration (m/s^2)



Instrument Response Library



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NSF | SAGE
Seismological Facility for the Advancement of Geoscience

Operated by EarthScope Consortium

DATA INSTRUMENTATION EDUCATION ABOUT

DATA SERVICES / NOMINAL RESPONSE LIBRARY

Nominal Response Library

Questions? Contact us

In 2006, the IRIS DMC began to collect an "authoritative" set of manufacturers' recommended nominal instrument responses in SEED RESP format and publish these on the web. The goal behind the Library is to make it easier for the seismological community to both share and create metadata for common instrumentation, and to improve response accuracy for users of the data. All links to responses are queries to the NRL web service.

To cite the the IRIS Nominal Response Library, please use - Mary E. Templeton (2017): IRIS Library of Nominal Response for Seismic Instruments.
Incorporated Research Institutions for Seismology. Dataset. https://doi.org/10.17611/S7159Q

Download the full Library as RESP or StationXML files.

Search for Manufacturer or Model

Search

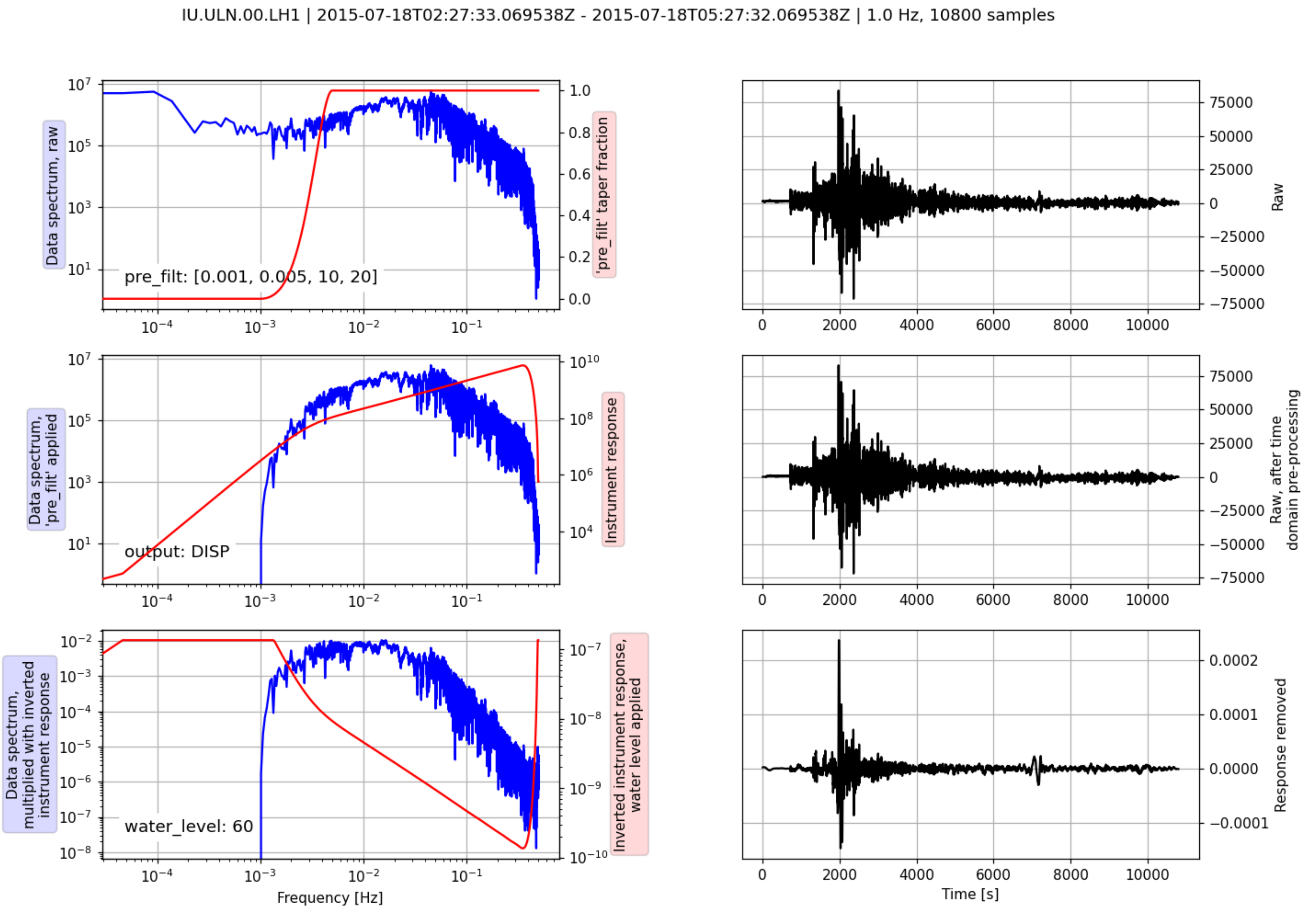
Response Formats

- RESP
  - Text-based, typically derived or extracted from a SEED or Dataless SEED volume
  - Slowly being phased out, but still around for backwards compatibility (there are a lot of OLD research codes that still use them)
- StationXML format
  - Modern XML-formatted standard for metadata and response information
- All available from the NRL

Instrument Response, an example

```
from obspy import read, read_inventory

st = read("/path/to/IU_ULN_00_LH1_2015-07-18T02.mseed")
tr = st[0]
inv = read_inventory("/path/to/IU_ULN_00_LH1.xml")
pre_filt = [0.001, 0.005, 10, 20]
tr.remove_response(inventory=inv, pre_filt=pre_filt, output="DISP",
                   water_level=60, plot=True)
```



IU.ULN.00.LH1 | 2015-07-18T02:27:33.069538Z - 2015-07-18T05:27:32.069538Z | 1.0 Hz, 10800 samples
Data spectrum, raw
'pre_filt' taper fraction
pre_filt: [0.001, 0.005, 10, 20]
Raw
Data spectrum, 'pre_filt' applied
Instrument response
output: DISP
Raw, after time domain pre-processing
Data spectrum, multiplied with inverted instrument response
Inverted instrument response, water level applied
water_level: 60
Response removed
Frequency [Hz]
Time [s]

Metadata

- Although seemingly trivial, ultimately is one of the most important things to keep track of, both for inventory and monitoring of equipment health and performance, but also critical for using the data correctly.
- Where is digitizer X? Where was it before?
- Which seismometer did we deploy there?

Key Metadata to track

- What do you think are important things to track for any given station?

- Start time
- Stop time
- Latitude
- Longitude
- Elevation

Key Metadata to track

- What do you think are important things to track for any given station?

- Start time
- Stop time
- Latitude
- Longitude
- Elevation
- Sensor type and serial number
- Component orientations (and inclination)
- Sensor depth
- Digitizer type
- Sampling interval
- Peak to peak voltage range
- Sensitivity
- Filter coefficients

Key metadata is inherited from the ground up

- The metadata for a network is ultimately derived and accumulated starting from each sensor at a station.
- We have a network, PQ. It has a number of stations within it. What are the key metadata for the network PQ?

Key metadata is inherited from the ground up

- The metadata for a network is ultimately derived and accumulated starting from each sensor at a station.
- We have a network, PQ. It has a number of stations within it. What are the key metadata for the network PQ?
  - *Start_time*
  - *End_time*

Aside on Dates

Convention for a currently running station is to have an end date of `2599-12-31T:23:59:59.999`

!!Y2.6K bug!!

- These values are derived from the earliest start date and latest end date for all stations within the network

Single Station Metadata

- Name Code
- Location Name
- Latitude
- Longitude
- Elevation

- Derived metadata from each Location ID (i.e., instrument)
  - Start Time
  - End Time

Single Instrument Metadata

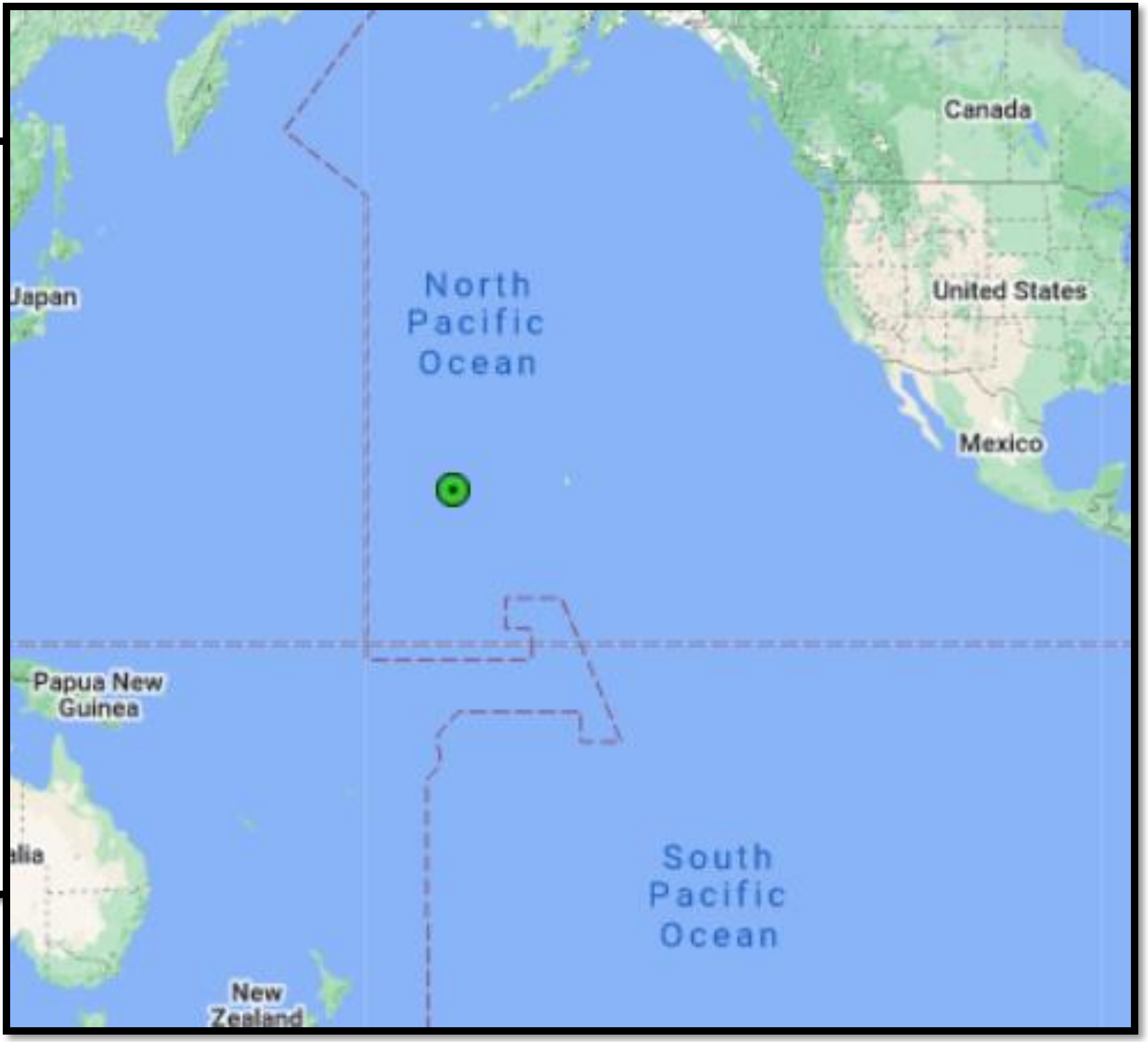
- Location Code
- Depth
- Start Date
- End Date

- Component/Channel Metadata
  - Orientation/Azimuth
  - Inclination

Example: IU.JOHN

IU : JOHN (1998-07-24 - 2599-12-31)

Network	IU Map DOI
Station	JOHN Map
Site Name	Johnston Island, USA
Start	1998-07-24T00:00:00 (205)
End	2599-12-31T23:59:59 (365)
Data Center	IRISDMC A
Latitude	16.7329
Longitude	-169.5292
Elevation (m)	2.0



2021-05-29T00:00:00 (149) - 2599-12-31T23:59:59 (365)

Location Code / Instruments / Channels

00
Streckeisen STS-2 Standard-gain
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

20
Kinemetrics FBA ES-T EpiSensor Accelerometer
HN1 100.0Hz IRISDMC A | HN2 100.0Hz IRISDMC A | HNZ 100.0Hz IRISDMC A
LN1 1.0Hz IRISDMC A | LN2 1.0Hz IRISDMC A | LNZ 1.0Hz IRISDMC A

2012-10-29T00:00:00 (303) - 2599-12-31T23:59:59 (365)

Location Code / Instruments / Channels

00
Streckeisen STS-2 Standard-gain
VMU 0.1Hz IRISDMC A | VMV 0.1Hz IRISDMC A | VMW 0.1Hz IRISDMC A

31
CI/PAS pressure sensor
LDO 1.0Hz IRISDMC A

2012-10-29T00:00:00 (303) - 2022-12-03T00:00:00 (337)

Location Code / Instruments / Channels

10
Trillium 240 broad band
VMU 0.1Hz IRISDMC A | VMV 0.1Hz IRISDMC A | VMW 0.1Hz IRISDMC A

2010-11-06T06:10:00 (310) - 2022-12-03T00:00:00 (337)

Location Code / Instruments / Channels

10
Trillium 240 broad band
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A
HH1 100.0Hz IRISDMC A | HH2 100.0Hz IRISDMC A | HHZ 100.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

2010-11-05T18:27:59 (309) - 2021-05-29T00:00:00 (149)

Location Code / Instruments / Channels

00
Streckeisen STS-2 Standard-gain
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

2010-08-09T00:00:00 (221) - 2010-11-05T18:27:59 (309)

Location Code / Instruments / Channels

00
Streckeisen STS-2 Standard-gain
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

2010-08-09T00:00:00 (221) - 2010-11-06T06:10:00 (310)

Location Code / Instruments / Channels

10
Trillium 240 broad band
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A
HH1 100.0Hz IRISDMC A | HH2 100.0Hz IRISDMC A | HHZ 100.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

2010-08-09T00:00:00 (221) - 2021-05-29T00:00:00 (149)

Location Code / Instruments / Channels

20
Kinemetrics FBA ES-T EpiSensor Accelerometer
HN1 100.0Hz IRISDMC A | HN2 100.0Hz IRISDMC A | HNZ 100.0Hz IRISDMC A
LN1 1.0Hz IRISDMC A | LN2 1.0Hz IRISDMC A | LNZ 1.0Hz IRISDMC A

2010-08-09T00:00:00 (221) - 2599-12-31T23:59:59 (365)

Location Code / Instruments / Channels

30
lower quality chip sensor in Setra box
LDO 1.0Hz IRISDMC A

2004-05-07T18:13:00 (128) - 2010-08-09T00:00:00 (221)

Location Code / Instruments / Channels

20
Kinemetrics FBA-23 Low-Gain Sensor
HNE 80.0Hz IRISDMC A | HNN 80.0Hz IRISDMC A | HNZ 80.0Hz IRISDMC A
LNE 1.0Hz IRISDMC A | LNN 1.0Hz IRISDMC A | LNZ 1.0Hz IRISDMC A

2004-05-07T18:09:00 (128) - 2010-08-09T00:00:00 (221)

Location Code / Instruments / Channels

10
Streckeisen STS-2 High-gain
BHE 40.0Hz IRISDMC A | BHN 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A
HHE 80.0Hz IRISDMC A | HHN 80.0Hz IRISDMC A | HHZ 80.0Hz IRISDMC A
LHE 1.0Hz IRISDMC A | LHN 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VHE 0.1Hz IRISDMC A | VHN 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

2004-05-06T22:50:00 (127) - 2010-08-09T00:00:00 (221)

Location Code / Instruments / Channels

00
Guralp CMG3-T Seismometer (borehole)
BH1 20.0Hz IRISDMC A | BH2 20.0Hz IRISDMC A | BHZ 20.0Hz IRISDMC A
HH1 80.0Hz IRISDMC A | HH2 80.0Hz IRISDMC A | HHZ 80.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

01
Guralp CMG3-T Seismometer (borehole)
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A

2003-11-06T19:51:00 (310) - 2004-05-07T18:13:00 (128)

Location Code / Instruments / Channels

20
Kinemetrics FBA-23 Low-Gain Sensor
HNE 80.0Hz IRISDMC A | HNN 80.0Hz IRISDMC A | HNZ 80.0Hz IRISDMC A
LNE 1.0Hz IRISDMC A | LNN 1.0Hz IRISDMC A | LNZ 1.0Hz IRISDMC A

2003-10-31T00:00:00 (304) - 2005-07-03T00:00:00 (184)

Location Code / Instruments / Channels

00
All Weather, Inc. microanemometer
LWS 1.0Hz IRISDMC A

2003-10-30T00:00:00 (303) - 2004-05-06T22:50:00 (127)

Location Code / Instruments / Channels

00
Guralp CMG3-T Seismometer (borehole)
BH1 20.0Hz IRISDMC A | BH2 20.0Hz IRISDMC A | BHZ 20.0Hz IRISDMC A
HH1 80.0Hz IRISDMC A | HH2 80.0Hz IRISDMC A | HHZ 80.0Hz IRISDMC A
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

01
Guralp CMG3-T Seismometer (borehole)
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDMC A

2003-10-30T00:00:00 (303) - 2010-08-09T00:00:00 (221)

Location Code / Instruments / Channels

00
Davis Instruments solar radiation sensor
LUX 1.0Hz IRISDMC A

2002-02-25T00:00:00 (056) - 2003-11-06T19:51:00 (310)

Location Code / Instruments / Channels

20
Kinemetrics FBA-23 Low-Gain Sensor
HNE 80.0Hz IRISDMC A | HNN 80.0Hz IRISDMC A | HNZ 80.0Hz IRISD
LNE 1.0Hz IRISDMC A | LNN 1.0Hz IRISDMC A | LNZ 1.0Hz IRISDMC A

1999-05-04T06:15:00 (124) - 2003-10-30T00:00:00 (303)

Location Code / Instruments / Channels

00
Geotech KS-54000 Borehole Seismometer
BH1 20.0Hz IRISDMC A | BH2 20.0Hz IRISDMC A | BHZ 20.0Hz IRISDM
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
UH1 0.01Hz IRISDMC A | UH2 0.01Hz IRISDMC A | UHZ 0.01Hz IRISDM
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A

10
Guralp CMG3-T Seismometer (borehole)
BH1 40.0Hz IRISDMC A | BH2 40.0Hz IRISDMC A | BHZ 40.0Hz IRISDM
HH1 80.0Hz IRISDMC A | HH2 80.0Hz IRISDMC A | HHZ 80.0Hz IRISDM
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A

1999-05-04T06:15:00 (124) - 2010-08-09T00:00:00 (221)

Location Code / Instruments / Channels

00
Quanterra DA temperature monitor
VK1 0.1Hz IRISDMC A
Quanterra DA voltage monitor
VE1 0.1Hz IRISDMC A

1999-05-04T06:15:00 (124) - 2002-02-25T00:00:00 (056)

Location Code / Instruments / Channels

20
Kinemetrics FBA-23 Low-Gain Sensor
HLE 80.0Hz IRISDMC A | HLN 80.0Hz IRISDMC A | HLZ 80.0Hz IRISDM
LLE 1.0Hz IRISDMC A | LLN 1.0Hz IRISDMC A | LLZ 1.0Hz IRISDMC A

1998-07-24T00:00:00 (205) - 1999-05-04T06:15:00 (124)

Location Code / Instruments / Channels

--
Geotech KS-54000 Borehole Seismometer
BH1 20.0Hz IRISDMC A | BH2 20.0Hz IRISDMC A | BHZ 20.0Hz IRISDM
LH1 1.0Hz IRISDMC A | LH2 1.0Hz IRISDMC A | LHZ 1.0Hz IRISDMC A
UH1 0.01Hz IRISDMC A | UH2 0.01Hz IRISDMC A | UHZ 0.01Hz IRISDM
VH1 0.1Hz IRISDMC A | VH2 0.1Hz IRISDMC A | VHZ 0.1Hz IRISDMC A
Guralp CMG3-T Seismometer (borehole)
HHE 80.0Hz IRISDMC A | HHN 80.0Hz IRISDMC A | HHZ 80.0Hz IRISD
SCI 40.0Hz IRISDMC A | SH1 40.0Hz IRISDMC A | SH2 40.0Hz IRISDMC
Kinemetrics FBA-23 Low-Gain Sensor
HLE 80.0Hz IRISDMC A | HLN 80.0Hz IRISDMC A | HLZ 80.0Hz IRISDM
LLE 1.0Hz IRISDMC A | LLN 1.0Hz IRISDMC A | LLZ 1.0Hz IRISDMC A
Quanterra DA temperature monitor
VK1 0.1Hz IRISDMC A
Quanterra DA voltage monitor
VE1 0.1Hz IRISDMC A

Metadata Search Tools

- IRIS MetaData Aggregator (MDA): http://ds.iris.edu/mda/

MDA

MetaData Aggregator

Legend: R P A

Browse Federated Metadata

Networks | Virtual Networks | Assembled

Search | Name or FDSN code

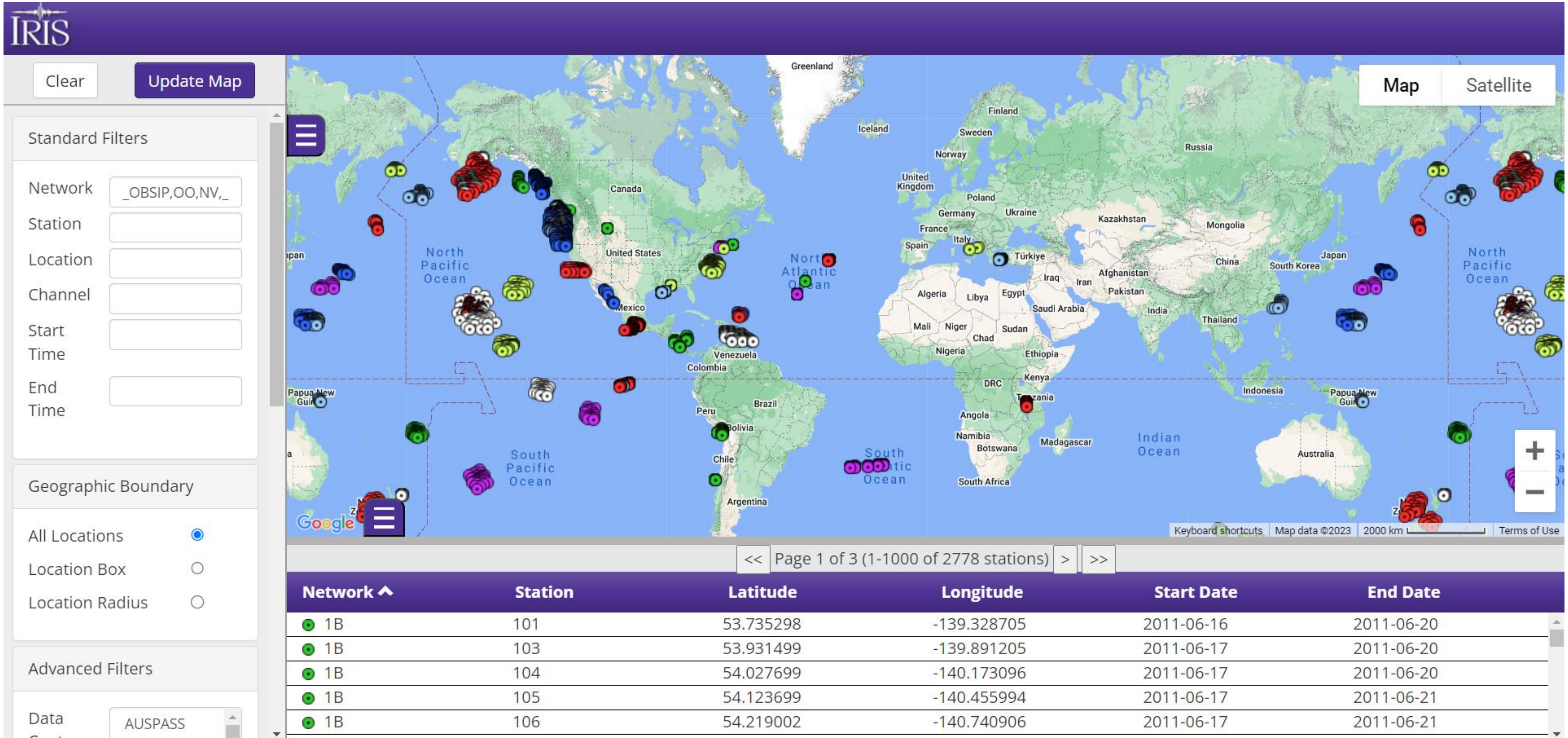
Filter

Network List (1602)

Network	Data Center	Description	Start Year	End Year
1A	IRISDMC A	Seismic monitoring of post-fire debris flows in northern Arizona	2019	2022
1A	GEOFON	Sri Lanka temporary broadband network	2016	2017
1A	IRISDMC A	Waste Isolation Pilot Plant Noise Analysis	2013	2013
1A	RESIF	Antartica 2009,ARLITA Eastern Antartica temporary experiment	2009	2012
1A	IRISDMC A	NCISP6	2007	2008
1B	RESIF	Italy 2021, Nodes and broadband data associated with DAS experiment at Stromboli volcano	2020	2024
1B	IRISPH5 A	Using passive seismics to determin a glacier sliding law	2019	2019
1B	IRISDMC A	Cholame Nodal Array 2018	2018	2018

Metadata Search Tools

- IRIS DS Map Service (GMAP): http://ds.iris.edu/gmap/



Data Formats

- Seismic data utilize fairly common formats and standards
- Passive and active source data tend to use different standards due to the workflow of processing
- <u>Active source</u>: commonly used formats is *SEGY*, which is better suited for stacking and closely-spaced linear arrays
- <u>Passive source</u>: *SEED, miniSEED, SAC*, *SEISAN, …*

Data Formats

- Instrument and digitizer manufacturers will predominantly use proprietary formats.
  - E.g. Nanometrics NP Binary

- Most will provide utilities for conversion to other common formats (predominantly miniSEED)

- When requesting passive source data from major datacenters, you will be receiving SEED or miniSEED data 95% of the time

Metadata Formats

- RESP
- SEED
- Dataless SEED
- STNXML

- If you are just getting started, do yourself a favour and start with STNXML. That is the modern standard, and will be the way of the future due to its extensibility

Datacentres and Data Access

- There are several key global data centres that host passive seismic data, associated metadata holdings, as well as other data types (e.g., magnetotellurics, GNSS, co-located meteorological data, etc)
- IRIS
- GEOFON (GFZ)
- GEONET
- Datasets are often duplicated between these various resources, and depending on the data protocol, they can also talk to each other transparently behind the scenes (getting better)

Datacentres

- Each of the datacentres provide similar services
  - Interrogate the metadata holdings for potentially available stations and instruments
  - Make an availability request
  - Make a data request (either in bulk or on a stream-by stream basis)
  - Query an event database or archive
- The different datacentres provide different web tools and interfaces to perform these tasks

Standardized Data Access

- One of the most common Data Access Protocols in use today, and supported by all the major data centers, is International Federation of Digital Seismograph Networks (FDSN) Web-Services
  - FDSN-WS
- This web-service protocol allows access to a structure archive of waveform data (also metadata, event data, availability) using a URL-building standardization

SAGE
Seismological Facility for the Advancement of Geoscience

EarthScope Operated by Consortium

WEB SERVICES / FDSNWS / STATION / DOCS / V. 1 / BUILDER

URL Builder: station v.1

Service interface | URL Builder | Help | Revisions

Use this form to build a URL to the **station** web service. Notice that as you edit the form, the link is automatically updated.

Usage

Network: CN

Station: HAL

Location: 00

Channel: HH*

Start Time: 2023-05-22T00:00:00

End Time: 2023-05-23T00:00:00

Level: response

Format: StationXML

Location:

All:

Lat/Lon Box:

Lat/Lon Radius:

Additional Options:

Include Restricted Channels: Yes No

Include Comments: True False

Include Data Availability:

URL Builder: station v.1

Service interface | URL Builder | Help | Revisions

Click the link:

https://service.iris.edu/fdsnws/station/1/query?net=CN&sta=HAL&cha=HH*&starttime=2023-05-22T00:00:00&endtime=2023-05-23T00:00:00&level=response&format=xml&includecomments=true&nodata=404

Station: HAL

Location: 00

Channel: HH*

Start Time: ☑ 2023-05-22T00:00:00

End Time: ☑ 2023-05-23T00:00:00

Level: response

Format: StationXML

All: ◉

Lat/Lon Box: ○

Lat/Lon Radius: ○

Additional Options:

Include Restricted Channels: ◉ Yes ○ No

Include Comments: ◉ True ○ False

Include Data Availability: ☐

URL Builder: dataselect v.1

Use this form to build a URL to the **dataselect** web service. Notice that as you edit the form, the link is automatically updated.

Usage

Network:	CN
Station:	HAL
Location:	00
Channel:	HH*
Start Time:	☑ 2023-05-22T00:00:00
End Time:	☑ 2023-05-23T00:00:00
Quality:	-
Format:	miniSEED
Minimum Length (seconds):	0.0
Longest Only:	☐
Use Authentication:	☐

URL Builder: dataselect v.1

Service interface | URL Builder | Help | Revisions

Use this form to build a URL to the **dataselect** web service. Notice that as you edit the form, the link is automatically updated.

Usage

Click the link:
https://service.iris.edu/fdsnws/dataselect/1/query?net=CN&sta=HAL&cha=HH*&starttime=2023-05-22T00:00:00&endtime=2023-05-23T00:00:00&format=miniseed&nodata=404

Channel: HH*

Start Time: [x] 2023-05-22T00:00:00

End Time: [x] 2023-05-23T00:00:00

Quality: -

Format: miniSEED

Minimum Length (seconds): 0.0

Longest Only: [ ]

Use Authentication: [ ]

Standardized Data Access…

- OBSPy (Python) has become one of the leading seismic data processing and analysis tools
- It has FDSN web services built directly into its core, making the automating and scripting of data access extremely simple compared to how these systems used to operate:
    - Identify stations
    - identify time windows
    - send a data request to a data centre (breq_fast, autodrm)
    - receive data (ftp, CD Rom, Exabyte tape)
    - unpack waveforms
    - convert to processable format…