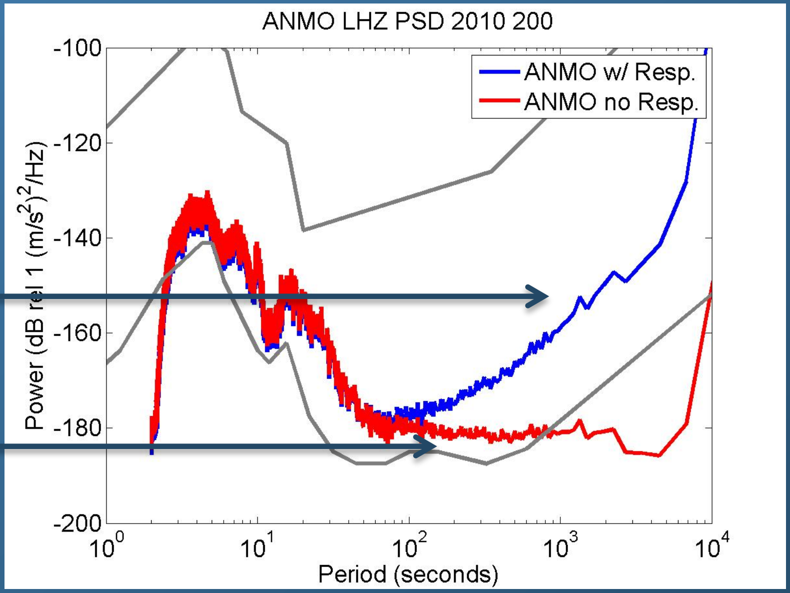
ASL Calibration processing

Calibrations now performed at every station on an annual basis.

- Characterize the overall shape of the instrument's response
  - Important for describing gain outside the pass-band of the instrument
- Identify instruments that may be producing compromised data
  - Deviations from a nominal response can indicate a problem with instrument (Hutt and Ringler, 2010)

Spectrum with response corrected

Spectrum with no response correction



Theoretical Model

Input into seismometer is ground motion, but output is ground motion convolved with instrument response

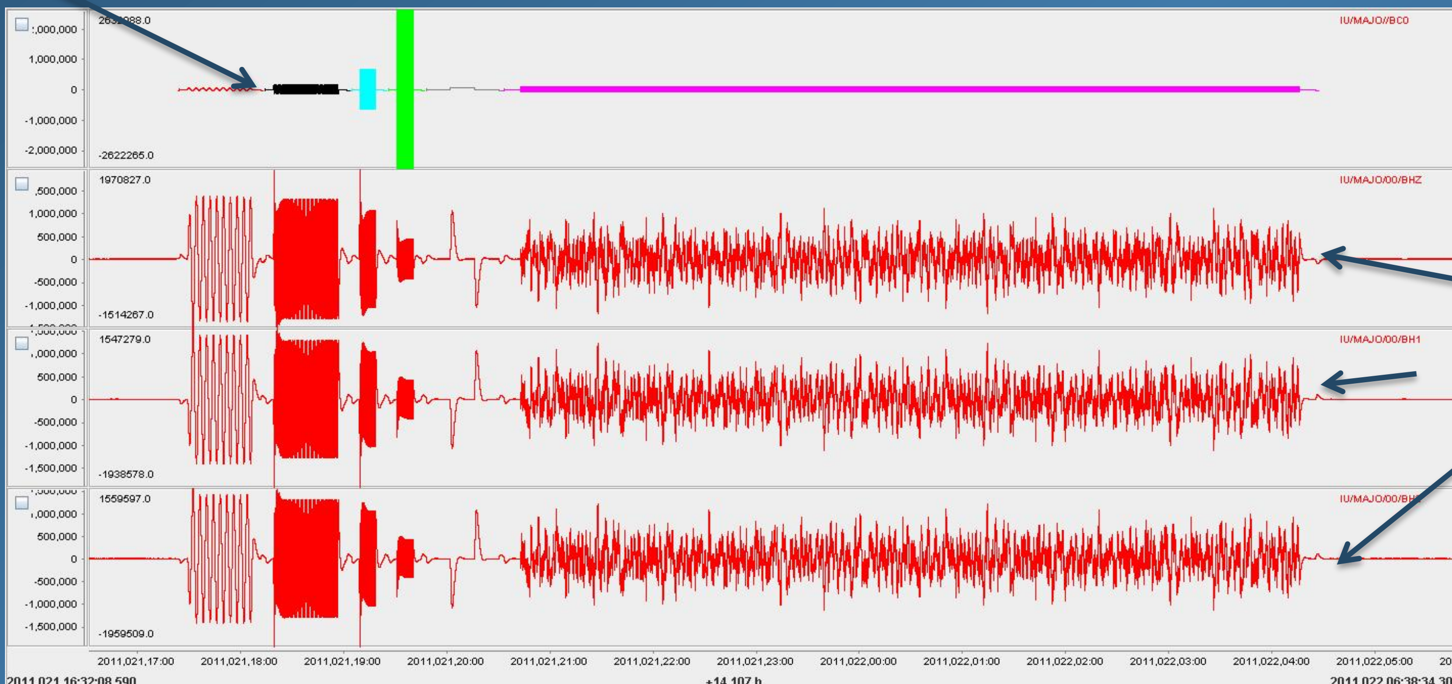
Ground motion * Response = Seismogram

Need to solve for instrument response

Running the Calibration

Inject known signal into seismometer using the calibration coil

Input signal



Seismometer output

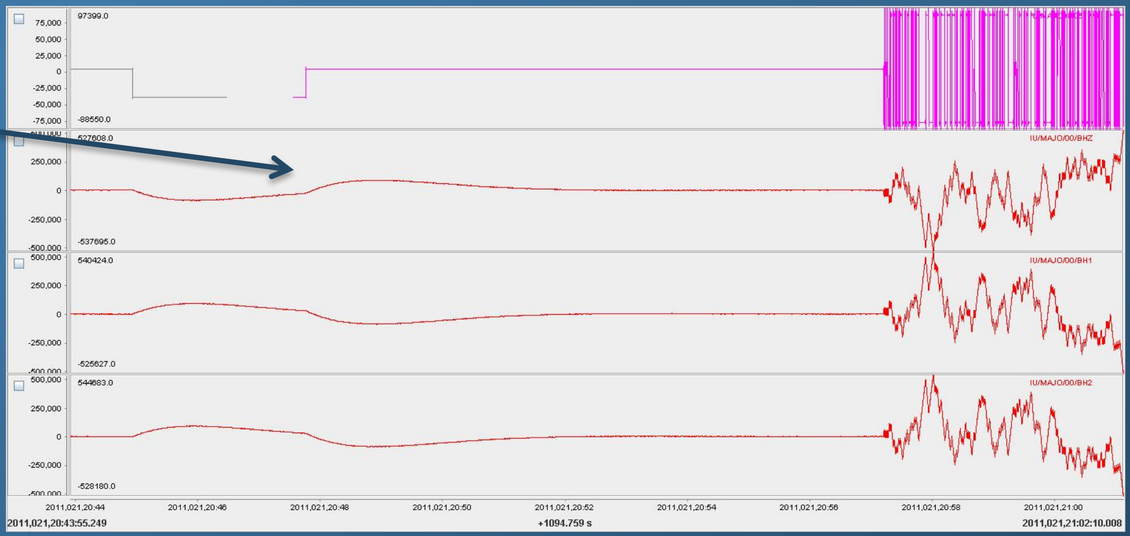
Calibration sequence for the STS-1 at MAJO (Matsushiro, Japan). The sequence is a collection of sines, followed by a step cal, and finally a random cal.

Running the Calibration

Make sure the calibration signal is well above the station noise with no large earthquakes during the time period

Let once the calibration coil relay turns on let the instrument settle before starting the calibration

Calibration relay pulse



Running the Calibration

Sine and step calibrations can be used to visually check if instrument sensitivity and response is correct.

For detailed analysis, we focus on the random binary calibration.

Calibration analysis is done in the frequency domain using very long time windows (8 hours long). This ensures a high quality measurement of the very long period instrument response (STS-1's have a 360 second, long period corner).

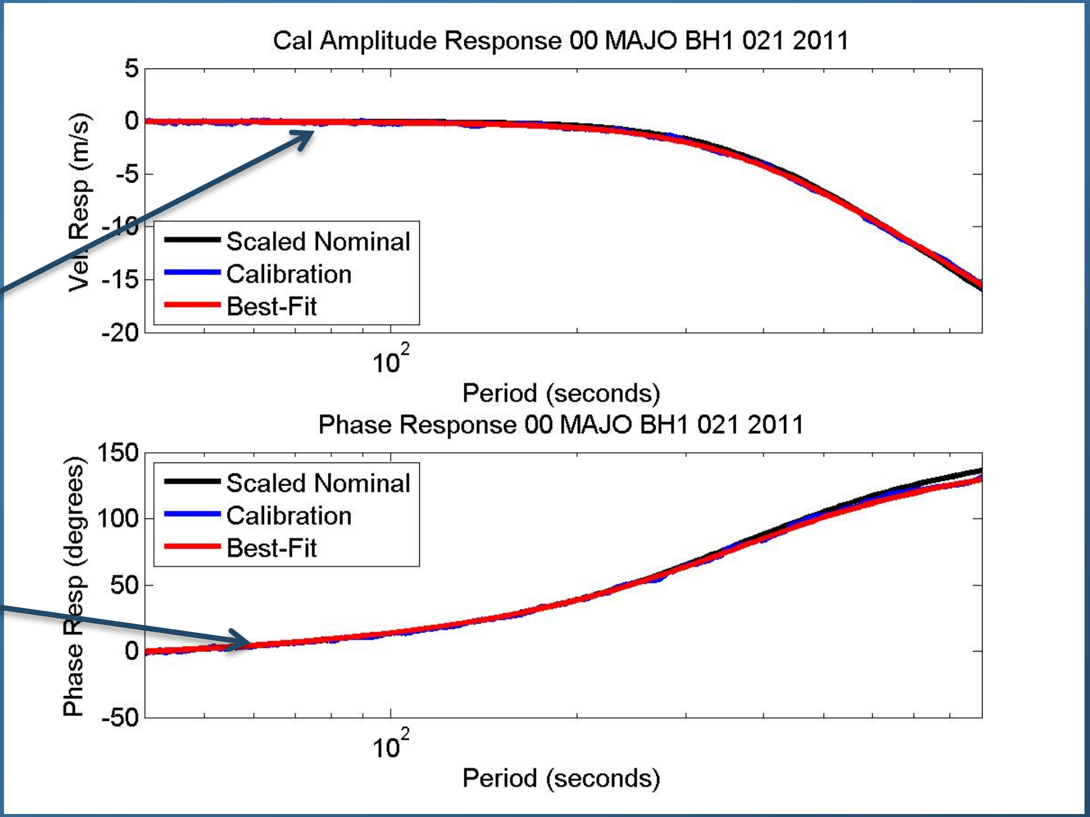
Analysis of the calibration

- Divide input signal by output signal to get response in the frequency domain this gives you a table of frequencies and their associated phases and amplitudes

Response can be described by two parts:

Amplitude (Top)

Phase (Bottom)



Analysis of the Calibration

- From response curve need to derive a model for the response (rational function with a number of poles and zeros)

- Estimate model using a non-linear inversion to minimize difference between model and response curve

$$\underline{p}_{bestfit} = \min_{p} \int \left(\frac{A_{cal}(f) - A_{mo}(\underline{p}, f)}{\max(A_{mo}(\underline{p}_{nom}, f))} \right)^2 + \left(\frac{\theta_{cal}(f) - \theta_{mo}(\underline{p}, f)}{\max(\theta_{mo}(\underline{p}_{nom}, f))} \right)^2 df.$$

Amplitude part

Phase part

Result

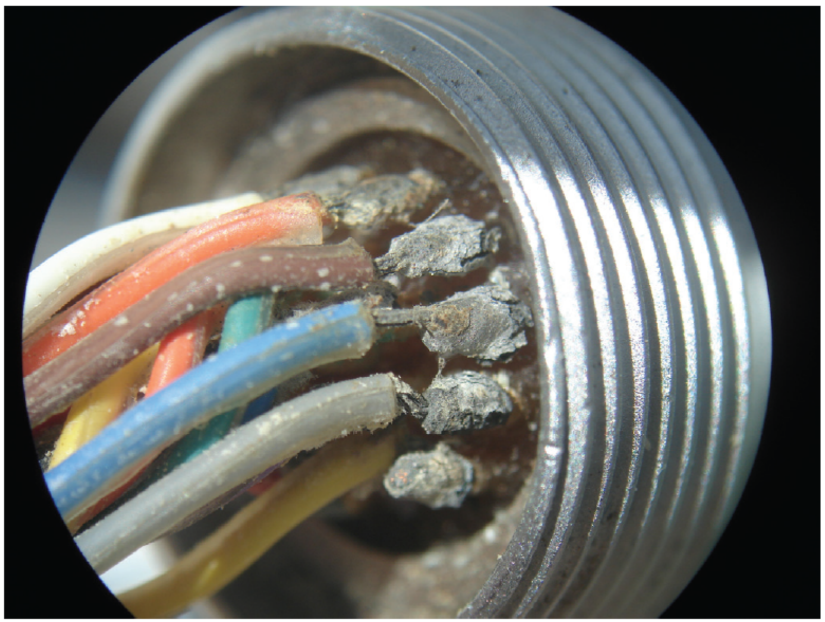
- From the inversion you get a collection of poles and zeros and various measurements of goodness of fit:

```
# Complex zeroes:
    # i real imag real_error imag_error
    B053F10-13 0 +0.000000E+00 +0.000000E+00 +0.000000E+00 +0.000000E+00
    B053F10-13 1 +0.000000E+00 +0.000000E+00 +0.000000E+00 +0.000000E+00
    B053F10-13 2 -1.329203E-02 0.000000E+00 4.759420E-04 0.000000E+00
    B053F10-13 3 -1.329203E-02 0.000000E+00 4.759420E-04 0.000000E+00
    # Complex poles:
    # i real imag real_error imag_error
    B053F15-18 0 -1.225218E-02 1.222000E-02 4.393788E-04 7.241187E-04
    B053F15-18 1 -1.225218E-02 -1.222000E-02 4.393788E-04 7.241187E-04
    B053F15-18 2 -7.658754E-03 0.000000E+00 1.202827E-02 0.000000E+00
    B053F15-18 3 -1.956167E-02 0.000000E+00 4.291105E-03 0.000000E+00
    B053F15-18 4 -3.918000E+01 +4.912000E+01 +0.000000E+00 +0.000000E+00
    B053F15-18 5 -3.918000E+01 -4.912000E+01 +0.000000E+00 +0.000000E+00
```

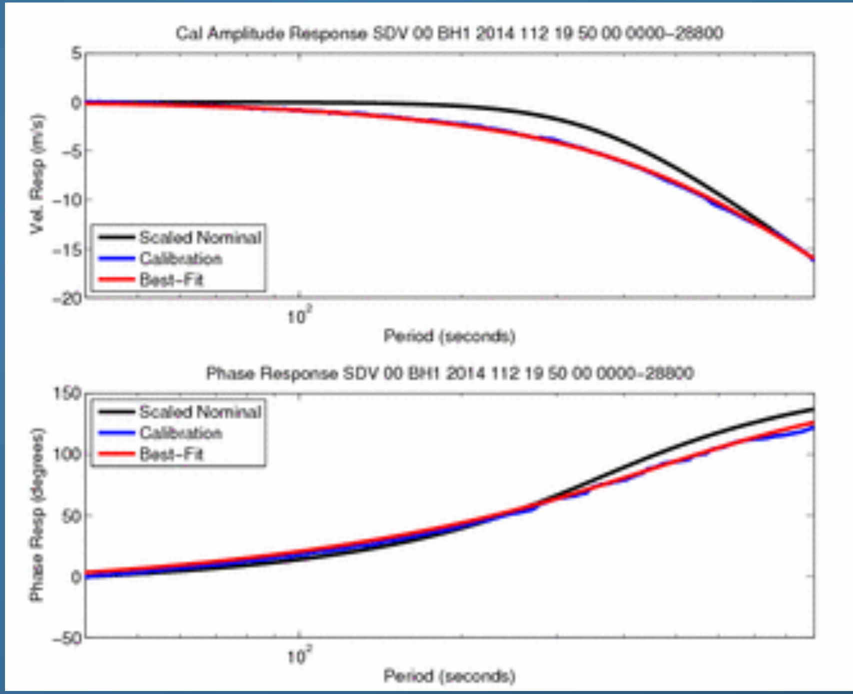
Calibration Successes

Identification and correction of response problems in STS-1’s.

- Metadata corrected to show overdamped response where possible.
- Cables rebuilt and potted to seal out moisture.



▲ **Figure 9.** Magnified view of connector pins from one of the STS-1 seismometer baseplates at GSN station KMBO. This corrosion resulted in electrical leakage between conductors, which caused an over-damped long-period response.



Hutt, C. R. and A. T. Ringler (2011). Some possible causes of and corrections for STS-1 response changes in the Global Seismographic Network, *Seis. Res. Lett.,* 82 (4), 560-571.

Thank You!

References

Hutt, C. R. and A. T. Ringler (2011). Some possible causes of and corrections for STS-1 gain changes in the Global Seismographic Network, *Seismological Research Letters,* **82**, 484-495.

Ringler, A. T., C. R. Hutt, R. Aster, H. Bolton, L. S. Gee, and T. Storm (2012). Estimating pole/zero errors in GSN-IRIS/USGS network calibration metadata, *Bulletin of the Seismological Society of America,* in press.

http://earthquake.usgs.gov