

### SensOrLoc

Albuquerque Seismological Laboratory





Setup independent station next to a permanent station to verify:

**Sensitivity** 

+

Orientation

+

Location

=

SensOrLoc



### **Details**

### SensOrLoc

Sensitivity, Orientation, and Location Checking Procedures at GSN and ANSS Stations

CRH

Version 2: 5 Feb 2008

The purpose of these procedures is to accurately check the sensitivity, orientation, and location of all seismic sensors at seismic stations without disturbing the installed sensors at the stations.

### Outline of steps:

Step 1: Calibrate reference system (seismometer and Q330 data logger with baler) at ASL.

Step 2: Ship reference system and orientation-determining equipment to station.

Step 3: Determine and mark reference azimuth where reference seismometer will be installed

Step 4: Set up reference system at station in a quiet environment.

Step 5: Record data on reference data logger overnight or during a quiet period while station system is recording data.

Step 6: Download data from baler onto laptop for safekeeping and transport back to ASL. Do not wipe the baler!

Step 7: Check sensitivity of station data logger channels using voltage reference.

Step 8: Determine location of station GPS antenna and location of station seismometers relative to station GPS antenna (this step may be done at any time – order

**seismometers** relative to station GPS antenna (this step may be done at any time – order is not important).

Step 9: Ship reference system and orientation-determining equipment back to ASL or to next site to be checked.

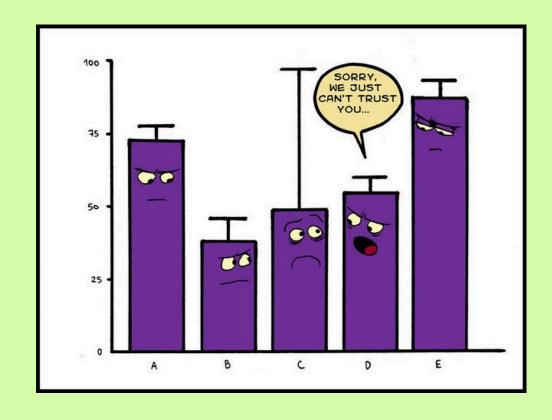
Step 10: At ASL, calibrate reference system again.

Step 11: Archive data from reference system in Data Center.

Step 12: QC analysts will compare data from station and reference system to determine sensitivity and orientation of station seismometer relative to reference seismometer.

## HIOW GOOC DO WE DO THE

Need to be able to measure and describe instrument parameters AND their errors





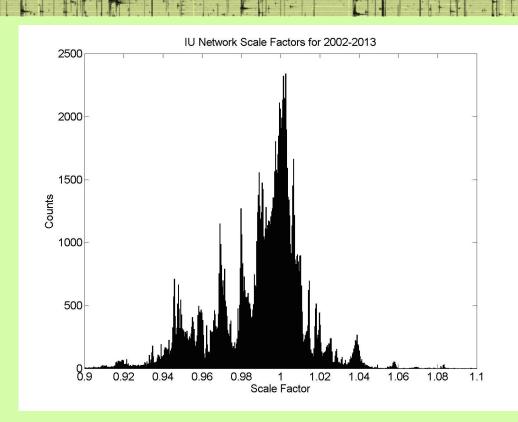
## Upper Bound on Sensitivity Error

±6% with 99<sup>th</sup> percentile confidence

±3.6% with 99<sup>th</sup> percentile confidence for 2012

Only estimating differential assuming no bias





145,972 daily vertical microseism (4 to 8 s) amplitude ratios between co-located sensors at IU stations (2002 to 2013)

## Lower Bound on Sensitivity



Vertical ASL table

**1**σ Error

Calibration	Vertical Sensitivity (V/m/s)	Error (V/m/s)
04/2011 Streckeisen	1500	15
06/2012 ASL	1502.58	0.26
11/2013 Conrad	1507.11	1.98
01/2014 ASL	1520.38	2.3



Step tested one STS-2.5 four times 1.5% with 99<sup>th</sup> percentile confidence

**Errors in Orientation** 

Finding North: 0.0048°±0.0035° (Gyro compass)

Transferring a North Line: 0.089°±0.11°

Installing the Sensor: 1.2°±0.91° (Long STS-2 rod)

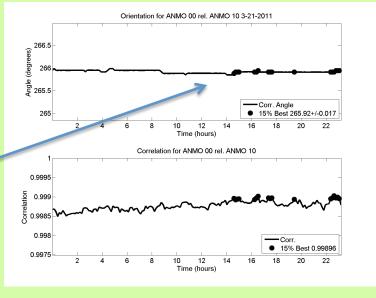
Differential Estimate: Limited by horizontal noise

Total (Worst Case): 2.82° with 95% confidence

E.G.: ANMO 00 to 10 less than 0.017°



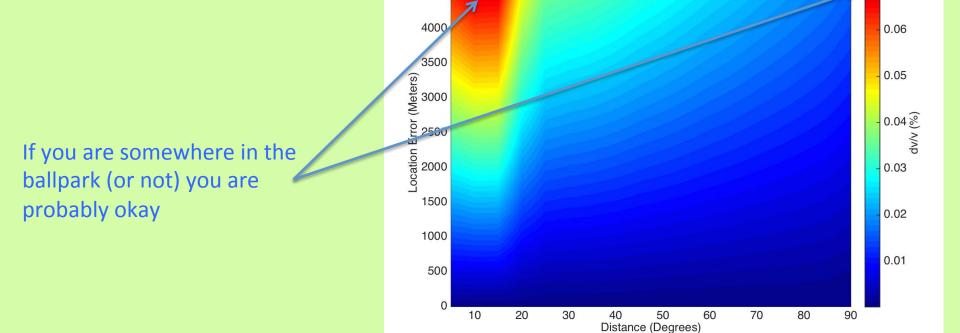




## Location Lirror (who cares?)

5000

4500





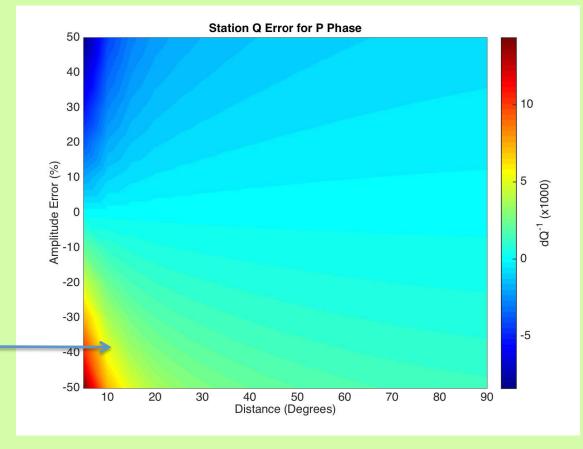
P-wave mantle velocity error as a function of event distance with a known sensor location error

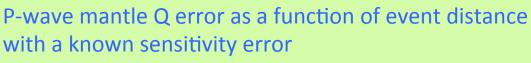
**Station Location Travel Time Error P phase** 

0.07

### Sensitivity Error (Weldo care)

Nearby events at stations with sensitivity errors could be interpreted as mantle structure







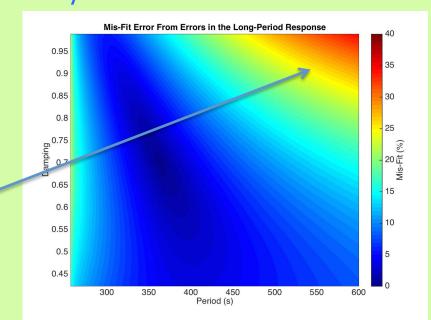
Can calibrate to ≈1.5%

Fielded instruments appear to be ≈3.6%

Orientation <2.82° assuming not dominated by horizontal noise

Long-Period damping and free-period also important (describe the poles/zeros well)





## Thenks for Listening





# Raferences - Line - Lin

Ringler, A. T., T. Storm, L. S. Gee, C. R. Hutt, D. Wilson (2014). Uncertainty estimates in broadband seismometer sensitivities using microseisms, J. Seismol., doi:10.1007/s10950-014-9467-7.

Ringler, A. T., C. R. Hutt, and K. Persefield (2013). Seismic station installation orientation errors at ANSS and IRIS/USGS stations, Seis. Res. Lett., 84 (6), 926-931.

Ringler, A. T., C. R. Hutt, R. Aster, H. Bolton, L. S. Gee, and T. Strom (2012). Estimating pole-zero errors in GSN-IRIS/USGS network calibration metadata, Bull. Seis. Soc. Amer., 102 (2), 836-841.

Ringler, A. T., J. D. Edwards, C. R. Hutt, and F. Shelly (2012). Relative azimuth inversion by way of damped maximum correlation estimates, Comp. and Geosci., 43, 1-6.

