

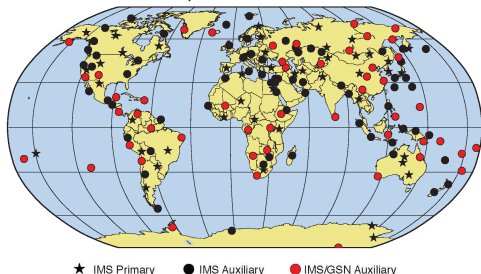
New High Quality VBB Borehole Sensor Upgrades and Additional Atmospheric Sensors at Global Seismographic Network (GSN)

Katrin Hafner (IRIS, hafner@iris.edu), Peter Davis (UCSD/IDA, pdavis@ucsd.edu), David Wilson (USGS/ASL, dwilson@usgs.gov),
Andy Frassetto (andfr@iris.edu), Carl Ebeling (cebeling@ucsd.edu)

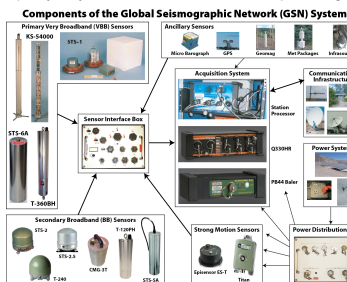


Upgrades in High Quality Instrumentation

The Global Seismographic Network is a multi purpose high quality seismic network that has been in operation for over 20 years. The data from its stations are used for fundamental research for earth processes, earthquake monitoring, tsunami warning, and nuclear explosion monitoring. Fifty of the GSN stations are co-located with the CTBTO Auxiliary Seismic Stations as shown in the map below.

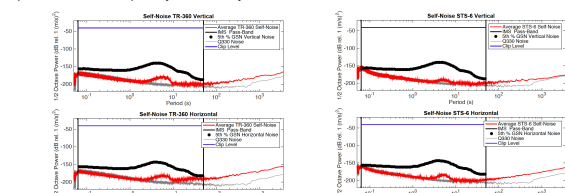


Beginning in July 2017, the GSN began to replace aging KS-54000 borehole sensors initially installed in 100 meter deep boreholes at ~40 of the GSN stations. In this poster we present the results of the deployment of this next generation of borehole/posthole sensors, their performance relative to IMS specifications, and their effect on improved station noise performance, particularly at longer periods. We also demonstrate how these new borehole sensors may provide a replacement for the STS-1 sensors still deployed at some high quality very broadband seismic stations operated globally by the GSN and other networks.



A variety of geophysical instruments are currently deployed at GSN stations. The very broadband seismic sensors are a key component for meeting GSN design goals and have consisted of KS-54000 borehole sensors and STS-1 vault sensors since the network's inception. Unfortunately, these sensors are now beginning to fail and are no longer manufactured. The GSN has begun deploying the Streckeisen STS-6A and Nanometrics T-360 borehole sensors to replace the KS54000. Note: There is currently no VBB vault sensor replacement for the STS-1.

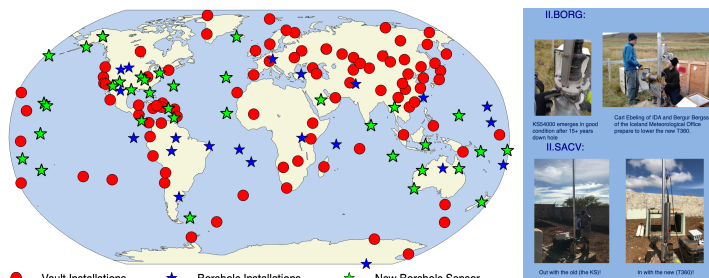
The newly deployed VBB borehole seismometers have improved self-noise characteristics and broader bandwidth than the generation of sensor they are replacing and also meet the pass-band sensor specifications for IMS primary and auxiliary seismic stations.



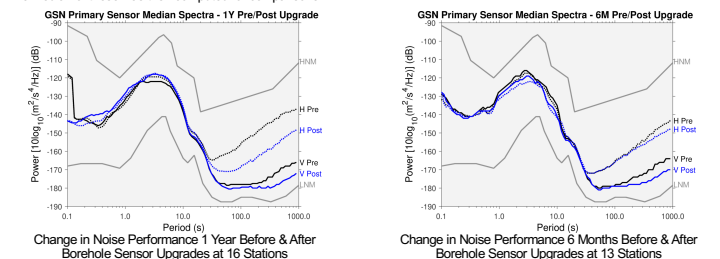
Self-noise analysis for T-360 (left) and STS-6A (right) seismometers (red) with vertical (top) and horizontal (bottom) components. The 5th Percentile noise levels for the Global Seismograph Network (GSN) secondary sensors are denoted by black dots. The vertical black bars show the pass-band for the IMS primary and auxiliary sensor specifications. The Quattera Q330 HR terminated input noise is shown in grey. The clip level is shown in blue.

Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

Deployment Methods and Performance of New VBB Borehole Sensors

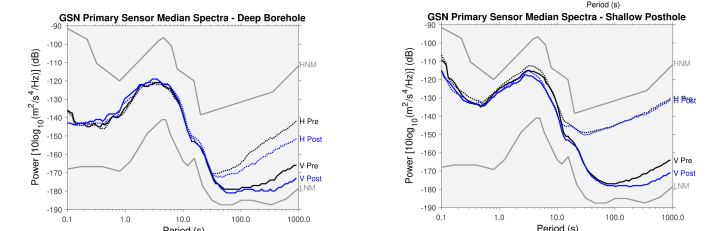


In the following examples, we compare the median spectral power for the vertical and horizontal components at upgraded GSN stations. These were extracted from the probability density function of power spectral density calculated by MUSTANG (<http://services.iris.edu/mustang/noise-nsd/1/>). For periods >14 sec., we used PSDs that were derived from the LH channel and calculated from a 3 hour window. For periods <14 sec., we used the BHHH channel which calculated PSDs using a 1 hour window. The median of these was then computed for comparisons.



We observe significant improved noise performance in both the vertical and horizontal channels at newly installed borehole stations, especially at the longer periods. Note that it appears to take the horizontal components longer to settle after installation as seen by the smaller change in the horizontal values after six months relative to one year.

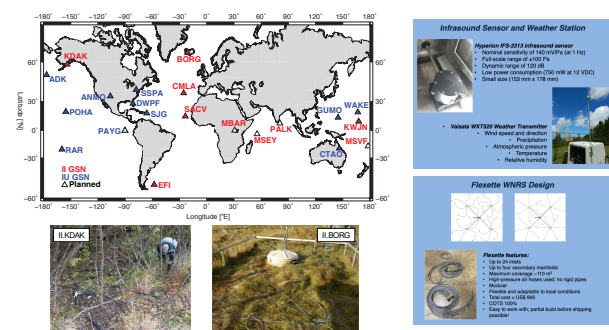
The GSN has been evaluating new borehole sensor installation techniques in order that maximize the noise performance of seismic instruments deployed at GSN sites. At IU.TUC an STS-6A was installed in a one meter deep posthole drilled through the pier into bedrock. To the right we compare the performance of the borehole sensor to the STS-1 installed on top of the pier.



Comparing the performance of the vertical and horizontal channels for sensors installed in boreholes from ~30 to 100 meters depth) with those installed in shallow postholes (one meter or less). It appears that the shallow installation technique provides approximately the same improvement in vertical performance, but horizontal improvements for those six stations are much less significant. (This does not take into consideration different site conditions.)

New Atmospheric Sensors

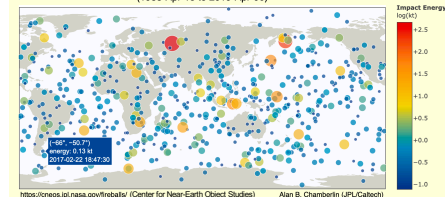
The GSN is diversifying the instruments installed at stations to broaden the variety of geophysical data collected. These instruments include meteorological stations and infrasound sensors intended to augment the infrasound network already deployed as part of the CTBTO's International Monitoring System and the IRIS Transportable Array.



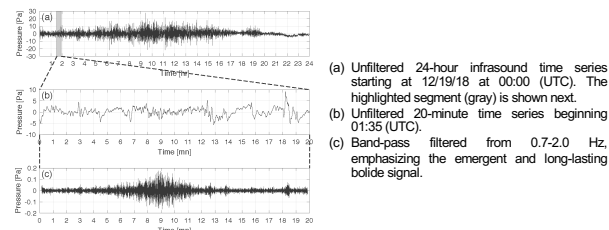
Sixteen stations in the IRIS/IDA (II) and IRIS/USGS (IU) networks that have added infrasound sensors and wind-noise-reducing systems. Five future installations are also marked.

Kamchatka/Bering Sea Bolide Event – December 2018

Fireballs Reported by US Government Sensors
(1988-Apr-15 to 2019-Apr-06)



Infrasound time series of the bolide event at the GSN station II.KDAK (Kodiak, Alaska). The explosion, which radiated an estimated 1.3×10^{11} kJ, took place at 12/18/18 at 23:48:20 (UTC). The bolide was 2100 km at an azimuth of 282.2 degrees from KDAK and traveling at an altitude of 25.6 km at 32.1 km/s when it exploded.



Acknowledgements

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