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# Maintaining High Quality Network Performance at the GSN: Sensor Installation Methods, New VBB Borehole Sensors and Data Quality Assessment from MUSTANG

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The goal of the Global Seismographic Network (GSN) is to provide the highest possible data quality and dynamic recording range in support of scientific needs. Considerable effort is made at each GSN seismic station site to achieve the lowest noise performance possible under local conditions. We continue to strive for higher data quality with a combination of new sensors and improved installation techniques. Most seismometers are installed either in 100 m deep steel-cased boreholes or in vaults tunneled underground. A few vaults are built at the surface or on the foundation of a building. All vault installations have a concrete pier, mechanically isolated from the floor, upon which the seismometers are placed. Many sites are now nearly 30 years old, and the GSN is investing in civil works at several stations to keep them in good condition or make critical repairs.

Using GSN data from inception to the present, we will present analyses that demonstrate how successful these sensor installation strategies have been and describe ongoing experiments at GSN testing facilities to evaluate the best, most cost effective strategy to modernize existing GSN facilities. To improve sensor performance at some vault sites, we will employ new sensor installation strategies. Years of experience operating the GSN and the USArray Transportable Array, along with focused testing of emplacement strategies, show that the vulnerability of a sensor's horizontal components to tilt can be mitigated if the sensor package is buried at even shallow depth. At selected vault installations, shallow boreholes will be drilled to accommodate recently developed borehole VBB sensor models. The incremental cost of modern VBB instruments over standard BB models is small, and we expect to be able to preserve the GSN's crucial very broad bandwidth while improving noise performance and reliability using this strategy.

A crucial link in making GSN station data available to the scientific community is the IRIS Data Management Center, which not only maintains the data archive, but also provides easy, rapid, and open access to data recorded from seconds to decades ago. All data flow to the IRIS DMC through the UCSD or ASL Data Collection Centers (DCCs). The DCCs focus on delivering data to the DMC, maintaining correct metadata for GSN stations, reviewing data quality from the stations that ASL and UCSD operate, and addressing circumstances that require special data handling, such as back filling following telemetry outages. Key to the high quality of the GSN data is the direct feedback on data quality problems identified by the DCC analysts to the network operations staff and field engineers. Aging of GSN equipment and station infrastructure has resulted in renewed emphasis on using data quality control tools such as MUSTANG. These tools allow the network operators to routinely monitor and analyze waveform data to detect and track problems and develop short and longer term action plans for improving network data quality. We will present summary data quality metrics for the GSN as obtained via these quality assurance tools.