UNAVCO GNSS Data: Real-time High-rate Streams, Geodetic Earthquake Magnitudes, Cloud Computing and Future Machine Learning Frameworks

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UNAVCO provides a diverse suite of geodetic data, derived products and cyberinfrastructure services to support the geodetic community, Earth science research and education. We present here an overview of recent developments related to real-time GNSS data streams, GNSS earthquake magnitude estimation, a new project focusing on machine learning for geoscience and hazards research, and cloud based GNSS data analysis experiments. UNAVCO operates the National Earth Science Geodetic Facility through a cooperative agreement with the U.S. National Science Foundation (NSF) and NASA.

Real-time (<2 seconds) high-rate (1 Hz) GNSS (RT-GNSS) data streams are now provided from ~900 UNAVCO sites. Streams include raw data in BINEX and RTCM3, and PPP solutions in ITRF2008 via Trimble PIVOT RTX software. Most UNAVCO RT-GNSS sites are within the Network of the Americas (NOTA). NOTA, which includes the historic Plate Boundary Observatory (PBO) network, is an extensive network of GNSS reference stations and other geophysical instruments in the United States, Mexico, Central America, the Caribbean and parts of South America. The network advances research into Earth systems from the core to the atmosphere. Recent advances include improved plate tectonic models, understanding earthquakes and slow slip/episodic tremor, measuring surface water load, deciphering ionospheric dynamics and measuring changes in permafrost. Beyond research the network provides information for earthquake and tsunami early warning systems (EWS), severe weather and space weather forecasts, volcanic activity alerts, drought and flood monitoring and other risk assessments. UNAVCO data are open access; an objective of the geodetic community is to enhance data access and data use for global hazard risk reduction.

Following an earthquake, RT-GNSS data streams can record peak ground displacement (PGD) measurements from long-period surface waves and provide a source-scaling relation that does not saturate with event magnitude. “Geodetic magnitudes” derived from RT-GNSS data can be estimated within seconds to minutes after an earthquake, and can improve earthquake and tsunami EWS. Dynamic displacements estimated in real time show reasonable agreement with post-processed estimates. And while individual position estimates have large errors, RT-GNSS solutions offer excellent operational potential for EWS, including the use of PGD to directly invert for finite-fault solutions. We will show PGD and geodetic magnitude estimate results from recent earthquakes including the 2018-11-30 Mw 7.0 Anchorage, Alaska earthquake. PGD’s from this earthquake were calculated automatically from the RT-GNSS displacement traces, which were large enough and recorded by enough sites to determine that, using GNSS data only, the event was ~M7 within 120s.

As the number of RT-GNSS sites increases, the volume of data and the complexity of automated analysis increase as well. When other data streams are factored in, such as seismic, ocean bottom pressure and satellite radar, the shear volume and complexity of these data streams, coupled with the need to model, analyze and assess hazards in a matter of only minutes, makes geophysical applications to hazards early warning a Big Data problem. To address this, UNAVCO is collaborating in an NSF project called “GeoSCIFramework: Scalable Real-time Streaming Analytics and Machine Learning for Geoscience and Hazards Research.” This project unites computer scientists and geoscientists to develop a data framework for generalized real-time streaming analytics and machine learning for geoscience and hazards research. The goals of this project, which was just initiated, will be presented.

In addition to real-time products, UNAVCO also provides post-processed position time series and velocities from 2000+ GNSS stations. These products are based on daily solutions generated using GIPSY PPP and GAMIT/GLOBK double-difference network software. This software is currently run on local computing clusters. As part of an NSF funded project called GeoSciCloud, we are testing our GIPSY and GAMIT workflows in two cloud computing environments: Amazon Web Services and NSF’s Extreme Science and Engineering Discovery Environment (XSEDE). The IRIS seismic data facility is a collaborative partner on this project and conducted similar experiments using seismic software and data. We summarize our latest findings from these cloud computing experiments including performance and cost relative to local systems.

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