UNAVCO GNSS Data, Analyses and Products for Seismogeodetic Studies and Early Warning Applications

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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 these resources as applied to earthquake studies at various time scales, from decadal time series to real time seismogeodetic peak ground displacement (PGD) estimates, using GNSS data from the Plate Boundary Observatory (PBO) and other regional networks. Results from analyses of real time and post-processed GNSS data products from recent earthquakes in Mexico and Alaska are highlighted.

UNAVCO provides post-processed decadal position time series and velocities for 2000+ GNSS stations. These products are based on daily position solutions generated by analysis centers using GIPSY Precise Point Positioning (PPP) and GAMIT/GLOBK double-difference network software. Time series and velocities are currently provided in ITRF2008 and North America fixed reference frames, and we are in the process of transitioning to ITRF2014. The position time series contain a multitude of offsets associated with coseismic and postseismic displacements, interseismic strain accumulation, episodic tremor and slip, and other natural and anthropogenic processes. Following an earthquake, post-processed coseismic offsets are estimated from a short span of data (~2 days) on either side of the event. Over time, coseismic offsets and postseismic log terms are also estimated from Kalman filter time series analyses.

UNAVCO also provides high-rate (1 Hz), low latency (<2 seconds) real time GNSS (RT-GNSS) data streams from 800+ stations. In contrast to post-processed daily solutions, these streams support investigation of coseismic and postseismic displacements at time scales of seconds to hours, in real time. In the case of earthquakes, these streams can record PGD from long-period surface waves and can provide a source-scaling relation that does not saturate with event magnitude. “Geodetic magnitudes” derived from RT-GNSS data streams can be estimated within seconds to minutes after an earthquake, and have the potential to improve earthquake and tsunami early warning systems. UNAVCO currently produces and distributes RT-GNSS raw data (BINEX and RTCM3) and PPP solutions in ITRF2008 via Trimble PIVOT (RTX) software.

The 2017-09-08 M8.2 Tres Picos, Mexico earthquake was the first great earthquake to occur within the UNAVCO RT-GNSS network. We compared and quantified the relative processing strategies for producing static offsets, moment tensors and geodetically determined finite fault models using data recorded during this event. We found that dynamic displacements estimated in real time show reasonable agreement with post-processed position estimates. And while individual position estimates have large errors, the RT-GNSS solutions offer an excellent operational input for early warning systems, including the use of estimated PGD for directly inverting for finite-fault solutions. The 2018-01-23 M7.9 Kodiak, Alaska earthquake was also recorded by the UNAVCO RT-GNSS network and similar analyses were performed. A geodetic magnitude of M7.8 was calculated within minutes of this event based on inversion of PGD estimates. The geodetic magnitude could have been calculated much more quickly if there were RT-GNSS stations closer to the hypocenter, but even with the nearest station being ~300 km away, it was clear within ~90 seconds that the earthquake magnitude was >M7.2 and that seismic magnitude estimates might have saturated.

Our data and findings suggest that RT-GNSS has excellent potential to improve earthquake and tsunami early warning systems in the future.

Keywords: Geodesy, GNSS, Earthquake Early Warning, Tsunami Early Warning, Peak Ground Displacement

