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Monuments Matter: Resolving Peak Ground Displacements in Real-Time GNSS PPP Solutions as applied to Earthquake Early Warning, an assessment of the M8.2 September 2017 Tehuantepec Earthquake.

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The goal of early earthquake warning (EEW) systems is to provide warning of impending ground shaking to the public, infrastructure managers, and emergency responders. Shaking intensity can be estimated using Ground Motion Prediction Equations (GMPEs), but only if general site characteristics, hypocentral distance and event magnitude are known. In recent years, effort has been focused on analyzing the first few seconds of the seismic P wave to derive event location and magnitude. While initial rupture locations seem to be sufficiently constrained, we know now that P-wave magnitude estimates tend to saturate at M>7. Regions where major and great earthquakes occur therefore may be vulnerable to underestimation of shaking intensity, if magnitudes are only estimated from P wave amplitudes. Crowell et al., (2013) first demonstrated that Peak Ground Displacement (PGD) from long-period surface waves recorded by GNSS receivers could provide a source-scaling relation that does not saturate with event magnitude. GNSS PGD derived magnitudes could therefore improve the accuracy of EEW GMPE calculations.

UNAVCO currently operates ∼770 real-time GNSS sites, most of which are located along the North American-Pacific Plate Boundary. In this study, we present an analysis of noise levels observed in real-time GNSS Precise Point Positioning (PPP) solutions generated and distributed in real-time by UNAVCO for periods from seconds to hours. We compare noise levels determined from various monument types and receiver-antenna configurations. This analysis provides a robust estimate of noise levels in PPP solutions because the position estimates used in the analysis are those that were generated in real time and thus contain all the problems observed in routine network operations e.g., data outages, high latencies, and data from research-quality to less than geodetic monumentation. Using these noise estimates, we can identify which sites are best able to resolve the PGDs for earthquakes of variable magnitude.

The 2017-09-08 earthquake M8.2 located 98 km SSW of Tres Picos, Mexico is the first great earthquake to occur within the UNAVCO-operated RT-GNSS footprint; accordingly, this provides a raw opportunity for rigorous analysis of our dynamic and static processing methods. We compare and quantify the relative processing strategies for producing static offsets, moment tensors and geodetically determined finite fault models using data recorded during this event. Dynamic displacements, estimated in real time show good agreement with final, post-processed position estimates, and while individual position estimates have large errors, the real-time solutions offer an excellent operational option for EEW systems, including the use of estimated peak-ground displacements or directly inverting for finite-fault solutions. In the near-field, we find that the geodetically-derived moment tensors and finite fault models differ significantly with seismically-derived models, highlighting the utility of using geodetic data in hazard applications.