The BARD Continuous GPS Network: Monitoring Earthquake Hazards in Northern California and the San Francisco Bay Area

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The Bay Area Regional Deformation (BARD) network of permanent, continuously operating GPS receivers monitors crustal deformation in the Bay Area and northern California. With measurements spanning nearly two decades, the BARD network is uniquely equipped to address longer-term deformation and its variability. The BSL maintains and/or has direct continuous telemetry from 33 stations comprising the BARD Backbone, while additional stations operated by the USGS, US Coast Guard and others fill out the extended BARD network. Twenty BARD Backbone sites are collocated with broadband seismic stations of the Berkeley Digital Seismic Network (BDSN), with which they share continuous telemetry to UC Berkeley. All BARD Backbone stations collect data at 1 Hz sampling frequency and have real-time data streams available to the public (http://seismo.berkeley.edu/bard/realtime). Together, PBO, USGS, and BARD stations provide valuable information on the spatial complexity of deformation in the San Francisco Bay Area and Northern California, while the BARD network has the infrastructure and flexibility to additionally provide information on its temporal complexity over a wide range of time scales and in real-time.

With support from the Gordon and Betty Moore Foundation, we have been working on integrating information from GPS into earthquake early warning (EEW) algorithms and have implemented this in the G-larmS module. G-larms is triggered by the seismic EEW system and is designed to enhance the existing system by providing improved estimates of magnitude and fault length for large earthquakes. Once triggered, it estimates the static offset at each station pair from the TrackRT output and inputs these into an inversion for fault slip on a pre-defined plane, which is updated once per second. This past year, G-larmS matured to production quality and demonstrated its functionality and utility for the first time during the M_w 6.0 South Napa earthquake. G-larmS' performance during this event, and in 13 aftershocks that had no measurable surface offsets, demonstrate that, in combination with the seismic early warning magnitude, M_w 6.0 is our current resolution limit. The first distributed slip model and magnitude estimates for the main shock were available 24 s after the event origin time (Fig. 1), which, after optimizations and reanalysis of the event in simulated real-time, could be reduced to 14 s (~8 s S-wave travel time, ~6 s data latency). However, to lower the computational cost, the solution for this event was based on the simplifying assumption that an earthquake would occur on a fault that is parallel to the San Andreas Fault. Since that time, we have begun implementing parallelized processing in G-larmS. Currently, this allows us to define multiple fault geometries that are predominant in different regions of California and convert the measured offsets to slip on each of these. The geometry, slip orientation and magnitude that best fit the data will be published to the early warning system as an updated solution every second.