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Robust Animation of Time Variable Earth Surface Deformation using 3D GPS Imaging: Example of the Central Walker Lane and Long Valley Caldera

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GPS observations from a stack of vertical position time series from 19 stations show that the uplift rate of the Sierra Nevada mountains of the western United States accelerated from ∼1 to ∼3 mm/yr during the period of severe drought in California 2011.7-2016.7. The Long Valley Caldera (LVC) sits astride the transition between the Sierra Nevada and the western Great Basin, which is the location of a zone of active tectonic transtension, the Central Walker Lane (CWL). During this drought period, the rate of active magmatic inflation at the LVC increased substantially and influenced the active strain in the adjacent CWL. The correlation suggests a connection between hydrological loading of the Sierra Nevada, magmatic inflation at LVC, and CWL tectonic deformation.

Because the active crustal deformation field contains signals that operate on various time scales, overlap spatially, and influence all three components of motion we integrate data from several GPS networks collected over the last 2 decades. These include continuous data from the NSF EarthScope Plate Boundary Observatory, USGS California Volcano Observatory, semi-continuous data from the MAGNET GPS network operated by the University of Nevada, Reno, and campaign mode GPS data from the USGS Crustal Deformation Monitoring project. The collection of constraints on crustal movement come from networks with highly variable geographic density, distribution, proximity to LVC, level of uncertainty, dates of coverage, and occupation style.

We integrate these observations using a robust framework into a spatially and temporally gridded three-component crustal motion field. The analysis is based on the MIDAS, GPS Imaging, and MELD algorithms (Blewitt et al., 2016; Hammond et al., 2016; Kreemer et al., 2018) that derive velocity and strain fields that are insensitive to error sources common in GPS time series, including undocumented steps, outliers, gaps in time series and irregularities in network spacing. The approach allows us to better visualize the crustal motion field with animations of velocity, uplift and strain rate changes, and make comparisons to other data such as timing of the drought. Results indicate that the drought-induced changes in CWL strain rate patterns are detectible, and may have influenced seismicity, up 60 km from LVC.

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