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The 2011-2020 long-term sustained inflation at Long Valley Caldera: investigation of the interaction of magmatic and tectonic processes

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The Long Valley Caldera, California (USA), has been restless over the past few decades, experiencing seismic swarms and ground deformation episodes. The last inflation began in late 2011, when a radially symmetric tumescence was detected coinciding with a large resurgent dome within the caldera. Since then, a continuous inflation with quasi-steady rate of ~1.5 cm/yr has been observed. Earthquakes mostly occur within the caldera along the South Moat Seismic Zone, to the south of the maximum deformation area. Although the area is tectonically active, increased seismic activity has been documented during periods of renewed inflation since the onset of this tumescence in 1978. In this study, we aim to investigate the nature and dynamics of the long-term unrest at Long Valley Caldera, as well as to provide new insights into the interaction between magmatic and tectonic processes. For this purpose, we consider a variety of datasets including geodetic and seismic records over the period spanning from late 2011 to the end of 2020. A complete seismic catalog supports our study, with more than 200 M2.5-4.5 earthquakes recorded since 2011, most with epicenters located within the caldera. Measurements from a dense network of continuous GPS stations collected in the last 10 years are analyzed in combination with high resolution Interferometric Synthetic Aperture Radar (InSAR) data. For full temporal coverage, we integrate InSAR velocities obtained from the acquisition of different satellite missions. We use, in particular, data from SAR systems operating with X and C-bands such as TerraSAR-X, COSMO-SkyMed and Sentinel-1. The multi-sensor dataset (i.e., GPS and multi-mission InSAR data) compensate the limitations of each technique, with reliable mapping of the deformation pattern evolving over several years. Data analysis highlights uplift velocities with peaks of ~2 cm/yr within the caldera and beyond its southern rim. Moreover, compared to the first half of the period of analysis (2011-2014), the area affected by high deformation rates is broader in the last several years (2017-2020). Models based on the geodetic data are developed to constrain the deformation source and to better interpret the observed signals. This study is motivated as a contribution to the understanding of this long-lived caldera unrest, for a more reliable hazard assessment.