Geodetic InSAR and GPS Monitoring and Inverse Modeling of Yellowstone Crustal Deformation from 1992 to 2013

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Episodic crustal deformation and magmatic and thermal unrest characterize the Yellowstone volcano since the last catastrophic eruption occurred approximately 640k years ago. Integrating multi-sensor Synthetic Aperture Radar Interferometric (InSAR) observations and Global Positioning System (GPS) measurements from the Plate Boundary Observatory (PBO) and several campaigns, we detail five major episodes of Yellowstone caldera inflation and deflation between 1992 and 2013: 1992–1995 (peak subsidence rate of about 2.7 cm/yr), 1996–2000 (slight subsidence of 0.5 cm/yr, with considerable uplift of 1.7 cm/yr at Norris, which is located near the northwest edge of the caldera), 2000–2004 (slow subsidence of 0.7 cm/yr, with slow local uplift of 0.6 cm/yr at Norris), 2004–2009 (rapid uplift of 3–8 cm/yr, with substantial subsidence of 1–4 cm/yr at Norris), and 2010–2013 (notable subsidence of about 1.2–2.4 cm/yr across the entire caldera floor). Out of 196 ERS and ENVISAT interferograms created using the 2-pass interferometric technique, we show only 17 representative interferograms documenting the five episodes of inflation and deflation. In contrast to previous conventional InSAR studies, we present new results using an advanced Small BAseline Subset (SBAS) algorithm. The Singular Value Decomposition (SVD) method is applied to link independent subsets separated by long baselines. This approach provides new time-dependent view and insight into the ongoing Yellowstone deformation. In addition, we present the first TerraSAR-X interferograms of high spatial resolution, which enables detecting small-scale deformational features at Yellowstone. Simultaneous inversion of InSAR interferograms and GPS time series indicates that one or two planar sources at average depths of approximately 8–12 km underneath the two resurgent domes can fit the caldera inflation and deflation very well, whereas a Mogi point, a penny-shaped crack, a prolate ellipsoidal, or a planar source located at depth ranging 10–16 km is consistent with the local deformation at Norris. Results show that no differential surface motions have occurred along any fault zone across the study region, thus the magmatic and hydrothermal processes beneath the active caldera and Norris are considered the main sources of crustal deformation.