Deformation Associated with Eruptive Activity at Mount St. Helens, Washington

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On September 23, 2004, a seismic swarm marked the onset of eruptive activity at Mount St. Helens, Washington, after 18 years of quiescence. A few days later, an intensely deforming, uplifted welt was recognized in the southeast part of the crater, and a series of phreatic explosions lasting five days began on October 1, 2004. The USGS Cascades Volcano Observatory and Plate Boundary Observatory responded by deploying 18 continuous GPS stations on and around the flanks of the volcano, in addition to other stations elsewhere in the region. The network has measured remarkably little deformation. Prior to the eruption, only one continuous GPS station, JRO1, was operating, 8 km north of the volcano. JRO1 recorded about 2 cm of displacement towards the volcano during the first two weeks of the unrest. Between mid-October 2004 and the end of 2005, the GPS network detected only a few cm of deflation of the volcano. Deformation from Interferometric Synthetic Aperture Radar (InSAR) is similarly muted; a stack of 9 RADARSAT interferograms spanning 2004-2005 shows only about 2 cm of line-of-sight deflation centered on Mount St. Helens.

Deformation from InSAR and GPS can be approximated by a volume loss of 20-30 × 106 m^3/yr at depths of 6 to 12 km (depending on the model geometry). Interestingly, during this time period at least 70 × 106 m^3/yr of lava was extruded. This discrepancy in volume does not necessarily imply recharge to the magma reservoir at depth. The difference can also be explained by the expansion of bubbles in the reservoir as volume is removed. Continued geodetic research at Mount St. Helens offers the chance to further investigate a variety of important issues in volcanology, including the relationship between erupted volume and modeled volume loss, the geometry and size of the magma reservoir, and the relationship between deformation rates and eruptive activity (e.g., explosive activity, effusion rate, magma chemistry, etc.).

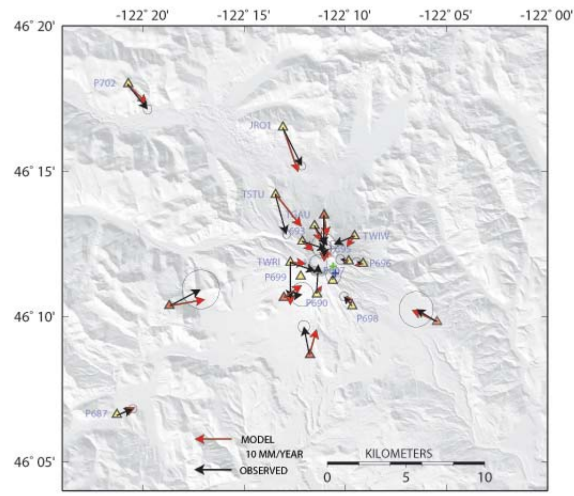
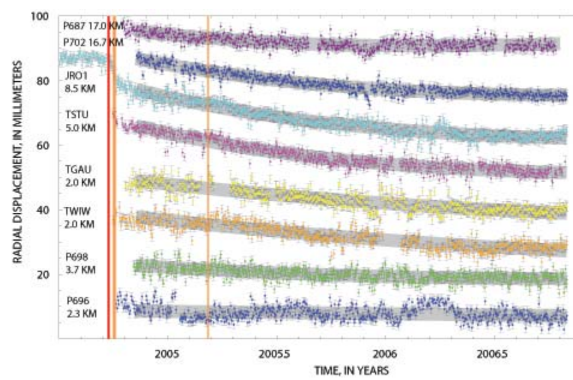


Figure 2. Top: Average observed (black) and modeled (red) GPS displacements from Mount St. Helens between October 15, 2004 and December 31, 2005. The model assumes a vertical prolate ellipsoid between 6 and 12 km depth beneath the volcano with a volume loss of 20 × 10^6 m^3/yr. **Bottom:** Time series of displacements from continuous GPS stations on the flanks of Mount St. Helens. Red line marks the onset of seismic unrest on September 23 2004.



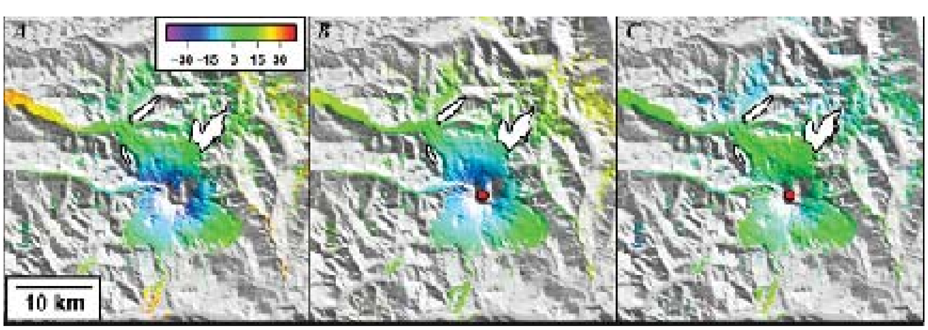


Figure 1. InSAR results from Mount St. Helens showing (A) observed, (B) modeled, and (C) residual deformation. Observed line-of-sight displacements are from a stack of 9 RADARSAT standard model 2 interferograms spanning 2004-2005. The model assumes a point source at 12 km depth with a volume loss of 27 × 10^6 m^3/yr.