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Traking volume changes at intereruptive stage near South Sister volcano (Oregon, USA)

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The cluster of glaciated stratovolcanoes called the Three Sisters spreads out 20 km along the crest of the Cascade Range in Oregon (USA). The Three Sisters volcanic region extends about 40 km north and south of the Three Sisters, and contains at least 466 Quaternary volcanoes, being one of the most active volcanic areas in the Cascade Range. Scientific interest in the Three Sisters volcanic cluster was aroused in 2001, when an uplift process centered about 5 km west of South Sisters was identified, first noticed by Interferometric Synthetic Aperture Radar (InSAR). The extensively monitored area by this technique has been actively uplifting since about 1998.
InSAR data from 1992 through 2001 showed an uplift rate in the area of 3-4 cm/yr. Then the deformation rate considerably decreased between 2004 and 2006 as shown by both InSAR and continuous GPS measurements. In order to analyze these features, the magmatic system geometry and location are determined. Then, a linear inversion of available deformation data (GPS and InSAR data) is performed to estimate the volume changes of the source along the analyzed time period. The strength of the methodology resides in allowing the joint inversion of InSAR measurements from multiple tracks with different look angles and three component GPS measurements from multiple sites. For this purpose, we apply a technique based on the Truncated Singular Value Decomposition (TSVD) of the Green's function matrix representing the linear inversion. We provide a cut-off criteria for truncation without too much loose of resolution against the stability of the method. Furthermore, a strategy for the quantification of the uncertainty of the volume change time series is developed.
Finally, the temporal behavior of the source volume changes is analyzed using a dynamic model based on Hagen-Poiseuille flow through a vertical conduit that leads to an increase in pressure within a spherical reservoir and time-dependent surface deformation. To consider the viscoelastic effects the reservoir is surrounded by a viscoelastic Maxwell shell. The volume time series are compared to predictions from the dynamic model to constrain model parameters, namely characteristic Poiseuille and Maxwell time scales, inlet and outlet injection pressure, and source and shell geometries. The modeling approach used here could be used to develop a mathematically rigorous strategy for including time-series of deformation data in the interpretation of volcanic unrest at intereruptive periods.