SBAS-InSAR analysis of surface deformation at Mauna Loa and Kilauea volcanoes in Hawaii

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Abstract

The Big Island of Hawaii is home to three volcanoes that have historically erupted. Hualālai, on the east side of the island, Mauna Loa, the largest volcano on the planet which has erupted 39 times since 1832 (most recently in 1984) and Kilauea, one of the most active volcanoes in the world and which has been in a state of continuous eruption since 1983 from vents on the volcano's east rift zone. Since March 2008, an eruption, characterized by mild explosive activity and persistent gas emission, has also been occurring at Kilauea's summit [1]. Deformation at Kilauea is characterized by summit and rift zone displacements related to magmatic activity and seaward motion of the south flank caused by slip along a basal decollement [2]. Geodetic monitoring at Kilauea includes continuous and campaign Global Positioning System (GPS) measurements, continuous borehole tilt and strain measurements, leveling surveys, and differential Synthetic Aperture Radar Interferometry (InSAR) measurements. Among these techniques, InSAR provides unparalleled spatial resolution of deformation [3] and its recent application to Kilauea Volcano has provided important ground motion data for monitoring and hazard assessment purposes [4].

We investigate in this study the deformation of Mauna Loa and Kilauea volcanoes by exploiting the advanced InSAR technique referred to as the Small BAseline Subset (SBAS) algorithm [5]; this techniques allows us to produce deformation time series and mean deformation velocity maps, by analyzing SAR data pairs characterized by small spatial and temporal separation between the acquisition orbits (baseline). The capability of the SBAS procedure to detect and investigate deformation phenomena affecting volcanic areas has been already shown in several applications (see, for instance, [6-7]).

In particular, we apply the SBAS technique to a set of 29 and 28 SAR data acquired by the ASAR instrument, on board the ENVISAT satellite, from the ascending (Mode: IS2; Track: 93, Frame: 387) and descending (Mode: IS2; Track: 429, Frame: 3213) orbits, respectively, between January 2003 and April 2008. We generate 84 multilook differential interferograms from the ascending data and 77 from the descending ones, using a pixel dimension of about 100 m x 100 m. Following phase unwrapping, the interferograms are inverted through the SBAS procedure and, for each coherent pixel of the radar images, we compute the time-dependent surface line-of-sight (LOS) displacements as well as the average LOS deformation rate. We also benefit from the use of the multi-orbit (ascending and descending) data which permit us to discriminate the vertical and east-west components of the displacements [8]. The derived InSAR measurements are also compared to continuous GPS data to asses the quality of the SBAS-InSAR products.

Our results provide a spatially and temporally complete data set of ENVISAT InSAR observations, showing the complex deformation behavior of Kilauea and Mauna Loa volcanoes. In addition, the possibility to invert the retrieved InSAR products, in order to model both deep geological structures and magmatic sources, represents a relevant future issue to be carefully exploited for a better understanding of volcano and earthquake processes on the Island of Hawaii.
Future applications of InSAR to Hawaii will build upon these results, especially using new sensors. Indeed, C-band interferograms are incoherent where vegetation is dense, including the rain forests of Hawaii. L-band sensors, however, can see through much of this vegetation, and offer promise for new insights into deformation of Kilauea and other volcanoes [9].

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Invited Session: Use of Remote Sensing Techniques for Surface Deformation Monitoring and Damage Detection in Volcanic and Seismogenic Areas

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