Deformation in Hawaii's volcanoes obtained from a ScanSAR-to-StripMap Small Baseline Subset Technique

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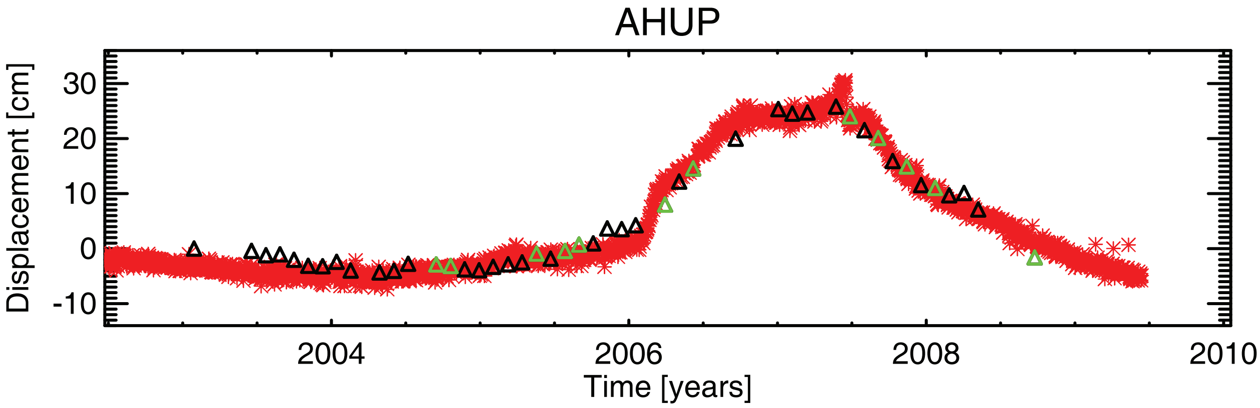
Interferometric Synthetic Aperture Radar (InSAR) is a remote sensing technique that exploits the phase difference between SAR image pairs acquired at different times to detect the relative displacement (projected along the sensor line of sight (LOS)) between acquisitions [1]. InSAR facilitates analysis of the temporal evolution of the surface deformation over large areas on Earth, with centimeter to millimeter accuracy, at the available observation epochs. To this end, several algorithms have been developed [2-4] over last years. Among these, the one referred to as Small BAseline Subset (SBAS) technique [2] allows the generation of mean velocity deformation maps and corresponding surface deformation time series from a set of multi-look differential interferograms with small baseline separations.

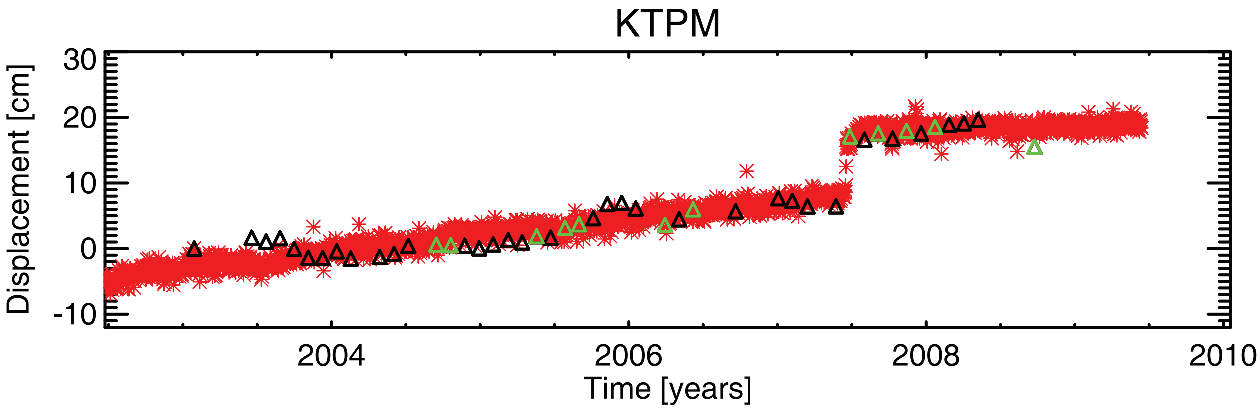
This work investigates the deformation occurring at Mauna Loa and Kilauea volcanoes (Hawaii Big Island) retrieved through an advanced scanSAR-to-stripmap SBAS analysis. Big Island is rich in volcanic activity with five volcanoes forming the island, three of which are active. Kilauea volcano located in the Southwest side of the island is one of the most active volcanoes on earth. The eruption of Kilauea Volcano that began in 1983 continues at the cinder-and-spatter cone of Pu`u `O [5]. On Father's day June 17, 2007 a series of earthquakes started a process that changed the path for lava flow into the ocean [5]. The summit began to deflate immediately, and volcanic tremor started to increase, indicating that the magma stored there was on the move [5]. Afterwards, Makaopuhi Crater/Kane Nui oHamo shield region started to extend reaching 2.5 cm/hr [5]. To model such geophysical events, InSAR data can be richer than GPS because of denser spatial cover. However, InSAR is limited in modelling rapidly varying and non-steady geophysical events such as Father's day event due to its temporally sparse observations of the area under study. The scanSAR mode [6] currently available in several satellites mitigates this effect because the satellite may illuminate a given area more than once within an orbit cycle. However, the scanSAR mode results in noisier interferograms. Previous SBAS deformation time series of Kilauea between 2002 and 2008 [7] had gaps in the known displacement signature where scanSAR acquisitions were taken. To date InSAR has largely been applied to homogeneous data sets of stripmap interferograms with consistent pixel averaging and coherence characteristics among interferograms. A first attempt at combining mixed sets of interferograms with heterogeneous coherence properties has recently presented in [8] by using sets of stripmap-to-scanSAR and stripmap-to-stripmap interferograms that are fed into a typical Small BAseline Subset algorithm.

As an example, the retrieved deformation around Kilauea between January 2003 and September 2008 at various GPS stations are shown in the plots of Figure 1. The effects of the Father's day event are clearly captured. Furthermore, the retrieved mean standard deviations of the difference between the GPS measurements and the InSAR time series are comparable to the ones previously obtained with stripmap only data [7]. This demonstrates that scanSAR and stripmap data can be jointly used to improve the time resolution of the SBAS time series without detrimental effects on its quality.

In this work we propose to further assess the capability of the developed scanSAR-to-stripmap SBAS method by using the ENVISAT-ASAR images acquired over the Big Island in all ascending and descending tracks from 2003 to 2009. The exploitation of multi-angle SAR observations allows the separation of the vertical and east-west components of the retrieved deformation.



(a)



(b)

Figure 1: Plots comparing InSAR and GPS displacement time series at AHUP and KTPM stations. AHUP is near Kilauea summit and shows inflation becoming deflation in June 2007. KTPM is near Makaopuhi Crater/Kane Nui o Hamo and shows a step increase in the deformation around the same time. GPS data is shown with red stars, stripmap acquisitions with black triangles and scanSAR with green triangles.

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