Geophysical Research Abstracts
Vol. 12, EGU2010-8624, 2010
EGU General Assembly 2010

Present day vertical deformation of Pico and Faial islands revealed by merged INSAR and GPS data

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In this paper we investigate the problem of the integration of repeated GPS geodetic measurements and interferometric Synthetic Aperture Radar (SAR) observations for the determination of high resolution vertical deformation maps. The Faial and Pico islands in the Azores archipelago were chosen as study area. These islands are characterized by a intense volcanic and seismic activity. Both islands are covered by huge vegetation and have very unstable atmospheric conditions which negatively influence the interferometric processing. In this work, we apply the advanced interferometric SAR processing based on Persistent Scatterers. However, the small number of man made structures reduces the density of Persistent Scatterers. Furthermore, the different ascending and descending acquisition geometries give different sets of Persistent Scatterers, with complementary spatial coverage, and different line-of-sight velocities. The estimated velocities are relative to the master image (different from ascending and descending) and must be referred to an absolute velocity (in the sense of referred to a geodetic reference frame).
The strategy used to overcome the aforementioned problems is based on the combination of sparse GPS 3D-velocities with two sets of Persistent Scatterers determined from ascending and descending passes. The input data are: a set of GPS - 3D velocities relative to ITRF05 (18 Stations) and two sets of Persistent Scatterers corresponding to the descending and ascending orbits. A dataset of 60 interferometric repeat-pass ASAR/ENVISAT images were acquired over the Faial and Pico islands, from 2006 to 2008, along ascending and descending passes. Each interferogram obtained by this dataset was corrected for atmospheric artefacts using a Weather Forecasting model. Initially, the horizontal velocity component (east and north) is assigned to each PS from interpolation of available GPS observations. Then, the vertical component of the velocity is determined from the SAR line-of-sight velocity and the GPS horizontal velocity component. Later, the vertical velocity offsets are numerically determined by comparison between GPS (ITRF velocities) and PS (the two ascending and descending sets) measurements. These values are then used to create the vertical deformation map of Faial and Pico islands with considerably better resolution and accuracy than using a single set of observations.
The vertical deformation map has identified a large continuous area of subsidence on the west of Faial island, on the flank of Capelinhos eruption cone, with a maximum subsidence range of 10 mm/yr. It has also revealed the subsidence of the summit crater of Pico island (9 mm/yr) and a large area of subsidence on the west of the island, corresponding mostly to creep movement.

Key words: SAR Interferometry, GPS-INSAR integration, Volcano, subsidence