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The evidences of progressive pressurization of volcanic conduit as driving forces of unrest phenomena analyzed via modelling of multiplatform geodetic measurements: Fernandina (GALAPAGOS) and Maunaloa (HAWAII) case studies

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We investigated the source of the ground deformation pattern affecting the Mauna Loa (Hawaii) and Fernandina (Galapagos) volcanoes by jointly exploiting different dataset collected by both GPS and multiplatform and multiorbit SAR sensors. We exploited the advanced Differential SAR Interferometry (DInSAR) techniques to analyze unrest episode in two different geodynamics context.
Our main goal is the understanding of the relationship among the spatio-temporal evolution of the ground deformation field and the temporal volumetric variation of the detected geodetic source during the uplift phenomena. We highlight the huge opportunity in understanding volcano unrest phenomena offered by the joint use of remote sensing data and inversion procedures: this prospect is particularly relevant for the analysis of uplift events, when other geophysical measurements are not available. For Mauna Loa (Hawaii) and Fernandina (Galapagos) volcanoes, the performed statistic analysis support the source pipe-like as the more suitable geometry to explain the unrest phenomena in which magmatic masses intrude in volcanic conduits. In particular, the deformation time series achieved at MounaLoa volcano are achieved by 23 GPS permanent stations of the Hawaii surveillance network, processed by Nevada Geodetic Laboratory, 7 SAR dataset acquired from ascending and descending orbits, with different look angles and along different tracks, by the C-Band Envisat satellite along the 2003 – 2010 time period for a total of 189 SAR imagery. Moreover, we exploited 2 dataset collected from ascending and descending passes by the X-Band Cosmo Sky-Med constellation during the 2012 – 2015 time span . These SAR datasets have been processed through the advanced DInSAR technique referred to as P-SBAS (De Luca et al., 2016), which allows us to retrieve the Line of Sight (LOS) projection of the surface deformation and analyze its temporal evolution by generating displacement time series. Starting this data collection, we determined the source responsible of deformation observed and in particular the results of our inversions show that the pipe source contributes substantially to both the ground deformation pattern and the cost function.
In the case of Fernandina Volcano (Galápagos) we exploited the advanced Differential SAR Interferometry (DInSAR) techniques to analyze the 2012-2013 uplift episode by using X-band data from the COSMO-SkyMed (CSK) satellite constellation. This volcano falls among those not well monitored, therefore, the availability of CSK data, acquired with a repeat time ranging from 4 to 12 days and with a ground resolution of 3 meters, represents a unique opportunity to perform a detailed study of the space and time ground deformation field changes (Sansosti et al., 2014). In addition, in this case study we computed the ground deformation time series by applying the Small BAseline Subset (SBAS)-DInSAR approach (Berardino et al., 2002) to CSK data, acquired from both ascending and descending orbits. The results of their combination (vertical and horizontal E-W components) are used in order to evaluate, through a cross correlation analysis (Tizzani et al., 2009; 2015), the volcanic areas that are characterized by similar uplift temporal behavior. Subsequently, we determine the geometry, location and the temporal evolution of the geodetic source responsible for the 2012 - 2013 uplift event by applying an inverse method to the DInSAR measurements. We search for its geometrical parameters and volume variation that minimize the difference between the observed data and the modelled ground deformation field. We tested various analytical models and finally, using the Akaike Information Criterion (Akaike, 1965) among the tested analytical sources, we selected the tilted pipe. The pipe model is similar to the prolate ellipsoid, but the size of the smaller axis is kept fixed to a very small value (i.e. 10 m). Despite having a similar fit with the prolate ellipsoid, the tilted pipe-like source has been selected because it has a lower number of degrees of freedom. Both vertical and E-W cross-correlated maps support the hypothesis of the existence of a single active source, characterized by a spatial stability over the entire considered time interval. Indeed, with the proposed source inversion procedure, we have

shown that the inflation of a SE dipping tilted closed pipe-like pressurized source explains the observed ground deformation pattern very well. This result suggests that the observed uplift phenomenon could be produced by the progressive pressurization of a shallow elongated magma chamber, before the eruption onset phase.

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