Geophysical Research Abstracts
Vol. 17, EGU2015-10353-1, 2015
EGU General Assembly 2015

Spaceborne Synthetic Aperture Radar (SAR) Doppler anomalies due to volcanic eruption induced phenomena

Marcello de Michele (1), Daniel Raucoules (1), and Christian Minet (2)

(1) French Geological Survey (BRGM), Orléans, France (m.demichele@brgm.fr), (2) Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, Germany

In the frame of the EU funded "MEDSUV" supersite project, we use multiple SAR data to investigate Doppler anomalies in the SAR signal occurring during volcanic eruptions. In Synthetic Aperture Radar, variations in the Electro Magnetic Waves travel time results in a change in the Doppler frequency that adds up to the one that is naturally generated by the relative motion between the platform and the ground targets. Within the SAR system, frequencies modulations control the image focusing along the two fundamental SAR directions, the azimuth (i.e. the platform motion direction) and the range (i. e. the sensor looking direction). During the synthetic aperture process (the so called image focusing) a target on the surface is seen along different paths. In standard focusing processing it is assumed both that ground targets are stationary and that between the sensor and the target the medium is the vacuum or a totally homogeneous medium. Therefore, if there is a significant path delay variation along the paths to a specific target this can result either in image defocusing or in pixel misregistration or both. It has been shown that SAR Doppler history anomalies can occur over volcanic areas. The goal of this study is to highlight Doppler history anomalies occurring during the SAR image formation over active volcanoes on a number of test cases. To do so, we apply a sub-aperture cross correlation algorithm on Single Look Complex data. Practically, we measure any pixel misregistration between two sub-looks of the same SAR acquisition. If a pixel shift occurs, it means that the expected radar wave path has been lengthened (or shortened) during the time when ground surface scatterers were illuminated by the sensor radiation either by a ground feature velocity (e. g. water flows, vehicles) or it is refracted by a strong medium discontinuity in the air (volcanic ash plume?). If a Doppler history anomaly is detected by the sub-aperture cross correlation, we try to explore whether it is possible to distinguish between signal delays due to the presence of a volcanic ash plume and the signal delays due to other volcano-related phenomena (such as lahars, lava flows velocity, ice melts, ocean currents induced/modified by lahars discharges), or simply non volcano-related natural phenomena such as ocean currents and river flows. We focus on the largest eruption producing an ash plume in the last decade, the 2010 Eyjafjallajokull eruption in Iceland by using a selected set of data from the German Space Agency (DLR) TerraSAR-X sensor. The first outcome of this analysis is that our methodology to detect Doppler anomalies on TerraSAR-X data works at least for extended surface motions signatures (ocean swell). A preliminary analysis of the results, allows us to reasonably state that we do not see a flashy impact of the ash plume on the Doppler history of the SAR data. We see sporadic, spatially discontinuous Doppler anomalies around the volcanic edifice and on the top, but it is premature to link those to the presence of a volcanic ash plume. On the other hand, our results put into evidence Doppler shifts reasonably due to eruption-induced ice melts, lahars, river discharge and consequent modification of the near shore ocean currents. These signals worth a deeper analysis as these natural eruption-induced phenomena heavily impact the surrounding environment. Besides, further investigations have to be performed both on archived C-band SAR on Etna volcano and, particularly important, on the new SENTINEL-1 data and its specific TOPSAR mode that could be more complex to use for such applications.