MONITORING VOLCANIC AREAS USING INTERFEROMETRIC METHODS WITH GROUND TRUTH

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Since SAR interferometry was introduced in the 1980s, it has become a standard method for deformation monitoring, especially for detecting surface deformations with precisions of centimeters or even millimeters. In reality, this level of accuracy is hard to achieve due to several errors including atmospheric delay, orbit error, an uncertain height reference and processing errors [1]. To eliminate these complex errors, parametric time series methods were developed using stable persistent scatters (PS), such as PS-InSAR, SBAS and recent PSP techniques [2][3][4]. The PS-based methods were successfully used in urban areas to detect long-term surface deformation [5][6]. Our goal is to apply this method in volcanic areas, i.e. mountainous areas where large height changes occur. Atmospheric stratification is one of largest uncertainties in the measurements. Unlike in cities, the tropospheric delay is significant between two PSs with even a small horizontal separation but with a large height difference. To construct a better network, not only the horizontal separation between PSs but also the height difference must be considered. The topographic dependent phase component could be integrated into the estimation system which was based on the STUN algorithm [7]. This research is a part of the German volcano monitoring project Exupèry, Work Package 2: 'Space based observation techniques' [8].

The main test site is located on the island of São Miguel in the Azores. It showed high seismic activity during 2006-2007 [9], which is a potential indicator of deformation on the island. A campaign was planned and carried out during Apr. – Aug. 2009 to test the installed volcano monitoring system. The system was composed of different types of ground instruments as well as two corner reflectors (CR) installed on the Lagoa do Fogo volcano. One CR was installed at the bottom of the mountain (CR1) and one on the top (CR2) in order to maintain coherence in X-band in this highly vegetated area. 11 TerraSAR-X stripmap images were collected during the campaign. The 2 CRs could be successfully located in SAR scenes and their actual coordinates and power could be measured directly from the images. The measured backscatter powers are in accordance with theoretical values which could be calculated with the CR size and the SAR wavelength [10]. An analysis of tropospheric effects was carried on with the help of the hourly ZDP (total zenith delay) product on Ponta Delgada GPS station (PDEL) which is part of the EUREF network and stable natural scatterers. The PS-InSAR system, PSI-GENESIS from DLR, was tested with CR measurements. Both CRs are used for accurate 3D-calibration of the geometry which is an indispensable requirement for the fusion of multi-geometry acquisitions.

Another ascending stack from the same test area was also processed with the same system. In the mountainous area, due to the side-looking acquisition geometry, there were many layover and shadowing effects. Therefore we fused the two PS point clouds together to obtain a more redundant solution and a better spatial and temporal coverage. Similar research on the fusion of ERS/ENVISAT PS stacks was performed by Ketelaar with a datum connection method based on point matching [11]. Thanks to the high precision of TerraSAR-X orbits, the geocoding was accurate to less than 1 m [12]. The elevation component was 3-5 times worse than the horizontal component. Given the precise CR coordinates the elevation component of the descending stack could be fixed. For the final paper, the elevation of the ascending stack will also be determined, using surface matching and a best fitting algorithm. After fusion, combined estimation using both stacks will be performed so that the 3D deformation can be better estimated.

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