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Quantification of dome growing and mass accumulation by double differential SAR-interferometry - a TanDEM-X application for volcano monitoring

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TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement) is a new SAR mission, formed by two almost identical spacecrafts flying in a closely controlled formation. The small distance between the two radar satellites allows the acquisition of two images at the same time (bistatic mode) which can be used to generate high resolution digital elevation models for each pass of the satellite pair. This presentation introduces a new research project funded by the German Federal Ministry of Economics and Technology (BMWi) that aims to examine the unique capabilities of the TanDEM-X system and to make them usable for the monitoring of active volcanoes. Merapi Volcano is one of the test sites of our project which started in January 2011.

The focus of our project is on the development and praxis test of a method to measure mass accumulation and surface deformation rates larger than 1 cm/day by double differential SAR interferometry, i.e. by evaluating differences between two bistatic acquisitions. The classical space-born SAR-interferometric approach – an analysis of the differential phase of two monostatic images taken at different times - has been successfully applied in the past to determine deformations of volcano edifices and to interpret the observations in terms of inflation/deflation. These methods, however, require stable backscattering conditions at the ground and cannot be used to observe lava production, dome growing and deposition of volcanic debris. The innovative bistatic operational mode of TanDEM-X in combination with a double difference approach allows an assessment of volume changes and/or substantial ground displacements without the requirement of coherence between different satellite passes. We will exploit this acquisition mode in order to monitor the temporal evolution of lava domes, lava flows and volcanic deposits by time series of differential digital elevation models (DDEM). The achievable relative height accuracy is expected to be of the order of 10 centimetres; the minimum spatial and temporal resolution is 2 by 3 meters and 11 days, respectively. From the observed height changes we aim to derive lava extrusion rates and gravitational mass flows. As a side issue, we will study deformation and stability changes of the outer crater rims loaded by a growing lava dome by a conventional PS-InSAR approach.

Merapi (Central Java) and Colima (Mexico) are the two test sites of our project. Both target volcanoes promise measurable topographic changes as they are in a state of a long term effusive eruption, which is interrupted every few years by phases of dome destruction, generation of pyroclastic flows and deposition of volcanic material. An important argument for choosing these test sites is the availability of extensive ground based data sets that open the possibility to validate the space born results. In our presentation, we will (i) review the basic ideas of the project, (ii) discuss the achievable accuracy for volume estimation and derived quantities, and (iii) present the actual data acquisition strategy for both volcanoes as well as first results. We are in contact with the German Aerospace Centre (DLR) in order to get access to bistatic images obtained during the commissioning phase of the satellite system that caught Merapi's eruption in 2010. Since validation is essential for an innovative method like DDEM, the primary goal of our presentation is to establish the basis for future collaboration that may comprise a dissemination of our results to interested researchers as well as a joint assessment of their accuracy, reliability and usefulness.