InSAR characterization of displacements related to lava flows at Piton de la Fournaise

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Résumé

At Piton de la Fournaise (La Réunion Island), the monitoring of ground displacements by InSAR is used to quantify evolutions of deep and superficial volcanic systems and to monitor the edifice over space and time. The observed ground displacements are caused by various processes sometimes difficult to discriminate. For example, it has been shown that the Eastern flank of the volcano is affected both by large wavelengths seaward sliding and by localize subsidence related to lava flows compaction and substratum flexure. Our study is a first step for a precise and global quantification of the displacements induced by the lava flows in order to separate them from the displacements related to the Eastern flank of the volcano, and so to improve the InSAR monitoring of the volcanic structure.
In our study, we attempt to produce an empirical model of lava-flow-related displacement using the October 2010 lava flow as the starting point of our study. We calculated a Small-Baselines (SBAS) Time Series of displacement with TerraSAR-X and CosmoSky-Med data between Mid-2011 to Mid-2015. An up-to-date Digital Terrain Model (5 m Lidar), which takes into account the October 2010 lava flow thickness (Bato et al. 2016), is used in this SBAS computation. This allowed us to extract the intrinsic displacements of the lava flow associated with both the thermo-mechanical compaction of the lava and the flexure of the substratum under the weight of lava.

Our results show that the main component of the lava flow displacement is a subsidence that continues through time with a maximum cumulative displacement of 10 cm. Temporal trends show an exponential and/or linear evolution that can be easily discriminated from other observed processes (Wittmann, Sigmundsson, and Lavallée 2017). Outside the lava flow, a flexure of the substratum is detected with a linear, temporal evolution of about 1 mm/yr within a margin a few tens-of-meters wide. Moreover, displacements are also detectable on older lava flows such as that of 2004, and we have also investigated the relationships between the temporal-displacement evolution and the thickness and age of the lava flow. Our algorithms appear applicable to other lava flows.

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Future works will refine the empirical laws that have been suggested between the temporal-displacement evolution, thickness and age of lava flows, will study further the flexure of the substratum in order to provide a clear view of the ground rheology, which is still being debated, and will apply these techniques and algorithms to new lava flows on Piton de la Fournaise.

References:

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