Geophysical Research Abstracts
Vol. 19, EGU2017-11790, 2017
EGU General Assembly 2017

Efficient inversion of volcano deformation based on finite element models : An application to Kilauea volcano, Hawaii

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The Kilauea volcano (Hawaii, USA) is one of the most active volcanoes world-wide and therefore one of the better monitored volcanoes around the world. Its complex system provides a unique opportunity to investigate the dynamics of magma transport and supply. Geodetic techniques, as Interferometric Synthetic Aperture Radar (InSAR) are being extensively used to monitor ground deformation at volcanic areas. The quantitative interpretation of such surface ground deformation measurements using geodetic data requires both, physical modelling to simulate the observed signals and inversion approaches to estimate the magmatic source parameters. Here, we use synthetic aperture radar data from Sentinel-1 radar interferometry satellite mission to image volcano deformation sources during the inflation along Kilauea's Southwest Rift Zone in April-May 2015. We propose a Finite Element Model (FEM) for the calculation of Green functions in a mechanically heterogeneous domain. The key aspect of the methodology lies in applying the reciprocity relationship of the Green functions between the station and the source for efficient numerical inversions. The search for the best-fitting magmatic (point) source(s) is generally conducted for an array of 3-D locations extending below a predefined volume region. However, our approach allows to reduce the total number of Green functions to the number of the observation points by using the, above mentioned, reciprocity relationship. This new methodology is able to accurately represent magmatic processes using physical models capable of simulating volcano deformation in non-uniform material properties distribution domains, which eventually will lead to better description of the status of the volcano.