Geophysical Research Abstracts
Vol. 17, EGU2015-8843, 2015
EGU General Assembly 2015

Topographic controls on deformation due to a shallow magma reservoir

Jessica Johnson (1), Michael Poland (2), Kyle Anderson (2), and Juliet Biggs (3)

(1) School of Environmental Science, University of East Anglia, Norwich, United Kingdom (jessica.johnson@uea.ac.uk), (2) Hawaiian Volcano Observatory, US Geological Survey, Hawaii Volcanoes National Park, Hawaii, USA, (3) School of Earth Sciences, University of Bristol, Bristol, UK

Surface deformation is a phenomenon commonly observed in connection with volcanic unrest. Most deformation models approximate the model volume as a linearly elastic, homogeneous half-space, with point sources of pressure. The point source estimation breaks down when the reservoir is shallow, and the presence of heterogeneous materials and high temperatures in volcanic regions affects the rheological behaviour of the medium surrounding the magmatic source.
At Kilauea Volcano in Hawaii, repeated ground deformation is measured using ground and space based geophysical methods. The repeating deformation is thought to be caused by cycles of pressurisation in a shallow ($\sim$ 1 km depth), well-established magma reservoir. However, the extreme topography of the caldera, the thermal effect of the reservoir and the proximity of the reservoir to the surface mean that traditional models may not be appropriate.
To assess the control of the caldera topography on surface deformation due to a shallow magma reservoir, 3D finite element models were constructed using COMSOL Multiphysics. The model geometries include linear cliffs, circular calderas and realistic topography from high-resolution digital elevation. Solutions of surface deformation and stress distribution due to a spherical pressurised body were calculated and quantified.
Results using a homogeneous elastic medium show that sharp topography can create a small magnitude secondary bulge. With radially symmetric geometry, the bulge can potentially flip the tilt vectors by 180o. With geometry that is not radially symmetric, such as a linear cliff, the deformation local to the bulge will dramatically affect both the magnitude and the azimuth of the tilt. This produces misleading tilt vectors, as has been observed in monitoring data at Kilauea Volcano. This effect is a function of source depth, cliff height, and source—cliff distance. Hence, when surface geometry and lateral location of the source are known, apparently anomalous tilt data could be used to constrain the depth of the pressure source. The existence of this secondary bulge should also be considered when designing tilt networks.