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Persistent inflation at Aira caldera accompanying explosive activity at Sakurajima volcano: Constraining deformation source parameters from Finite Element inversions

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Aira caldera is located within Kagoshima Bay at the southern end of Kyushu, Japan. Sakurajima is an active post-caldera andesitic stratovolcano that sits on the caldera's southern rim. Despite frequent Vulcanian-type explosive activity, the area is experiencing continued uplift at a maximum rate of approximately 1.5 cm/yr with a footprint of 40 km, indicating that magma is being supplied faster than it is erupted. This is of particular concern as the amplitude of deformation is approaching the level inferred prior to the 1914 VEI 4 eruption. Using GPS data from 1996 – 2007 we explore causes for the uplift. To solve for the optimum deformation source parameters we use an inverse Finite Element method accounting for three-dimensional material heterogeneity (inferred from seismic tomography) and the surrounding topography of the region. The same inversions are also carried out using Finite Element models that incorporate simplified homogeneous or one-dimensional subsurface material properties, with and without topography. Results from the comparison of the six different models show statistically significant differences in the inferred deformation sources. This indicates that both subsurface heterogeneity and surface topography are essential in geodetic modelling to extract the most realistic deformation source parameters. The current best-fit source sits within a seismic low-velocity zone in the north-east of the caldera at a depth of approximately 14 km with a volume increase of 1.2 x 108 m3. The source location underlies a region of active underwater fumaroles within the Wakamiko crater and differs significantly from previous analytical modelling results. Seismic data further highlights areas of high seismic attenuation as well as large aseismic zones, both of which could allude to inelastic behaviour and a significant heat source at depth. To integrate these observations, subsequent forward Finite Element models will quantify the importance of rheology and temperature-dependent mechanics when assessing volcanic deformation in this region. This research received funding through the EC FP7 "VUELCO" (#282759) project.