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Volcanic sources retrieved from geodetic data: constraints to their geometry, shape and mechanism

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Modern Geodesy technologies enable us to measure millimetric surface displacements, to map large and arduous or dangerous areas and to detail elastic/inelastic behaviors from deformation time series in volcanic environments. In turn, mathematical representation of volcanic sources has been improving from very simplified models such as pressurized point-source spheres and opening tensile cracks within a homogeneous half-space to more complicated triaxial ellipsoids arbitrarily oriented in space, moment tensor sources and aggregates of amorphous sources. The main objective is to give insights into the volcanic activity, retrieving the magmatic source parameters (location, depth, shape), and its volume and/or volume variation within inversion frameworks. In this work, we investigate several aspects of the volcanic source retrieval from geodetic data. We consider the common assumption of fixing a priori the source shape, discussing the potential bias on the source parameters retrieval. For instance, spherical sources are located shallower than sill-like sources fitting similarly the data. Furthermore, there are cases in which a triaxial ellipsoid, the most general pressurized point-source, may not be suitable, e.g., the recent unrest at Campi Flegrei (2011-2013, 15 cm uplift). In magma intrusion processes across pre-stressed solid rock, a shear stress release takes place, that cannot be provided by pressurized sources. A completely general approach describes a deformation source in terms of a suitable moment tensor distribution and its physical interpretation in terms of a pressurized cavity or else must be proposed only a posteriori. We discuss also the effects on the source parameters if the structural heterogeneities of a complex environment such as a volcanic area are taken into account: the source is typically much deeper and the mechanism may differ significantly from homogeneous half-space models. As a final outcome, we inquire the rigorousness of the extension of single source models to amorphous aggregates of small sources, which are suitable to describe thermo-poro-elastic sources, but cannot reproduce pressurized cavities.