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Gravimetric control of active volcanic processes

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Volcanic activity includes phases of magma chamber inflation and deflation, produced by movement of magma and/or hydrothermal processes. Such effects usually leave their imprint as deformation of the ground surfaces which can be recorded by GNSS and other methods, on one hand, and on the other hand they can be modeled as elastic deformation processes, with deformation produced by volcanic masses of finite dimensions such as spheres, ellipsoids and parallelograms. Such volumes are modeled on the basis of inversion (non-linear, numerical solution) of systems of equations relating the unknown dimensions and location of magma sources with observations, currently mostly GNSS and INSAR data. Inversion techniques depend on the misfit between model predictions and observations, but because systems of equations are highly non-linear, and because adopted models for the geometry of magma sources is simple, non-unique solutions can be derived, constrained by local extrema. Assessment of derived magma models can be provided by independent observations and models, such as micro-seismicity distribution and changes in geophysical parameters.
In the simplest case magmatic intrusions can be modeled as spheres with diameters of at least a few tens of meters at a depth of a few kilometers; hence they are expected to have a gravimetric signature in permanent recording stations on the ground surface, while larger intrusions may also have an imprint in sensors in orbit around the earth or along precisely defined air paths. Identification of such gravimetric signals and separation of the “true” signal from the measurement and ambient noise requires fine forward modeling of the wider areas based on realistic simulation of the ambient gravimetric field, and then modeling of its possible distortion because of magmatic anomalies.
Such results are useful to remove ambiguities in inverse modeling of ground deformation, and also to detect magmatic anomalies offshore.