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The added value from time-variable volcano gravimetry

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Temporal changes of the gravity field in volcanic zones are related to sub-surface mass redistributions in response to magmatic processes and are variable in space (wavelengths from hundreds of meters to tens of kilometers) and time (periods between seconds and years), according to the size, depth and rate of evolution of the source processes. As a result, both campaign and continuous gravity observations can make valuable contributions to better understanding how volcanoes work.
Gravity measurements have great potential for imaging subsurface processes at active volcanoes (including some processes that might otherwise remain "hidden"), especially when combined with other methods (e.g., ground deformation, seismicity, and gas emissions). Indeed, by supplying information on changes of bulk mass over time, gravity studies alleviate ambiguity on the nature of magmatic sources, which may affect the interpretation of ground deformation and other measurements. Furthermore, time-variable gravimetry can provide information regarding processes such as magma accumulation in void space, gas segregation at shallow depths, and convective overturns in a shallow reservoir over short time scales.
Despite its obvious potential, time-variable volcano gravimetry is an underexploited method, mainly due to instrumental challenges and the difficulty of retrieving useful information from gravity changes in noisy volcanic environments.
Here, the potential of gravity studies to provide insight into the processes that drive volcanic activity is shown through case studies from volcanoes around the world. We review the inherent challenges in volcano gravimetry and suggest how these challenges can be overcome, with a view towards expanding future exploitation of the capability.