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Optimization of network configuration for an array of low-cost gravimeters at Mount Etna

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Volcano deformation and seismicity are often caused by magmatic processes which may or may not be accompanied by subsurface mass redistribution. For example, the same amount of pressurization may be due to injection of new magma into a reservoir or vesiculation of pre-existing magma. Gravimetry allows resolving these ambiguities. The recent development of a new generation of gravimeters may help overcome some of the limitations of volcano gravimetry and boost our ability to detect mass transport at depth. In order to maximize the sensitivity of new gravity networks to the spatial pattern and intensity of detectable gravity changes, several parameters including instrumental accuracy, network configuration, site accessibility and likelihood of possible scenarios must be factored in.

We address the problem of optimizing the configuration of a gravity network through combining concepts from geodetic network design and genetic algorithms, taking into account plausible sources of mass change based on the results of past gravity studies on Mt. Etna. In the optimization procedure we account for the volcanic edifice topography and logistic constraints.

We apply our method to find the optimal configuration for an array of low-cost gravimeters that are under development in the framework of the NEWTON-g project and will be deployed at Mt. Etna. Existing superconducting gravimeters will be complemented by $\sim$30 microelectromechanical system (MEMS) gravimeters, anchored to an absolute quantum gravimeter. Preliminary optimizations result in network configurations involving a few single-sensor sites and several sites with clusters of sensors. Conventional configurations including uniform grids of sensors lead to smaller sensitivities. We show that our method can handle complex constraints imposed by field conditions and instrumental limits and that with appropriate modifications it can be applied to gravity networks at other volcanoes.