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Analytical modeling of gravity changes and crustal deformation at volcanoes: the Long Vally caldera (CA) case study.

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Geodetic measurements of ground deformation (including micro-gravity) are an indispensable component for any volcano monitoring strategy. A number of analytical and numerical mathematical models are available in the literature that can be used to fit geodetic data on ground deformation and to forecast future deformation patterns. Analytical models offer a closed-form description of the source of volcano deformation. This allows one, in principle, to readily infer the relative importance of any of the source parameters. The simplifications that make analytical models tractable, however, may result in misleading volcanological interpretations, particularly for the case of structural discontinuities. Thus the limited extent of geodetic and geotechnical measurements at many volcanoes may not allow clear discrimination between the simple analytical models and the more realistic (complex) numerical models. We use the historical unrest at Long Valley caldera (California) from 1982 to 1999 to illustrate the practical application of analytical modeling. The inflation source is a slightly tilted prolate ellipsoid (dip angle between 91° and 105°) at a depth of 6.5 to 7.9 km beneath the resurgent dome with an aspect ratio between 0.44 and 0.60, a volume change from 0.161 to 0.173 km^3 and a density of 1241-2093 kg/m^3. Our results do not support hydrothermal fluid intrusion as the primary cause of unrest, and suggest the intrusion of silicic magma with a significant amount of volatiles (probably CO_2) beneath Long Valley caldera.