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Insights into the internal dynamics of active volcanoes through joint inversion of deformation and gravity data

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During the last few decades, joint investigation of microgravity and deformation measurements have played an increasingly important role in studying the internal dynamics of active volcanoes. Since it allows constraints to be set on both the volume and mass involved in the source mechanism, the cross-analysis of deformation and microgravity data furnishes a clearer picture of the studied volcanic processes than attainable through the application of a single technique. Deformation and microgravity measurements have been accomplished at Mt. Etna since the eighties. Past datasets encompassing important paroxysmal events can be utilized as case study to both (i) test the possibilities of nowadays more powerful inversion tool and improved analytical formulation to model the source-mechanisms of volcano-related deformation and gravity changes and (ii) in turn obtain new insights into the functioning of the plumbing system of the volcano. In the present study we re-analyze two datasets, the first one encompassing the March 1981 eruption, the second one collected for some months before the start of the July-August 2001 eruption. In both cases, the joint inversion of multimethod geophysical data was regarded as a multiobjective optimization problem and was solved through a Genetic Algorithm technique. Large horizontal dislocations were evidenced on the flanks of the volcano through EDM measurements during a 1-year time interval encompassing the March 1981 eruption. Elevation changes, evidenced through leveling measurements during the same period, were comparably small and took place only close to the eruptive fissure. Contemporaneous gravity measurements evidenced positive changes, spatially well correlated with elevation changes, but having a larger wavelength. Results of the inversion procedure suggest that an intrusive mechanism more complex than postulated in previous studies, which did not take into account all

the available data, triggered the 1981 eruption. For 5 months before the 2001 flank eruption of Mt. Etna a progressive gravity decrease was measured along a profile of stations on the southern slope of the volcano. Elevation changes observed through GPS measurements during a period encompassing the 5-month gravity decrease, remained within a few centimeters all over the volcano. We review both gravity and elevation changes by a model assuming the formation of new cracks, uniformly distributed in a rectangular prism. Results show that, although it is possible to explain the observed gravity changes by means of the proposed analytical formulation, calculated elevation changes are significantly higher than observed. Two alternative solutions are proposed to solve this apparent discrepancy.