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Insights into the dynamics of Etna volcano from 20-year time span microgravity and GPS observations

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A common ground deformation and microgravity array of benchmarks lies on the southern slope of Mt. Etna volcano and is routinely measured by GPS and relative gravimetry methods. The array was installed for monitoring the ground motion and underground mass changes along the southern rift of the volcano and data are usually processed and interpreted independently. The benchmarks have been installed mainly along a main road crossing the southern side of the volcano with an E-W direction and reaching 2000 m of altitude. The gravity array covers the entire path of the road, while the ground deformation one only the upper one, due to the woods at lower altitude preventing good GPS measurements. Furthermore, microgravity surveys are usually carried out more frequently with respect to the GPS ones. In this work, an integrated analysis of microgravity and ground deformation is performed over a 20-year time span (1994-2014). Gravity variations have been first corrected for the free-air effect using the GPS observed vertical deformation and the theoretical vertical gravity gradient (-308.6 μGal/m). The free-air corrected gravity changes were then reduced from the high frequency variations (noise) and the seasonal fluctuations, mainly due to water-table fluctuations. This long-term dataset constitutes a unique opportunity to examine the behavior of Etna in a period in which the volcano exhibited different styles of activity characterized by recharging phases, flank eruptions and fountaining episodes. The gravity and deformation data allow investigating the response of the volcano in a wider perspective providing insights into the definition of its dynamic behavior and posing the basis to track the unrest evolution and to forecast the style of the eruption. The joint analysis highlights common periods, in which the signals underwent contemporaneous changes occurring mainly in the central and eastern stations. On the other hand, no significant changes in the behavior of deformation and gravity signals have been observed in the westernmost stations. Specifically, we observed at least four periods characterized by different correlation between the two time series. Indeed, the integrated analysis of the spatio-temporal variations of the gravity and the ground deformation data highlights different volcanic processes controlling the dynamical behavior of Etna volcano in this sector.