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New insight into the December 2018 Etna eruption through the joint inversion of ground deformation and gravity data

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We focus on the eruption of Mt. Etna which took place on 24 December, 2018. The eruption occurred after a month of unrest and was accompanied by a seismic swarm that culminated in the M4.9 earthquake on the 26th, with epicentre on the eastern flank of the volcano. We jointly analyse ground deformation and gravity data to estimate the geometrical and kinematic parameters of the source structure, together with the density of the intruding material. The data used in this study were recorded by stations in the INGV-OE monitoring network (21 GPS stations and 2 gravity stations equipped with superconducting gravimeters), during the interval of 23 to 28 December (pre to post eruption). We assume a dike-type source for the forward calculation in the defined objective function. A pattern search algorithm (PSA) is used for the iterative minimization of the misfit error. In order to estimate the posterior probability density function (PDFs) of the model parameters, we also use a Markov Chain Monte Carlo (MCMC) approach. Indeed, the calculated PDFs provide more information about the uncertainties of the model parameters, which helps to understand overall tendencies of the solutions. We first test the constrained inversion of the gravity data, to calculate the density of eruptive magmatic body, by fixing the geometrical parameters of the dike, previously retrieved through inversion of the deformation data only. Using this approach, it is possible to suitably explain the deformation data and the gravity change observed at the station in the near field (MNT), while the gravity change at the other station (SLN) remain unexplained. We then invert jointly both deformation and gravity datasets, in order to adequately fit all the observations. The final model gives a density value of ~1.8-2.0 g/cm³. This value is significantly lower than the density of bubble-free magma and indicates either the involvement of gas in the intrusive process, or the formation of dry fissures during the emplacement of the dyke.