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Tracking magmatic intrusions in real-time by means of free-shaped volcanic source modelling

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Nowadays continuous measurements of geophysical parameters provide a general real-time view of current state of the volcano. Nonetheless, a current challenge is to localize and track in real-time the evolution of the magma source beneath the volcano. Here we present a new methodology to rapidly estimate magmatic sources from surface geodetic data and track their evolution in time without any a priori assumption about source geometry. Indeed, the proposed approach takes the advantages of fast calculation from the analytical models and adds the capability to model free-shape distributed sources. Assuming homogenous elastic conditions, the approach can determine general geometrical configurations of pressured and/or density source and/or sliding structures corresponding to prescribed values of anomalous density, pressure and slip. These source bodies are described as aggregation of elemental point sources for pressure, density and slip, and they fit the whole data (keeping some 3D regularity conditions). In this work we show an application of the methodology to model the real-time evolution of the volcanic source for 2008 eruption of Mount Etna (Italy). To this aim the High-Rate GPS data, coming from the Continuous GPS network, are processed in real-time to obtain sub-daily solutions for tracking the fast dynamics of the magma migration. In our test case we reproduced the real-time scenario of the eruption. Though the data of the test were processed after data collection, real-time operation was emulated. From the results, it is possible to extrapolate the dynamic of a deep and a shallow magma source and the dyke intrusion. In particular, results show at 5 am UTC a magma batch likely migrating towards the surface leaving behind a deflating volume at about 2 km bsl and a deep elongated body from 2 km bsl to 10 km bsl which runs along the High Vp Body and likely represents the deep conduit from where the magma rises up. We demonstrate that the proposed methodology is able to supply essential information for volcano surveillance addressing in real-time the question on where magma is going beneath the ground surface and how fast it moves and hence it is suitable to be integrated in the routine monitoring system of any volcano observatory to give first order results in an automatic and objective way during an unrest period.