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Geophysical signatures of pre-eruptive deep magma dynamics

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Understanding the meaning of geophysical signals registered in volcanic areas in terms of possible magma movement is crucial for our capability to identify pre-eruptive warnings. We present here an analysis of gravity, deformation, and seismic signals associated with convection and mixing in magma chambers and volcanic conduits/fissures, due to the arrival at shallow depth of batches of compositionally different, CO_2 and/or H_2O rich magma. In order to simulate the signal source we make use of a recently developed finite element code which simulates the transient 2D dynamics of multicomponent magma in the incompressible and compressible regimes. The numerical simulations take into account conditions pertaining to explosive eruptions at Campi Flegrei and Stromboli volcanoes, and employ advanced models of magma properties and magma/system characteristics determined for specific eruptions having great relevance for the volcanic hazard at the two volcanic areas. The numerical results describe the space-time evolution of magma composition, flow variables, and magma properties, and provide the source for the geophysical signals transmitted to the Earth surface. In this investigation we model the free-air corrected gravity change, and adopt a one-way coupling between magma and country rocks to model ground deformation and seismic signals related to deep magma dynamics. The results allow the identification of geophysical signatures peculiar of the simulated pre-eruptive magma dynamics, and open the way to a more physically sound interpretation of geophysical signals and more confident definition of pre-eruptive warnings at active, potentially dangerous volcanoes.