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Ground deformation at calderas driven by fluid injection: modelling unrest episodes at Campi Flegrei (Italy)

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Campi Flegrei collapse caldera (Italy) is a high risk volcanic area located close to Naples and including part of the densely populated city. Such area is characterised by large up and down ground displacements. The last large uplift episode caused 3.5 m of cumulative vertical displacement at the center of the town of Pozzuoli, in the period 1969-1984. Up and down ground movements at this area, normally occurring with no eruptions, are similar to what observed at other calderas worldwide, but appear here more evident and amplified. Understanding the mechanism of such movements is crucial for hazard assessment and eruption forecast, mainly at this densely populated area. This work presents a detailed model for ground displacements due to deep fluid injection in shallower layers. Such a model explains in a natural way the occurrence of uplift and subsidence without eruptions. For the first time, we show which is possible to fit observed ground deformations at this area with such a fluid-dynamical model. The obtained model is consistent with other observations like microgravity changes, changes in CO2 flux, etc. This paper then rigorously demonstrates that significant uplift and subsidence at calderas can be due to effects of deep fluid injections other than magma, such effects being also in agreement with a large body of different data (i.e. geochemical, gravimetric, seismic).