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Quantifying the errors due to the superposition of analytical deformation sources

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The displacement field due to magma movement in the subsurface is often modelled using a Mogi point source or a dislocation Okada source embedded in a homogeneous elastic half-space. When the magmatic system cannot be modelled by a single source it is often represented by several sources, their respective deformation fields are superimposed. However, in such a case the assumption of homogeneity in the half-space is violated and the interaction between sources in an elastic medium is neglected.

In this investigation we have quantified the effects of neglecting the interaction between sources on the surface deformation field. To do so, we calculated the vertical and horizontal displacements for models with adjacent sources and we tested them against the solutions of corresponding numerical 3D finite element models. We implemented several models combining spherical pressure sources and dislocation sources, varying the pressure or dislocation of the sources and their relative position. We also investigated three numerical methods to model a dike as a dislocation tensile source or as a pressurized tabular crack.

We found that the discrepancies between simple superposition of the displacement field and a fully interacting numerical solution depend mostly on the source types and on their spacing. The errors induced when neglecting the source interaction are expected to vary greatly with the physical and geometrical parameters of the model. We demonstrated that for certain scenarios these discrepancies can be neglected (<5%) when the sources are separated by at least 4 radii for two combined Mogi sources and by at least 3 radii for juxtaposed Mogi and Okada sources