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Evidence for fluid migration as the source of deformation at Campi Flegrei caldera (Italy)

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We model the location, geometry and density of the source of the recent geological unrest at Campi Flegrei caldera (Italy) by inverting levelling, trilateration and gravity measurements collected between 1980 and 1995.

First order optical levelling data, referenced to benchmark 1 in Naples, are available in the whole period 1980-1995, at a number of points increasing with time. Distance changes in an EDM network covering the caldera were determined for 13 baselines between 1980 and 1983 (during inflation), and 21 baselines between 1991 and 1995 (during deflation). The number of gravity stations available for our analysis is 6 sites between 1981 and 1983, and 10 sites between 1991 and 1995.

The inversion is performed using a weighted least squares algorithm with search grid. The covariance matrix, besides the measurements error, includes an error of 2 mm/$\sqrt{\text{yr}}$ taking into account monument instability. The best fit model is determined using a reduced chi-square test and 95% confidence limits are computed by a bootstrap percentile method. We test three source geometries: a spherical source, a vertical prolate spheroid, and a horizontal penny-shaped source, all in an elastic, homogeneous, isotropic half-space.

The best fitting source for the 1980-84 inflation is a horizontal penny-shaped crack with a density 142 to 1115 kg/m^3. The source best fitting the deflation period (1990-95) is a vertical spheroid with density between 902 and 1015 kg/m^3. These results exclude the intrusion of magma, and indicate the migration of fluid to and from the caldera hydrothermal system as the cause of ground deformation and consequent unrest.