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Study of the 2011-2013 unrest at Campi Flegrei caldera (Italy) through InSAR and 3D modelling

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Campi Flegrei is a nested caldera in Italy, at the western edge of the Bay of Naples. Together with Vesuvius and Mt Etna, it is one of the Italian GeoHazard Supersites. The area is characterized by one of the highest volcanic hazard in the world, due to the very high density of inhabitants (1800/km^2), the persistent activity of the system and the explosive character of volcanism. A major unrest episode took place in 1982-84, when the town of Pozzuoli, located at the caldera center, was uplifted by 1.80 m ($\sim$1 m/yr). Minor uplifts of few cm, seismic swarms and degassing episodes took place in 1989, 2000 and 2004-06. Since 2005 Campi Flegrei is uplifting, reaching a ground velocity of 9 cm/yr in 2012, showing that the caldera is in a critical state on the verge of instability.

In the present work we consider InSAR time series of the recent activity (2010-2013) detected by COSMO SkyMed satellite. In particular, the time series show a progressive velocity increase of ground deformation during 2012, while it slowed down in 2013 approaching zero. The cumulative displacement from COSMO SkyMed descending orbit (March 2011 – March 2013) show a semicircular pattern centered in Pozzuoli with a maximum LoS (Line of Sight) displacement of 11 cm and maximum velocity 9 cm/yr reached along the coastline. The spatial distribution of the cumulative displacement from COSMO SkyMed ascending orbit show a similar behavior, confirming the bell-shaped pattern of the deformation at least inside the inner rim of the caldera. The cumulative ascending LoS displacement between March 2013 - September 2013 is 1-2 cm, confirming the stall of the unrest after the first few months of 2013 as observed by GPS.

Initially, several source geometries are adopted (sphere, spheroid, sill) to model the cumulative deformation between 2011 and 2013. All the sources are located offshore Pozzuoli at a depth of about 2 km. The sphere and spheroid result to dilate at an annual volume variation rate of the order of 10^6 m^3/yr. All the models show a general good agreement with geodetic data but systematic overestimates are found for the enhanced negative horizontal and vertical deformation across the South-West rim of Campi Flegrei. This suggests that an additional deformation mechanism may be active in that area. Numerical models including the structural characteristics of Campi Flegrei are also attempted in order to model the complete deformation pattern and to better define the source parameters. A deeper understanding of these characteristics, together with microgravity and geochemical data, may help to discern between magmatic (e.g., the large uplift episode during 1982-84, most probably due to deep magmatic source) and hydrothermal (e.g., mini-uplifts of 2000 and 2004-06 most probably due to pressure variations in the shallow aquifer) origin of the source responsible of the recent deformation. Source definition may have important implications in terms of civil protection.