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Joint use of long water pipe tiltmeters and sea level gauges for monitoring ground deformation at Campi Flegrei caldera

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The Campi Flegrei caldera, located in the Campanian Plain, Southern Italy, 15 km west of the city of Naples, is a nested, resurgent, and restless structure in the densely inhabited Neapolitan area. The main caldera at Campi Flegrei is 12 – 15 km across and its rim is thought to have been formed during the catastrophic eruption, occurred 39 ky ago ca., which produced a deposit referred to as the Campanian Ignimbrite. The volcanic hazards posed by this caldera and the related risk are extremely high, because of its explosive character and the about 1.5 million people living within the caldera. Campi Flegrei area periodically experiences significant unrest episodes which include ground deformations, the so-called “bradisismo”. Following the last eruption (Monte Nuovo, 1538) a general subsidence has been interrupted by episodes of uplift, the most recent of which occurred in 1970-72 and 1982-84. Since 1950 the caldera is showing signs of unrest with ground uplift, seismicity, and composition variation of fumarole fluids. In particular, subsidence has been replaced by intermittent episodes of inflation with short time duration and various maximum amplitude. They occurred in 1989, 1994, 2000, 2005-06, 2008-09 and 2011-2014 with duration of few months and maximum amplitude ranging between 3 and 18 cm., approximately.

In the last years an array of water-pipe tiltmeters with lengths between 28 m and 278 m in tunnels on the flanks of the region of maximum inflation has been installed to avoid problems common to the traditional tiltmeters. The tiltmeters record inflation episodes upon which are superimposed local load tides and the effects of the seiches in the Bay of Naples and in the Tyrrhenian sea. We use data recorded by three tide gauges in the Bay of Pozzuoli (Pozzuoli, Miseno, Nisida) to compare water pipe data with sea level to extract astronomical tidal components (diurnal and semidiurnal) and seiches periods (particularly between 20 minutes and 56 minutes) that could constitute local loading frequencies recorded clearly by tide gauges and tiltmeters. We perform an analysis of the amplitude stability of seiches amplitudes. After the removal of the tides and seiches component we compare tilt residual and sea level trend for the same periods of time. The comparison between these two kind of data enables a more sensitive definition of the low level uplift with an accuracy of 1% for nanoradiant tilts in the period range 10 minutes to 10 hours with a long term tilt stability of approximately 0.1 microradiant/yr.