SEASONAL TROPOSPHERIC OSCILLATIONS OBSERVED IN INSAR TIME SERIES

Geomatics Canada
Scientific Presentation 4

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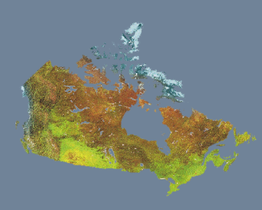


ABSTRACT

Applying the Multidimensional Small Baseline Subset Interferometric Synthetic Aperture Radar (MSBAS InSAR) algorithm to 250 ENVISAT and RADARSAT-2 SAR images spanning 2003-2013 we computed time series of ground deformation over Naples Bay Area in Italy. Two active volcanoes, Vesuvius and Campi Flegrei, are located in this area in close proximity to a densely populated city of Naples. For the first time with a remarkable clarity in the vertical component of time series we observed elevation dependent seasonal oscillations with an amplitude of up to 1.5 cm, substantially larger than the long-term annual deformation rate. Analysis, utilizing ground weather station and radiosonde data, linked observed oscillations with seasonal fluctuations of water vapor, air pressure and temperature in a lower troposphere. Atmospherically corrected time series confirmed continuing subsidence at Vesuvius previously observed by GPS and levelling techniques. Developed methodology demonstrated that for spatially localized studies the Atmospheric Path Delay (APD) can be successfully modeled as an elevation dependent seasonally oscillating signal.

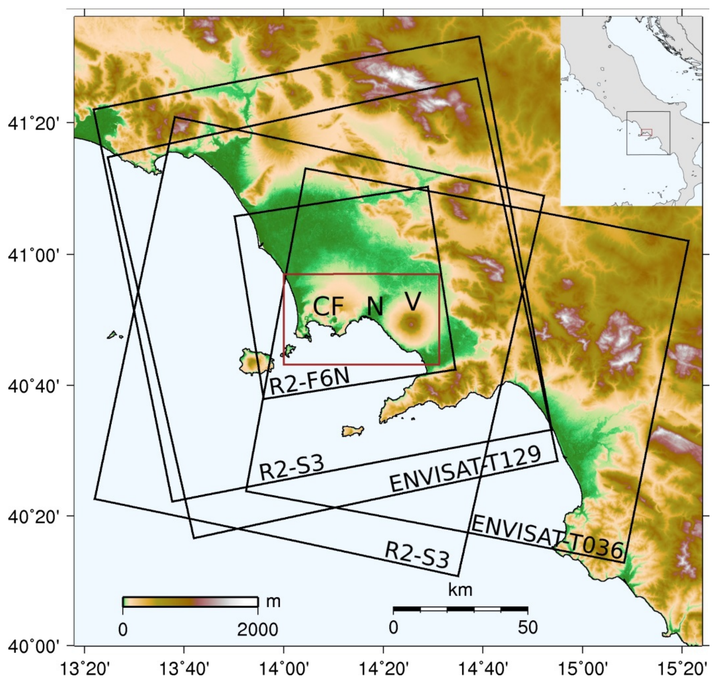
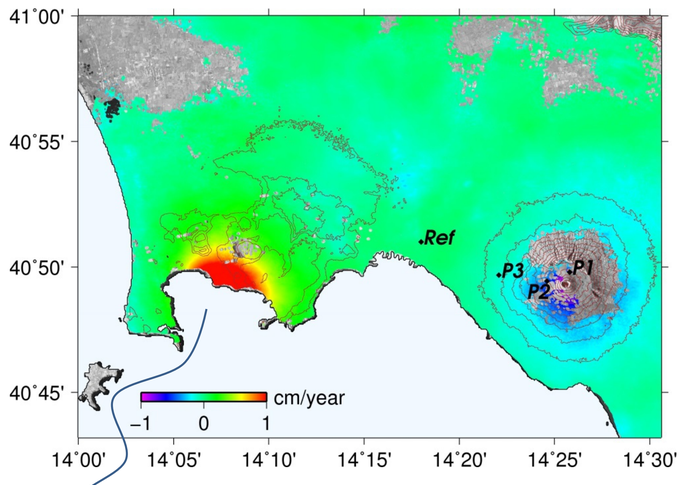


Figure 1. Naples Bay Area in Italy (see extent in top-right corner). SAR frames (in black): ENVISAT ascending track 129, descending track 036, and RADARSAT-2 ascending tracks Fine-6 Near (F6N) and Standard-3 (S3) and descending Standard-3 (S3). Region of interest (in brown) covers Campi Flegrei (CF), Vesuvius (V), and City of Naples (N). Background is 30 m ASTER DEM (from http://gdex.cr.usgs.gov/gdex/).

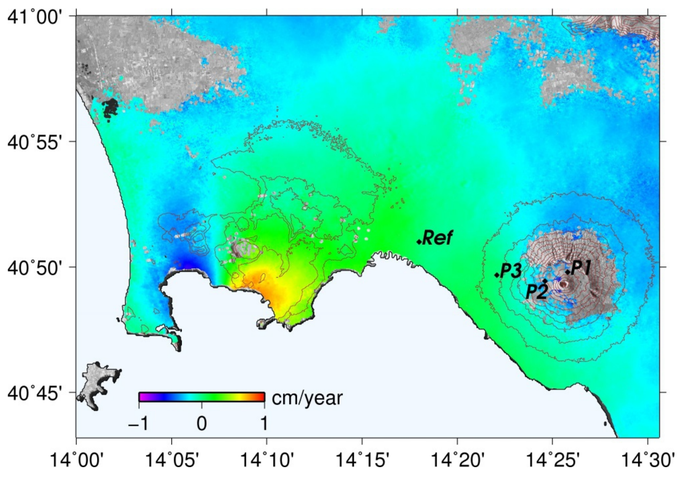
Table 1. ENVISAT and RADARSAT-2 Synthetic Aperture Radar data used in this study, θ is azimuth and ϕ is incidence angles, N is number of images and M is number of interferograms computed for each data set.

InSAR set	Orbit	UTM	Coverage	$\theta°$	$\phi°$	N	M
ENVISAT, Track 129	asc	20:47	20021113-20091216	344.0	22.8	55	276
ENVISAT, Track 036	dsc	09:20	20030605-20101021	195.9	22.8	58	196
RADARSAT-2, S3	asc	16:57	20090119-20130215	348.7	35.1	39	156
RADARSAT-2, S3	dsc	05:10	20081227-20130216	190.4	35.1	50	422
RADARSAT-2, F6	asc	17:09	20081229-20121208	351.0	48.3	48	407
Total:			20030605-20130215			250	1457

2003-2013 vertical deformation rate



2003-2013 horizontal east-west deformation rate



1993-2013 time series from Campi Flegrei

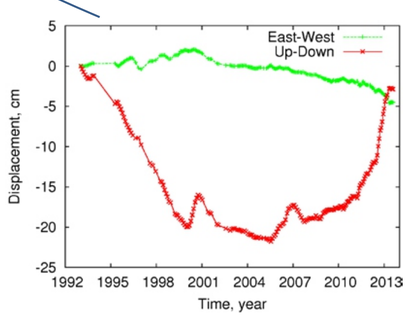
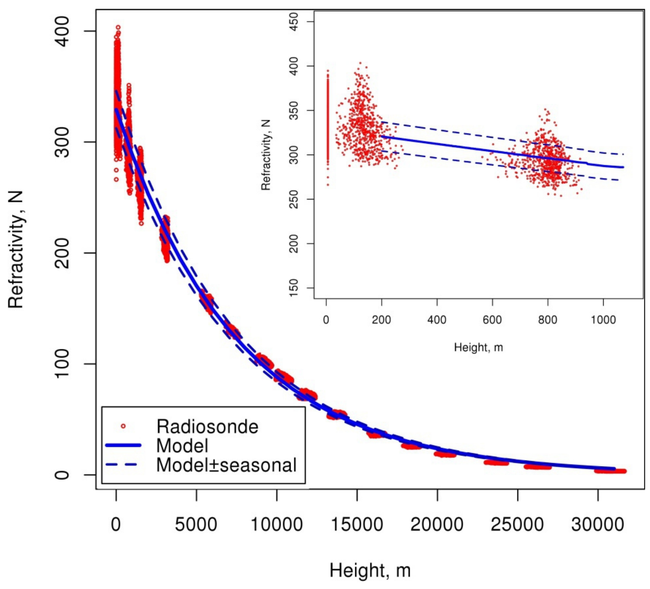
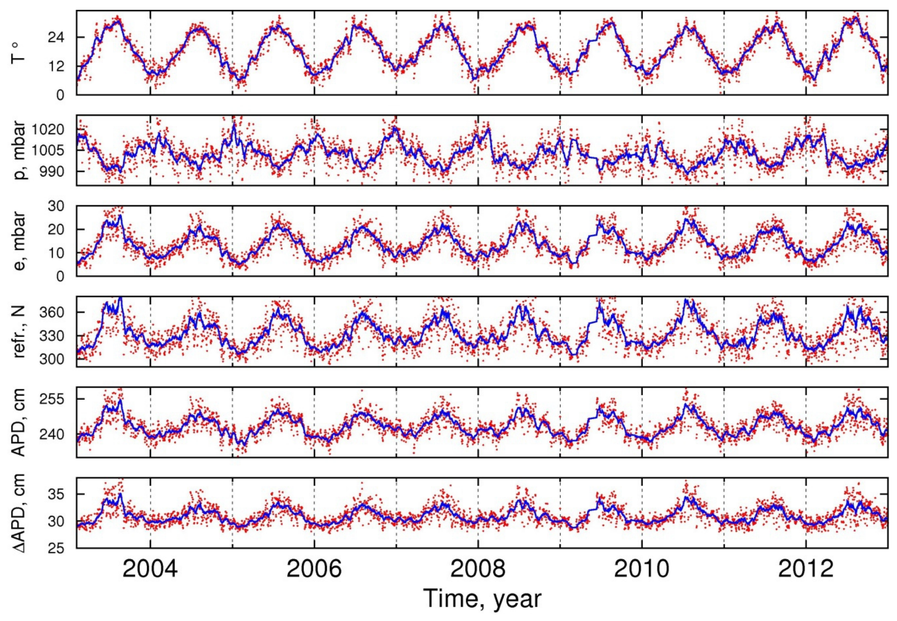


Figure 2. Vertical and horizontal displacement rate from ENVISAT and RADARSAT-2 data acquired during 2003-2013 period and calculated with Multidimensional Small Baseline Subset (MSBAS) technique (Samsonov and d'Oreye, 2012; Samsonov et al., 2014). 100 m topographic contour lines are shown in brown. Reference region is marked as ``Ref'' and measurement points are marked as P1 - P3. For visualization displacement rate values were limited to [-1;1]. To the left time series from Campi Flegrei from a larger dataset additionally containing 1992-2008 ERS data.





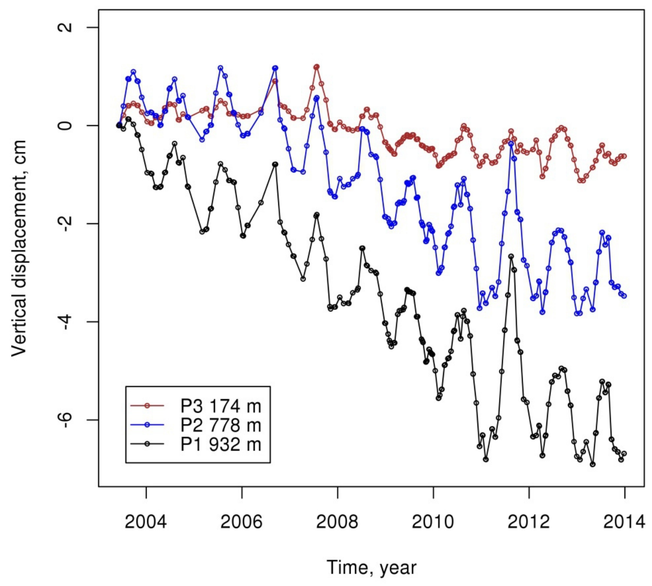


Figure 4. Time series of vertical deformation measured at points P1 - P3
32 m

Figure 3. {(left) Refractivity as function of height computed from radiosonde measurements of temperature, atmospheric and water pressures (in red) observed twice daily during 2012. Fitted mean and seasonal fluctuation of exponential model (in blue). Radiosonde data was acquired by Pratica di Mare weather station located near Rome, Italy (from http://badc.nerc.ac.uk). Insert shows same data at 0-1000 m elevations. (right) Parameters measured at weather station Napoli/Capodichino approximately co-located with ``Ref'' point from \ref{figure2} (left): temperature (T), atmospheric pressure (p), water vapor pressure (e) and computed parameters: refractivity (ref) at earth's surface, atmospheric path delay (APD) at earth's surface, and fraction of APD (ΔAPD) accumulated between reference and measurement points with elevation difference of 1000 m. 20 day average is plotted in blue.

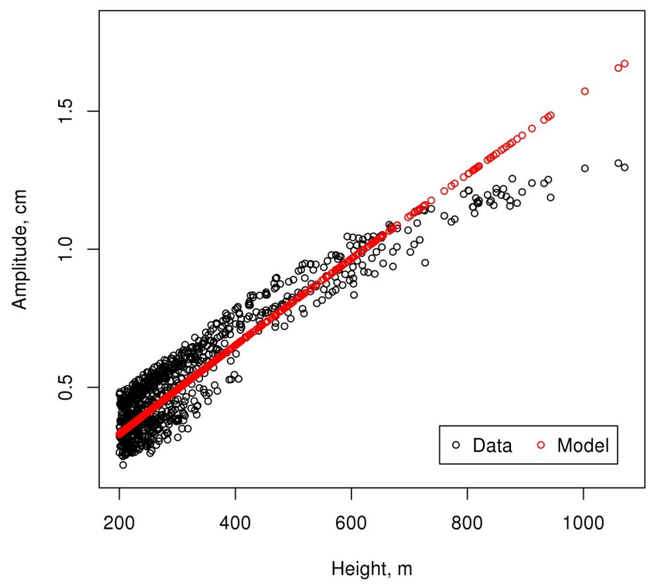
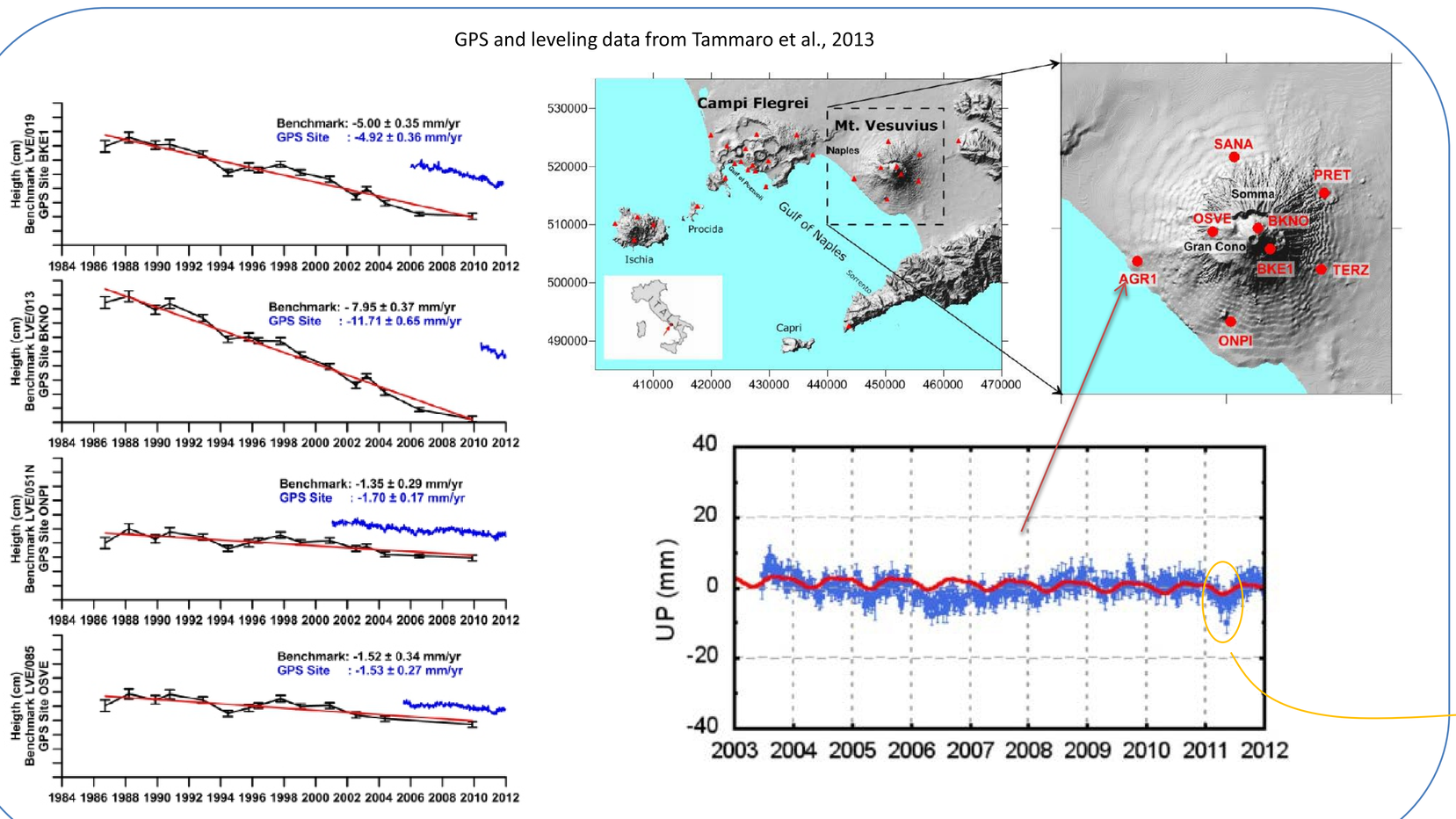


Figure 5. Amplitude of seasonal oscillations observed in vertical component of deformation time series as function of height (in black). Amplitude based on exponential decay model with parameters derived from radiosonde measurement (in red)

GPS and leveling data from Tammaro et al., 2013



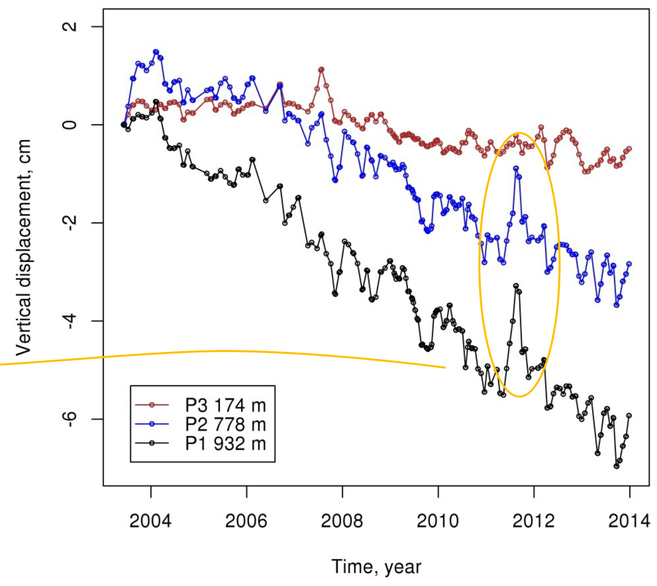


Figure 6. Same as in Figure 4 time series of vertical deformation after applying atmospheric correction.

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