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D3.6

Deformation maps obtained from the harmonization of InSAR and GPS data integration

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PP	Restricted to other programme participants (including the Commission)	
RE	Restricted to a group specified by the consortium (including the Commission)	
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MARSite (GA 308417) D3.6 Deformation maps obtained from the harmonization of InSAR and GPS data integration

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1. INTRODUCTION

SAR Interferometry (InSAR) and advanced version as Persistent Scatterers (PS) and Small Baseline Subsets (SBAS) are widely exploited to evaluate the seismic phases of an earthquake cycle thus playing an important role for the hazard mitigation in seismic areas. However, these techniques allow to measure movements occurring only along the satellite Line-of-Sight (LOS). Due to the particular SAR viewing geometry the estimation is more precise especially when considering a deformation field mainly characterized by a vertical component.

The synergic use of satellite data acquired along both ascending and descending orbits allows evaluating across-track deformation (eastward or westward) but its estimation accuracy is lower than the vertical component. Therefore, the integration and the harmonization of SAR data with other source of deformation measurements such as the ones provided by a GPS network, is strictly needed to validate the results.

Indeed, a GPS station measures 3D coordinates of the GPS sites with high temporal resolution but low spatial resolution thus being fully complementary to the InSAR informations.

By comparing the SAR deformation rate values extracted in correspondence to the GPS sites with the GPS measurements projected along the satellite LOS it is possible to constrain the deformation field caused by a seismic phenomenon.

Deliverable 3.6 contains the GPS velocity maps and the comparison with the InSAR results provided by applying the Persistent Scatterer Interferometry (PSI) data processing technique to a huge dataset covering the time period 1992-2010. The region of interest is extended from the Metropolitan area of Istanbul far to the East beyond the epicenter of 1999 Duzce earthquake. ERS and Envisat data satellite missions have been exploited to obtain the SAR mean velocity field and the related time series of deformation (see deliverable D3.5 for further details).

In the present D3.6 the synthesis of results is heavily related to the results, figures and tables presented in D3.5. In particular, PSI maps already described and analysed in previous deliverables have not been proposed again here.

MARSite (GA 308417) D3.6 Deformation maps obtained from the harmonization of InSAR and GPS data integration

2. SAR MEAN VELOCITIES AND GPS COMPARISON

2.1 SAR MEAN VELOCITIES AT GPS MONUMENTS

The following table reports the extracted mean surface velocity for the PS closest to the GPS monuments in the study area, and for each SAR dataset, i.e., the velocity map obtained from ERS descending set, Envisat ascending set, and Envisat descending set.

GPS Site	Lat	Long	ERS desc	Envisat asc	Envisat desc
1	41.0335	29.9731	-1.81	0.39	-1.54
2	41.0446	31.1979	0.15 (328m)	0.81 (500m)	-0.18 (530m)
3	40.8291	30.2387	-1.42	-0.24	0.98
4	40.7052	29.8038	-0.4	2.48	-1.2
5	40.6701	29.8187		2.77	
6	41.0483	30.2936	0.29 (160m)		-1.23 (280m)
7	40.7348	30.8266			
8	40.6143	30.6381		5.13	4.3 (300m)
9	40.6697	30.2453		5.78 (250m)	-5.79 (170m)
10	40.6671	29.5853	-1.65	1.38	-4.2
11	40.8243	30.5952			-0.52 (600m)
12	40.6116	30.3252		4.63	0.62
13	41.1795	29.6232	0.34	1.35	-0.02
14	40.7867	29.4507	-0.36	-0.55	0.62
15	40.9370	31.4388			
16	40.7453	30.1303		-1.3	
17	40.6897	30.1340	-2 (170m)	4.27	
18	40.7298	30.1587	2.1 (140m)		2.13 (76m)
19	40.6908	30.1760		6.54 (200m)	0.06 (150m)
20	40.7349	30.1813		-2.96	-0.2 (355m)

Table 1. List of the PS SAR mean velocities at the GPS monuments. Numbers in brackets

For the points where both ascending and descending velocities are available, i.e., only for Envisat data, the EAST and UP component of the SAR velocities is also derived to be compared with the GPS measurements, and these horizontal and vertical estimates are reported in table 2. It is worth to note that with respect to the North component of the displacement, the SAR measurements are not reliable, having a very low sensitivity in such a direction. Therefore in order to avoid misleading conclusions, the joint analysis of SAR and GPS measurements should account for such issue.

GPS Site	Lat	Long	Envisat UP	Envisat EAST
1	41.0335	29.9731	-0.62	-1.3
2	41.0446	31.1979	0.34	-0.6
3	40.8291	30.2387	0.4	0.82
4	40.7052	29.8038	0.7	-2.29
8	40.6143	30.6381	5.12	-0.01
9	40.6697	30.2453	-0.01	-7.41
10	40.6671	29.5853	-1.53	-3.73
12	40.6116	30.3252	2.85	-2.28
13	41.1795	29.6232	0.72	-0.8
14	40.7867	29.4507	0.04	0.75
19	40.6908	30.176	3.59	-3.78
20	40.7349	30.1813	-1.72	1.59

Table 2. List of the PS SAR EAST and UP mean velocities at the GPS monuments.

These data can also be used to map the east velocity vectors on a map, to better figure out the deformation field of the area.

The map is showed on figure 1 and the east-west motion that characterise the dextral fault mechanism is clearly visible.



Figure 1. Map of the SAR East velocities along this sector of NAFS. Yellow lines refer to major faults of the area.

2.2 GPS AND SAR DATA COMPARISON

The available GPS measurements derived from field campaigns cover a time interval 2004-2009. The GPS vectors have been expressed in yearly mean velocities and projected into the LOS (ascending and descending) directions to be compared with the SAR outcomes.

Here below we report the scatter-plot between GPS velocities (x-axis) and SAR velocities (y-axis), figure 2. The analysis of the plot shows some discrepancies probably ascribable to the non homogeneous data available. It is worth noting how GPS data are derived from campaigns, while SAR results derive from a set of images sampling at monthly rate the investigated period. In addition, SAR data provide two lines of sight, so that vertical and EW displacement components can be detected. On the contrary, GPS vectors are dealing with E-N-Up components.

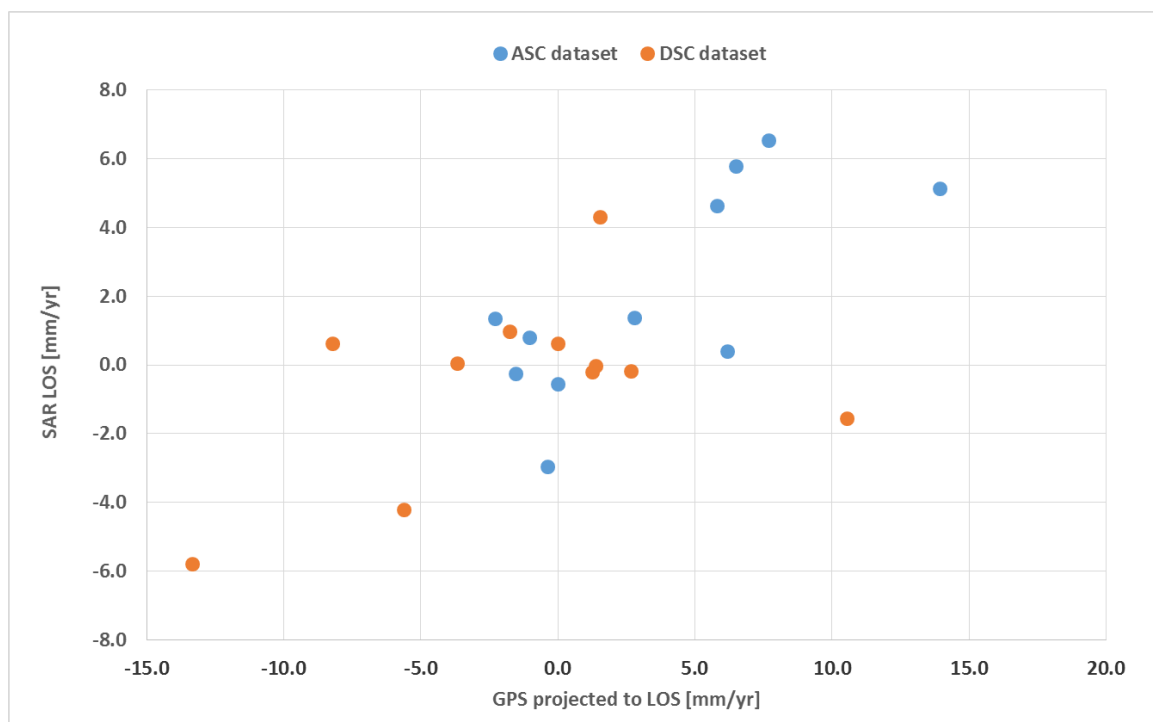


Figure 2. Scatter-plot of SAR vs. GPS measurements.

Due to the issues discussed above, the cross comparison between GPS and SAR data provide a qualitative agreement, while the quantitative analysis provides a resulting RMSE not quite good.

In order to better understand such discrepancies, we plot the east GPS velocity on the map with the major faults as already done in figure 1. The map of vectors, showed in figure 3, is in agreement with the tectonic setting of the area and the expected, long term, movements along this sector of NAFS, characterized by a dextral slip. Such relative movement of the N and S portions of the fault can be easily recognized and estimated by both GPS and SAR data.



Figure 3. Map of the GPS East velocities along this sector of NAFS. Yellow lines refer to major faults of the area.

In addition, we have analysed the SAR time series of PSs around selected GPS sites (see figure 4). The time series are referred to a number of PS within a distance of 1.5 km from the selected GPS site. The cumulative displacement is measured along the LOS from ascending orbit covering the time span 2003-2009. In particular, in Figure 5 we have considered two GPS sites, one (SISL) North of NAFS, one (SMAS) South of it. Detected displacements are in agreement with the GPS EW velocities in Figure 3, where the GPS in the south sector of NAFS show a much larger movement than those to the north. It is worth noting that PS around SISL reach a maximum displacement of about 7 mm in 2003-2009, while around SMAS PS move up to 32 mm in the same time span.

Detected deformation can be the result of post 1999 (Izmit earthquake) seismic movements with, in addition, aseismic contribution due to creeping causes.

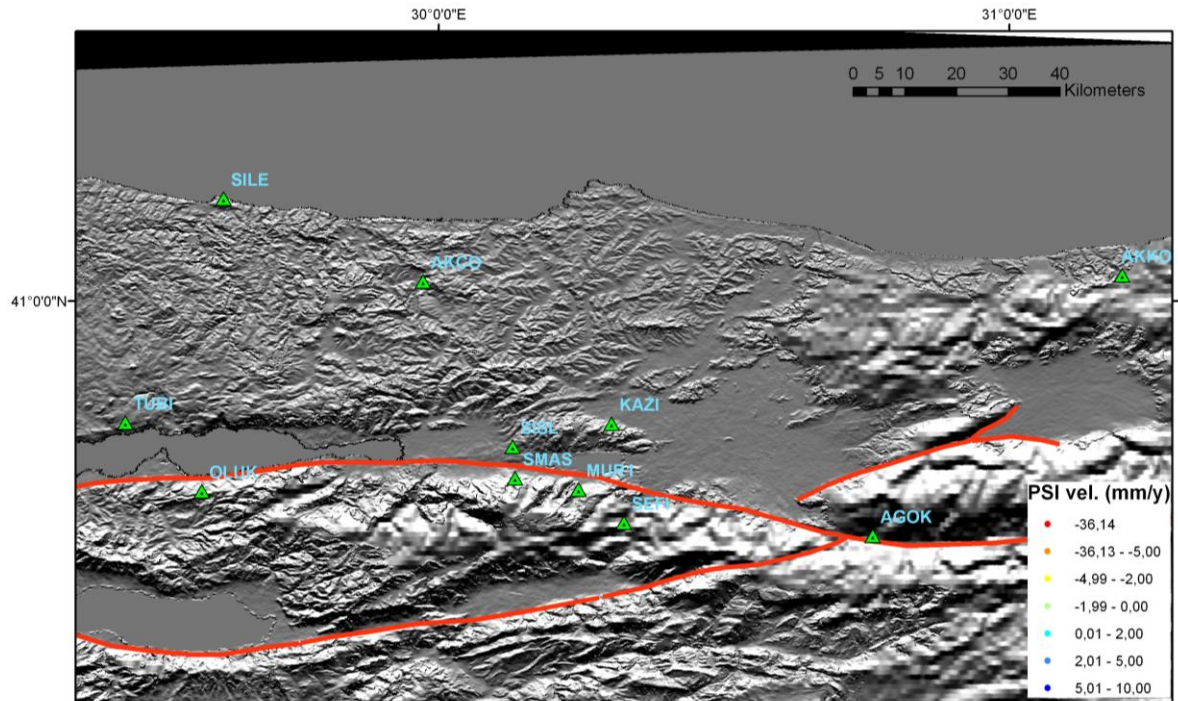


Figure 4: Map of GPS sites.

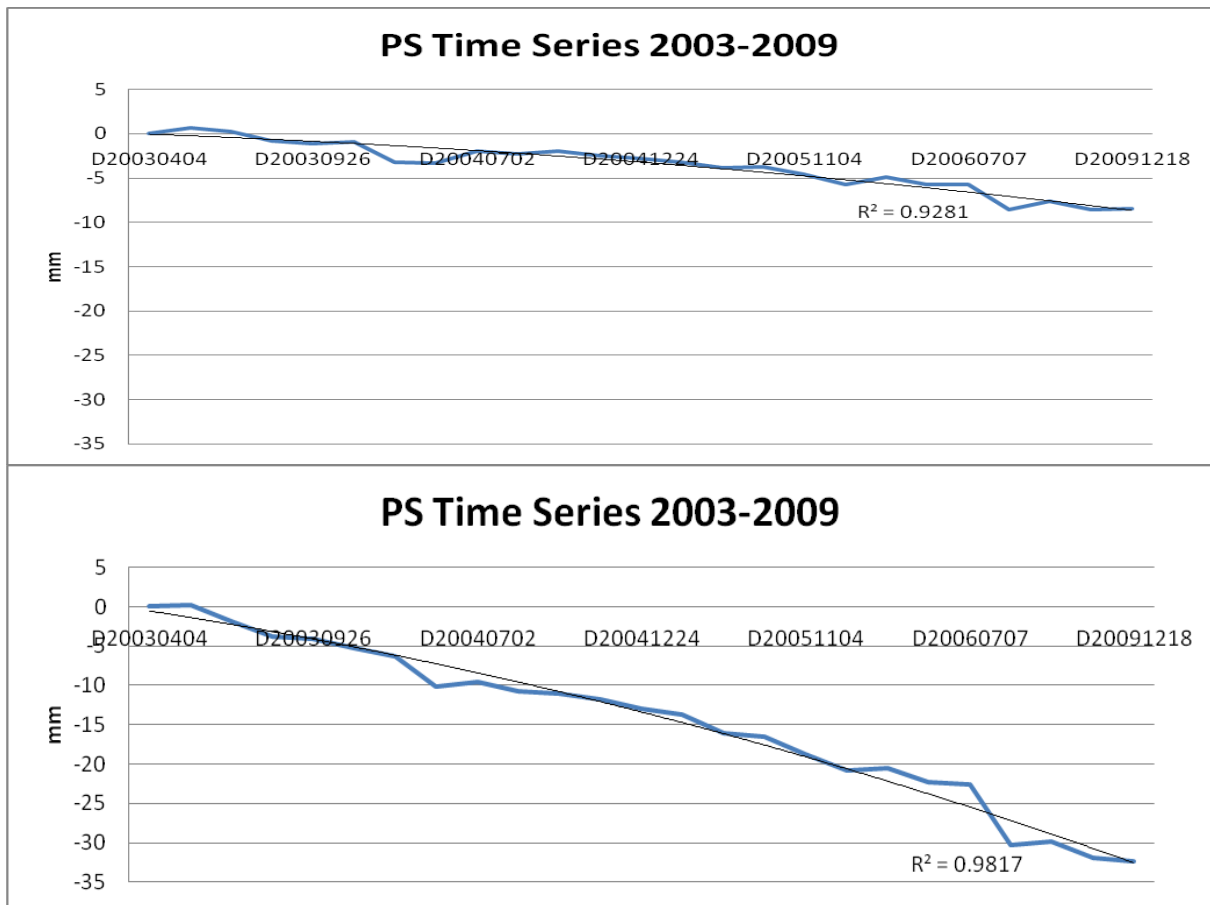


Figure 5: time series from selected PS in proximity of SISL (upper) and SMAS (lower) GPS site and covering the interval 2003-2009. The cumulated displacement is along the LOS from ascending orbit. It results from averaging PS in a range of 1.5 km from the GPS. A second order trend line has been added.