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DETECTION OF GROUND MOTION IN THE LISBON REGION WITH PERSISTENT SCATTERER INTERFEROMETRY (PSI)

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Abstract: We present evidence of ground motion detected in and around Lisbon with Radar Interferometry (Persistent Scatterer Interferometry - PSI). The work was done in the scope of GMES Terrafirma project, and two datasets of PSI data were used, with different orbital tracks. The first, provided by Tele Rilevamento Europa, is a standard TRE's PSInSAR processing chain H1 map of the Lisbon area. It covers the period from 1992 to 2003 and uses 55 Synthetic Aperture Radar Scenes from the ESA satellites ERS1/2 (orbital track 452, descending pass). The second set of data spans the period 1992-2006 and was provided by Altamira Information: it consists of (1) a standard SPN H1 product map of the area to the South of Lisbon, and (2) the result of running the SPN medium resolution processor for the Lisbon area and northwards. The Altamira maps were produced using 100 SAR scenes from both ERS1/2 and ENVISAT satellites (orbital track 223, descending pass). The delivered PSI maps give, for the spanned period, the mean velocity (in the line of sight of the satellite) and velocity time series for over 500.000 points in the area. The PSI maps were interpolated, detrended, contrast-enhanced, and compared with mapped geological features, soil classes, aeromagnetic and gravimetric data. At a regional scale, the results show a correlation between deep geological features inferred from geophysical techniques and psi-derived velocity patterns. At a more local scale, the main results are the detection of an area of ground subsidence (~6Km2) in the centre of Lisbon, and of another area possibly affected by slope movement in the north of Lisbon, close to the main highway.

1. INTRODUCTION

We present results of the application of Persistent Scatterer Interferometry (PSI) to study ground motion in the area of Lisbon. The technique, first developed by Ferretti et al. (2001), allows the measurement of mm-scale displacements of individual features on the ground using a large number of images collected over the target area by spaceborne Synthetic Aperture Radar (SAR) sensors. The work was done in the scope of ESA GMES Terrafirma Service.

2. DATA USED

Two datasets of PSI data were used, computed from SAR scenes acquired from different orbital tracks. The first, provided by Tele Rilevamento Europa, is a standard TRE's PSInSAR processing chain H1 map of the North Lisbon area. It covers the period from 1992 to 2003 and uses 55 SAR images from the ESA satellites ERS-1 and ERS-2 (orbital track 452, descending pass). Figure 1 shows TRE's mean velocity psi map depicting, for the spanned period, the mean velocity (in the line of sight of the satellite) for over 200.000 points in the area of Lisbon.

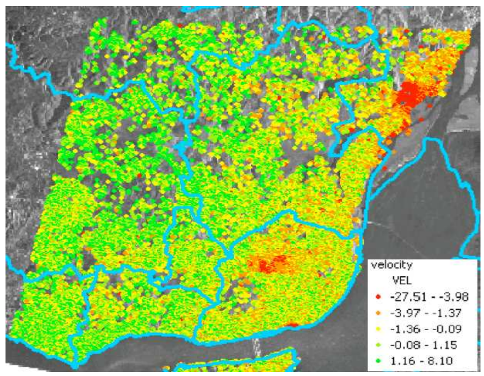

Figure1 - TRE's psi mean velocity map (in mm/yr)

The second set of data spans the period 1992-2006 and was provided by Altamira Information: it consists of (1) a standard SPN H1 product map of the area to the South of Lisbon, and (2) the result of running the Stable Point Network (SPN, Duro et al., 2005) medium resolution processor for the Lisbon area and northwards. The Altamira maps were produced using 100 SAR scenes from both ERS1/2 and ENVISAT satellites (orbital track 223, descending pass). Figure 2 displays one of Altamira's psinsar maps, displaying the LOS mean velocity for over 350.000 points.

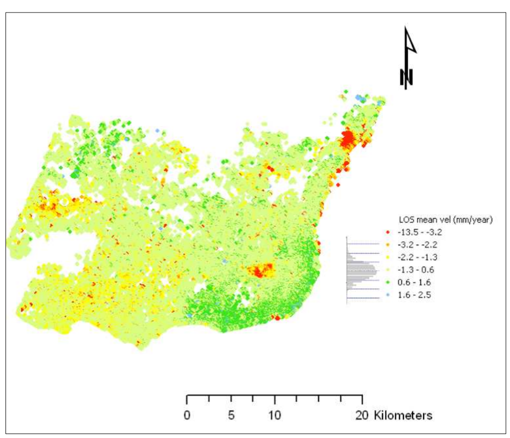

Figure 2 - Altamira's psi mean velocity map

3. ANALYSIS

The PSI maps were spatially analysed in the ArcGIS environment. They were de trended for detection of possible orbit-related errors, and smoothed both with IDW and kriging interpolators (figure 3). At a regional scale, the interpolated data correlates with deep buried basement geological features revealed by gravimetric (figure 4) and aeromagnetic data (Carvalho, 2003; L. Torres, pers.com.). Several areas of subsidence also appear bounded by known outcropping faults or by the drainage network (figure 5).

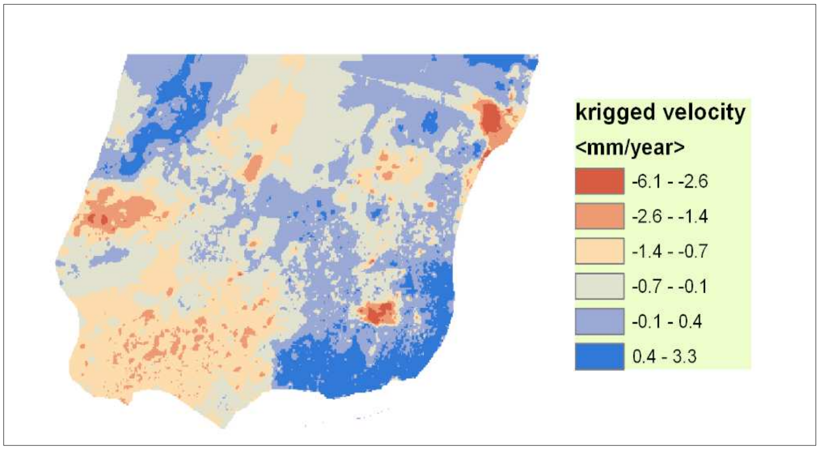

Figure 3 - Kriged PSI data

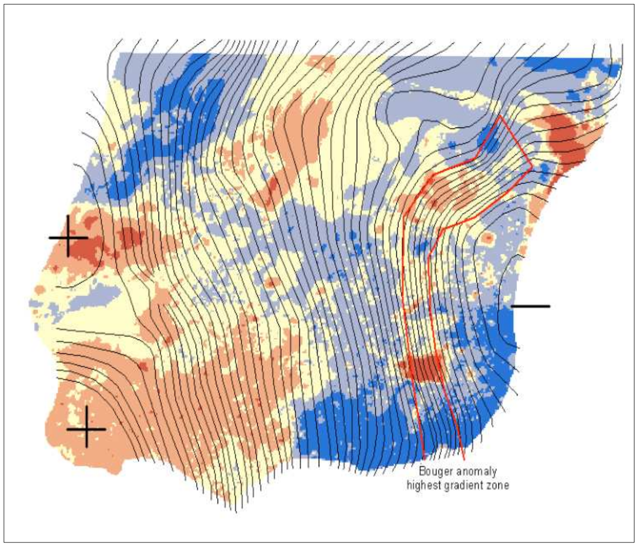

Figure 4 - Kriged PSI data compared to 1st degree Bouger anomaly contours. +/- indicate positive/negative anomalies. The red line depicts the area of smallest contour spatial separation, or strongest gravimetric gradient.

4. DISCUSSION

A relevant observation is the coincidence between a ENE-WSW followed by N-S trace seen in the interpolated PSI data, and lineaments associated with strong gravimetric and aeromagnetic contrasts. The latter have been recently interpreted by Carvalho et al. (2007), together with seismic reflection, well, and seismicity data, as delineating a 40 km-long fault zone crossing the centre of Lisbon (figure 5). To the West of this area, a smaller N-S aligned segment, not correlated with any known fault but coinciding with a riverbed, appears conspicuously in the kriged PSI map (figure 5), separating two blocks with differential movement above 1mm/year.

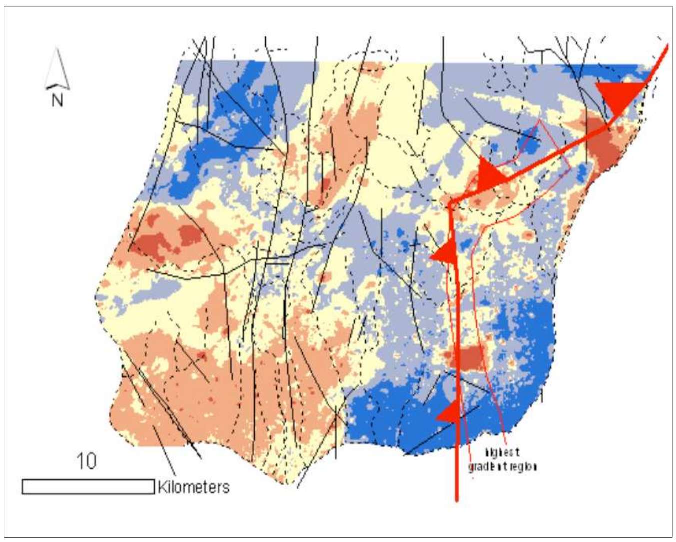

Figure 5 - Comparison of kriged PSI data with outcropping faults (black solid lines), drainage network (black doted lines), and independently-interpreted fault zone (red line with filled triangles) by Carvalho et al. (2007).

At a more local scale, the main results are the detection of an area of ground subsidence (~6Km2) in the centre of Lisbon, and of another area possibly affected by slope movement in the north of Lisbon, close to the main highway (both clearly seen in figures 1 and 2).

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