THE COSMO SKYMED CONSTELLATION TURN ON THE L'AQUILA EARTHQUAKE: DINSAR RESULTS OF THE MORFEO PROJECT

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1. INTRODUCTION

SAR systems have been proven to be valuable sensors for analyzing the effect of earthquakes and monitoring post seismic displacements. Many examples of the application of the Differential SAR Interferometry (DInSAR) technique, including multi-temporal stacking are given in the current literature to measure the co-seismic ground displacements: see for instance [1] [2] for co-seismic data analysis relative to the Landers (USA) and Bam (Iran) earthquakes and [3] for the to monitor post-seismic effects of the Athens (Greece) earthquake.

COSMO/SKYMED is worldwide the only constellation of SAR sensors usable also for the civilian use. It is composed of 4 medium-size satellites (three of which already operational) each one equipped with a microwave high-resolution synthetic aperture radar (SAR) operating in X-band, having the capability to change attitude in order to acquire images at both right and left side of the satellite ground track. COSMO/SKYMED is devoted to provide products/services for the following purposes environmental monitoring and surveillance applications for the management of risks. MORFEO is a project dedicated to the monitoring of the landslides risk by means of Earth Observation data. Within the MORFEO project two partners, IREA-CNR and GAP (a spin-off of the Politecnico of Bari), are in charge of the interferometric processing of SAR data.

On April 6th 2009, at 01:32 GMT, a Mw 6.3 earthquake struck the city of l'Aquila and the surrounding region, killing more than 300 people. During the next week the main shock was followed by seven major aftershocks (Mw>5), and over 6 thousands smaller events occurred in the next few months in an area extended NW-SE for about 35 km. Starting from this date, following an official request of the Italian Department of Civilian Protection the COSMO/SKYMED constellation was "turn on", with the highest priority, to the monitoring of the L'Aquila area. Co-seismic displacement maps were generated a few days after the earthquake by using COSMO/SKYMED, Envisat, TerraSAR and Radarsat data: see [4] for the results of the analysis of mainly Envisat data, [5] for the

modelling of co-seismic displacements and [6] for first results by using both C- and X-band SAR data. From April 2009 to October 2009 the constellation was capable to acquire in HIMAGE mode 33 acquisitions with ascending passes and 15 acquisitions with descending passes. Details on the ascending pass distribution, beam H4-09 (incidence angle ~ 40.1°), are provided in Table I.

2. RESULTS

In this work we discuss the results of the multi-temporal DInSAR results obtained by the two MORFEO SAR processing groups. The first results were achieved by GAP with SPINUA (Stable Point INterferometry over Unurbanised Areas) technique [7] over the area of Paganica town for both ascending and descending passes. Figure 2 shows the result relevant to the ascending passes; 26 out of 33 images were considered in this case, see the last row in Table I. Here the presence of a clear post-seismic displacement pattern was detected along the Paganica fault along a NW-SE direction, approximately located by the red line in Figure 2. These significant results were achieved thanks to the availability of a unique temporal acquisition rate which is currently possible only by using the COSMO/SKYMED constellation. Data were then delivered to IREA and were processed by a Small BAseline Subset (SBAS) like technique: SBAS [8] is characterized by the capability of working at low spatial resolution in such a way to achieve a large spatial coverage. Starting from the low resolution product, a full resolution analysis were carried out in IREA by using a 4D (space-velocity) imaging based approach [9] which uses amplitude and phase of the received signal: the full resolution data evidenced, as for the SPINUA processing, a spatial distribution of monitored point which is significantly denser than that typically obtainable with medium resolution SAR systems, such as those onboard the ERS and Envisat satellites. For space reasons here we present only the low resolution results achieved by IREA group. Several post-seismic interferograms generated during the SBAS processing already proved evidences for the presence of a larger (compared to the SPINUA high resolution results) after the main shock deformation pattern with a “drop shape” extending outside the Paganica town along the fault. This pattern were confirmed by mean deformation velocity map achieved by the processing all the available data with the low resolution SBAS technique shown in Figure 3. note that almost the whole area of about 40x40 Km were covered.

The discussed results clearly show the potentiality of the COSMO-SKYMED constellation use for emergency monitoring. Analysis of the earthquake induced deformation, as well as monitoring of buildings, infrastructures, clearly is possible by using such system to an unprecedented accuracy.

3. ACKNOWLEDGMENTS

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	18	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Month	April '09					May '09				June '09				July '09					August '09						September '09						October '09		
Day	04	12	13	20	29	06	14	30	31	07	15	16	23	02	09	17	18	25	02	03	10	18	19	26	03	04	11	19	20	27	05	06	13
Sensor	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S3	CSK-S1	CSK-S2	CSK-S2	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1	CSK-S2	CSK-S3	CSK-S1
B_t (days)	0	8	9	16	25	32	40	56	57	64	72	73	80	89	96	104	105	112	120	121	128	136	137	144	152	153	160	168	169	176	184	185	192
B_p (m)	686.0	254.6	220.4	-164.2	-333.8	-581.0	-255.4	119.6	-2.3	-75.2	418.5	340.3	263.0	-90.5	-113.8	-237.6	-53.0	0.0	136.0	497.2	242.1	8.8	-46.4	-122.4	-76.5	-12.5	15.6	296.3	441.0	623.0	528.4	434.9	175.4
f_{DC} (hz)	-322.3	-579.6	-1278.1	-517.9	-1216.2	-499.6	-545.1	-486.0	-1195.0	-408.4	-554.8	-1262.0	-470.2	-1233.3	-420.1	-497.5	-1218.4	-440.5	-456.9	-1135.4	-553.0	-591.7	-1291.5	-518.3	-569.8	-1249.3	-427.8	-546.2	-1187.0	-397.9	-667.8	-1268.6	-457.9
IREA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
POLIBA	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗

Table I: Parameters of the ascending pass COSMO/SKYMED dataset

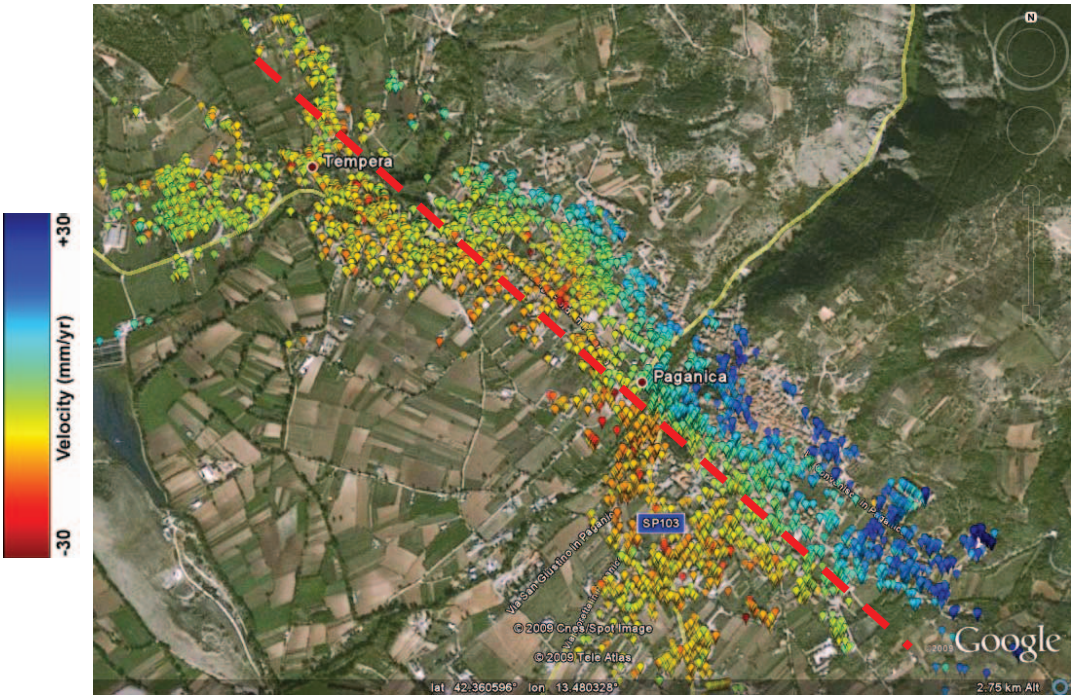

Figure 1: Mean deformation velocity map achieved by the SPINUA technique

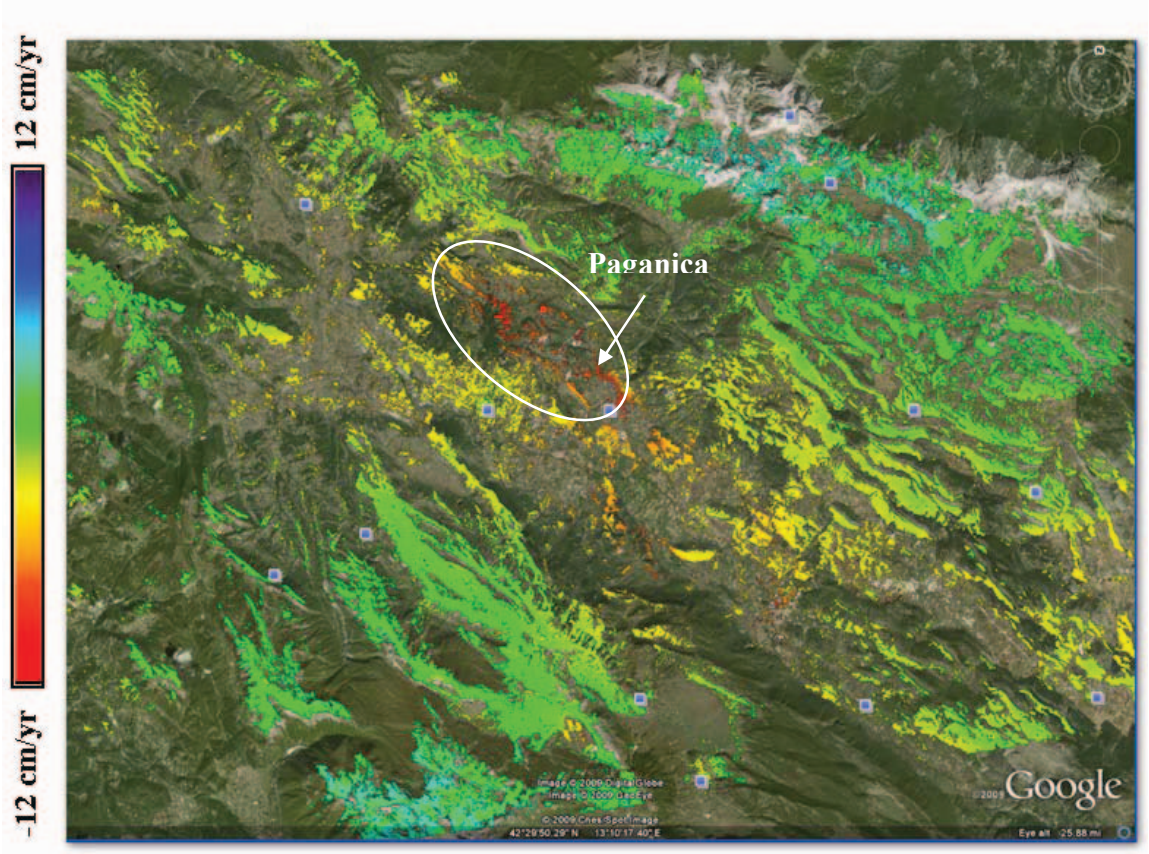

Figure 2: Mean deformation velocity map achieved by the SBAS technique