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Mapping the Local hazard of the Larissa National Airport in Central Greece using space based-SAR Interferometric techniques

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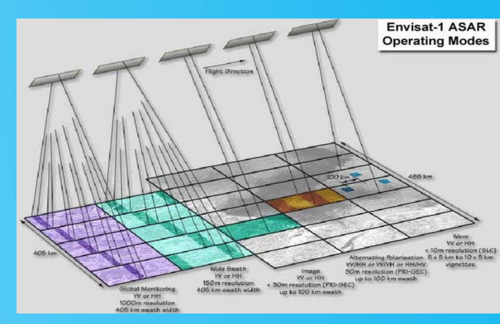
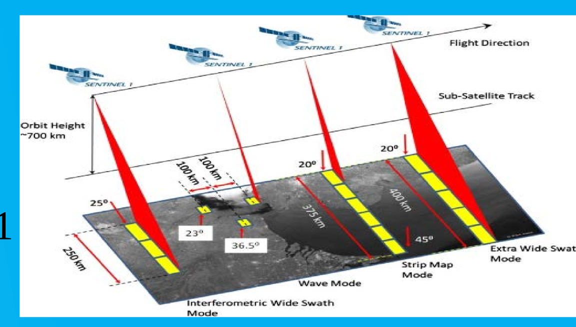
From ERS_1/2

And ENVISAT



To Sentinel-1



High qualitative and quantitative Local and Reginal InSAR Time series maps

Abstract

The possibility of use the productions of Earth Resource Satellite (ERS-1/2) and Advanced Environment Satellite ENVISAT SAR (Synthetic Aperture Radar) and Sentinel-1 C-band have given the potential to detect and estimate the time series of dynamic ground deformation within high spatial and temporal resolution. Additionally assess the details scale ground degradation effects the environment. The Larissa National Airport in Central Greece is suffering from continued ground deformation as evidenced by the presence of ground fissures and sinkholes as well as observed land subsidence. Synthetic Aperture Radar interferometric techniques (InSAR) were used to detect short- and long-term ground deformation dynamics in the airport using the GAMMA Software (S/W), and SNAP from ESA. The results indicate complex subsidence and uplift processes at ranges between – 15 and + 25 mm a-1 to co-occur in different parts of the study region. The observed ground deformation processes are likely to result from volume changes in expansive soils and human induced groundwater lowering with possible micro-tectonic movements.

Material and methods

1- Study Area

The Larissa National Airport is located in the Eastern part of Larissa in the northern Thessaly region in Central Greece (Fig. 1 a, b, c). It was built in 1912 and functioned as the main airport of the city until 1997 when it was closed from civil uses. Currently it still serves as a military airport. Thessaly, both in general and in particular in the sector corresponding to the Tyrnavos Basin, as well as most of the villages in the region, are settled on thick Quaternary fluvio-lacustrine deposits and therefore on highly vulnerable geological conditions (Caputo, 1993; Caputo and Helly, 2005).

2- SAR data and Processing

Ground deformation was monitored by the use of 24 Single Look Complex (SLC) SAR C-band images of ERS-1/2, during 1995 – 2000 and 15 SLC images of ENVISAT ASAR acquired during 2003 – 2008 by ESA . The examined time period extends from 1995 till 2006 (11 years). Two SAR interferometric techniques (InSAR) were used with the GAMMA processing software (S/W) (Gamma Remote Sensing, 2008) and SNAP from ESA.

We applied Differential INSAR (DInSAR) technique to study short-term ground deformation by using one image pair for winter (from 28th of February 1996 to 3rd of March 1996) and another one for late summer (2nd of August 1998 to 6th of September 1998). As well as other images pair were used from Sentinel-1 for winter (from 27th of February 2015 to 4th of April 2015) and another one for summer (2nd of August 2015 to 7th of September 2015).

Persistent Scatters Technique (PSI) (Interferometric Permanent Target Analysis (IPTA)) was applied to identify ground deformation over longer times and in relation to groundwater level fluctuations.

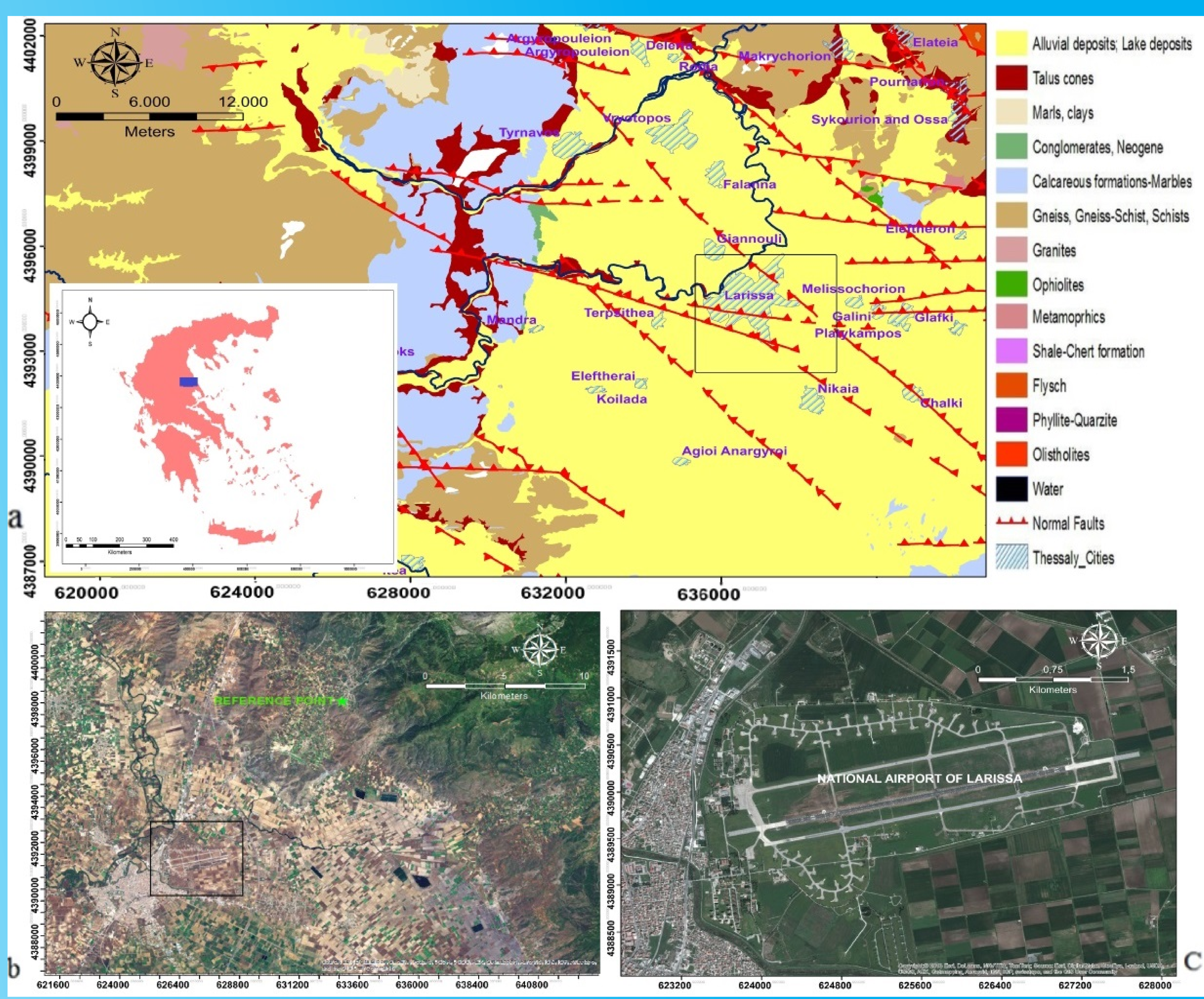


Figure 1.a, b, c Location of the study area and geological map of the Larissa region as modified from IGME – Greek Institute of Geology and Mineral Exploration http://www.managenergy.net/actors/1337.

Results

Short term changes

Conspicuous spatial patterns can be observed in both of the conventional SAR Inferometry assessments in the study area 1996, 1998 (Fig. 2a, b) and 2015 (Fig. 2c and d).

Long term changes

236 PS candidate points were defined in the study area and their changes were monitored from 1995 to 2006 (Fig. 3). Change dynamics in five PS candidate points selected from different parts of the airport area illustrate a general trend of uplift in the region (Fig. 4).

Precipitation and groundwater level

The precipitation in the study area shows distinctive monthly, seasonal and inter-annual variations (Fig. 5 a, b). The groundwater level indicates fluctuations resulting from the mutual recharge and discharge of the aquifer (Fig. 4).

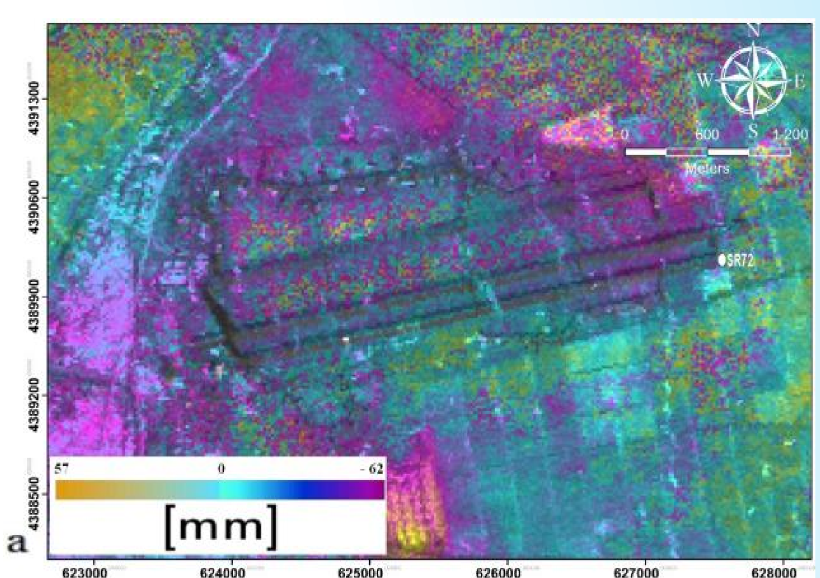


Figure 2. Two conventional InSAR interferogram images of the study area. (a) Representing the period from 28 February 1996 to 3 April 1996 within the track 143.

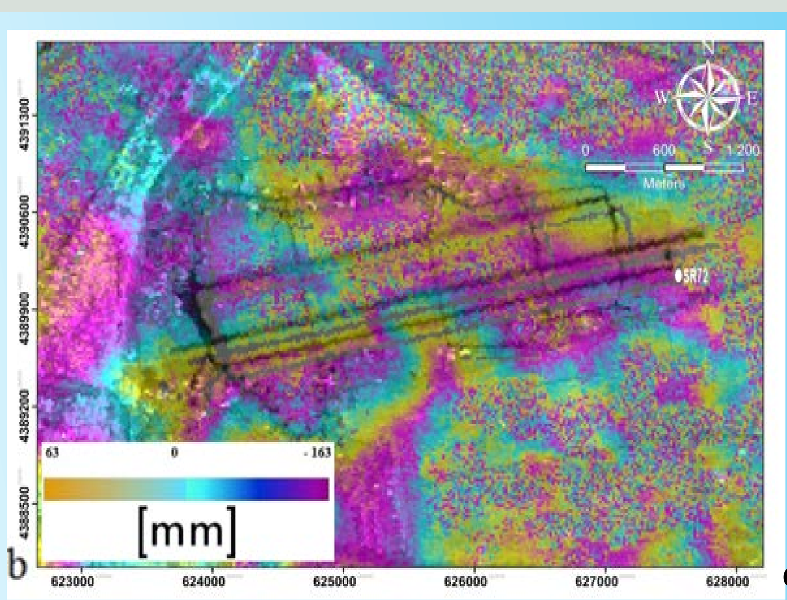


Figure 2. (b) The period from 2 August 1998 to 6 September 1998 within the descending track 279. The position of the groundwater borehole well SR72 is shown with white point.

Figure 2. (d) The period 27th of February 2015 to 4th of April 2015 within the descending track IW3 Sentinel-1 C band.

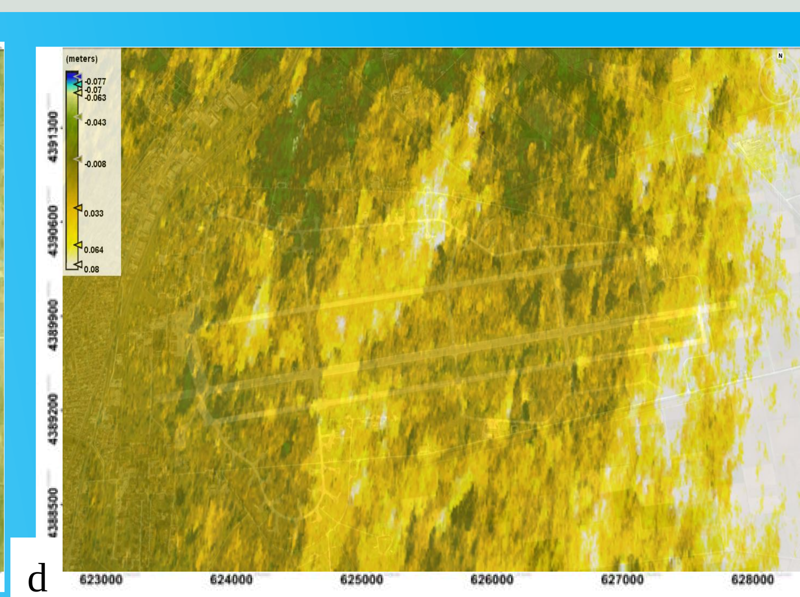


Figure 2. (c) The period 2nd of August 2015 to 7th of September 2015 within the descending track IW3 Sentinel-1 C band.

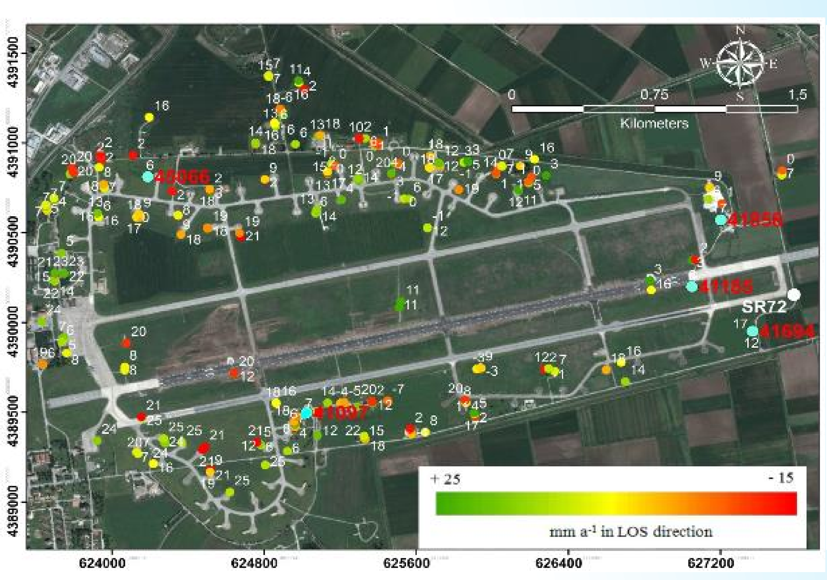


Figure 3. Average LOS velocity image along the runway and areas of Larissa National Airport for the period 1995 to 2006. The image has been saturated at ±0.1myear-1 for visualization purposes. The numbers besides the PS candidate points indicate persistent scatterers. The borehole SR72 is shown in white and the PS candidate points used in Figure 5 are in cyan.

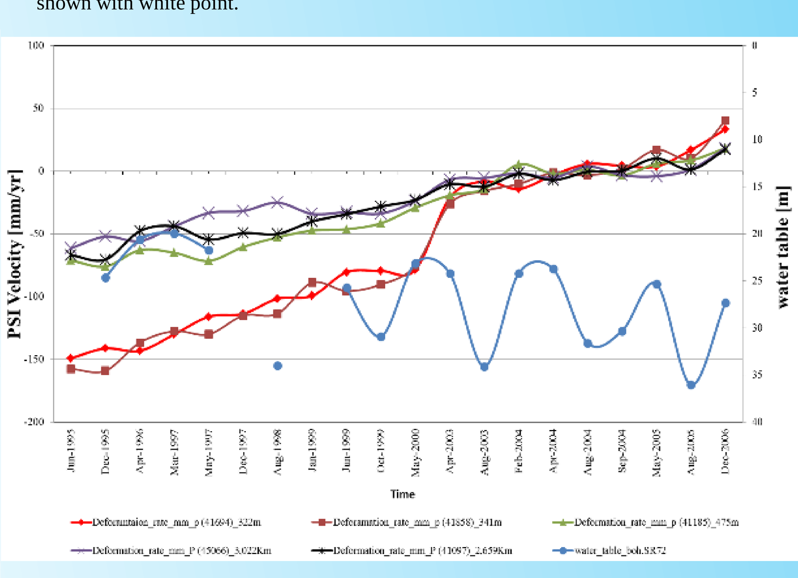


Figure 4. LOS Displacemnt of three candidate points of PSI corresponding to groundwater level of borehole SR72. Displacement time series of point candidates are rescaled to the first acquisition (i.e. 28 June 1995).

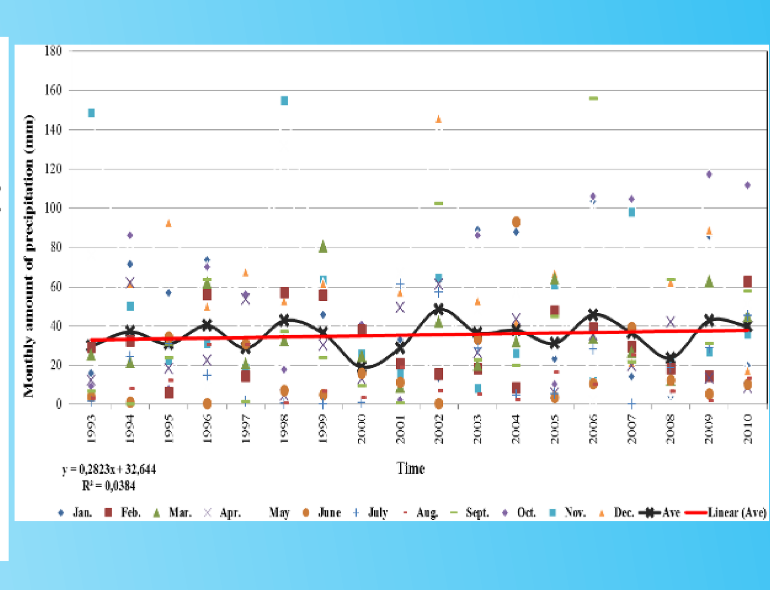


Figure 5 . a. Monthly precipitations (point symbols) and the yearly averages of monthly precipitations for the period 1992–2010 (data is from the Larissa meteorological station operated by the Hellenic national meteorological service HNMS).

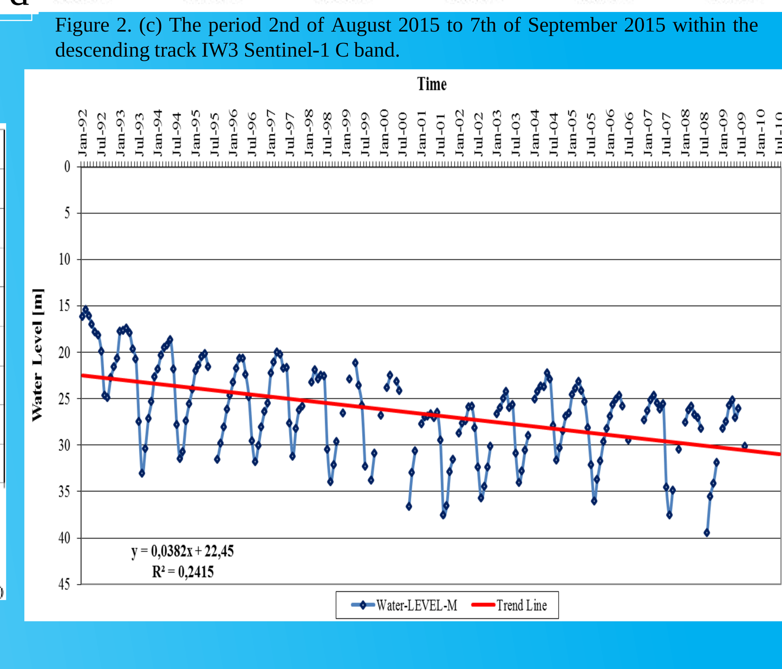


Figure 5 b. Fluctuations of groundwater level for borehole SR72 during the period 1992–2010.

Conclusions

The possibility of use the productions of Earth Resource Satellite (ERS-1/2) and Advanced Environment Satellite ENVISAT SAR (Synthetic Aperture Radar) C-band have given the potential to monitor, detect and estimate the ground deformation during long-and short-term and also assess the time series of dynamic ground deformation within high spatial and temporal resolutions. The combined use of two different InSAR techniques resulted in spatially and temporally accurate monitoring of ground deformation dynamics in Larissa National Airport. The results confirm detailed-scale changes in ground level in both short and long observation periods. The factors causing such changes may include the swelling and shrinkage of clay minerals (expansive soil), which can be activated through groundwater withdrawal and recharge, but the potential contribution of simultaneous micro-tectonic changes through preexisting faults cannot be fully excluded.

ADD THE RESULT OF A NEW INFGMS

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