MONITORING SLOW GROUND MOUVEMENTS AROUND TUNIS CITY BY DIFFERENT SAR INTERFEROMETRIC MEASURES

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1. INTRODUCTION

A precise knowledge of the Earth form and its dynamic deformations is fundamental for a great number of scientific problems. SAR and differential SAR interferometry are operational tools for topographic profile reconstruction [1] [2] and ground surface deformation monitoring [3] [4]. Since 1992, differential interferometry has improved considerably ground deformation measurements and several softwares have been developed for that purpose.

During the last years, Tunis City (Tunisia, North Africa) has launched a huge city planning project by banking water areas and has known a big growth in urban building and infrastructure. Nevertheless, this investigation may conduct to some residual consequences on the area notably ecological system perturbations causing some ground movements. The differential SAR interferometry is applied to detect, map and quantify the subsidence occurred around Tunis City. A large database of ERS and ENVISAT images has been acquired on this geographical area. This paper describes the temporal survey of Tunis City by different SAR interferometric measurements. Theses measurements are obtained using two well known and high-performance interferometric tools which are DIAPASON and ROI_PAC.

2. DIFFERENTIAL SAR INTERFEROMETRY PROCESSING

In this study, SRTM DEM and several SAR images, including ERS Tandem data, are used to produce multiple interferograms. Two typical methods for interferogram generation and deformation detection, done simultaneously and independently are discussed. The first method generates differential interferograms using DIAPASON tool. The estimation of ground movement is done by applying multi-scale complex correlation between interferograms covering the same period to reduce atmospheric effects. For the second approach, ROI_PAC software is used to produce the same amount of interferograms starting from the same SAR images. A new filtering technique based on a multi-temporal coherence map is proposed to deal with ROI_PAC filtering errors especially in poor coherent regions. Then, ground movements are quantified by stacking unwrapped interferograms covering the same period. Finally, a comparison between the two set of resulted measurements is done to validate ground movement estimation.

2.1. First interferometric technique

Initially, we generate by means of DIAPASON software a database of interferometric products starting from ERS and ENVISAT archive acquisitions. To facilitate the first interpretation of the generated products, we carry out a first post treatment which is the generation of HSV (Hue-Saturation-Value) compositions based on generated DIAPASON coherence images to filter out non reliable phases. The contribution of this treatment consists not only in the improvement of visual quality but also in the removal of the noise since we highlights only ground deformation in coherent areas.

Then, based on the random behavior of troposphere, there are supposedly poor chances that atmospheric fringes related to two different acquisitions occur with the same manner at the same place. Therefore, the two interferograms common fringes resulting from four different acquisitions are most probably due to ground movements. In this logic, the correlation method measures the dependence of two phase signals in order to detect subsidences. This method proceeds in two stages: first, we select regions presenting similar behavior in two interferograms; what consists in making a multi-scale complex correlation. Second, we measure the ground movement by applying a complex average between phases. HSV composition is then used to analyze subsidence results.

2.2. Second interferometric technique

After applying the different ROI_PAC processing steps on SAR images in order to generate multiple interferograms, we notice that ROI_PAC filtering technique presents some limits. Thus, we propose a new filtering approach based on temporal coherence information. Starting from the generated interferograms, a global coherency map is calculated taking into account the pixel spatial, contextual and temporal information. Standard deviation images are produced for each individual interferogram and then combined by a simple average. The resulted coherence map provides global information which

persists for all acquisitions. It highlights regions corresponding to reliable phase values which are going to be used for ground movements estimation.
Interferometric fringes which are not filtered by this technique correspond to subsidence or atmospheric artefacts. In order to differentiate between theses two kinds of information, we stack unwrapped interferograms covering the same period. Noisy regions indicate pixel phase variable in time related to atmospheric effects while homogeneous regions show constant temporal pixel phase behaviour associated with ground movement effects.

3. RESULTS

This work is experimented using 26 archive ENVISAT and 7 archive ERS radar images covering the region of Tunis City (acquired by means of ESA project C1P.5054). Two sets of 58 differential interferograms were calculated and treated separately by means of DIAPASON and ROI_PAC processing. Theses interferograms allow the detection and the measurement of several ground movements around the Tunis Lake (cf. figure1). The convergence of the two different interferometric techniques done simultaneously and independently confirms results accuracy (see table1). Similar results have been obtained by both methods. This tends also to prove that ground movements really occurred on this area.
In a future work, more reliable measurements will be produced based on Permanent Scatterers technique [5].

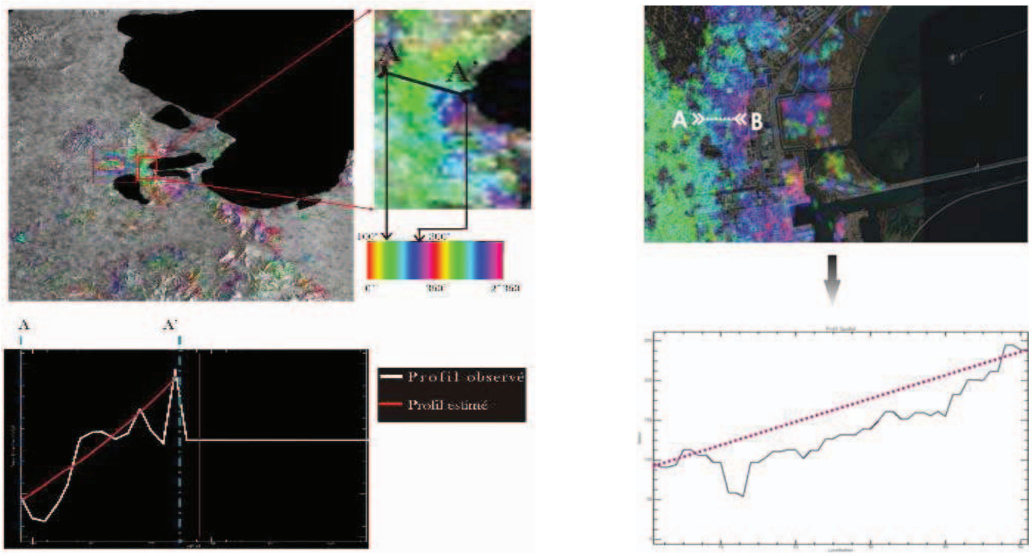

Figure1: The same SAR couple Subsidence profiles-Lake West Region. (left) Interferogram resulted from the first interferometric technique: 0.74mm/mois; (right) Interferogram resulted from the second interferometric technique: 0.69mm/mois.

Table1: Comparison between the two interferometric subsidence measures for three selected regions around Tunis City

	Surface area	Subsidence measure (mm/mois)	
		First technique	Second technique
Region1: Ben Arous town	7.32 km	0.80	0.76
Region2: Lake West region	600m	0.71	0.68
Region3 : El kram town	3.36km	0.36	0.29

4. REFERENCES

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