Quantifying Earth's surface deformation caused by moderate earthquakes using InSAR techniques

Sihem FZ. MILOUDI[1], Mustapha. MEGHRAOUI[2]

e-mails : miloudi.cts@gmail.com
m.meghraoui@unistra.fr

[1] *Département de Géodésie Spatiale, Centre des Techniques Spatiales, B.P. N°13, Rue de la Palestine, Arzew, Oran, ALGERIE*

[2] *Institut de physique du Globe (IPGS), Strasbourg, France*

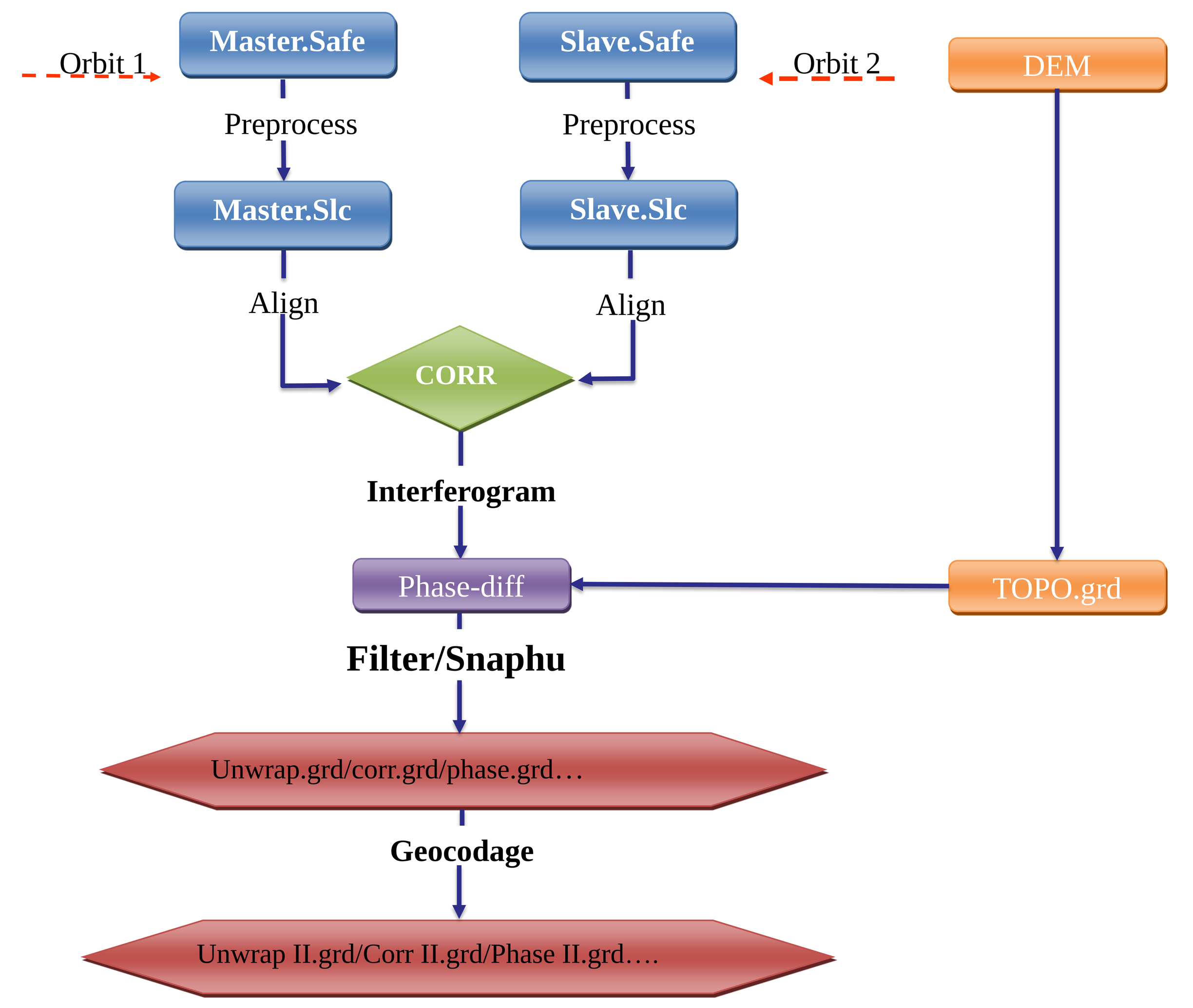
❑ Introduction

SAR imagery is a useful tool for quantifying co-seismic and post-seismic deformation of the Earth's surface. The application of the InSAR methods to Ain Témouchent's earthquake (22/12/1999) with magnitude Mw=5.7 and Zemmouri's earthquake (21/05/2003) with magnitude Mw=6.8 have shown the existence of co-seismic and post-seismic deformations visible on the surface, thanks to ERS and ENVISAT images provided free of charge from the ESA (Belabess et al., 2009). In this work, we are looking for the level of detection of surface deformation with moderate earthquakes magnitude (Mw < 5.5). Herein, we present the identification and analysis of surface displacements, associated with the superficial Mihoub earthquake of 2016 May 28, with an estimated magnitude Mw=5.4 and 5.4 km ± 2 km deep, located at 60 km southeast of Algiers (Khellif et al., 2018). For this purpose, the processing of Sentinel 1A images was used to highlight the deformation zone and to characterize the magnitude of surface displacements related to the main shock. This processing takes into account the effects of topography through the use of SRTM 1sec data (USGS, 2018), as well as orbital and atmospheric corrections that may affect the radar signal (Goldstein and Werner, 1998). From a set of interferograms with three fringes, distributed in lobe, indicate a minimum displacement of 8.4 cm in LOS, which implies a good surface deformation signature. The InSAR method makes it possible to characterize a surface co-seismic displacement linked to an earthquake of moderate magnitude (Mw < 5.5).

❑ Processing Parameters

- Downloading Sentinel 1A images (Descending : between 13/05/2016 and 06/06/2016) & (Ascending : 12/05/2016 and 23/07/2016).
- Combination of interferometric pairs: pre-processing data and orbital information .
- Generation of interferograms.
- Image filtring: interfering images using the topographic phase, all phases corrections are applied with the filtering Algorithm (Goldstein) .
- Phase unwrapping of interferograms .
- Geocoding all products by transforming the distance / azimuth coordinate system of the Master image into longitude and latitude.

❑ Organigram illustrating the development of InSAR processing with GMTSAR



❑ Conclusion & discussion

- The processus was focused on the 2016 Mihoub Earthquake area of interest. Two ascending and descending interferograms were obtained.
- The interferogram of descending SAR images for an interval between two images of about a month shows a complex interferogram including the co-seismic period. After a detailed analysis of the signal, we have identified at least three gringes that correspond to an 8.4 cm deformation in LOS (Line Of Sight displacement), and hency we have obtained the deformation maps (displacement, velocity).
- The ascending co-seismic interferogram is also generated according to the same processing strategy as that used for the descending interferogram. Two fringes are observed, which corresponds to about 5.6 cm of deformation of the Earth's surface in the line of sight.
- Similar results were obtained using SARscape and its application to the detection of a small amplitude surface deformation related to the 1999 Ain Temouchent earthquake (Mw5.7). These results show a lobe fringe in the epicentral area that indicates 14 cm of surface displacement in the direction of LOS [Belabbes, 2008].

❑ Results

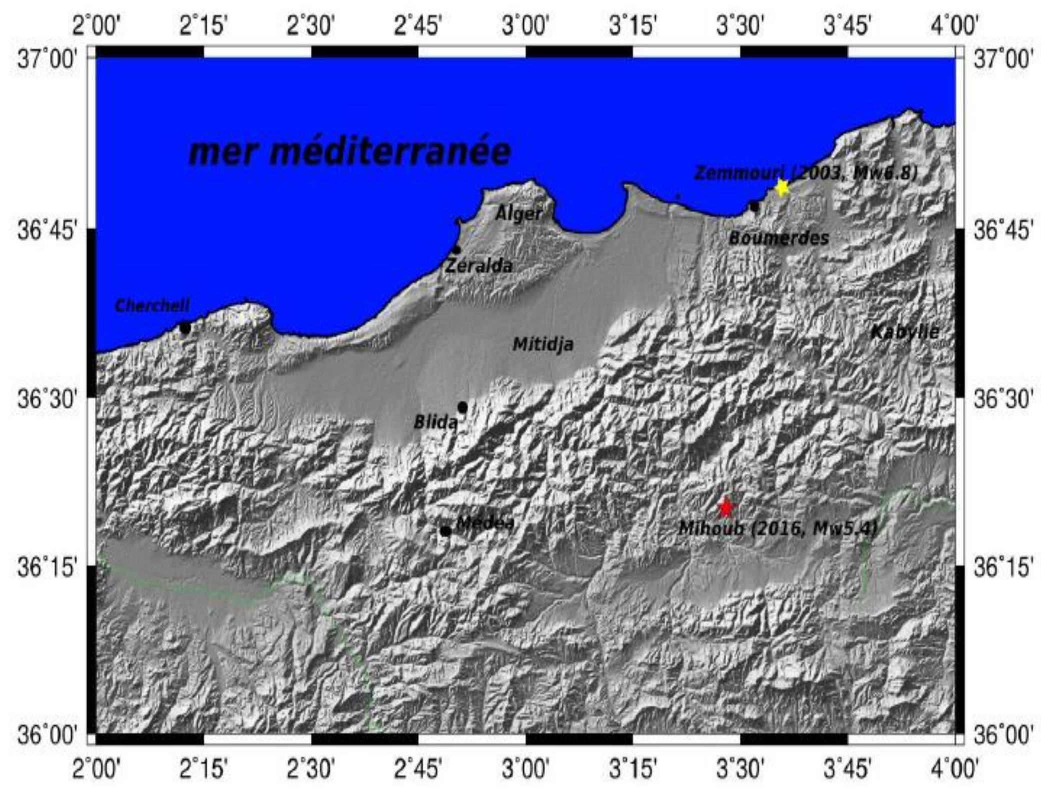


Fig. 1. Map showing the location of the epicenter of the Mihoub Earthquak (red star) and Zemmouri (yellow star).

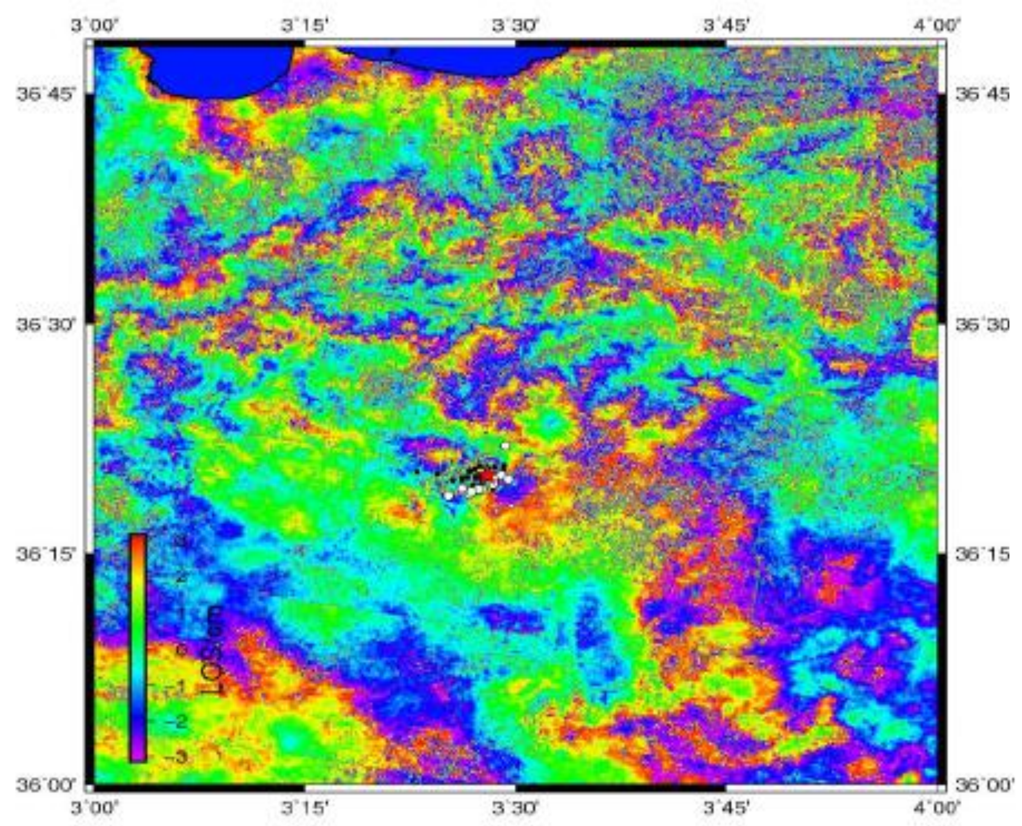


Fig. 2. General interferogram showing fringes of co-seismic deformation of the Mihoub earthquake : Mw 5.4 (the star symbol represents the epicenter) and aftershoks (white: 4<w<5 black: 3<w<4) [Khelif et al., 2016].

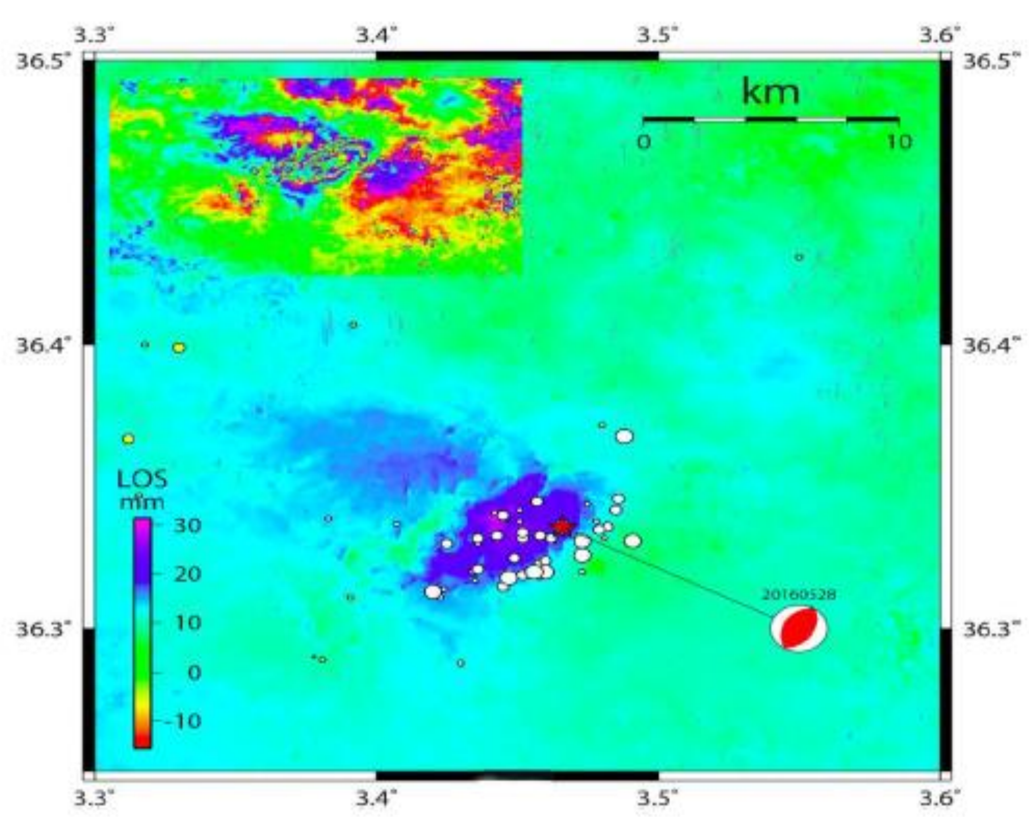


Fig. 4. Phase-unrolled (Descending) image with the epicenter (red star) of the earthquake and its focal machanism with reverse fault according to deformation zone of the Tell Atlas. The inlaid illustration is the raw interferogram showing the deformation fringes.

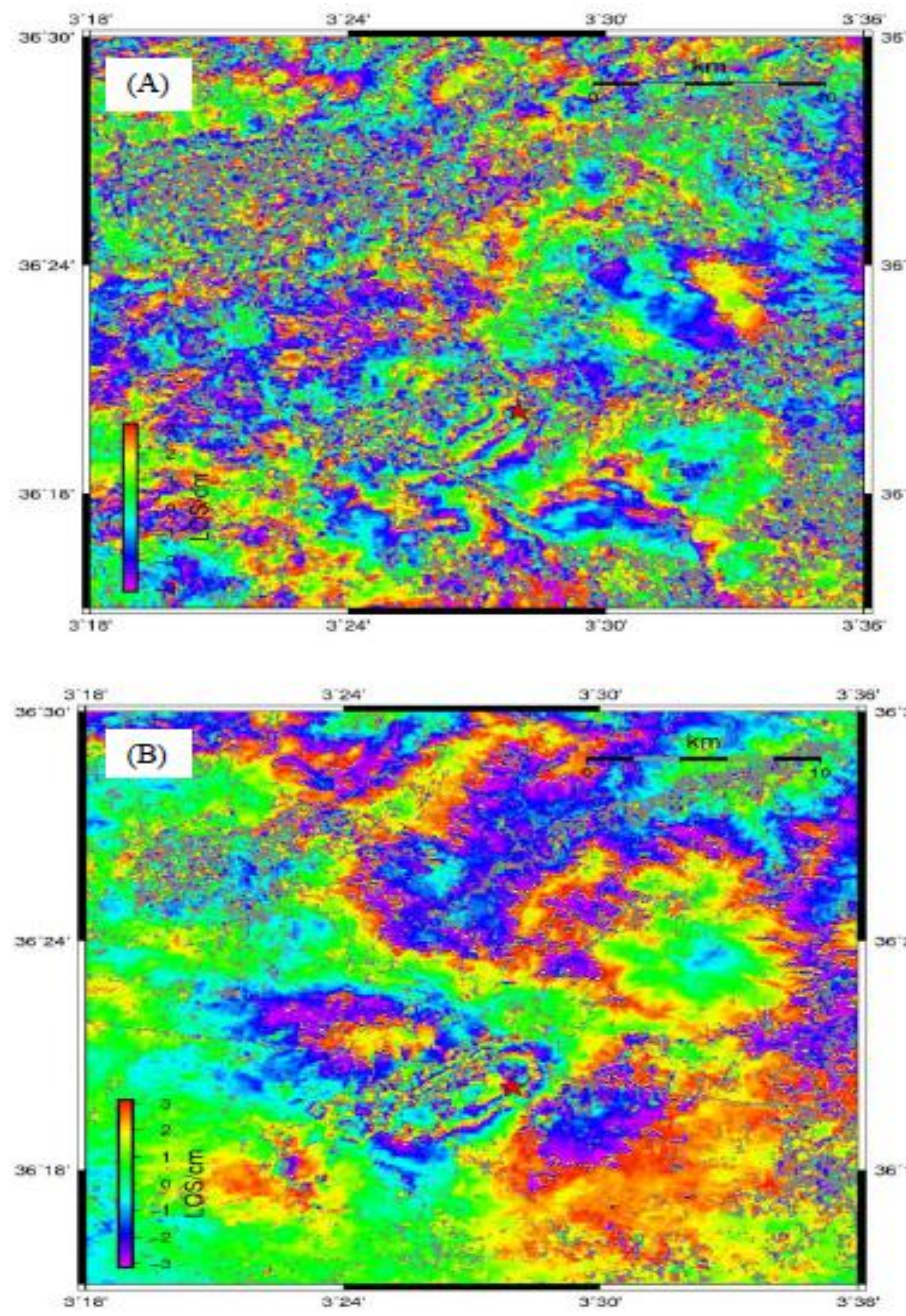


Fig. 3. Filtred phase images: ascending (A) descending (B), the franges on the map are related to the co-seismic deformation. The star represents the epicenter of the 2016 Mihoub earthquake that coïncides with one of the surface co-sismic deformation.

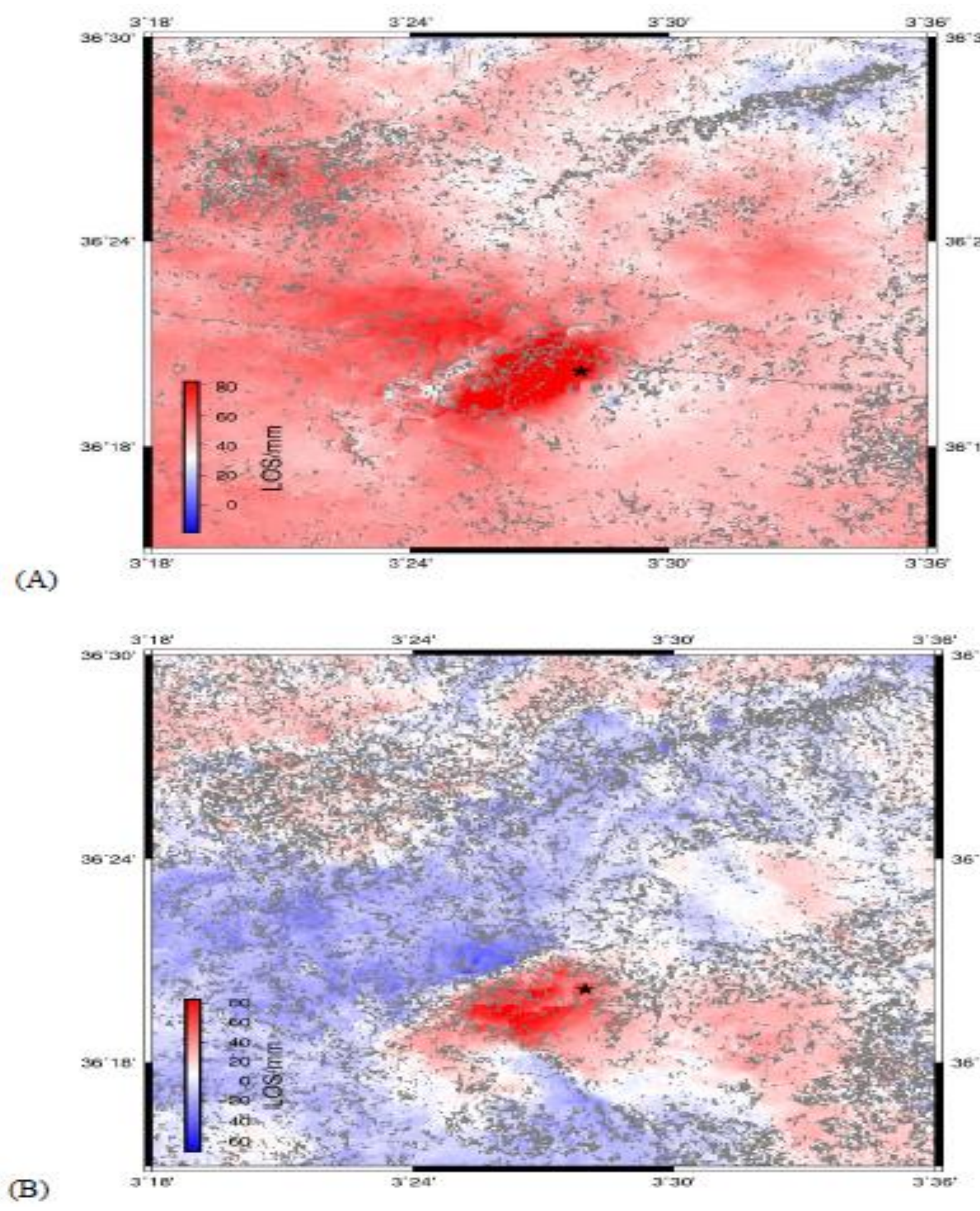


Fig. 5. LOS (line of sight displacement): DInSAR result based on the distribution of the line of sight. Descending (A) – Ascending (B).

❑ Bibliography

- Belabbes, S. (2008), Caractérisation de la déformation active par l'Interférométrie Radar (InSAR) : Failles sismiques aveugles et cachées de l'Atlas Tellien, Thèse de Doctorat, Université de Strasbourg, pp. 195.
- Goldstein, R. M. and Werner, C.L., 1998, Radar interferogram filtering for geophysical applications. Geophysical Research Letters, 25, 4035-4038.
- Khelif, M. K. et al. (2018), The 2016 Mihoub(north-central Algeria) earthquake sequence: Seismological and tectonic aspects, Tectonophysics 736, 62-74
- Sandwell, D. ., R. . Mellors, X. Tong, M. Wei, and P. Wessel (2011), Open radar interferometry software for mapping surface deformation, Eos Trans. AGU, 92(28).