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Complex investigation of the moderate seismicity in the Mediterranean

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Introduction

InSAR is capable of providing alternative and independent method for locating and source parameters retrieving for moderate size (less than 6.0) shallow earthquakes (Mellors et al. 2004). Although the determination of surface deformations of large events appears relatively easy, in the case of small- and moderate-size earthquakes the limitations such as temporal decorrelation, topography, atmospheric propagation and data availability constraints have much stronger role. The variations in atmospheric water vapour in combination with highly variable topography have the most significant influence on the phase signal for moderate-size events

(Hanssen 2001). Nevertheless, under favourable conditions, like short temporal and spatial baselines, InSAR could provide significant results for small- and moderate-sized shallow earthquakes (Belabbès et al. 2009). Since the precise localisation and characterisation of the sources of such events by seismological approaches often run into difficulties, mainly due to poor geometry of the seismic networks, InSAR provides several potential advantages over the seismic data, the main of which is that InSAR models are relatively independent of the seismic velocity model (Mellors et al. 2004) which influences directly the accuracy of the seismological depth estimation (Ilieva 2011).



Fig.1. Review of the moderate-size ($5 < M < 6$) earthquakes in Europe for the period 1992-2010 (after the start of ERS mission till now) according to the Harvard CMT catalogue

Mw 5.3 Konitsa earthquake (North-Western Greece)

Ascending ERS-2 images are used to generate co-seismic interferogram, comprising the July-August 1996 Konitsa earthquake sequence manifested mainly by three moderate-size events with magnitude of Mw 5.0-5.3. The interferogram embraces a time span of only one month and indicates at least two fringes or 5.6 cm deformation in the satellite's line-of-sight (LOS) direction. The phase information from the interferometric pattern is used as a basis in an inversion procedure in order to propose the most suitable model of the fault: strike 18° , dip 59° , strike-slip 75cm, length 16km, width 10km, depth to the upper edge 2.5 km, seismic moment $3.6e+18Nm$ (Ilieva 2011).

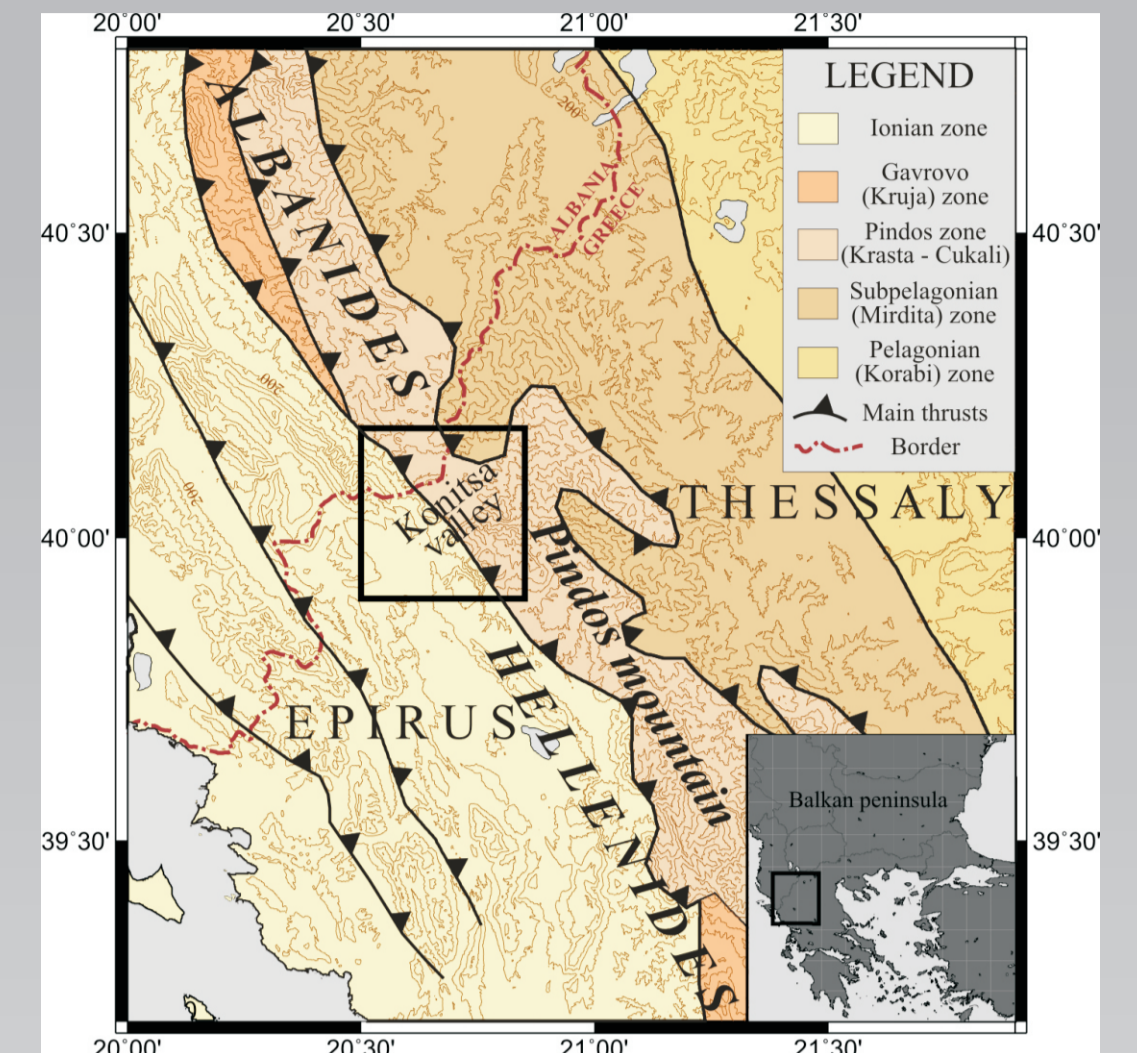


Fig.2. Konitsa valley - geology after Robertson and Shallo (2000) and van Hinsbergen et al. (2005)

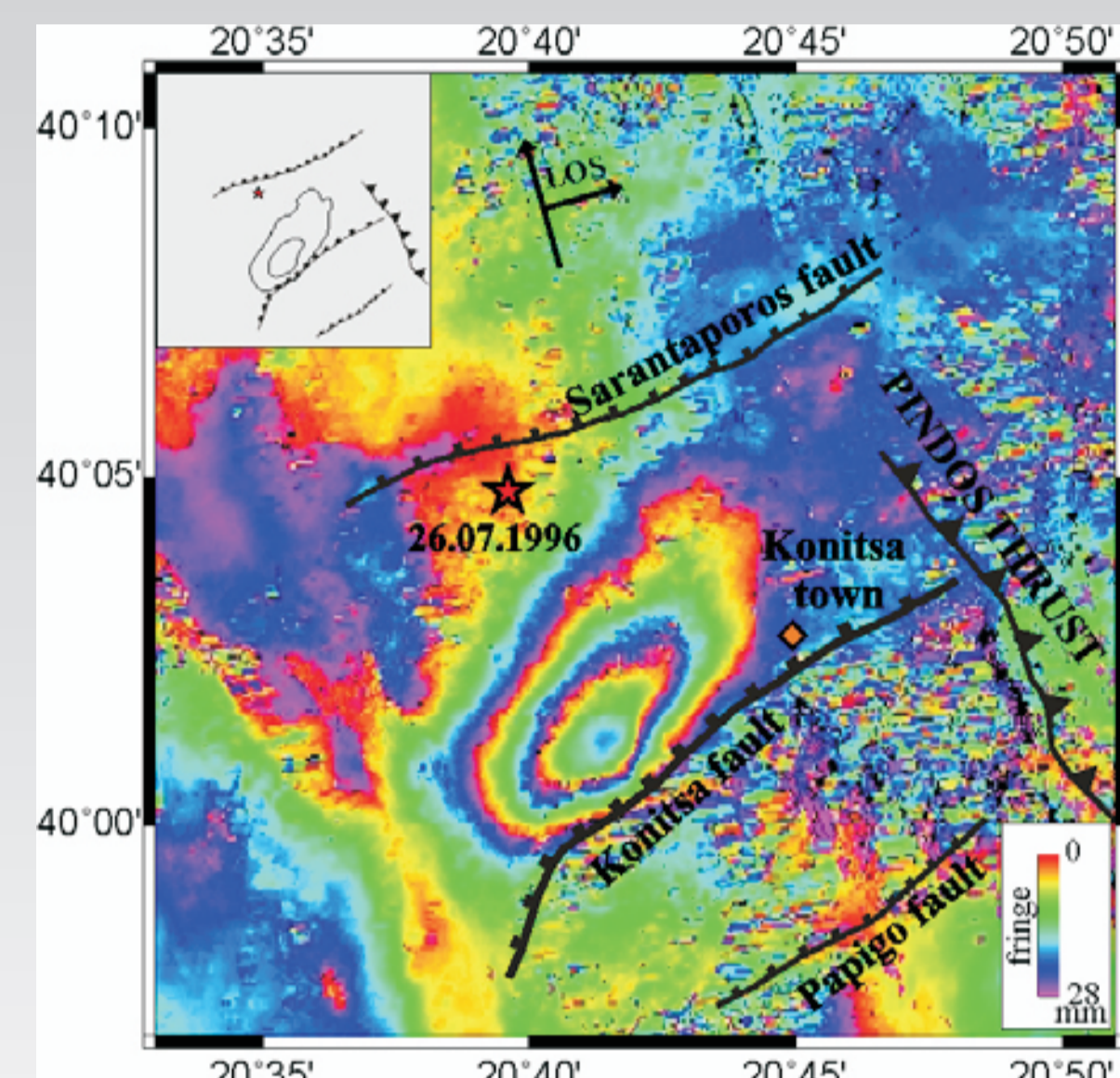


Fig.3. Ascending differential co-seismic interferogram - ifg8 ($B_t = 35$ days and $B_p 95m$).

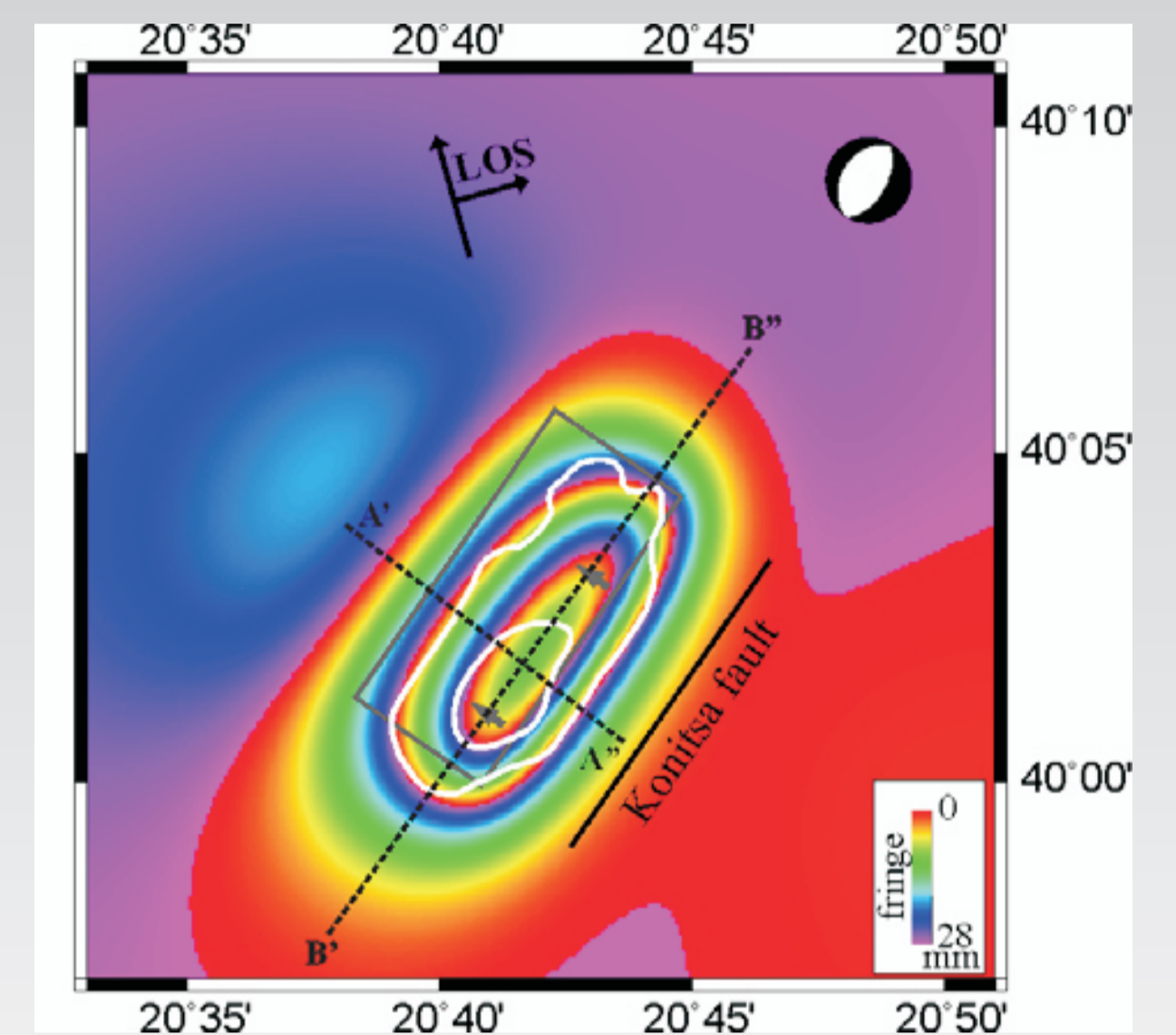


Fig.4. Synthetic ascending interferogram compared with the observed fringes (white) from the real interferogram.

Mw 6.2 Lefkada earthquake (Ionian Sea - Greece)

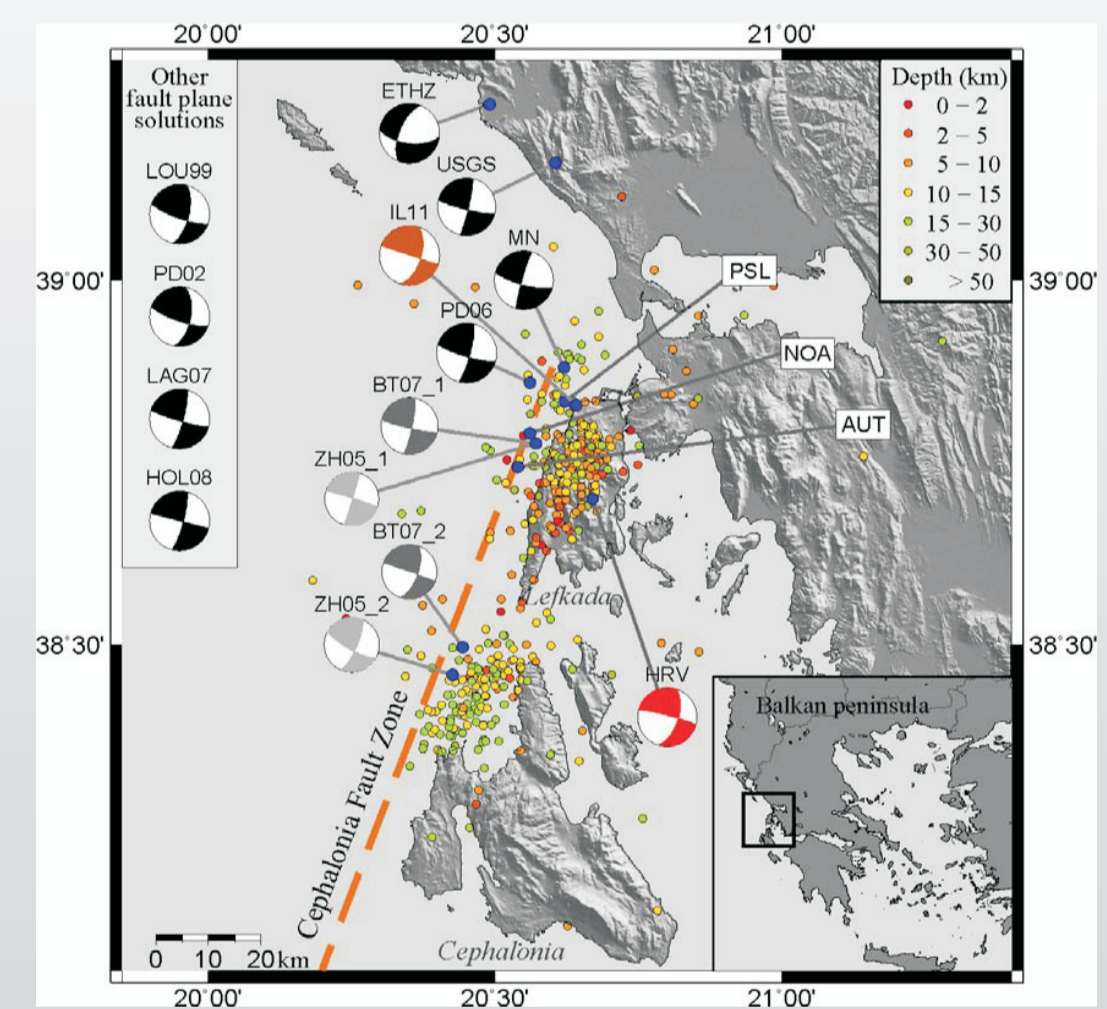


Fig.5. The 14th August 2003 Lefkada earthquake from different sources. In present investigation the Harvard solution (in red) is taken as a basic in inversion process. The final solution of this study is shown in brown (IL11) referred to the centre of the fault predicted by the fault model.

On 14th August 2003, an earthquake with magnitude Mw 6.2 occurred offshore the Lefkada Island in the Ionian Sea – one of the most seismically active areas in the Mediterranean. Seven ascending ENVISAT images are used to process six co-seismic interferograms. The formation of the co-seismic pairs is limited by the significant restriction of the existence of only one pre-seismic image. On the other hand, dense vegetation is covering the island, which is another obstacle in getting a high level of coherence, since Cband images are used. Another contribution to these circumstances is that of the vast water areas around the island. Nevertheless, ground deformation, in the line of sight of the satellite, of at least 5.6 cm (two fringes) is detected in all six co-seismic interferograms (Ilieva 2011).

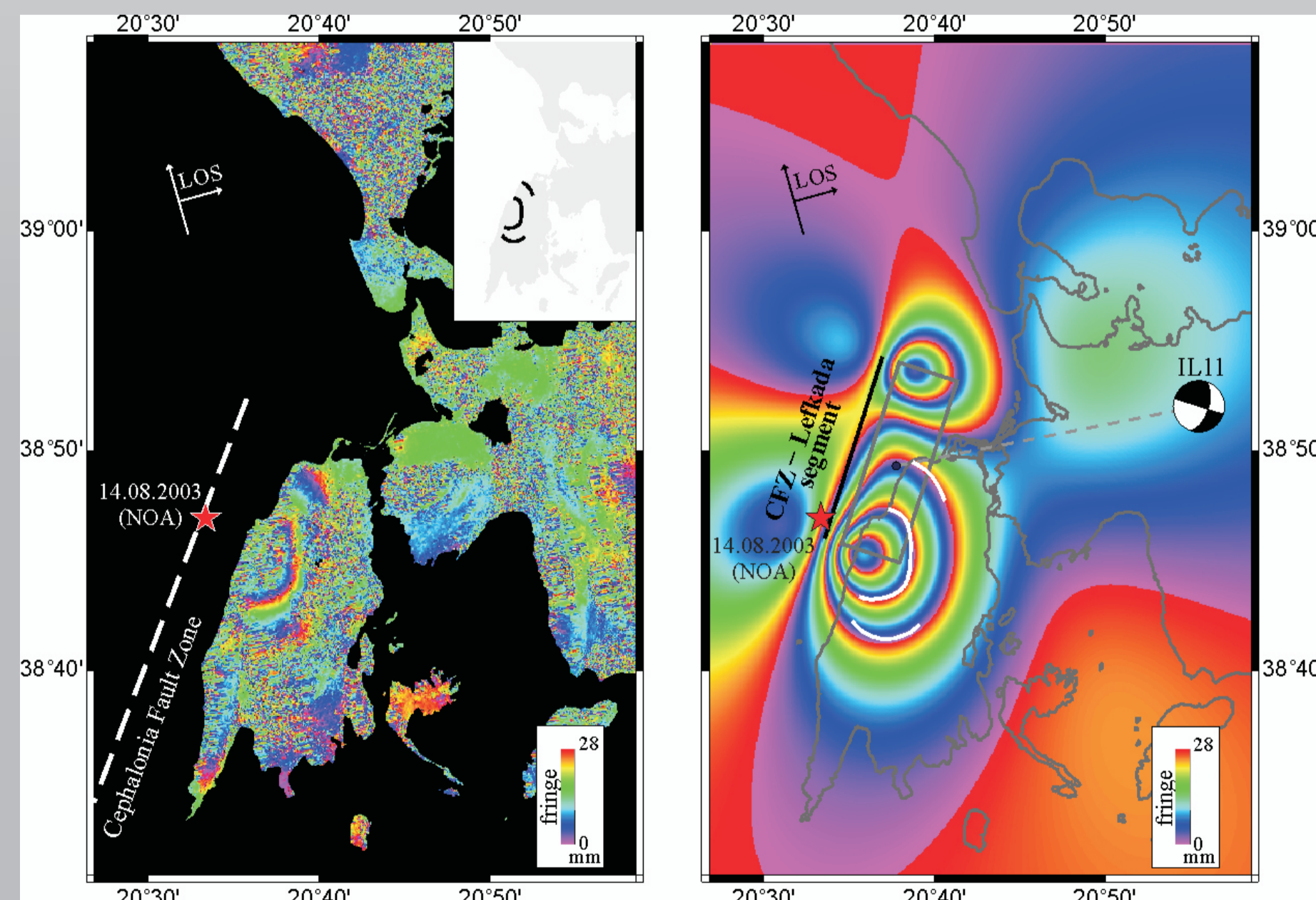


Fig.6. (Left) Differential ascending interferogram - (BL 88m). The star shows the main shock according to NOA. Inset: The observed fringes. (Right) Synthetic ascending interferogram obtained from inversion of the received observed fringes (left). The rectangle represents the approximate model of the fault segment: strike 18° , dip 59° , strike-slip 75cm, length 16km, width 10km, depth to the upper edge 2.5 km, seismic moment $3.6e+18Nm$

Mw 5.1 Lorca earthquake (South East Spain)

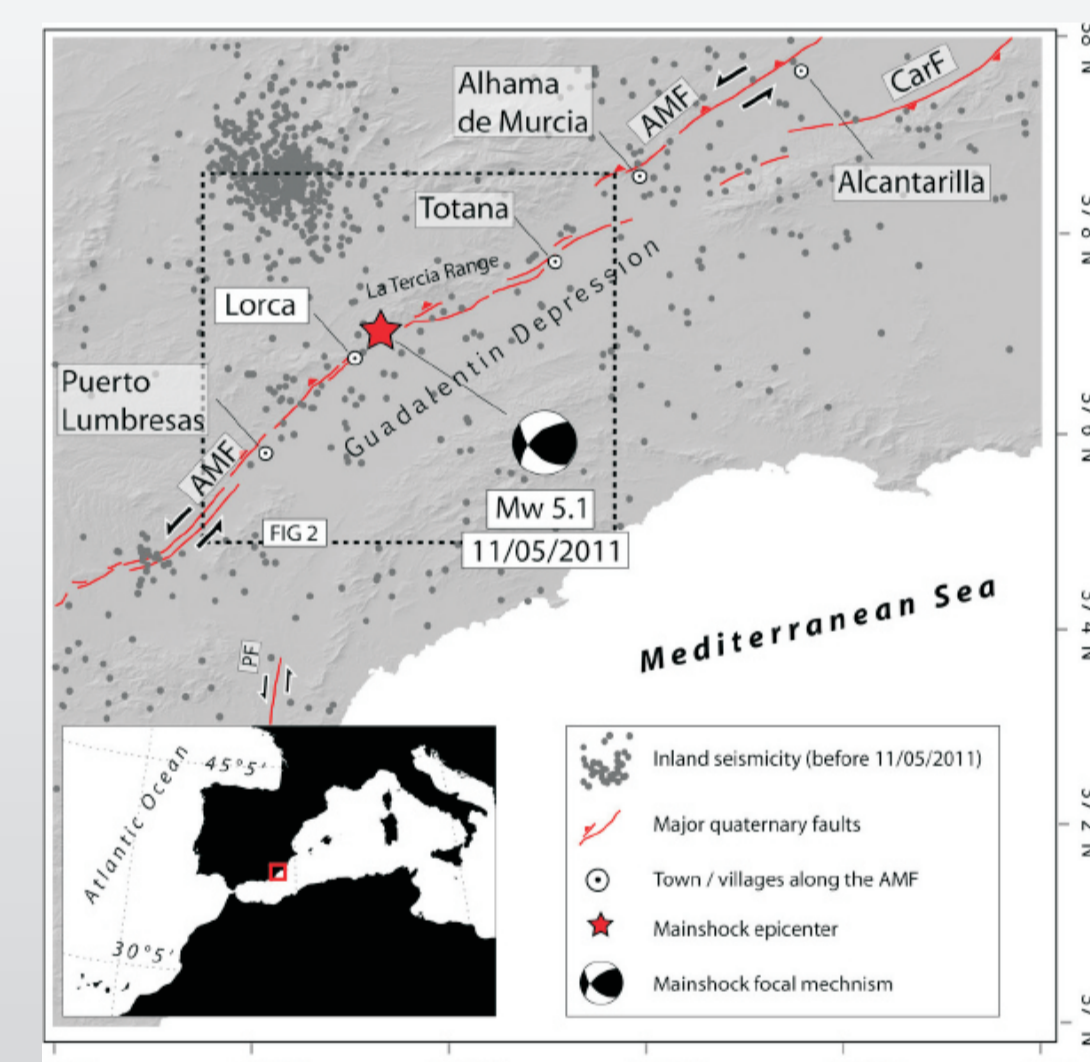


Fig.7. Locations of quaternary faults in red after Martinez-Diaz 2000. The epicenter (red star) and focal mechanism of the main shock is from the IGN moment tensor solution. AMF: Alhama de Murcia Fault; PF: Palomares Fault; CarF: Carrascoy Fault.

Four SAR data acquired from the European C-band Advanced SAR (ASAR) sensor onboard Envisat satellite are used to map the ~3 cm of surface displacement field produced by the 11 of May 2011 Lorca earthquake. Then, a simple elastic dislocation model is applied to characterize the fault plane geometry and the fault slip at depth. It was found that the Lorca earthquake ruptured a ~3 km segment of the Alhama de Murcia Fault, centered at 4.2 km depth and produced ~21 cm reverse slip with ~6 cm left lateral component on a 45° plane striking N65E. This study presents the first InSAR earthquake-related displacement field mapped from the ASAR sensor since Envisat extension orbit has been implemented (de Michele et al. 2011).

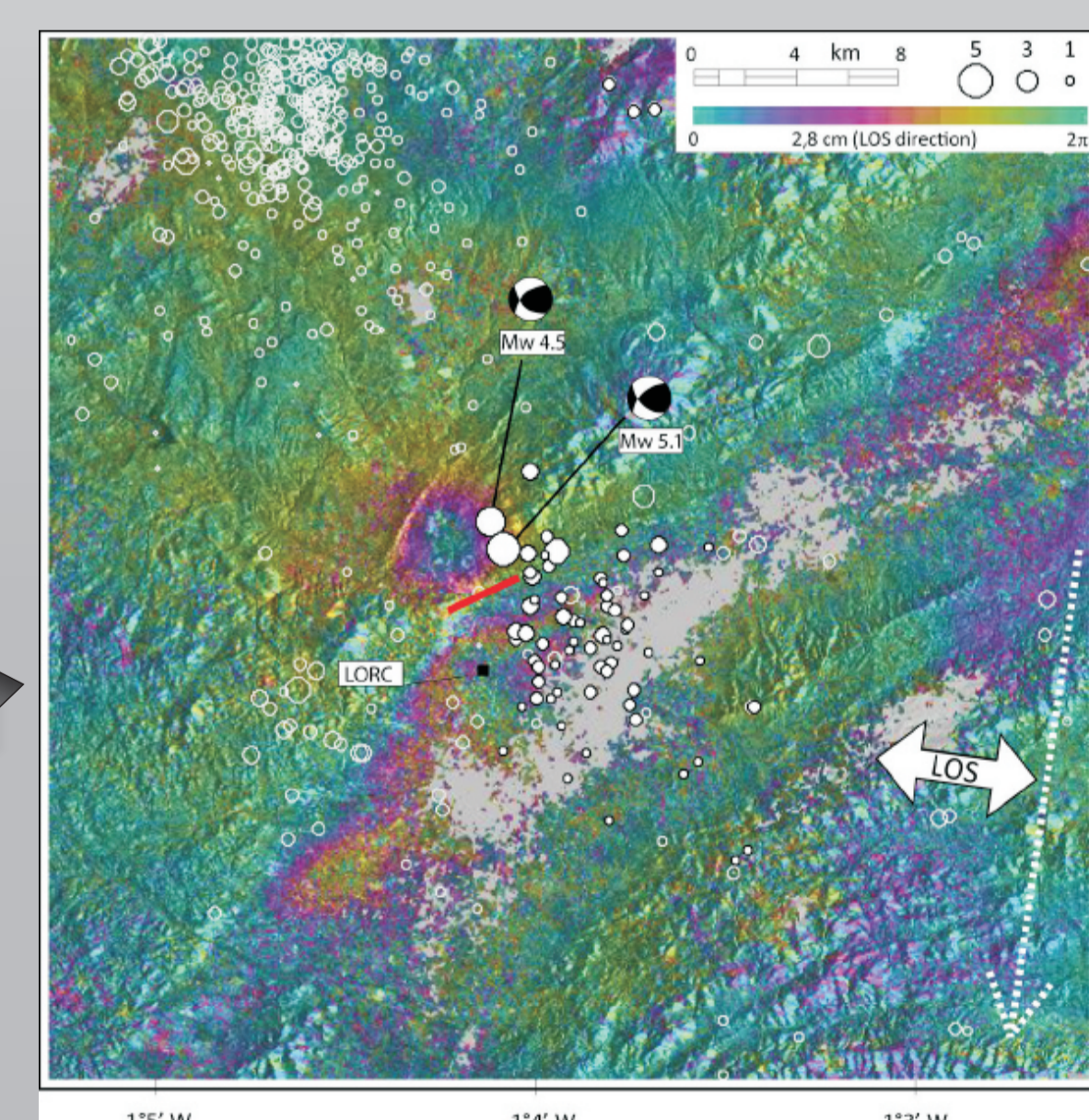


Fig.8. Surface displacement field due to both the Lorca earthquake and 5.2 months of water pumping in the Guadalentin basin.

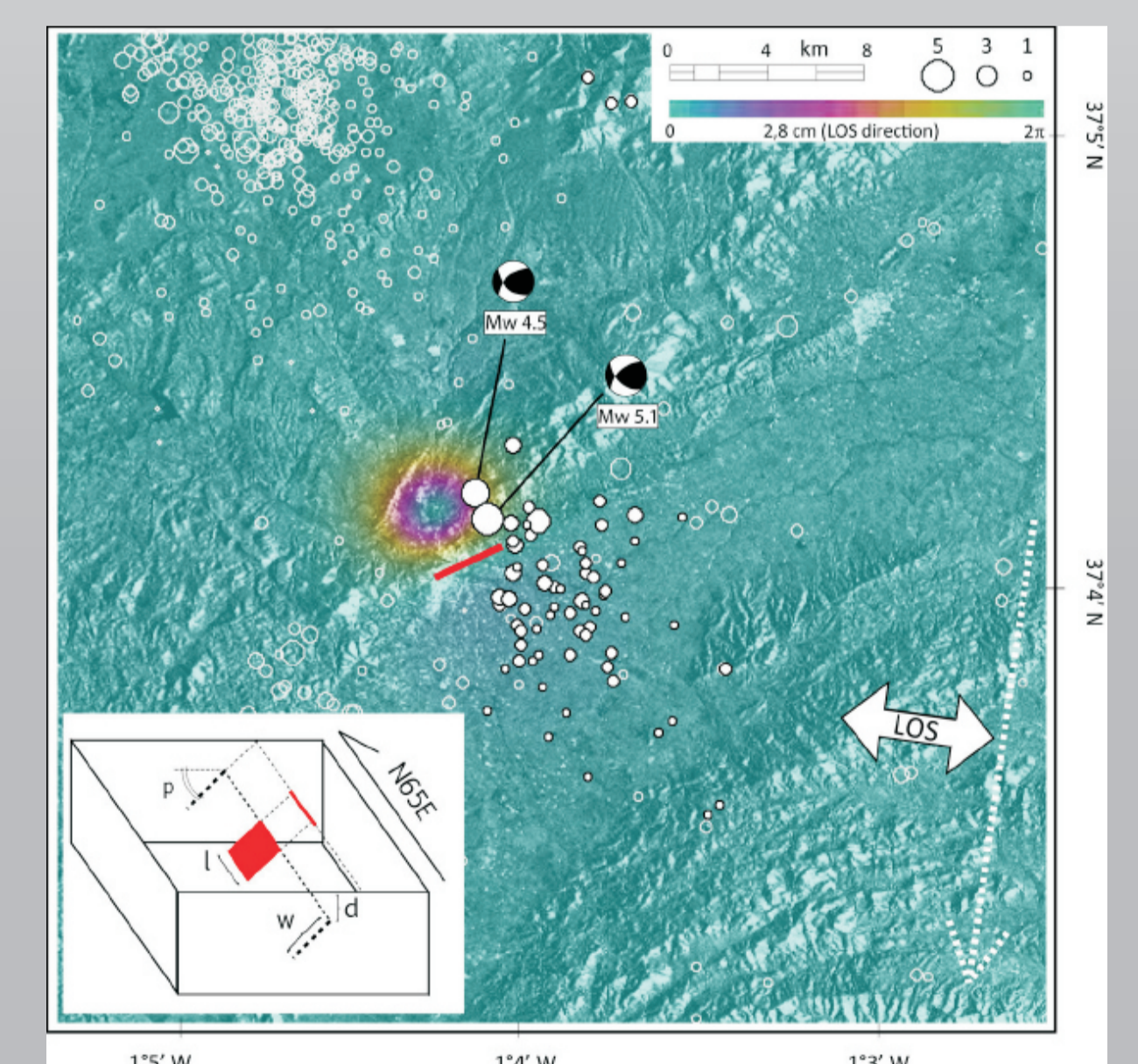


Fig.9. Surface displacement of the Lorca earthquake as inferred from our elastic dislocation model. The white rectangle inset represent a cartoon of the modeled fault plane; $l = 2.9$ km; $w = 2.9$ km; $d = 3.2$ km; $p = 45^\circ$

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