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Edited by

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Analysis of the September 7, 1999 Athens earthquake deformation field using ERS-2 SAR interferometry

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Abstract

On September 7, 1999 at 11^h 56^m 50^s UT a magnitude M_w=5.9 earthquake struck the city of Athens. Its epicenter was located at 38.1°N; 23.56°E which is about 20km NNW from the Athens center. The earthquake was a rather unexpected event, it was strongly felt by the Athenian population and caused many damages. Intensive field checks conducted immediately after the earthquake did not show any direct reactivation evidence of any of the faults. For the purpose to locate the seismogenic fault, several operations have been initiated to record the magnitude and distribution of aftershocks. For the same reason a parallel activity was initiated at the Institute for Space Applications and Remote Sensing of the National Observatory of Athens (NOA) which focused on the use of radar interferometry to map the co-seismic deformation field associated with the earthquake.

Several ERS-2 SAR images were collected for interferometric calculations. Their acquisitions were extending in the period between December 1995 to October 1999, providing the possibility to calculate various co-seismic interferograms, as well as interferograms corresponding to times before the occurrence of the main shock. The calculated co-seismic interferograms show that the earthquake caused surface deformations, which appear with at least two concentric, but not symmetric fringes, centered at 38.10°N; 23.60°E. This point is located in a distance of less than 2.7 km away from the main epicenter (38.10°N, 23.56°E). The resulted fringes indicate 56 mm of change in slant range direction. The study of the interferograms shows that the observed fringes are rather constant in shape, position and magnitude and that they are the result of a co-seismic surface deformation. The fringes define an active zone of more than 20km in the E-W and 10km in the N-S directions, bounded by the Fili mountain in the NE and the Aegaleo mountain in the SE. This area encompasses the vast majority of the epicenters located in the period from September 8^{th} to October 5^{th} 1999, extending S-W to the Fili mountain with a striking along a WNW-ESE axis.

We have used the observed fringes to infer a modeled solution of the seismogenic structure. For this purpose a least squares inversion algorithm which assumes a dislocation of a rectangular fault in an homogeneous elastic half-space, has been employed. Two faults were suggested by our solution. A main fault which is

responsible for the 90% of the total energy released having the following characteristics: length=12km, width=6.5km, depth of upper edge=8km, strike=97.5°, dip=43°, seismic moment=11.6 10^{17}. The second fault was smaller and has been added only to fit the asymmetry of the fringes to the east. According to our modeling the main fault has experienced a slip of 50cm at the depth of 8km and it is responsible for the observed surface deformations. Above this depth no slip was predicted. According to this study the modeled faults intersect the Earth surface at points 38.17^{o}N; 23.53^{o}E and 38.14^{o}N; 23.76^{o}E, defining a trace which lies about 5 km northern to the Thriassion depression, crosses the Fili mountain and shows a WNW-ESE trending.

Our study returns strong evidence that in general, the activation of a fracture zone located at the Fili mountain is mainly responsible for the observed surface deformations. However, the fact that no direct association to any of the existing faults was possible make us to believe that is very probable that it could have been activated one not mapped, not visible or most likely a blind fault existing in the affected area. It is certain that we need to conduct further research integrating SAR interferometric and tectonic observations together with aftershock data to clarify and determine more reliably the seismic characteristics of the area.