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The June 12th, 2017 Lesvos Island, Greece, earthquake: comparison between observed and modeled ground deformation

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On June 12th, 2017, a strong seismic event occurred offshore the southeastern shores of Lesvos Island in eastern Aegean region, Greece, causing extensive damage to infrastructure, injuries and one fatality. The mainshock had a magnitude of Mw = 6.3, while the aftershock sequence includes events of significant magnitude (Mw = 5.2, Mw = 4.7 and Mw = 4.9). Based on the aftershock sequence spatial distribution, bathymetric data and the tectonic regime of the area, the seismogenic fault was modeled and it is a NW – SE normal fault with a very small left-lateral component. The tips of the modeled fault are 26˚18'40.7843"E/38˚56'40.7626"N and 26˚30'41.4278"E/38˚52'51.4243"N, while the calculated length and width of the fault are 18.74 km and 14.36 km respectively. Furthermore, the modeled fault strikes at N112E, while it dips towards the SW by 50° and its rake plunge is -91°.
Based on the aforementioned modeled fault characteristics, the stress transfer during the main shock was estimated for three different fault depths. Specifically, shear, normal and Coulomb stress changes were determined for the top (0.0 km depth), the middle (5.5 km depth) and the bottom (11.0 km depth) of the seismogenic fault. The analysis of shear stress change shows that stress transfer from the northwestern to the southeastern part of the study area occurs mainly between 0.0 and 5.5 km depth, while in deeper parts of the fault the shear stress is gradually eliminated from 5 to -5 bar. Regarding the normal stress, the three depth models show concentration of the highest values, approximately 5 bar, near the surface, abrupt decrease and almost zero values in 5.5 km depth and gradual increase, approximately 4 bar, up to the 11.0 km depth. The Coulomb stress change analysis shows a NW to SE stress transfer (as in shear stress change), receiving the greatest values, approximately 5 bar, at 5.5 km depth. A gradual decrease of values is recorded, associated with the depth increase, while remarkable values, between 2 and 4 bar, are detected in 11.0 km depth (as in normal stress change).
In order for the surface deformation to be assessed, the Okada deformation model was implemented. The results show the highest horizontal displacements, ranging between 24 and 42 mm, near the projected fault surface and gradual decrease further away. The horizontal displacement is larger towards the fault's northern part. On a limited scale, a south to southeastern horizontal displacement is observed, associated to a probable fault segment, secondary to the main fault.GPS recordings of nearby permanent stations were also analyzed, and the results show significant similarities with the modeled ones. A typical example is the MYTI station, being the closest to the epicenter one, where the instrumentally recorded displacements show values of 0.018 m Easting, 0.031 m Northing and 0.01 m Upwarding, while the modeled values are 0.016545 m, 0.046635 m and 0.004653 m, respectively. This generally good agreement between modeled and observed surface deformation confirms the modeled geometric characteristics of the seismogenic fault.