



Interactive comment on “DInSAR coseismic deformation of the May 2011 M_w 5.1 Lorca earthquake, (Southern Spain)” by T. Frontera et al.

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This paper provides very welcome and interesting data on the 11 May 2011 earthquake at Lorca in the eastern Betic Cordillera of southern Spain using GPS and DInSAR data, the latter supported by numerical modelling. The GPS data based on the CuaTeNeo geodetic network unfortunately fail to reveal coseismic deformation, but GPS velocities based on observations between 1997 and 2009 provide clear evidence of sinistral oblique reverse motion along the Alhama de Murcia Fault (AMF). This is well in line with both the focal mechanism of the earthquake and with geological observations along the fault zone showing a remarkable mutual consistency (Vissers and Meijninger, 2011). The DInSAR images clearly lend further support to a reverse component of coseismic fault motion on the AMF, and with the authors I regret the lack of data allowing a study

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with a shorter temporal baseline, in particular in view of the marked effects of ground-water extraction in the Guadelentin depression. This is counterbalanced by the authors via a numerical model study of coseismic crustal deformation that grossly confirms the 3 cm uplift of the northern (hanging wall) block inferred from differential interferometry.

As a geologist I am not in a position to evaluate the numerical model quoted, but the used values of the input parameters raise some questions as follows. These parameters include the (average) slip, length, width, strike, dip and rake of a dislocation in a layered half-space crustal velocity model. While the latter three parameters can be inferred from the focal mechanism, the first three at first instance cannot, and the authors use empirical relationships from Wells and Coppersmith (1994) to arrive at values of 15 cm, 4 km and 2 km for respectively the slip, length and width of the dislocation. With the seismic moment M_0 known (4.9×10^{23} dyne cm), and noting that M_0 equals the shear modulus μ times the average slip d times the rupture area S :

$$M_0 = \mu \times d \times S$$

it follows that the shear modulus implied should be 408 dyne/cm² (i.e. 40.8 Gpa). This value is markedly higher than the commonly assumed 30 Gpa for mechanically coherent crustal rocks, and in all likelihood much higher than values to be expected for intensely prefractured cataclastic fault rocks such as reported in structural studies of the AMF (e.g., Rutter et al., 1986; Martinez Diaz, 2002; Meijninger and Vissers, 2006).

Two types of information suggest that the coseismic rupture area of the Lorca earthquake was possibly larger than suggested by the authors. First, after removing very small events with either unspecified or very large uncertainties, the early series of 13 aftershocks, i.e. within the first 24 hours after the mainshock event, is distributed over a depth range between 2 and 11 km, with a cluster of 8 events at 10–11 km, 4 shallower ones, and one exceptionally deep event at 17 km which I tend to reject. While the inferred length of the rupture is grossly consistent with the spatial distribution of the early aftershocks, and of the aftershock series recorded over a 5 day period, their vertical

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distribution may well be consistent with a width of the rupture significantly larger than 2 km. Secondly, albeit surrounded with uncertainties related to the wavelengths involved, the centroid depths listed by IGN and EMSC are 6 km whilst Geoazur and the Global CMT project indicate depths of 11 and 12 km, respectively.

Turning back to the parameter values used to model the coseismic vertical motions, the question arises in how far the observed 3 cm vertical uplift of the northern block can be successfully modelled with a larger rupture area, in combination with smaller values of the shear modulus and consequent variable values of the average slip. Some insight in the effects of varying these parameters would doubtlessly strengthen the argument.

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