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Solid Earth
Discussions

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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Thank you for your comments on the short note "DInSAR coseismic deformation of the May 2011 Mw 5.1 Lorca earthquake (Southern Spain)". The accordance of the results obtained in this work with the conclusions by Vissers and Meijninger (2011) concerning the structural characteristics of the Alhama de Murcia fault (AMF) is highly encouraging.

We agree with you about the over-estimation of the shear modulus (mu) used for the numerical model calculation, that you have deduced from the relation Mo = mu x d x S, where Mo is the seismic moment, d is the average slip and S is the rupture surface. The value of 40.8 GPa (1) is too high in comparison with the commonly assumed 30 GPa, which additionally does neither consider the zone peculiarities nor the focal depth.

Thus, we have elaborated a test to find out how sensitive the model is to the variation of the shear modulus in function of the hypocentral depth.

First of all, we have selected an inferior limit value of mu that takes into account the shallowness of the rupture and the existence of prefractured rocks. Then, we have computed the vertical surface displacement model considering different rupture and slip dimensions compatible with this value of mu at diverse hypocentral depths. Finally, we have compared the results with those obtained from numerical model and DInSAR imaging as presented in our short note.

Considering the current velocity models used for observational seismology (Delouis et al., 2009) we take a S-wave velocity vs of 1.9 km/s and a density ro of 2 g/cm3 to obtain a lower limit for the shear modulus value mu = ro x v x s2 = 7.22 GPa, which is approximately 6 times lower than the mu considered in the short note presented calculations. Therefore, to keep the same Mo, it is necessary to multiply by 6 the factor d x S. In Table 1 (see supplement) we summarize the results of the maximum vertical displacement (delta_max) at the surface of the northern block, computed considering two alternative assumptions:

- We have kept the average slip constant, i.e. 15 cm, and we have multiplied by 6 the rupture area, taking into account three different values for the minimum distance between the surface and the rupture plane (Zmin) and, consequently, the hypocentral depth (ZHyp), which is considered to be in the center of the rupture area (Tests 1, 2 and 3 in Table 1)

- We have doubled the average slip, so it becomes 30 cm, and we have multiplied by 3 the rupture area. In this case, we have also considered three different depths (Tests 4, 5 and 6 in Table 1).

The results show some compatible configurations with the predicted vertical displacement of the surface of the northern block. For both assumptions (average slips 15 cm and 30 cm) we find a hypocentral depth in accordance with the results obtained in the SED short note. For Test 2, which considers d = 15 cm and ZHyp = 4.3 km, it is computed a delta_max = 4.5 km; and for Test 5 (d = 30 cm and ZHyp = 5.6 km), delta_max = 4 km. It should be pointed that both assumptions in the model keep a shallow focal depth and a deeper hypocenter would not reproduce a maximum vertical surface displacement around 4 cm on the northern block. Moreover, these hypocentral depths agree with the centroid depths listed by IGN and EMSC.

We would not consider higher depths, as suggested by Géoazur and the Global CMT project, because this consideration would imply the assumption of a higher shear modulus and, in consequence, smaller dimensions for the rupture plane and slip that would not provide results in agreement with DInSar observations.

Concerning your comment about the aftershock distribution consequences, both for the rupture area extension and for the hypocentral depths, we would remark that aftershocks do not seem to be linked to the AMF rupture plane, since the AMF dips towards the NW and the aftershocks are spread within the Alto Guadalentin Valley, in the southern block of the AMF.

There still rest some incertitude about the extension of the rupture and the average slip displacement, which will presumably be solved when more information about rupture dynamics will be available. Nevertheless, even with a lower shear modulus, we obtain compatible combinations of average slip and rupture extension that imply quite shallow focal depths, as assumed in the short note.

References

Delouis, B., Charlety, J. and Vallée, M.: A Method for Rapid Determination of Moment Magnitude MW for Moderate Earthquakes from the Near-Field Spectra of Strong-Motion Records (MWSYNTH), Bull. Seismol. Soc. Am., 99 (3), 1827-1840, doi: 10.1785/0120080234, 2009

Vissers, R.L.M. and Meijninger, B.M.L.: The 11 May 2011 earthquake at Lorca (SE

Spain) viewed in a structural-tectonic context, Solid Earth, 2, 199–204, 2011.

— (1) Please, note that there is a typing mistake in your comment: you have written 408 dyne/cm2 (i.e. 40.8 Gpa), instead of 408 x 10 9 dyne/cm2. —

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/3/C516/2011/sed-3-C516-2011-supplement.pdf

Interactive comment on Solid Earth Discuss., 3, 963, 2011.