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Faults geometry and rupture evolution of the May 2012 Emilia (Northern Italy) earthquakes: hints from high precise relocated hypocenters and coseismic deformation

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This study presents seismological, geodetic and geological data used to better understand the spatial and temporal evolution of the blinds faults of the Ferrara Arc that generated on May 2012 two earthquakes of ML 5.9 and 5.8, that caused several casualties and the collapse of many historical buildings and industrial sheds. Even if many recently studies about the 2012 Emilia (Northern Italy) seismic sequence, improved the knowledge about the seismic hazard of the central part of the Po Plain, some important questions are also pending. In particular, concerning the fault sector that generated the 29 May 2012 (ML 5.8) earthquake, a disagreement in terms of dip values, as provided by the geodetic (from 20° to 40°) and the seismological data (from 45° to 85°), is also presents. Moreover, concerning the maximum magnitude, as mentioned in the paper of Pezzo et al. (2013) “given the similar geometry and kinematic of the two main structures activated during the first 10 days of the sequence, their simultaneous rupture during a single event cannot be excluded(Hayes et al., 2010). In this case an event with ML >6 could occur”.
The main scope of this work is to merge the knowledge coming from high precise relocated hypocenters and geodetic evidence in order to capture, at least in part, some of the abovementioned doubts. Indeed, even if more recent Italian cases (e.g., the April 2009 L’Aquila sequence) demonstrated that the satellite images are able to fast provide detailed information about the seismic source, also detailed seismological studies related to an important seismic sequence can provide constraints on the genetic sources. In particular, when analyzing a seismic sequence it is quite common to find events that show similar waveforms (i.e. multiplet) when recorded at a common receiver. Such coherent events should derive from subsequent breaks related to energy release due to repeated slip on the same fault plane during foreshock-mainshock-aftershock sequences. In this case, starting from more than 5.000 relocated hypocenters (Carannante et al., 2015), a waveforms cross correlation analysis was performed in order to detect multiplets with the aim to discriminate different asperities. The analyses was computed considering the vertical component of each waveform, filtered on the basis of the signal to noise ratio, considering portion of windows able to capture both P and S phases. The calculated matrix provided more than 1 million pair of events with an associated cross correlation coefficient (ranging from 0 for absence of correlation to 1 for a total correlation), allowing to build a detailed history of the sequence, clearly discerning different type of multiplets associated with the 20 and 29 May fault plane respectively. The results are compared and considered together those coming from the geodetic data modeling operated by Pezzo et al. (2013), able to identify two main fault planes obtained inverting InSAR (COSMO-SkyMed and Radarsat-1 InSAR data) and GPS data.