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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Width of surface rupture zone for thrust earthquakes. Implications for earthquake fault zoning." *by* Paolo Boncio et al.

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Reply to the comments of Referee #2

We would like to thank the reviewer for the appropriate and very useful comments and suggestions. We are going to comply all the comments in the revised version of the manuscript. The Reviewer's major issues and recommendations have been replied in the following section.

REVIEWER: 1. My first comment concerns the Bending-Moment and Flexural Slip ruptures (distributed deformation features). The authors do not consider these in their analysis because "strictly related to the structural setting of the area (presence and wavelength of the fold". I don't really understand this statement because each rupture,

its splays, its pattern of surface deformation is somehow related to a specific structural pattern (geometry of the fault at depth, segmentation, local arrangement of rock packs, etc). Maybe the authors have in mind the fact that BM and FS are rather related to Co-seismic folding (ductile deformation) during earthquake than to Coseismic propagation of the rup-ture plane to the ground surface? I would suggest to the authors to discuss the way these BM and FS distributed ruptures could be accounted for: this is a critical issue for Italy where thrust-related earthquakes usually occur on blind faults and BM and FS on associated fold are the actual main hazard. In section 3, line 173, the authors seem to mean that there is a direct relation between fold wavelength and location of BM-FS ruptures: this could be a proxy and a way to map and define "Warning or Susceptible zones" to include them in zoning. In line 245-246, the authors write that the "knowledge of the structural setting of the area help in identifying zones potentially susceptible to BM and FS faulting", then why not suggest that such structural features (active folds associated with a thrust) could be defined as "Susceptible Zones"?

RESPONSE: We fully understand the Reviewer's criticism. In fact, the most correct approach for considering secondary faulting (particularly ruptures very far from MF) is a difficult task. Basically, our aim in the paper is to distinguish, if feasible, secondary ruptures that occur in a rather "systematic" way compared to the main fault (i.e., only related to the propagation of the main rupture up to the surface), called "simple thrust ruptures", from secondary ruptures that can be affected by structural features that are not systematic (large-scale folds, lithology of folded rocks, ...). For sure, we have to discuss this point more deeply and more clearly. We are going to improve this discussion in the revised version. Most importantly, we decided to analyze the data both with and without BMF and F-S secondary ruptures (two different PDFs), and discuss the results and the possible implications. Therefore, we think the paper will be largely improved from this point of view.

REVIEWER: 2. My second comment deals with the definition of metrics and the chosen hypotheses to calculate dis-tances between secondary ruptures and main ruptures. The Figure 1 presents the approach consid-ering a quite simple case, where the “average MF direction” is easy to infer. It is not clear to me how the authors would cope with curved and/or discontinuous ruptures and scarps; at which scale does the average trace is designed? This would change depending on the rupture size (ex. 240 km of Wenchuan vs 15 km of San Fernando). The MS would largely benefit from the inclusion of the rupture maps, so that the reader would understand the authors' method and eventually reproduce the method to improve their work in further steps. Other questions arise for this point: for instance, how the authors measured the distance of secondary ruptures at the tip of the fault, out of the main trace?

RESPONSE: We will add electronic supplementary material including a summary table with all the measured data and several maps, one for every earthquake, showing the measurement details, including the chosen average strike of the main fault. Moreover, we will explain better the method in the text. In general, we were careful in defining the average strike of the MF and the measurement azimuths, taking into account the variations in strike of the main fault (only first-order, kms-scale strike variations have been considered), and avoiding duplication of measurements. The maps we are adding in the auxiliary material will help the reader in judging our choices. We are also adding data from the Nagano 2014 earthquake, as suggested.

REVIEWER: 3. Third comment. The results in terms of statistical outcomes are sufficient to support the conclusions (i.e. definition of three different levels of zones). However, I find the section “Conclusions” look like an Abstract. They should include some perspective or prospective insights, like for instance: - How to take the BM and FS ruptures into account? - Do we need more data to build more robust zoning results? – Would this work or compiled database useful in Probabilistic approach of Fault Displacement Hazard Analysis? - Could future similar developments be applied to other tectonic and permanent deformation features like folding, tilting, extensional/compressional strain (see discussions in ANSI/ANS-2.30-2015 Criteria for Assessing Tectonic Surface Fault Rupture and Deformation at Nuclear Facilities)?

RESPONSE: We thank the Reviewer for this good suggestion. This will improve the paper.

RESPONSE to MINOR SPECIFIC POINTS: All the specific points and minor corrections suggested by the Referee will be carefully taken into account during the revision.

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