Nat. Hazards Earth Syst. Sci. Discuss.,
doi:10.5194/nhess-2017-123-RC2, 2017

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.

Anonymous Referee #2

Received and published: 20 May 2017

General comments

The MS represents a substantial contribution to mitigation of surface faulting hazard, which falls into the scope of NHESS. The paper uses existing worldwide datasets to propose easily applicable criteria to mitigate the surface displacement hazard that can occur during earthquakes. The authors statistically process worldwide data to define "setback" zones as avoidance or warning zones for human occupancy facilities. According to my knowledge, this approach is innovative. Usually, statistics on datasets are used in Fault Displacement Hazard for deriving prediction equations (probability of rupture, attenuation of displacement with distance), but my feeling is that this work is an appropriate and valid way to treat the problem. An interesting outcome is that the statistics tend to confirm part of the Italian regulation lines, but on the other hand the results suggest that the avoidance should be increased for well-mapped cases. I find

the discussion on Bending-Moment and Flexural-Slip ruptures a bit disappointing (see below). Also, the proposed conclusion is more an abstract and I would expect some perspectives to the work that has been done (see below). The MS is clear and concise; contents are well exposed and structured, easy to understand for a wide audience. Figures are good, except the Figure 4 where labels are too small. English is clear to me (English is not my native language). Figures are generally relevant, but I wonder if the Figure 2 (Scarp classification) is really helpful. I suggest to the authors to include in Supplementary Material the rupture maps which would (probably) help the reader to understand some choices about calculation of distances, definition of "average MF direction", etc (see below). The title and abstract clearly and unambiguously reflect the contents of the paper. The authors use an adequate number and quality of accessible references, from which they extract a fair and relevant content. Therefore, I would suggest that Scientific Significance and Quality are good and Presentation Quality is very good (even if some minor corrections would improve the MS). To me, the MS would be accepted after some revision such as follows.

Major issues and recommendations

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 Coseismic folding (ductile deformation) during earthquake than to Coseismic propagation of the rupture 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”? My second comment deals with the definition of metrics and the chosen hypotheses to calculate distances between secondary ruptures and main ruptures. The Figure 1 presents the approach considering 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? 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)?

Specific points

Replace “associated to” by “associated with” or “related to” Lines 50 51 – Define “main

fault” and “secondary faulting” Line 63 - Ambiguous statement: “The AP act defines a minimum distance (. . .) within which critical facilities and structures designed for human occupancy cannot be built”. Delete “Critical facilities” because AP Act is only for housing. Line 68 – Please specify which facilities are concerned by “land management” term: only housing, or also lifelines, pipelines, storages or other facilities Line 73 – The fault zones’ widths vary at different Levels instead of The fault zones vary at different Levels Line 82 – Please explain what is decided when the “Susceptible Zone” is defined: Avoidance? Line 88 – Rephrase “In general, worldwide the width of the rupture zone . . .” Lines 92 to 95 – Sentence is to be rephrased. Ambiguous sentence: “1: to collect the data from well-studied (. . .) earthquakes” is not exactly was has been done. Instead, it is a compilation of surface maps and displacement observations, not a collection of data (in the field). Lines 117 to 129 - after reading the whole paper, I am not really sure that this description of scarp classification and related section is useful. What is finally used in the conclusions? The authors may earn space here. Lines 135-136 - clarify whether the scarps are described according to the same classification in the references. Or is it a re-interpretation based on drawings, map? Line 142 – The collected data were instead of The collected data was Lines 154 and 155 – The sentence suggests that there is surface geology information in the references: is that the case or is this an assumption? Line 162 - Subsurface data give indication of the location of an anticline on top of the fault: where are located the FS ruptures with respect to this fold? Lines 168-169 – “the distribution of the BM faults for the El Asnam earthquake is very similar to the distribution of extensional ruptures for the San Fernando earthquake”: please provide an explanation to this surprising statement. Is there a similar wavelength of associated fault? So no dependence on magnitude (7.3 against 6.6)? Line 182 – Please explain the Kolmogorov-Smirnov test (if you decide to mention it), its specificity and the reason why it has been selected. Otherwise, you can skip this information. Line 186 – Explain why “the 90% probability (. . .) seems to be a reasonable value to cut the outliers”: for statistical reasons considering the examined population? Or because its outcome in terms of setback size fits with an a priori? Line

204 – “the data with BM and FS faults are excluded” instead of “the data with BM and FS faults is excluded” Line 209-210 – “the maximum WRZ, including the secondary ruptures away from the main fault, can be up to 200 m or wider”: did you explore if there is a relation between this max. width and the earthquake magnitude? Lines 221 to 225 – I would suggest to moderate this with the conclusion coming from the MB and FS analysis. In cases of verified active folds (related to thrusts), this conclusion should be revised, especially for Italy where most of the thrusts are blind (Po Plain) and could cause folding and BM-FS ruptures at the surface as the major hazard. Line 234 – “Assuming that this relation is robust enough” instead of “Assuming that this relation is real” would be better, I think Line 248 – I was wondering if any BM reverse faulting has never been observed in the synclinal axis. This part requires more perspective. How can we account for these ruptures? Any recommendation? Line 282 – This confirms that the avoidance zone should be larger” would be more appropriate than “This suggests that the avoidance zone should be larger” Table 1 - Why 2014 Nagano earthquake rupture has not been included? Figure 1 - There is a different approach for short, intermediate and long secondary ruptures in measuring distance to main fault. Explain please. Caption - Main fault: How is defined main fault? Max. displacement? On the map, this “main fault” runs along the base of the scarp I presume. In complex cases like (d), (e), (f), Main fault trace is traced along the free face or along the more external topographic bulge? Figure 2 – Explain where the Main fault would be mapped on Figure 1 on each case.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-123, 2017.