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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Earthquake-induced ground failures in Italy from a reviewed database" *by* S. Martino et al.

S. Martino et al.

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The Authors wish to thank the two referees for his useful suggestions and contributions provided during the on-line Discussion for improving this paper. In the following, we report the replies to the referee and the actions that we're going to carry on in the reviewed version of the manuscript and of the figures, according to all the suggestions given. Moreover, the Authors decided to improve the completeness of the submitted study by including and discussing the most recent data referred to the last 2012 Emilia earthquake; the reason of this choice is due to the fact that, during the time of the on-line Discussion, some papers were already published by other Authors on the induced ground effects due to the Emilia earthquake. Moreover accordingly to the aforemen-

tioned data addition and to provide more explanation on the topics suggested by the two referees, in the reviewed version of the paper the Author: 1) will upgrade all the graphs and figures which report percentage and statistics; 2) will add two more figures (already proposed in the following reply document to the referees) ; 3) will insert a "Discussion" section before the "Conclusion" one.

Reply to Anonymous Referee #1's comments and Actions taken

Comment-1: Although the incompleteness of the CEDIT catalogue is acknowledged the paper lacks a clear analysis of the incompleteness of the ground failure records. What effect have the incomplete ground failure numbers on the presented statistics and the overall results? If the outcomes shown in figures 8-12 are based on incomplete data, then what is their value? What are the implications? Or these outcomes could be potentially misleading and confusing? Reply-1: incompleteness is an unavoidable problem when referring to historical or even pre-historical events. The effect of incompleteness is nevertheless meaningful when dealing with the computation of the frequency of occurrence, as it is the case of the computation of the seismicity rates in the earthquake hazard analysis. In our work we didn't provide any estimate of the time frequency of occurrence of ground failures, nevertheless the Authors are confident that the most important cases for which some documentation is available have been included. In fact, even for recent events we could miss many small effects but sure it is much more unlikely to miss some relevant effects (see for a comparison the different liquefaction effects detected for the recent Emilia 2012 earthquake reported by Emergeo – NHESS-13-935-2013, and those reported by ISPRA – Annals of Geophysics 55-4-2012, as an example how the completeness can be problematic even for current events, due to problems related to the scale of the survey and to the dimension of the detectable effects). Action-1: According to Keefer 2002 (INVESTIGATING LANDSLIDES CAUSED BY EARTHQUAKES – A HISTORICAL REVIEW: Surveys in Geophysics 23-473), we stressed in the paper the limited usefulness of conclusions based on data before 1783 Calabria earthquakes, that nevertheless constitute only

a small amount of the whole database (approximately 10%). Moreover, a thorough discussion of the completeness with a revised figure 4 has been inserted in the main text.

Comment-2: With reference to figures 12 and 13, how is the occurrence probability of ground failure types defined and calculated? In terms of exceedance probability? But what threshold? This need to be explained. Or the probability simply refers to the statistical properties of the incomplete catalogue. If so, there are no implications as far as the actual relations between the ground failure triggering and earthquake parameters are concerned. Reply-2: the occurrence probabilities were computed on the basis of a Weibull distribution applied to the frequency distributions shown in each figure. Thus, figure 12 shows the non-exceedance probability of a given site intensity for each category and figure 13 shows the exceedance probability of a given distance for each category. Nevertheless, we acknowledge that the exceedance probabilities for distance are of limited usefulness, since attenuation with distance depends on magnitude and therefore better represented by relationships as those shown in figure 14. Action-2: the use of Weibull distribution to compute the occurrence probabilities are now explained in the text. Figure 12 has now the y-axis labeled as non-exceedance probability and also shows the frequency distribution of each category. In figure 13 the probability curves have been discarded.

Comment-3: With reference to Fig. 14, apart from the great data scatter (any explanation?), why is the linear scale used for Mw? Wouldn't it be appropriate to use log scale here considering that attenuation relations are not linear? Please explain. Another problem with using the maximum epicentral distance as an index parameter is that earthquake depth and rupture mechanisms are ignored. So what does it all mean? Reply-3: Mw scale (X-axis) in figure 14 is rightly in linear scale, while the distance scale (Y-axis) is in log-linear scale, according to attenuation relations where the ground motion (in log-scale) is linearly related to magnitude and non-linearly related to distance. Moreover, graphs appear in the same manner in other similar papers, such

as in Delgado et al. 2011 (fig. 2), Rodriguez et al. 1999 (figs. 3 to 5), and Keefer 1984 (fig. 2). As it regards depth all the earthquakes listed in table 1 refer to crustal earthquakes (depth less than 30 km) and most of them are shallower than 20 km. Thus, depth may be regarded as an invariant while for the focal mechanism we have no evidence of relationships scaled to fault mechanism, whose indication is moreover missing in the CPTI earthquake catalogue. Action-3: figure 14 is now splitted into two figures, one for liquefaction and one for landslide, each one separating data before and after the instrumental era (1908 A.D.) in order to take into account the different reliability of all the parameters (magnitude, epicentral location and distances). This is now consistent with the new discussion of completeness that is also incorporated in the revised figure 4 (see reply to comment 1, above). The data scatter is more clearly explained by the error bars now shown in figure 14, which take into account errors in magnitude determination and in distance computation due to the approximation in the effect location.

Moreover, a new figure (16) has been introduced to show the potentiality of the database for improved correlations among distributed effects and fault parameters (such as dip and depth), as for the distance distributions as a function of the fault side:

Comment-4: I was also puzzled by the use of very coarse lithologic data. 1:250,000 scale? Poor resolution of lithology, with the uncertainty in the locations of historic failures - what is this good for? The use of similarly coarse geologic maps could be perhaps justified in the case of some parts of Africa. Note that in China, which is MUCH bigger than Italy, 1:50,000 gologic maps are now used to investigate relations between earthquake triggered ground failures and lithology. Reply-4: The Italian geological map 1:250.000 by APAT 2012 is based on 1:100.000 and 1:50.000 (where available) field survey data; the included geological information and comments to the map (available at the web site http://www.isprambiente.gov.it/it/cartografia) are suitable for attributing the seismically-induced ground effects to the lithologies reported in Fig.8. Action-4: A

more complete explanation of the geological base map and of its source data is now provided in the manuscript and a lithotechnical attribute (soil/weak rock/hard rock) is now associated to the lithologies distinguished in the graph labels of Fig.8. Moreover the labels are now re-ordered according to the lithotechnical categories.

Comment-5: Can we learn something new from an incomplete catalogue and associated statistics? How do the summary statistics of the CEDIT database compare with some other published works based on more complete data? Reply-5: Data are not less incomplete or unreliable than other published databases, such as those clearly stated by Keefer 1984 (page 408 and Table 7), Rodriguez et al. 1999 (page 329), Bommer and Rodriguez 2002 (page 200), Delgado et al. (page 207). As for other regional databases (e.g. Bommer and Rodriguez 2002), summary and inferential statistics from the CEDIT database move towards the direction to provide evidences of the earthquake-induced ground failure susceptibility in a variety of seismotectonic and geological environments, as advocated by Keefer in his paper of 2002. Even for the oldest earthquakes, data provided are useful for a perspective assessment of the environmental response to earthquakes, as the lesson learned after the Emilia 2012 earthquake that showed a similar pattern of ground failures as reported and documented by the CEDIT catalogue for the same area of a previous earthquake dated back to 1570 AD. Action-5: advantages and shortcomings of the statistics here presented are included in the discussion. A comparison with other magnitude-distance relationships (Keefer 1984, Galli 2000) is provided and discussed.

Minor comments: Page 2053 “Source-to-site distance is the key parameter for characterising the susceptibility of an area to failures triggered by earthquakes.” – this is simply wrong. The referee doesn’t explain why this statement should be wrong. As clearly stated just after the sentence, the distance modulates the seismic shaking by attenuating the intensity and by lengthening the duration and the fundamental period of vibration, all matters that influence the ground response. Nevertheless, at page 2051 it’s as many clearly stated that ground failures depend on “the released seismic

energy, source-to-site distance and local conditions”, topics covered and discussed through figures 9, 13 and 11, respectively.

If the geology map is “reporting only substratum” (page 2051), then how did you get debris and alluvial deposits (page 2050)? EDITED: the reference geological map reports the outcropping lithologies.

Conclusions – last sentence: poorly written, unclear. REWRITTEN

Some references missing and some works included in the reference list are not cited in the text. CORRECTED

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 2041, 2013.

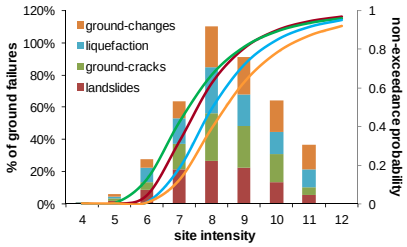

Fig. 1. Action1

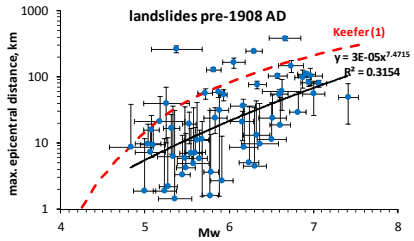

Fig. 2. Action3

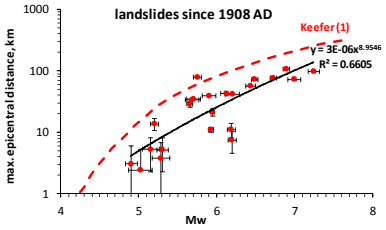

Fig. 3. Action3

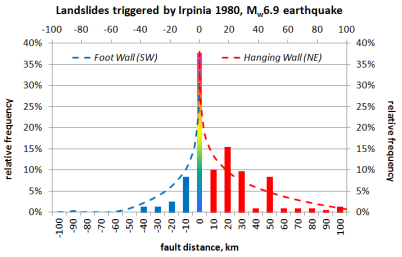

Fig. 4. Action3