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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Evaluation of shallow landslide triggering scenarios through a physically-based approach: an example of application in the southern Messina area (north-eastern Sicily, Italy)" *by* L. Schilirò et al.

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Dear Referee,

Thank you for your careful, constructive and detailed review of our manuscript. You can find the new version of the paper in the supplementary material. As suggested, we performed additional numerical simulations by varying several input parameters of the model. Specifically, we took account of the variability of the soil texture by using three different grain size distributions referred to the investigated soil, then testing with HY-

DRUS 1-D and TRIGRS the consistency of the parameters used (Table 5 and Fig. 10b). The new results of the back-analysis show an actual improvement of the model calibration, considering that the model predicts about 70% of the 2009 landslides (compared to 47% of the old simulation). As a consequence, even the results of variable triggering scenarios are significantly different: the short duration (1-3 hours) rainfall events cause a much higher number of unstable pixels compared to events characterized by the same rainfall amount but longer duration. In order to explain and validate the new results, the model output has been thoroughly analysed by running different scenarios for a representative grid cell (Fig. 13), describing the variation of FS and pressure head over time. Furthermore, every single suggestion has been considered by implementing the text where more detailed explanations or adjustments were needed. With regard to the specific questions:

1) (p. 2976, lines 16-17 of the old version of the manuscript): your observation is correct. However, as mentioned above, new numerical simulations have been performed, and the new results significantly differ from the preceding ones. In fact, on equal rainfall amount, the highest instability is predicted for shorter events, due to the greater rainfall rate. Furthermore, analysing the instability process over time, it results that the maximum number of unstable pixels occurs one hour after the end of the rainfall event (Fig. 10b, Figure 13, Table 8);

2) (p. 2980, line 6 of the old version of the manuscript): your observation is correct. In fact, the new calibrated value of Ks is equal to 6.6 x 10-5 m/s (237.6 mm/h), so approximately 2x greater than the maximum rainfall peak (111 mm/h);

3) (p. 2980, lines 21-29 of the old version of the manuscript): the information has been plotted in the new version of Fig. 2a;

4) (p. 2981, line 16 of the old version of the manuscript): correction made;

5) (p. 2982, line 21 of the old version of the manuscript): correction made;

6) (p. 2984 line 24 of the old version of the manuscript): the model assumptions used in our analyses have been stated at the end of Sect. 4.1;

7) (p. 2986 lines 16-17 of the old version of the manuscript): as mentioned above, we performed different numerical simulations considering three different grain size distributions. The HYDRUS results show a variation in Ks across an order of magnitude (Table 5), while the other parameters (except diffusivity) are substantially similar for all the three samples. However, we decided to consider the grain size characteristics of sample n.1 as the most representative of the investigated soil, due to the remarkable delay of the instability peak observed in the TRIGRS simulations performed by using the grain size characteristics of the other two samples (Fig. 10b);

8) (Table 5 of the old version of the manuscript): your observation is correct. In fact, the new value of cohesion has been progressively increased to 3 kN m-2 so that only very few cells (i.e. 260, which represent about 0.04% of all grid cells in the study area) result unstable before the beginning of the event. In any case, the chosen value lies within the range of values reported by other authors for the same material (see Sect. 4.2);

9) (p. 2991 lines 24-28 of the old version of the manuscript): considering the significant improvement of the back analysis results (with about 70% of correctly predicted landslides), we believe that the modified model can be considered sufficiently reliable to evaluate different triggering scenarios. Therefore, if we consider that at the current state of our work no particular attribute can be related to grid cells with false positive and false negative values, the mismatch between model results and field evidence can be attributed to simplifications and uncertainties inherent in deterministic models;

10) (p. 2992 sect. 5.3 of the old version of the manuscript): your suggestion regarding the evaluation of modeling results against recent landslide events is reasonable. However, in the discussion of results we emphasized the importance of hourly rainfall data for this type of instability phenomena. For this reason, we have simulated the

25 October 2007 event (the only recent landslide event for which hourly rainfall data are available) with the aim of confirming the statements inferred from the simulation of 2009 event, considering the similarity between the two events (Table 9). Unfortunately, unlike the 1 October event, a spatial comparison between predicted and real landslides triggered during the 2007 event could not be performed, due to the lack of a specific landslide inventory. For the same reason, we are not able to make such comparison with even more previous events;

11) (p. 2993 lines 1-8 of the old version of the manuscript): in this new version of the manuscript we analysed the pressure head and FS output of a representative grid cell for different rainfall scenarios (Fig. 13). The comparison confirm that the lower the duration of rainfall events, the lower the Safety Factor and, consequently, the higher the pressure head, on equal rainfall amount. Furthermore, analysing the process over time, it results that the maximum pressure head develops one hour after the end of the rainfall event, which represents the time required by water to reach greater depths;

12) (p. 2993 lines 24-27 of the old version of the manuscript): as in the case of question 1), the new value of Ks is higher than the maximum rainfall rate (i.e. 85 mm/h).

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/3/C1453/2015/nhessd-3-C1453-2015-supplement.pdf

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