

Interactive comment on “A coupled distributed hydrological-stability analysis on a terraced slope of Valtellina (northern Italy)” by C. Camera et al.

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Responses to Referee number 2 (HESSD, 10, C1707-C1712)

NOVELTY OF THE PAPER

This paper represents the development of the studies authors did on the subject. These studies were performed by collecting many field data and performing many laboratory tests and field monitoring. These works brought to the development of numerical models for groundwater flows and stress-strain behaviour of these systems, which allowed to deeply investigate very peculiar variables (such as dry stone wall mechanical parameter and processes (such as formation of perched water table) affecting stability of terraced slope and the failure mechanism (slide, bulging) at the scale of the single or

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few terraces. In this work we have completely changed the study scale trying to develop an approach that can be used to evaluate stability at the slope scale; this work takes advantages from the previous studies in terms of variables selection and expected processes, but required a complete new approach in terms of variables determination (such as DEM and soil depth map) and modelling development. The specific environment of terraced slope makes the change of scale of analysis very difficult because of the reasons already pointed out in the manuscript (above all the highly irregular topographical surface, and the high variation of soil depth at the back of the wall over a short spatial scale and the impossibility to use standard methods as the infinite slope, usually adopted for distributed stability analysis). We have proposed a possible mix of techniques and methods that can be used to perform these analyses.

HYDROLOGICAL STUDY

We can provide all the necessary equations that are contained in STARWARS, and a more detailed description on initial and boundary conditions etc. We did not assume that the model works; results and discussion section contains model calibration based on experimental data together with a discussion on results quality. Anyway, as suggested by Referee 1, we will re-arrange this section of the manuscript by splitting results and discussion in two different sections, so to give more readability to the text.

DETAILED COMMENTS

Page 2290 lines 9-10. We will insert the suggested references.

Page 2292 lines 24-26. We can highlight differences in the method.

Page 2293 line 18. We will give more details on STARWARS.

Page 2293 line 25. We can provide how we identified hydraulic parameters.

Page 2294 line 1. We agree that the use of an exponential form of the SWRC can be an approximation, that's why we performed calibration and we think that results cannot be transported to cases where calibration is not performed.

Page 2294 line 22. All the water that cannot infiltrate in impervious areas (asphalt or rock outcrops) or in general in areas where precipitation is higher than the infiltration capacity, is accumulated along the linear drainage system. Then it can infiltrate in the first cell with a suitable infiltration capacity. All the water that cannot infiltrate within the current time-step is considered as superficial runoff at the outlet. This is one of the causes because the results between the daily and the hourly time-step are different. With the hourly time-step, it is possible that in occasion of high intensity rainfalls a certain amount of water cannot infiltrate and leave the slope as superficial runoff. With a daily time-step, rainfall is averaged on 24 hours and so there is a sort of smoothing of the peaks and a higher amount of water can infiltrate.

Page 2295 line 20. Apparent cohesion for soil suction was not taken into account in the model, while it was considered in our previous studies in the detailed analyses of failure mechanisms. In these studies we noticed that the development of a perched water table was highly significant in influencing the terraced slope stability. A possible influence of failure for matric suction dissipation was also observed, even if resulting as much less important. So unsaturated condition was considered in the hydrogeological (formation of the perched water table) part but not in the geotechnical part (failure condition occurs under the development of positive pore-water pressures). Sarma method is very useful in this case because it allows to evaluate F_s in a closed form while considering the cells of the model as single slices for the stability analysis.

Page 2297. We agree and it is one of the key point of the work in this specific environment.

Page 2298 line 19. We will use also another fitting index as the critical compound error.

Page 2298 line 23. We are sorry the map was not clearly explained. We will improve it. The classes of soil depth in the map are obtained through a categorization of soil depth values by defining ranges which identifies five classes obtained from field measurements, from the one with soil depth (sd) = 0 to the one where sd is higher than

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3m.

Page 2299 line 24. We agree and we move this part in the proper section.

Page. 2300 line 13. This is the part of the model validation so we use real measured rainstorms generating perched water tables that have been monitored.

Page. 2301 Line 1. We agree and we will rephrase this part.

Page. 2302 line 12. We will include equation in the manuscript and as mentioned before in the responses to Hydrological study we will modified and extend the results and discussion sections. Yes, results can be considered preliminary results, we will specify it.

Page 2302 line 14. We agree, the term over-estimate is not appropriate here.

Page 2302 line 26. Soil suction was not taken into account in the model as mentioned before, so problems of instability under dry condition should be related to drawbacks of the model only as stated in the text.

Figure 3. Figure 3c is derived from Fig 3a, map construction and validation is explained in the text. We will work on it to make it clearer.

Figure 4. We agree that the point worth a more extended explanation. The fact is that geophysics in this environment suffers from the abrupt changes of slope dip angle. The purpose was to check if it could give trend of soil depth similar to the one obtained with other methods, not to quantitatively compare soil depth values. We will introduce this explanation in the text.

Figure 5. It is mainly due to the time-step duration and how infiltration and superficial runoff are modelled (see answer p. 2294 line 22)

Figure 6. The position of the walls is in Figure 1, caption of Figure 6 indicate it. We will add this information in the text too.

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Figure 9. US terraces have not been used in the figure just to keep it simple and easy to be understood.

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