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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Probabilistic landslide ensemble prediction systems: Lessons to be learned from hydrology" *by* Ekrem Canli et al.

Anonymous Referee #1

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General comments:

The paper reviews recent developments in applying ensemble prediction systems to probabilistic hydrologic forecasting and uses a case study to demonstrate how ensemble prediction might be applied to landslide forecasts. The paper is well written and could be accepted with minor revisions. The discussion and conclusions would benefit by (1) adding brief remarks about additional sources of uncertainty from DEM data, especially given the sensitivity of the infinite slope model to slope angle; (2) commenting about treatment of large-scale heterogeneity in regional scale model ensembles; (3) clarifying how validating landslide models using extreme events degrades model or forecast accuracy. These points are amplified in my detailed comments below. I have also noted several minor editorial corrections.

Specific comments:

Page 7, lines 5-7, Greco and Pagano (2017) seem to indicate in their Figure 2, that warning needs to start during the latter part (triggering rainfall) of Phase 1. Common sense indicates that warning or at least issuing an advisory that slides are likely with additional rainfall during this stage is prudent. Waiting until stage II is probably too late.

Page 13, line 1, it is probably worth mentioning either here or somewhere that for the sake of simplicity, you varied only three of the most sensitive model parameters, cohesion, friction, and soil depth, but in an operational landslide forecasting system varying additional sensitive parameters would be prudent.

Page 15, line 19, consider inserting "or a property zone map" between "soil depth map" and "is provided"

Page 16, line 14, What is meant by "unpicking?" separating?

Page 17, lines 23-33, Although "large scale" and "small scale" are used correctly in previous sections of the paper, they are used incorrectly here. Large scale maps and models are detailed (see https://en.wiktionary.org/wiki/large-scale). Similarly, small-scale maps and models are generalized (cover large area with little detail). It would be clearer to use "local scale" and "regional scale" or similar terms.

Page 17, lines 25-34, occurrence of landslides on more gentle slopes that have low susceptibility according to the model ensemble (Fig. 5, Page 14, lines 28-29,) as well as the modeling artifact mentioned on page 14, lines 9-10 suggest that even using an ensemble, the modeler needs to account for certain inhomogeneity, including infrastructure, such as retaining walls, as well as broad deterministic differences imposed by geology, etc. Given the high sensitivity of the infinite slope model to slope, why are effects of uncertainty in the DEM on model results still mostly unexplored? Shouldn't DEM uncertainty be an area for further research?

Page 18, lines 3-5, See Gioia et al. (2015) for a case study of using literature values to parameterize such a model.

Page 18, lines 21-29, The WMO (2012) argument makes sense for meteorological and hydrological models because they are calibrated to variables that can be measured continuously (temperature, humidity, precipitation, streamflow, and so on). Please clarify how the argument applies to landslides when the models are calibrated to landslide events, which as the authors point out, are rare. Thus, in this case, the statistical distributions are trained to the extreme events. The only common, almost daily events to which landslide models could be compared for validation are the absence of landslides. While it's true that most recent publications about rainfall thresholds for landslides have included some non-landslide inducing precipitation in developing or validating thresholds; it seems uncommon to continuously evaluate those thresholds against daily absence of landslides. This is an important point, because, if I understand correctly, you are arguing that the way that process-based landslide susceptibility models are being calibrated or validated (by comparison with past events) is biasing them in a way that decreases forecast accuracy. If so, and a new or different approach is needed for validating models, what do you suggest?

Page 18, line 27-29, The problem here is not just a matter of lowering model sensitivity. In many cases, available data are not adequate to create a very sensitive model using any procedure. For example, in the rolling hill terrain of the Esino River Basin, Gioia et al. (2015) found there was no well-defined relationship between topographic variables and landslides, making it difficult to attain high model sensitivity. For other areas, such as the Colorado Front Range (Alvioli and Baum, 2016), model sensitivity was impaired by the quality of available DEMs, such as those derived from legacy photogrammetrically mapped topographic contour data, as well as other data uncertainties. Mergili et al. (2014b) similarly seem to have experienced difficulties obtaining high sensitivity even when using a 3-D method and ranges of depth, cohesion and friction. While I appreciate main the point of your paper that accounting for uncertainty through the use of model ensembles will improve forecasts, it seems clear that continued research is

needed on other fronts as well to overcome some of the challenges in making accurate forecasts.

Page 19, lines 8-9, What do you mean here by averaging performed by the infinite-slope stability model? Don't 3-D models such as the model of Xie et al. (2003, 2004, 2006), r.slope.stability (Mergili et al. 2014a), and Scoops3d (Reid et al. 2015) perform a sort of averaging over the neighborhood of each point in the search grid? By considering a group of neighboring cells in each trial failure, the 3-D models effectively average out effects of the ground surface irregularities at the same time as they account for effects of the finite extent and lateral boundary effects of realistically shaped trial landslides.

Technical corrections:

Page 2, line 29, change "explicitly introduces in into the model" to "explicitly introduces it into the model"

Page 6, line 24, capitalize "it"

Page 8, line 22, change "provide" to "provides"

Page 8, line 31, change "if" at the end of the line to "it"

Page 13, line 13, change "a proof on concept" to "a proof of concept"

Page 15, line 16, change "parameter" to "parameters"

Page 16, line 22, delete comma after "data assimilation applications in both"

Page 18, line 16, change "calibration if capable" to "calibration is capable"

Page 18, line 27-28, change "had to be" to "must be"

Page 18, line 30, change "a nonsuperior state over" to "an inferior state below"

Figure 4, add outline of area shown in Figure 5.

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