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Hydrology and
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Discussions

Interactive comment on “A new method for determination of Most Likely Initiation Points and the evaluation of Digital Terrain Model scale in terrain stability mapping” *by* P. Tarolli and D. G. Tarboton

P. Tarolli and D. G. Tarboton

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The authors thank Referee #1 for the review and comments on this paper.

The first point made by this reviewer was that very few references were cited. In the revised paper that we are submitting the literature review has been expanded to include review of Iverson (2000) and other papers that this and other reviewers have suggested.

The reviewer next makes the point that there is a scale limitation associated with the infinite slope model and grid cell size. It is theoretically incorrect to use an infinite slope model when slopes are computed at small scale and can not be approximated as being infinite. This is a good point and provides another reason why the model performs best for 10 m resolution Digital terrain models. In the revised paper we note that at very fine resolution, slopes from the DTM may also lose their representativeness as the slope of the failure surface in the infinite slope stability model. We suggest this as one of the reasons why a 10 m resolution DTM works best in this setting.

The reviewer next makes the point that the landslide mapping did not discriminate between source, transport and deposition sectors, nor did it distinguish different landslide types. We have noted in the text, and emphasized this more in the revisions that one of the reasons for developing the most likely landslide initiation approach was to be able to evaluate the discriminating capability of a terrain stability model by comparison against landslides where the entire landslide scar, rather than the initiation zone had been mapped. With respect to landslide type, the infinite plane slope stability model only applies to shallow translational landslides. The landslides mapped in this study are believed to all be of this type.

The reviewer notes that the analysis was performed on a post failure DTM that will therefore result in computation of post failure slopes. This is acknowledged to be a limitation. A pre-failure DTM is not available and attempting to reconstruct a pre-failure DTM would introduce additional uncertainties. We do note however that the failure depths of the landslides are quite shallow, 0.5 to 1.5 m, so for DTM scales greater than 10 m the effect of topographic changes due to landslides is diminished. This may be yet another reason why models using DTMs finer than 10 m scale do not work as well as the 10 m DTM in discriminating landslide locations.

The reviewer notes that vegetation and soil (both thickness and mechanical characteristic) variability within the study area directly control the slope stability results, so the assumption of a random value within a certain range is not the best approach if not supported by at least some field observations. We do not fully concur with the reviewer on this point. It is because of the variability in these properties that a random approach is used. The random approach is one of the few modelling approaches that can actually accommodate variability and uncertainty in the material properties. We do agree with the reviewer that such a modelling approach could be improved by using field observations to set the probability distribution bounds. Such analysis was beyond the scope of this paper where the main purpose is not to specifically optimize the characterization of terrain stability for this area, but to introduce the most likely landslide initiation method as an approach that can provide useful information for the analysis of terrain stability and for evaluation of the performance of different terrain stability models.

The reviewer suggests describing if rock outcrops or similar areas have been eliminated from the analysis. The study area does not contain any bedrock outcrops. In the text it was a mistake when we wrote “the remaining 6% of the area is bedrock outcrops and unvegetated landslide scars and deposits”. We delete “bedrock outcrops” in the revised paper.

The reviewer noted that the highest SI threshold value of 10 that was used corresponds to a factor of safety of 10. The reviewer notes that engineering practice would more typically consider a value of between 1.3 and 3. The point of this high SI value is to have a non-discriminating threshold. The thresholds 0.2, 0.5 and 1 are discriminating, and then the value of 10 is used to select all the terrain for analysis. This is clarified in the revised paper.

The reviewer noted that on the map in figure 10 the most likely landslide initiation points often coincide with landslide scarps that are steeper areas in post failure morphology and that the model performance may simply be due to steep slopes. A comparison with a simple slope gradient is suggested. In the revised paper we have included a comparison with simple slope gradient as a stability index and we find that the most likely landslide initiation points derived from the SINMAP stability index have significantly higher density in the landslide scars than the most likely landslide initiation points derived from slope alone. This leads us to conclude that the information provided by contributing area that is input to SINMAP contributes in a significant way to the discriminating capability of the SINMAP stability index.

The reviewer notes that a limitation of the most likely landslide initiation point model is that it only identifies one most likely landslide initiation point along each flow path, whereas the possibility exists that landslides may initiate at different locations along a unique flow line. The MLIP approach may give contradictory results because it promotes as initiation points cells with a SI higher (less critical) than other cells because they are not the minimum along a specific flow line. This is a valid point. Most Likely Landslide Initiation Points are exactly what they claim to be, the location with the most critical SI value along a flow path. A threshold is used in the procedure for identifying MLIP to preclude identifying very stable non critical points. However one should keep in mind that MLIP do not quantify the potential terrain instability at each and every location. They are not a substitute for a stability index. Rather they are additional information that complements the information in a terrain stability map that were shown to be useful in this paper for evaluating the discriminating capability of a terrain stability map where comparison is against entire landslide scars, not only initiation regions. They may have other uses, for example as trigger points in dynamic modelling or simulation of landslides, a potential use that we have not yet explored.

The reviewer suggests some consolidation of tables and figures. We have adopted some of these suggestions in the revisions. Table 1 has been eliminated and figures 7 and 8 combined. We prefer to keep figure 4 because we believe that it makes an important point about the spatial distribution and density of LIDAR points that is important in assessing the uncertainty associated with the LIDAR derived DTM data.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 395, 2006.

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