USING LIDAR DATA FOR DEBRIS-FLOW MODELLING

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INTRODUCTION

Determination of hazard areas due to different mountain hazards has gained wide acceptance in alpine countries. Among others, debris flows are one of such hazards. Due to their relatively rare and sporadic occurrence in many areas, their numerical modelling is an important part of debris-flow hazard assessment. The reliability of such a modelling is a function of several input parameters, but to a different extent for each one of them. Our past experiences with sensitivity analyses using widely used numerical model (Flo-2D; Sodnik et al., 2010), the most influential parameters were event magnitude and topographic data of an investigated area (Sodnik et al., 2009). For natural conditions prevailing in Slovenia, we have already checked different methods for estimation of debris-flow magnitudes (Sodnik and Mikoš, 2006). Now we have tried to evaluate the usefulness of LIDAR data for numerical debris-flow modelling in comparison with other DEMs.

TOPOGRAPHIC REPRESENTATION OF A HAZARD AREA

For topographic description of a hazard area there are several possibilities. In Slovenia, all territory is covered by publicly available DTMs with resolutions 25m, 12.5m and 5m that were prepared using different methods and there accuracy and for that also applicability when modelling smaller area is questionable. LIDAR data that are of significant higher accuracy is a good alternative. This is especially important when modelling dynamics of debris flows on torrential fans with pronounced torrential channel. At present, the availability and also their price is the main obstacle to use LIDAR data widely, this is true for Slovenia, where coverage of all territory is planned and still not reality.
Another important parameter for modelling is geometry of numerical grid that is prepared on the basis of topographic data with resolutions from 0.5 m with LIDAR data to 25 m with DTM25. Using LIDAR data one can treat original data and decreases their resolution to the one of the numerical grid (e.g. 5 x 5m) or use the original data with their original resolution and generates adequate numerical grid. When there are built structures on a torrential fan (such as houses) they influence movement of a debris flow. It should be kept in mind that publicly available DTM data does not incorporate such structures and their heights. With LIDAR data one should firstly treat the original cloud of data and decide whether to produce DTM (digital terrain model - no structures) or DEM (digital elevation model – with structures).

FLO-2D APPLICATION ON THE KOROŠKA BELA TORRENTIAL FAN, NW SLOVENIA

Our experiences with modelling debris flows on a torrential fan (Koroška Bela, NW Slovenia) using Flo-2D showed that the most useful was the option with representing structures (there are close to 70 houses on this fan) as blocked cells that remained dry during modelling (Sodnik et al., 2009). This approach makes possible debris-flow modelling between structures with all details (local flow accelerations, flow afflux). The advantage is also that all computing cells next to the existing structures stay at their original heights and no smoothing effects of the numerical grid is needed to incorporates structures into terrain and therefore the accuracy of the results is higher.

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Furthermore, a narrow and incised torrential channel on a torrential fan asks for such a DEM that this channel is represented as detailed as possible; if not a debris flow sooner or later “jumps” out of it and the designated hazard area is in most cases quite wrong. Fig. 1 shows the modelled maximum flow depths on the Koroška Bela fan using 2 different DEMs. Using LIDAR0.5 data instead of DEM5 data enhances the flow in the torrential channel, as well as gives quite different flooding pattern. We have also tested other combinations of topographic input data under a similar scenario.

Fig. 1 The modelled maximum flow depths using Flo-2D on the Koroška Bela torrential fan with the average torrential channel width = 4 m, numerical grid 5 x 5 m, Q_{max} = 400 m^3/s, Manning roughness 0.04 $m^{-1/3}/s$, debris-flow duration = 4 min., influences of built structures were neglected : a) DEM5 (left), b) LIDAR0.5 (right).

CONCLUSIONS

From presented numerical results it seems obvious that the usage of more precise LIDAR data for numerical debris-flow modelling is justified. Better quality of input topographic data assures higher accuracy of results and therefore also accuracy of hazard maps produced in such a way. The LIDAR data promises better representation of torrential channels on torrential fans and computed results (velocities, depths) are generally better estimated and therefore delineation of a hazard area into corresponding zones is of higher accuracy for a selected debris-flow scenario.

The negative side of using LIDAR data are highly increased computational times. Using publicly available DEM5 the computational time for a 4-minute debris-flow event is 1 hour, and computational time increases to 4 hours when applying LIDAR data; numerical grid stays the same (5 x 5 m). The factor between computational times to event duration goes from 15 (for DEM5 data) to 60 (for LIDAR data). For longer debris-flow event durations these factors may be a practical obstacle. Last but not least, when assessing the influence of input data quality on modelling results we should not forget also other input data that have impact on modelling results, such as debris-flow event magnitude resp. debris-flow scenario and rheological characteristics of debris flows.

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