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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Experimental and numerical study on the design of a deposition basin outlet structure at a mountain debris cone" *by* B. Gems et al.

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The present authors' comment, referring to the discussion paper titled "Experimental and numerical study on the design of a deposition basin outlet structure at a mountain debris cone", is aimed at the referee comment published by B. Mazzorana on 29 August 2013. Focusing on the critical thoughts and the review formulated by B. Mazzorana, the following four issues are briefly pointed out:

(a) General intention and aims of the planned defence works at the Larsennbach torrent: The mentioned project objectives are exclusively addressed to the reduction of

the torrential hazard potential and do not also focus on ecological and sediment continuity aspects (EU water framework directive). The models extent and especially the location of the downstream boundary are critically questioned within this context.

(b) Suitability of the chosen model approaches in view of the simulated process characteristics: The referee suggests the general use of a process conform numerical model for the preliminary study. In case of debris flows, the significance of the 3D hydrodynamic model would not be given since the analogy to the process pattern of the experimental model vanishes. Due to the impact of three dimensional effects in the Larsennbach deposition basin, the use of both, the 3D hydrodynamic and a 2D morphodynamic model is recommended, whereat also debris flow conditions should be considered.

(c) Hydrological/morphodynamic loading of the numerical and the experimental model: Both, evaluation and optimization of the planned protection measures are based on the simulation of a 150 yr design flood event, wherein the bed-load component is constantly set to 10 % of the clear water fraction. In this context, the referee questions, whether the exclusive consideration of torrential design flood conditions allows for the finding of technically and economically optimized protection measures, which best possibly fulfil the intention and aims of the project.

(d) Definition of the sediment characteristics used for experimental modelling: The grain size distribution is chosen solely according to samples taken after a large flood event in a neighbouring torrent with similar process behaviour. The transferability between the two torrent catchments and the expediency of further samples at different locations in the Larsennbach catchment are questioned.

The authors of the discussion paper are grateful for the constructive referee comments as they draw particular attention to the need of a holistic planning process within torrent defence management, to a careful choice of modelling approaches and the extent of modelling and, thus, to the simulation of all relevant torrential hazard scenarios and conditions. The authors appreciate the mentioned issues as a valuable supplement to the paper and comment on it as follows:

Ad (a): Referring to the technical guidelines on torrent and avalanche control and to the EU water framework directive respectively, a holistic planning process within torrent defence and flood protection management, that fully considers the aforementioned aspects, is a mandatory objective. Negative effects on the ecological status of the water body, resulting from specific torrent defence measures, are to be avoided within the sense of the prevention of water deterioration. Providing a great public importance of the respective engineering measures and for the case that specific aims are not compatible with each other or the available economic resources are not sufficient to fulfil all requirements, a weighting of interests and a classification of the project aims according to their importance and priority, is required. In respect of these legal requirements, the project at the Larsennbach torrent was permitted and confirmed with the local law, environmental law and forest law permissions. Both, the aims of the project and as well the extent of the investigation area resulted from balancing and weighting of all relevant interests under the constraints of the available financial resources. Regarding the achieved results within the experimental analysis for the optimized design layout, bed-load transport processes are characterised by a continuously, to some extent dosed output from the deposition basin. For small discharges in the Larsennbach torrent, the outlet structure does not affect the bed-load transport, whereas for medium and flood discharges, the sediment transport processes perform more uniform than for the actual condition. The main receiving water course is assessed to feature sufficiently high transport capacities in order to fully move on the entrained material. With this in mind, also the situation for the sediment continuity is more likely improved with the optimized structure at the end of the deposition basin. With regard to the passability of the analysed section of the Larsennbach torrent, the optimized design layout of the outlet structure does not seem to represent a barrier. Consequently, without explicitly focusing also on the ecological aspects of the planned protection measures in the planning process and the definition of the project aims, the optimized torrent defence

measures basically conform to the ecological requirements.

Ad (b): The application of a process conform numerical model, allowing for an adaequate simulation of all relevant processes, has to be generally strived for in the field of hydraulic engineering. The authors fully agree with the referee's comment here. Nevertheless, a 3D hydrodynamic model was applied for the analysis at the Larsennbach torrent, which can be accounted for with the following aspects/arguments – they are partly mentioned in the discussion paper:

(i) Relevance of three dimensional hydrodynamic effects at the transition of deposition basin and lined trench; as already mentioned by B. Mazzorana, well established three dimensional morphodynamic models are not available.

(ii) Non-relevance of debris flow processes in the Larsennbach torrent catchment, since the torrential hazard processes correspond to the typical Limestone Alps' process behaviour: Satisfactory significance of the hydrodynamic model within the course of a preliminary study is given, so as to deduce conclusions from the bottom-near velocity field on the character of bed-load transport processes.

(iii) Time expenditure for the application of a 2D morphodynamic model as a preliminary study of the experimental test series: The morphodynamic model is characterized by considerably higher computation times than the hydrodynamic model. The benefit of a comparatively expeditious tool, which allows for a quick and manageable initial screening of design layouts within the hybrid modelling concept, would no longer be available.

(iv) Lack of calibration/verification data for the morphodynamic model: From the authors' viewpoint, the validity and thus the benefit of a morphodynamic model only appears, if there is measurement data available for model calibration and validation. Morphodynamic models usually contain a large number of parameters, which to some extent have a large impact on the results. Without the availability of any field data, the significance of a sediment transport model is not fully given.

However, the additional application of a morphodynamic model, for instance TRENT 2D or BASEMENT, represents an interesting and valuable task for further research, even though it is highly elaborate. It could be used to confirm the results from experimental modelling, to perform further torrential hazard scenarios at a low cost or to extend the lateral and downstream model boundaries in order to better simulate overbank sedimentation and the bed-load transport processes in the receiving water course. In general, for the case that debris flows represent a relevant process pattern, which is not the case for the Larsennbach torrent, a morphodynamic model (TRENT 2D) could further be applied in order to simulate the entire spectrum of possible torrential hazard processes.

Ad (c): Under the prerequisite that the intention of the planned measures are primary aimed at the reduction of torrential hazard potential and flood risk (issue (a)), the main consideration of a specific design event, representing the worst case scenario but also reflecting the residual risk of the protective engineering measures, seems a reasonable modelling approach to the authors. Naturally, the determination of the design flood hydrograph and, surely, the estimation of the corresponding bed-load fraction are associated with modelling uncertainties and specific assumptions/simplifications: A uniform spatial pattern of the rainfall within the torrent catchment or the hypothesis of an equal reoccurrence interval of the triggering rainfall and the resulting flood discharge for instance. For the case of the Larsennbach torrent, intensity, duration and temporal pattern of the triggering rainfall were varied within the applied rainfall runoff model. Featuring a reoccurrence interval of 150 yr each, these rainfall events resulted in flood hydrographs at the catchment outlet with different peak discharges and total volumes. Due to the relevance and the impact of the bed-load transport processes on the flood risk at the Larsennbach torrent, not the hydrograph with the highest peak but that with the highest total load was selected as the decisive and most unfavourable scenario. It yielded the largest amount of incoming bed-load and continuously ensured the input of sediment in the deposition basin during the falling limb of the hydrograph. This process behaviour has been documented by residents during the past historic flood events and

was therefore evaluated to be crucial for the appearance of heavy aggradation in the lined trench and for overbank sedimentation.

Ad (d): We fully agree with the general intention of analysing, sampling and reproducing the sediment inventory within that catchment being subject of investigation. However, it appears to us equally important to comply with the parameter characteristics, which are relevant and crucial for torrential hazards or rather the design flood conditions. It is already mentioned in the discussion paper that the samples, taken at the Larsennbach deposition basin in December 2011, were not representative for the considered hazard scenarios. However, what is not described is that they were initially tested within experimental modelling before modifying the sediment mixture according to the samples of the neighbouring torrent catchment. From a qualitative viewpoint, these initial tests showed an aggradation and transport process behaviour in the deposition basin and in the lined trench, which did not conform to experiences of well reputed historic flood events. Using the coarser material according to the analysis after the 2005-flood-event, the accomplished tests met the prototype process characteristics well. The experimental modelling was as well examined from the Austrian Service for Torrent and Avalanche Control as from involved residents. With this in mind and due to the fact, that both torrents follow a similar process pattern, which is typical for Limestone Alps' torrents, the experimental modelling was continued accordingly. Undoubtedly, additional information from the upper part of the Larsennbach catchment would have been valuable information. However, a more detailed field survey was not realized for practical reasons due to the largely limited accessibility of the upper part of the Larsennbach catchment. Addressing a further aspect to this issue, it is mentioned that all experimental tests were accomplished with the supply of bed-load, where the grain size distribution was set constant and independent from discharge. Changes in the characteristics of the incoming sediment during the timeframe of a flood hydrograph were neglected in the tests. Both, the testing of further flood hydrographs (issue (c)) and a sensitivity analysis concerning a variation of the grain size distribution indubitably represent interesting tasks for further research. However, from the author's viewpoint, these tests would not imply a different optimized design layout of the planned torrential hazard protection measures. Additionally, an experimental test series could be accomplished, where the effect of an overload scenario, for example a 300 yr flood event, on the extent of overbank sedimentation and the extent of losses is analysed. These tests could deliver highly valuable information for practical evacuation plans, the use of temporary protection measures and the quantification of residual risks.

The mentioned issues are considered within according minor revisions in the manuscript.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 3169, 2013.