Geophysical Research Abstracts,
Vol. 11, EGU2009-10472, 2009
EGU General Assembly 2009

Spatial distributed hydrological-hydraulic modelling as a basis for the evaluation of flood mitigation measures in a large alpine catchment

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ABSTRACT

Background
Precipitation and discharge characteristics have changed in alpine regions within the last decades. Moreover, the changes in the characteristic and superposition of heavy precipitation and snow melt processes as well as modified land use patterns have induced a higher frequency of flooding events. To cope with modified flow characteristics and increasing flow peaks, a sustainable flood control management has to verify, adapt and enhance existing protection measurements. Structures with multifunctional purpose for flood protection as well as hydropower utilization are possible and represent appropriate measurements. Especially when considering large-scale catchment areas, a spatial distributed rainfall runoff modelling including mitigation measures is of importance.

Situation
The presented contribution deals with the integrated evaluation and upgrade of flood protection structures in an alpine valley located in the Tyrol (Austria). The investigated catchment has an area of $\sim$660 km^2 and a total main stream length of 22 km. It is situated to the south of the Inntal. It's elevation ranges from 1100 m.a.s.l. up to 3774 m.a.s.l.. Roughly 20% of the total catchment area is permanently glaciated.

The used modelling approach incorporates rainfall-runoff models as well as 1D- and 2D-numerical river flow models. Sediment transport processes are going to be considered respectively. More than 30 tributaries to the main receiving water course are modelled using the SCS-procedure. Totally 20 rain gauges with temporal resolutions of at least one hour being available in and in close proximity to the catchment are used as input to the models. Additional five gauges with daily measurements are used. Torrent control measures and sediment transport on the alluvial cone thereby are included using an empirical approach.

The 1D-numerical model set up represents the main river in the valley. The dynamic inputs to the model are obtained from the hydrological models. Both - the hydrological models as well as the 1D-numerical model - are run and calibrated collectively using the data of totally seven gauging stations along the main river. The considered heavy precipitation events were selected to cover different flow magnitudes as well as different characteristics of spatial rainfall distribution.

The 2D-numerical simulations are covering the densely settled areas for the assessment of local flood characteristics as a basis for subsequent impact evaluations. Input boundary conditions are taken from the 1D-simulations. The described modelling approaches are used to cover the existing situation as well as scenarios which include

additional flood control reservoirs. The spatially distributed hydrological model allows implementing additional reservoirs. As precipitation events vary in their spatially distribution this enables a more differentiated evaluation with respect to the location.

On basis of the above described simulations a cost benefit analysis is carried out where the total costs of the measures and the avoided damages are evaluated. A stochastic approach is used to link event-based modelling results for hydraulics and damages to lifetime cost of the applied structures. Modelling results using scaled rainfall inputs are categorised with respect to their reoccurrence intervals. Random generation of flow events over the structures life time allows a cumulated cost-benefit analysis that is non-dependent on event based evaluations.

Thus, the presented contribution illustrates the evaluation of a flood control management concept applied in the Austrian Alps. The used approach for hydrological-hydraulic modelling considers spatial effects as well as morphodynamic processes. Focusing on a cost benefit analysis of the measures, the simultaneous evaluation of impacts onto different location is a vital instrument in order to gain a holistic view. The developed methodology is as well transferable to other catchment areas in the Alps.

Keywords:
Flood protection, multi-process-modelling, hydrological-hydraulic engineering