Geophysical Research Abstracts
Vol. 18, EGU2016-16860-3, 2016
EGU General Assembly 2016

Distribution of uncertainties at the municipality level for flood risk modelling along the river Meuse: implications for policy-making

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Flood risk modelling has been conducted for the whole course of the river Meuse in Belgium. Major cities, such as Liege (200,000 inh.) and Namur (110,000 inh.), are located in the floodplains of river Meuse. Particular attention has been paid to uncertainty analysis and its implications for decision-making.

The modelling chain contains flood frequency analysis, detailed 2D hydraulic computations, damage modelling and risk calculation. The relative importance of each source of uncertainty to the overall results uncertainty has been estimated by considering several alternate options for each step of the analysis: different distributions were considered in the flood frequency analysis; the influence of modelling assumptions and boundary conditions (e.g., steady vs. unsteady) were taken into account for the hydraulic computation; two different landuse classifications and two sets of damage functions were used; the number of exceedance probabilities involved in the risk calculation (by integration of the risk-curves) was varied. In addition, the sensitivity of the results with respect to increases in flood discharges was assessed. The considered increases are consistent with a "wet" climate change scenario for the time horizons 2021-2050 and 2071-2100 (Detrembleur et al., 2015).

The results of *hazard* computation differ significantly between the upper and lower parts of the course of river Meuse in Belgium. In the former, inundation extents grow gradually as the considered flood discharge is increased (i.e. the exceedance probability is reduced), while in the downstream part, protection structures (mainly concrete walls) prevent inundation for flood discharges corresponding to exceedance probabilities of 0.01 and above (in the present climate). For higher discharges, large inundation extents are obtained in the floodplains.

The highest values of *risk* (mean annual damage) are obtained in the municipalities which undergo relatively frequent flooding (upper part of the river), as well as in those of the downstream part of the Meuse in which flow depths in the urbanized floodplains are particularly high when inundation occurs. This is the case of the city of Liege, as a result of a subsidence process following former mining activities. For a given climate scenario, the uncertainty ranges affecting flood risk estimates are significant; but not so much that the results for the different municipalities would overlap substantially. Therefore, these uncertainties do not hamper prioritization in terms of allocation of risk reduction measures at the municipality level.

In the present climate, the uncertainties arising from flood frequency analysis have a negligible influence in the upper part of the river, while they have a considerable impact on risk modelling in the lower part, where a *threshold effect* was observed due to the flood protection structures (sudden transition from no inundation to massive flooding when a threshold discharge is exceeded). Varying the number of exceedance probabilities in the integration of the risk curve has different effects for different municipalities; but it does not change the ranking of the municipalities in terms of flood risk. For the other scenarios, damage estimation contributes most to the overall uncertainties.

As shown by this study, the magnitude of the uncertainty and its main origin vary in space and in time. This emphasizes the paramount importance of conducting distributed uncertainty analyses. In the considered study area, prioritization of risk reduction means can be reliably performed despite the modelling uncertainties.

Reference

Detrembleur, S., Stilmant, F., Dewals, B., Erpicum, S., Archambeau, P., & Pirotton, M. (2015). Impacts of climate change on future flood damage on the river Meuse, with a distributed uncertainty analysis. *Natural Hazards*, **77**(3), 1533-1549.

Acknowledgement

Part of this research was funded through the ARC grant for Concerted Research Actions, financed by the Wallonia-Brussels Federation. It was also supported by the NWE Interreg IVB Program.