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Flood damage maps: ranking sources of uncertainty with variance-based sensitivity analysis

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In order to increase the reliability of flood damage assessment, we need to question the uncertainty associated with the whole flood risk modeling chain. Using a case study on the basin of the Orb River, France, we demonstrate how variance-based sensitivity analysis can be used to quantify uncertainty in flood damage maps at different spatial scales and to identify the sources of uncertainty which should be reduced first.

Flood risk mapping is recognized as an effective tool in flood risk management and the elaboration of flood risk maps is now required for all major river basins in the European Union (European directive 2007/60/EC). Flood risk maps can be based on the computation of the Mean Annual Damages indicator (MAD). In this approach, potential damages due to different flood events are estimated for each individual stake over the study area, then averaged over time - using the return period of each flood event – and finally mapped. The issue of uncertainty associated with these flood damage maps should be carefully scrutinized, as they are used to inform the relevant stakeholders or to design flood mitigation measures.

Maps of the MAD indicator are based on the combination of hydrological, hydraulic, geographic and economic modeling efforts: as a result, numerous sources of uncertainty arise in their elaboration. Many recent studies describe these various sources of uncertainty (Koivumäki 2010, Bales 2009). Some authors propagate these uncertainties through the flood risk modeling chain and estimate confidence bounds around the resulting flood damage estimates (de Moel 2010). It would now be of great interest to go a step further and to identify which sources of uncertainty account for most of the variability in Mean Annual Damages estimates.

We demonstrate the use of variance-based sensitivity analysis to rank sources of uncertainty in flood damage mapping and to quantify their influence on the accuracy of flood damage estimates. We use a quasi-Monte-Carlo scheme to propagate input uncertainties through the computation of the Mean Annual Damages indicator and to compute importance measures – Sobol' sensitivity indices – for each source of uncertainty. The variability of the MAD indicator and the associated sensitivity indices are estimated at different spatial scales: individual stake, district, flood plain…

This approach is illustrated on a case study on the Orb River fluvial plain, France. By mapping the uncertainty of the MAD indicator, we identified zones – mostly urban areas – where flood damage estimates were less accurate. Then, sensitivity indices allowed ranking the sources of uncertainty at different scales. The accuracy of the digital elevation model proved to be the key source of uncertainty when estimating the MAD indicator on an individual stake (e.g. a single building), whereas return period of flood events were the most influential when examining the accuracy of total MAD over a larger zone. Finally, maps of sensitivity indices showed the spatial variability of sensitivities over the study area.