Quantifying Uncertainties to Improve the Quality and Value of Flood Early Warning Systems

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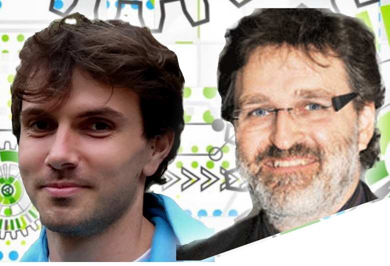

Research Summary

Floods are one of the most devastating natural disasters. Related socio-economic impacts are considerable and require adequate prevention measures. Traditionally, risk reduction is preferred over relief for economic and human considerations. Skillful Early Warning Systems (EWS) have the capability to offer flood prevention by issuing warnings up to several days before the flood event. Unfortunately, EWS are imperfect and will remain imperfect mainly because of the different sources of uncertainty that lies in the hydrometeorological modeling chain. A better quantification of uncertainties should improve the quality of the forecast and therefore should provide better decisions.

A comparison of six Early Warning Systems (EWS) based on contrasted hydrometeorological forecasting systems is performed to investigate how the quantification of uncertainties affects the quality of a decision. These hydrometeorological forecasting systems differ by the location of the sources of uncertainty, and the total amount of uncertainty they take into account. Generally, three sources of uncertainty are regarded as dominant: the hydrological initial conditions, the hydrological model structure and its parameters, and the meteorological forcing. These uncertainties have different natures and affect the quality of the hydrometeorological forecast in different ways and lead times. Therefore, one needs to resort to distinct methods to quantify and reduce them specifically. Three hydrometeorological tools are identified to improve forecast qualities: the Ensemble Kalman Filter (EnKF), a hydrological multimodel, and a meteorological ensemble forcing. The contribution of each tool to the overall forecast quality and value, and the way they complement each other is investigated.

The six systems are assessed with the Relative Economic Value (REV), which is a flexible measure to quantify the potential economic benefits of an EWS. The REV is computed for a wide range of cost-loss ratios, i.e. for various costs of mitigation and avoidable losses due to an adverse event. Therefore, numerous potential cases can be built upon this synthetic assessment.

Results show that all systems provide a gain over the case where no EWS is used up to 9 days ahead for most cost-loss ratios. The most complex systems, i.e. those that consider more sources of uncertainty in the forecasting process, are those that showed the most reduced expected damages. Each hydrometeorological tool contributes to improving the REV. Data assimilation acts mostly on shorter lead times, meteorological ensemble forcing on longer lead times, while the contribution of the hydrological multimodel approach appears constant throughout all horizons. The tools are complementary and should be used jointly to maximize the REV.

Like for the economic value, the use of hydrometeorological tools improves both forecast accuracy and reliability. Also, a preliminary investigation of a relationship between the quality and the value of a forecasting system revealed that, in general, better accuracy and reliability translate into higher economic values as measured by the REV. However, while the link was more clearly defined for the forecast accuracy attribute, the same was not observed for reliability. Our results showed that the relationship between the REV and reliability strongly depends on the system and on how reliability and ensemble spread vary with lead time.

Overall, these results suggest that a suitable quantification and reduction of uncertainties carried out by a set of appropriate hydrometeorological tools can contribute to mitigating flood losses and increase the economic value of a forecast system.