Appropriate river basin modelling to assess the impact of climate change on river flooding

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Extended abstract

How good should a river basin model be to assess the impact of climate change on river flooding for a specific geographical area? The determination of such an appropriate model should reveal which physical processes should be incorporated and which data and mathematical process descriptions should be used at which spatial and temporal scales. It should be based on sensitivities and a right balance between uncertainties of inputs, parameters and process descriptions resulting in an output uncertainty acceptable for the model user and feasible in view of data availability and computational possibilities. A procedure for determining an appropriate model is explained and applied to the above mentioned specific case. The results obtained with the appropriate model are compared with observations, results obtained with a simpler and a more complex model and uncertainties in the results.

The model appropriateness procedure consists of three steps. First, the processes of importance for the specific problem are identified through a time series analysis of relevant input and output variables. These identified processes are translated to key variables by means of a qualitative analysis. In the second step, a (geo)statistical analysis with respect to these key (or indicator) variables results in appropriate spatial and temporal scales for each key variable and key variable scale-output variable relationships. These latter relationships are used to combine the appropriate spatial and temporal scales to one appropriate spatial and temporal model scale. In the third step, mathematical process descriptions consistent with these model scales are selected and used in the model.

The procedure is applied to construct a model for the river Meuse basin in Western Europe to assess the impact of climate change on river flooding. Precipitation and discharge times series are used in the first step of the analysis. In the second step, ground-based and modelled climate data (precipitation, temperature) and ground-based and remotely sensed river basin data (land use, topography, soils etc.) are utilised. Moreover, a preliminary scale analysis gives additional directives for the derivation of appropriate scales. The resulting model scale is used in an existing modelling framework (IHMS) and therefore a limited number of process descriptions consistent with model scale is available. Besides the appropriate model, two additional models (a simpler one and a more complex one) are constructed to assess the sensitivity of the results to model complexity.

The three models and observed rainfall input are used to simulate discharge series and derive extreme value distributions (EVDs). Comparison with the corresponding observed EVD reveals the goodness-of-fit of the models. Next, a stochastic rainfall model generates rainfall input for the current and changed

climate. These rainfall inputs are used in the three river basin models to simulate discharge series and derive EVDs for the different climates. These EVDs are compared to assess the sensitivity of the results to model complexity. Finally, the uncertainty in the derived EVDs with respect to the most important inputs and parameters in the appropriate model is estimated and compared with the results from the other two models to assess the significance of the model results as a function of model complexity.

The preliminary scale analysis showed that relative large spatial scales for a few important processes were appropriate to simulate extreme discharges in an acceptable way. In accordance with this, large spatial correlation lengths from the climate data analysis seem to support relative large spatial scales. As expected the river basin analysis revealed different appropriate scales for the key variables. Peak discharge appeared to be highly dependent on precipitation and elevation resolutions and less dependent on land use and soil resolutions. Therefore, the former resolutions determine to a large extent the final model resolution. The climate data analysis showed large errors and uncertainties in RCM and GCM simulated (extreme) precipitation although corrected for averaging effects. Relative coarse spatial resolutions of the river basin data as compared to the appropriate scales do not appear to be dominant uncertainty sources.