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Assessing the impact of spatial resolution of flexible meshes on discharge and inundation estimates from spatially coupled hydrologic-hydrodynamic models

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In recent years, losses due to riverine inundations have been increasing due to growth of both population and asset values in floodplain areas as well as changes in river regimes. As global flood risk will even increase in the future, it is paramount for the scientific community to provide sound flood hazard, exposure, and vulnerability estimates for improved flood risk management. Since inundations are a large-scale hazard, two main requirements for modelling efforts can be formulated. First, large-scale models need to be applied to capture the spatial correlation of flood events in neighbouring river basins, and second, modelling approaches need to be able to simulate future climate conditions and the resulting hydrologic response.

Both requirements can be met by employing global hydrologic models (GHM). Obtaining the required information from GHM at a locally relevant resolution, however, remains a major research challenge. For instance, the coarse spatial resolution of such models hampers a detailed representation of channel and floodplain geometry, and simplistic routing schemes implemented often fail to capture discharge dynamics. In addition to other current approaches trying to overcome these issues, Hoch et al. (2016, in review) applied a spatially explicit coupling scheme between the global hydrologic model PCR-GLOBWB and the hydrodynamic model Delft3D Flexible Mesh. Two main features are central to this study. First, the water balance computations were performed by PCR-GLOBWB, while the routing was explicitly performed by FM solving the full shallow water equations. Results indeed showed that such a spatial coupling approach can simulate discharge more accurately than both models stand-alone. Second, the model domain was schematized by a flexible mesh which allows for smaller grids for areas such as channel and floodplain areas while preserving coarser spatial resolution in more remote areas. As a result, computational costs can be strongly reduced compared to regular grids.

Since the use of a flexible mesh is still a novelty in riverine inundation modelling, there is no study dealing with the impact of spatial resolution of flexible meshes on discharge and inundation estimates. Better understanding is however required as there can be a wide range of possible schematizations of one model domain. We therefore applied the coupling approach by Hoch et al. (2016, in review) to the Elbe Basin, employing different hydrodynamic schematizations. Preliminary results indicate that the impact of spatial resolution on simulated discharge is limited, but more pronounced for water depth than for discharge estimates, in particular for more upstream locations. Simulated discrepancies are mainly caused by differences in grid size which potentially increase towards more upstream areas. A reason for this process is the smaller channel size in these areas which may lead to a limited refinement of the grid.

Thus, a priori decisions have to be made for which areas what estimates are required at optimal quality. When constructing a model with these aspects in mind, using flexible meshes can provide great advantages for large-scale inundation modelling due to strongly reduced computational costs while at the same time providing fine-scale inundation estimates where necessary. In a coupled setting, these estimates can be of particular interest as they eventually may help to provide scientifically sound and locally relevant information for global flood risk management.