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

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Introduction

In large-scale flood hazard modelling studies, the way how input data is assigned or interpolated to a model grid can greatly influence output quality, as Savage et al. (2016) have found employing different spatial resolutions of a regular grid. For large-scale application, it has been shown that the use of flexible meshes can strongly contribute to reduce computational demand. At the same time it allows for detailed spatial resolution in areas of interest, e.g. river floodplains. However, their application adds complexity to elevation assignment due to the higher possibilities of grid generation.

The here presented analysis is a first step to achieve a better understanding of how variations in spatial resolutions of a flexible mesh may impact model results. To that end, six different Delta3D Flexible Mesh set-ups were designed (Figure 1 & Table 1). All schematizations are forced with estimates of runoff and discharge which is based on the approach recently presented by Hoch et al. (2017), who coupled the global hydrologic model PCR-GLOBWB to the hydrodynamic model Delta3D Flexible Mesh on a grid-by-grid basis and using online-coupling (Figure 2).

Results & Interpretation

- Computed discharge tends to be overpredicted for all schematizations which is mainly due to the general overprediction of discharge by PCR-GLOBWB.
- Applying regular grids does not necessarily contribute to improved discharge estimates. This is because the finest spatial resolution of the flexible mesh is found at the channels and floodplains where discharge is measured.
- The spatial resolution of the 2-D grid impacts the amount and dynamics of simulated discharge. This can be related to the spatial interpolation of input elevation data onto the grid, influencing the surface variability. Coarser spatial resolution may lead to smoother surface elevation, resulting in larger floodplain areas and lower variability due to the increased attenuation potential.
- Water depth results follow closely the dynamics also observed for discharge simulation as we generally obtain less dynamic and overpredict observations.
- With coarser spatial resolution, simulated water depth tends to deviate stronger from the observations. This indicates that increasing the cell sizes generally results in lower/higher elevation values at the observation stations.
- Differences between schematizations increase at upstream locations due to higher probability of coarser cells.
- Water depth dynamics at locations close to the model boundary are strongly influenced by the input signal, in particular for models with coarse spatial resolutions due to less attenuation potential.

Conclusions

- The spatial resolution of model schematizations can influence model accuracy, both for discharge and water depth estimates.
- Degree of grid refinement potentially adds another layer of uncertainty to model results.
- Use of flexible mesh can yield great advantages, but requires a priori knowledge of areas of interest which need to be schematized finely.
- Consideration of both accuracy and run time should be central in model set-up and determined beforehand.
- Absence of dikes in model schematizations may strongly impact output accuracy.