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 Delft3D 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 Delft3D Flexible Mesh on a grid-by-grid basis and using online-coupling (Figure 2).

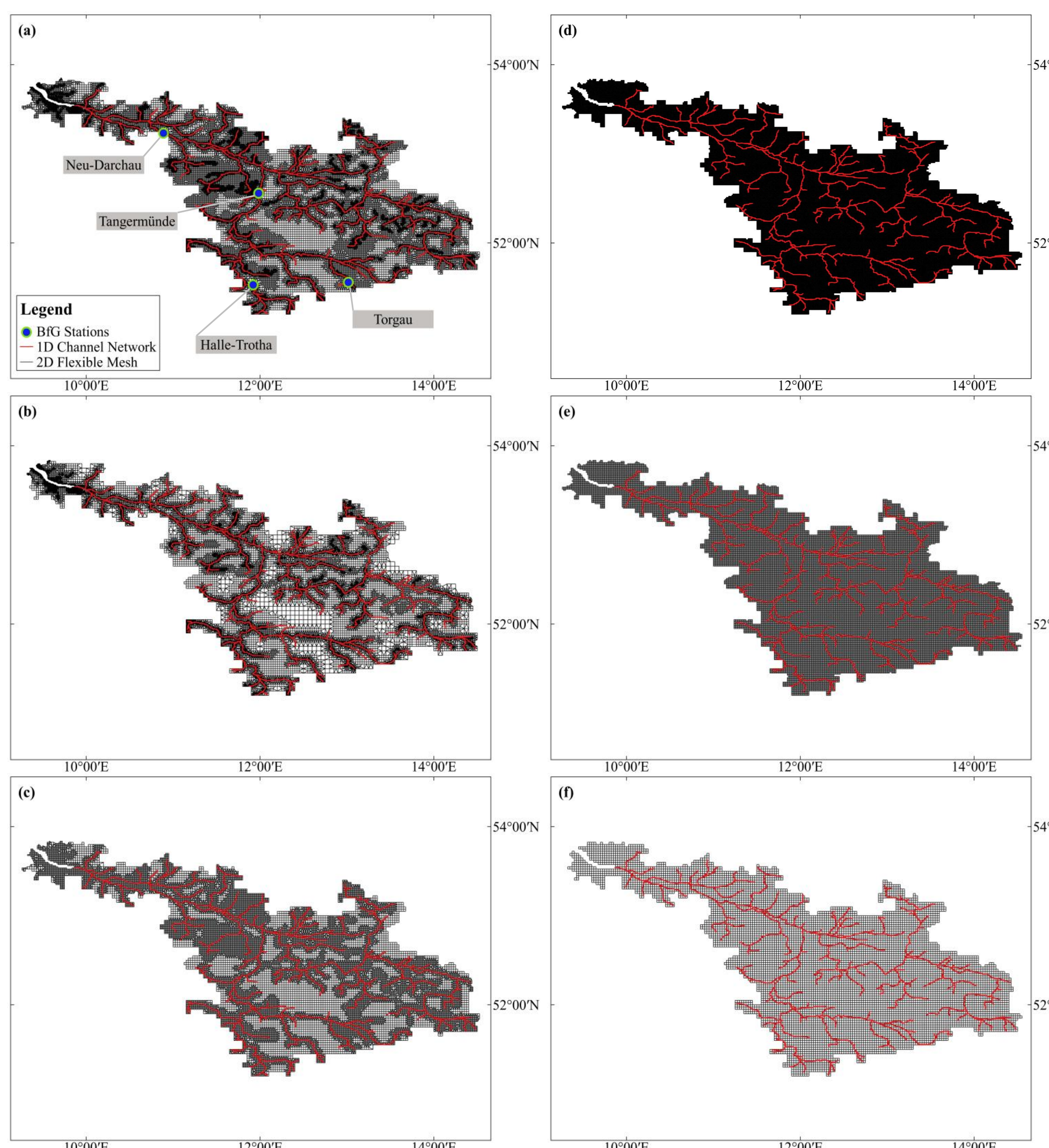

Figure 1: Locations of observation stations used for model validation as well as different schematizations/runs of the Elbe Basin in Delft3D FM: (a) n400; (b) d400; (c) c800; (d) r_400; (e) r_800; and (f) r_1600.

Run Name	n_400	d_400	c_800	r_400	r_800	r_1600
Min. Cell Size [m]	400	400	800	400	800	1600
Max. Cell Size [m]	1600	3200	1600	400	800	1600

Table 1: Properties of different Delft3D Flexible Mesh schematizations used in the study.

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.

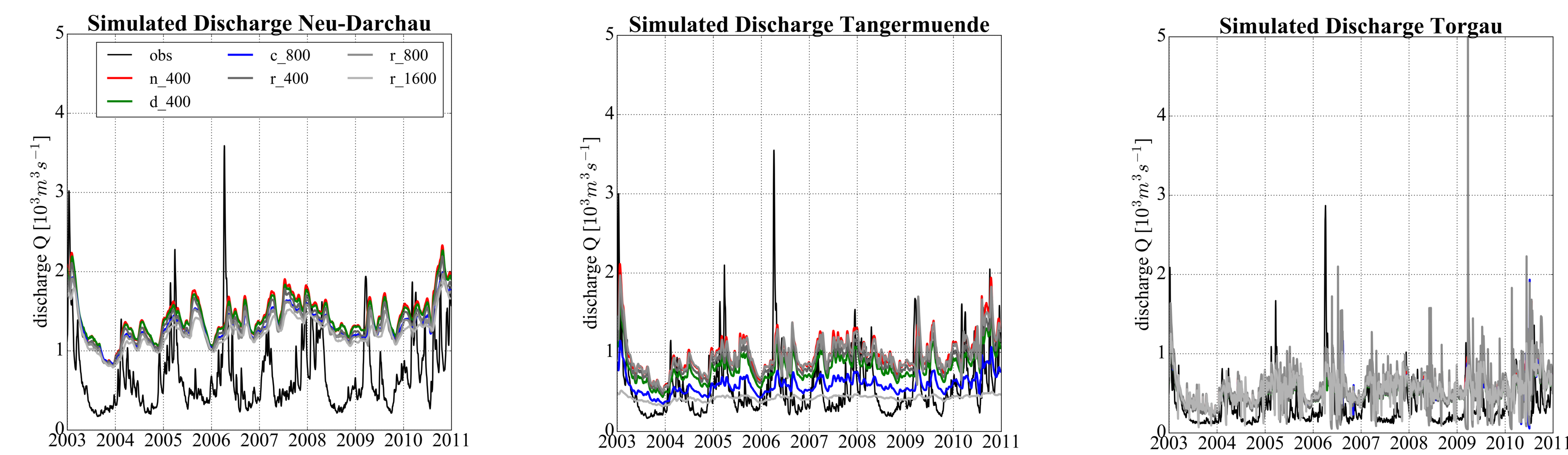

Figure 3: Comparison of simulated and observed discharge at three observation stations in the Elbe basin for all six model schematizations.

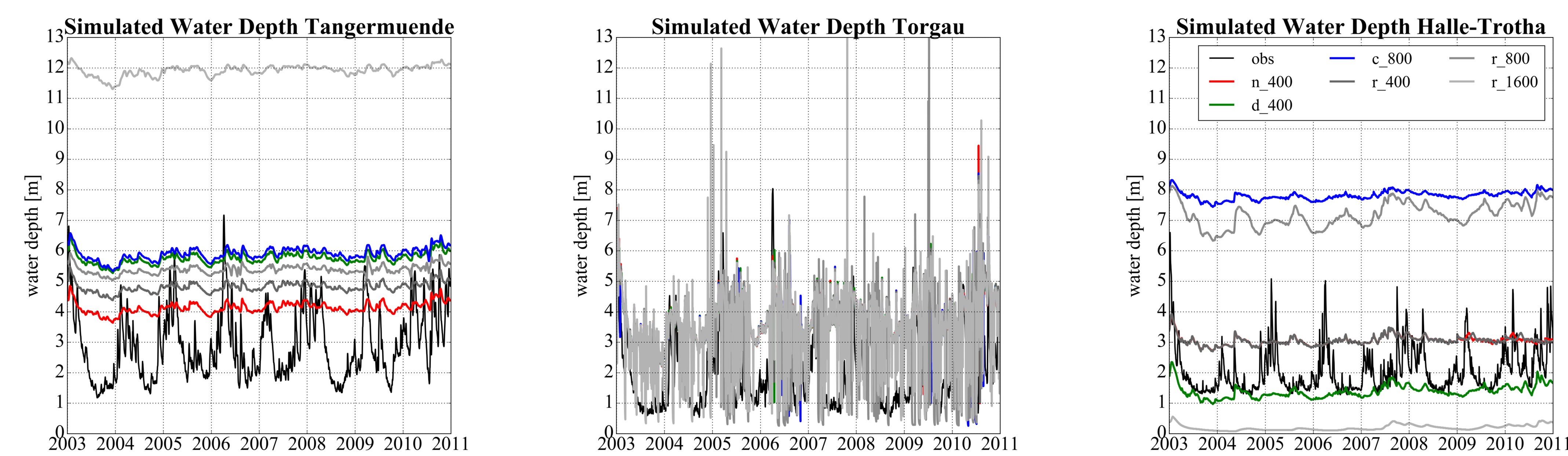

Figure 4: Comparison of simulated and observed water depth at three observation stations in the Elbe basin for all six model schematizations.

- 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 increases 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.

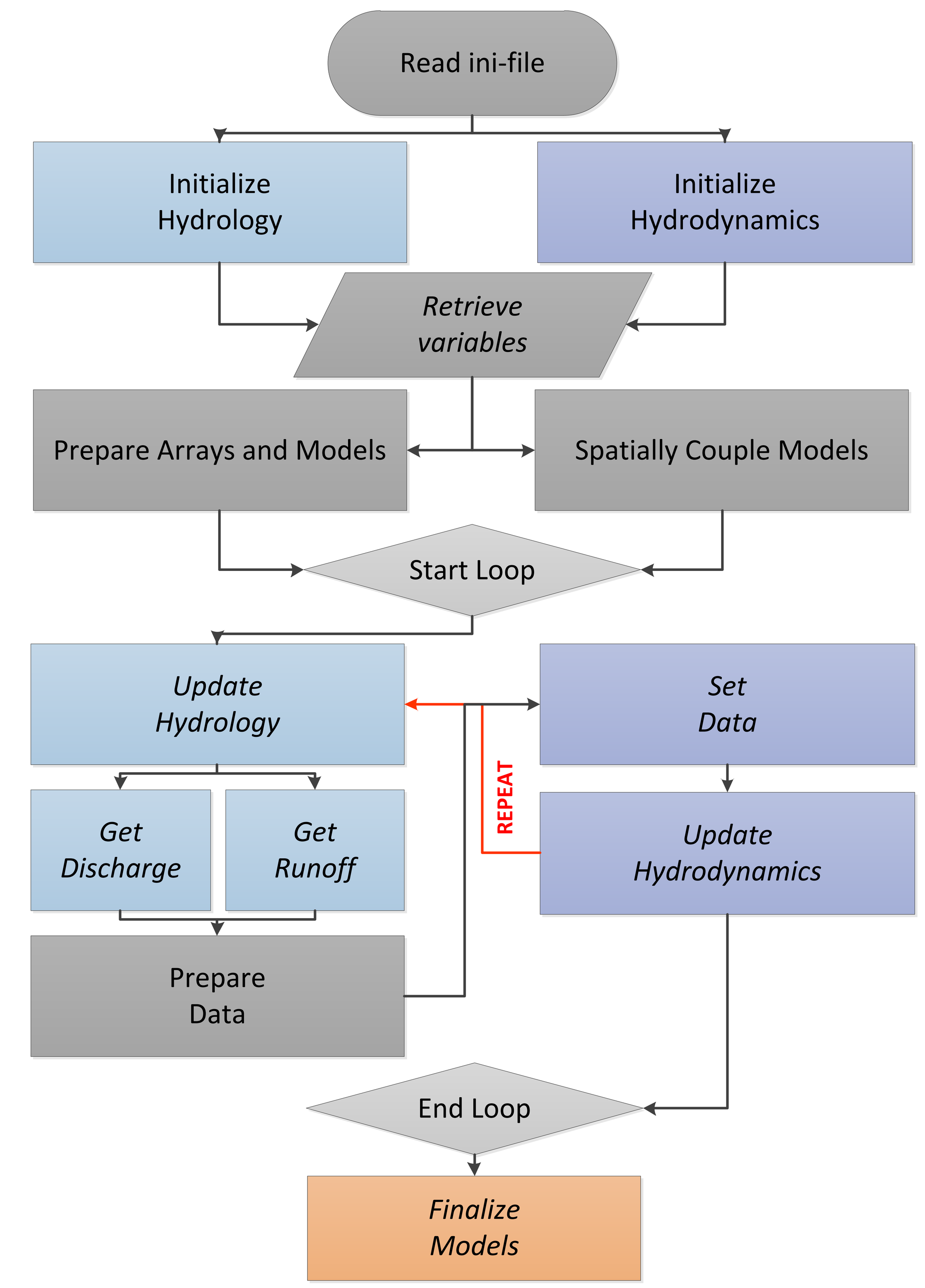

Figure 2: Flow diagram of steps taken for online-coupling of PCR-GLOBWB to Delft3D Flexible Mesh in a spatially explicit way; all steps in italic are performed by using the Basic Model Interface (BMI) from Peckham et al. (2013).

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.

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