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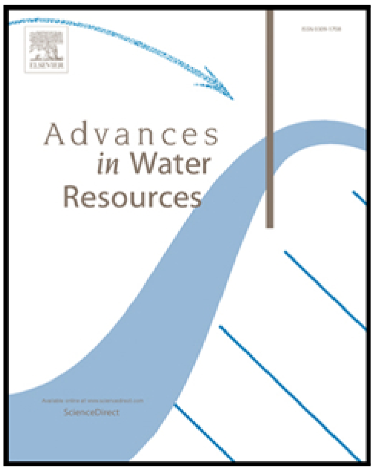

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Benchmarking flexible meshes and regular grids for large-scale fluvial inundation modelling

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Abstract

Damage resulting from flood events is increasing world-wide, requiring the implementation of mitigation and adaption measures. To facilitate their implementation, it is essential to correctly model flood hazard at the large scale, yet fine spatial resolution. To reduce the computational load of models, flexible meshes are an efficient means compared to uniform regular grids. Yet, thus far they have been applied only for bespoke small-scale studies requiring a high level of a priori grid preparation. To better understand possible advantages as well as shortcomings of their application for large-scale riverine inundation simulations, three different flexible meshes were derived from Height Above Nearest Drainage (HAND) data and compared with regular grids under identical spatially explicit hydrologic forcing by using GLOFRIM, a framework for integrated hydrologic-hydrodynamic inundation modelling. By means of GLOFRIM, output from the global hydrologic model PCR-GLOBWB was passed to the hydrodynamic model Delft3D Flexible Mesh. Results show that applying flexible meshes can be beneficial depending on the envisaged purpose. For discharge simulations, similar model accuracy was obtained between flexible and regular grids, with the former generally having shorter run times. For inundation extent simulations, however, the coarser gridding of flexible meshes in upstream areas results in a poorer performance if assessed by contingency maps. Moreover, while the ratio between minimum and maximum spatial resolution of flexible meshes has limited impact on discharge simulations, water level estimates may be stronger influenced by the application of larger grid cells. . As this study presents only a small set of possible realizations, additional research needs to unravel how the data and methods used as well as the choices for discretizations influence model performance. Generally, the application and particularly discretization process of flexible meshes involves more options, bringing more responsibilities for the user. Once an a priori decision is made on the model purpose, flexible meshes can be a valuable addition to modelling approaches where short run times are essential, facilitating large-scale flood simulations, ensemble modelling or operational flood forecasting.

1. Introduction

In recent years, losses due to riverine inundations increased strongly: between 1980 and 2013, they exceeded $1 trillion of direct economic losses and more than 220,000 fatalities (Munich Re, 2013). This development can be attributed to the growth of both population and asset values in floodplains (Ceola et al., 2014; Winsemius et al., 2016) as well as changes in river regimes (Jongman et al., 2012; Munich Re, 2010; Visser et al., 2012; Winsemius et al., 2016). Despite inherent uncertainties, several studies indicate that flood risk will enhance in the future (Hirabayashi et al., 2013; Jongman et al., 2014; Winsemius et al., 2016).

To capture the driving climate-flood interactions and processes world-wide, it is beneficial to apply global hydrologic models (GHMs) to guarantee seamless large-scale inundation modelling across basins and borders. Besides modelling flood hazard at such scale, information should be