EGU2020-14885
https://doi.org/10.5194/egusphere-egu2020-14885
EGU General Assembly 2020

Hydrodynamic modelling of compound flood drivers in estuaries

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Compound flooding in deltas and estuaries can be defined as the combination of various flood drivers leading to a significant flood impact (Zscheischler et al., 2018). For example, elevated sea-levels can impede flood drainage and create backwater effects that worsen flood damages. This was observed recently in March 2019 during cyclone Idai, where devastating floods from a high storm surge and discharge destroyed the port city of Beira. Even though the importance of accounting for compound flooding in flood risk assessments has been heavily underlined in recent literature, little research has been done on the impacts of compound flood events globally.

In this study, we investigate how compound flood hazard in estuaries is influenced by their various geophysical characteristics and the nature of their upstream river basins. The influence of riverine and coastal flood drivers on the water level varies along the estuary. The water level at the river mouth is dependent on sea-levels, whereas one can expect this influence to reduce moving upstream in the river system and to become negligible completely upstream in large river systems. The location within a river system where both riverine and coastal flood drivers significantly contribute to the water level is referred to as the transition zone (Bilskie and Hagen, 2018).

We set up a model experiment to compare maximum water levels across realistic estuary types and boundary conditions. We use the 1-D unsteady hydrodynamic model LISFLOOD-FP to simulate water level time series for average and anomalous compound flood events of sea-levels and discharge. For each estuary type, resulting water level time series are analyzed to quantify the contribution of each flood driver in the maximum water level obtained along the complete coastal river profile and on the extent of the transition zone. We find that the interaction between the extreme sea level and extreme discharge is highly nonlinear and that this effect strongly varies depending on the estuary shape and length. We foresee this extensive overview of estuarine compound flood behavior to globally identify areas particularly vulnerable for interactions between extreme discharge and sea levels.