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Development of a global river-coastal coupling model and its application to flood simulation in Asian mega-delta regions

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The world's mega-delta regions and estuaries are susceptible to various water-related disasters, such as river flooding and storm surge. Moreover, simultaneous occurrence of them would be more devastating than a situation where they occur in isolation. Therefore, it is important to provide information about compound risks of fluvial and coastal floods at a large scale, both their statistical dependency as well as their combined resulting flooding in delta regions.

Here we report on a first attempt to address this issue globally by developing a method to couple a global river model (CaMa-Flood) and a global tide and surge reanalysis (GTSR) dataset. A state-of-the-art global river routing model, CaMa-Flood, was modified to represent varying sea levels due to tides and storm surges as downstream boundary condition, and the GTSR dataset was post-processed to serve as inputs to the CaMa-Flood river routing simulation and a long-term simulation was performed to incorporate the temporal dependency between coastal tide and surge on the one hand, and discharge on the other.

The coupled model was validated against observations, showing better simulation results of water levels in deltaic regions than simulation without GTSR. For example in the Ganges Delta, correlation coefficients were increased by $\sim$0.06, and root mean square errors were reduced by $\sim$0.22 m. Global coupling simulations revealed that storm surges affected river water levels in coastal regions worldwide, especially in low-lying flat areas with increases in water level larger than 0.5 m. By employing enhanced storm surge simulation with tropical storm tracks, we also applied the model to examine impacts of past hurricane and cyclone storm events on river flood inundation.