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Editorial: Coastal Flooding: Modeling, Monitoring, and Protection Systems

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Editorial on the Research Topic

Coastal Flooding: Modeling, Monitoring, and Protection Systems

Coastal flooding has received significant attention in recent years due to future sea-level rise (SLR) projections and intensification of precipitation, which will exacerbate frequent flooding, coastal erosion, and eventually create permanently inundated low-elevation land. Coastal governments will be forced to implement measures to manage risk on the population and infrastructure and build protection systems to mitigate or adapt to the negative impacts of flooding. Research in this area is required to establish holistic frameworks for timely and accurate flooding forecast and design of protection systems.

In this Research Topic, a combination of Original Research Articles on monitoring and modeling of coastal flooding, design of protection systems, and economic perspective of coastal damage provides up-to-date information on diverse aspects of the risk and impact of coastal flooding and how it can be predicted and mitigated. The next paragraphs describe each of the published articles within the themes covered by the special issue.

The improvement of storm surge forecasting is necessary to implement strategies to minimize the damage of coastal flooding. The works by Callahan and Leathers and Callahan et al. study the impact of hurricanes in the Mid-Atlantic along one of the most developed and commercially active regions in the USA, the Delaware and Chesapeake Bays. The analysis of the spatial variability of the detrended and normalized skew surge combined with regional storm rankings and storm tracks allow to identify the surge impact of past TC on nearby coastal communities and set the approach to predict future risk damage (Callahan and Leathers). They evaluate two traditional approaches [namely, Block Maxima fit to General Extreme Value distribution (BM/GEV) and Points-Over-Threshold fit to Generalized Pareto distribution (POT/GP)] to determine the return sea levels for extreme skew surge (Callahan et al.). They conclude that POT/GP is more consistent with the data and has a narrower uncertainty band. The increased reliability of projections of extreme water levels using POT/GP will help plan more effective mitigation and adaptation strategies.

In addition to being reasonably accurate, storm surge forecasts must also be timely and be made available to users well before the onset of the event. The work by Li et al. focuses on the improved efficiency of the Coastal and Estuarine Storm Tide (CEST) model developed to simulate the storm surge due to the combined action of (anti)cylonic winds and astronomical tides. The new model version includes an upgraded advection algorithm and a simpler parallelization. As a proof-of-concept, they consider the impact of hurricane Irma in South Florida that lasted 4 days

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and the improved CEST model was able to run it in just 22 min. Coastal flooding is not only attributed to storm surge, the work by Loveland et al. analyzes the combination of storm surge and river discharge as a specific case of compound flooding related to hurricane. The authors present a coupled modeling approach to simulate and forecast compound flooding using the Advanced Circulation (ADCIRC) model as the primary model to simulate the compounding effects of fluvial flooding and storm surge at regional scale. They stress the need to account for river discharge to accurately predict flood patterns, water surface elevations, and duration of drainage. However, in order to capture the complexity of compound flooding at the large regional or even global scale, it is envisaged to develop new holistic and numerically integrated models for compound flooding description.

Damage of flooding upon storm surge can go beyond the coast and affect inland regions. In their work, Kim et al. propose a probabilistic scenario generation approach to forecast coastal and inland flooding coupling coastal and fluvial models and incorporating uncertainty of hurricane landfall locations and inland precipitation intensity. In the simulation scenarios, the authors consider the case of Hurricane Harvey that devastated coastal areas of Texas and Louisiana (USA) in August 2017. A probabilistic scenario generation approach provides better tools to decision makers for mitigation strategies and preparedness decisions.

Flood-prone inland areas are also subject to the consequence of erroneous modifications of natural drainage systems. The work by Saad and Habib investigates the effect of large-scale channel modifications via riverine dredging. The article analyzes the case of Vermilion River in south Louisiana (USA) and shows that dredging can increase the hydraulic conveyance of the river system but also the runoff volumes delivered by the urbanized tributaries which can outweigh the larger in-channel storage. Moreover, as the work by Bilskie et al. shows, antecedent rainfall has an important effect on the flooding of south Louisiana. The results show that antecedent and TC-driven rainfall increase simulated peak water levels within the watershed. The work highlights the need to extend both the spatial and temporal boundaries of flooding prediction in coastal regions. This is particularly important in those areas with complex hydrological features. There it is recommended to undertake a watershed-centered approach instead of a riverine-centered approach combined with earlier storm events to plan flood mitigation strategies.

Damage to coastal areas due to flooding can be significant but it could also be challenging to assess, especially in environmentally vulnerable regions. The paper by Rifai et al. presents a holistic approach for damage assessment caused by severe hydrologic events. The approach combines a water quality model, Environmental Fluid Dynamic Code-Storm Surge model (EFDC-SS), and Facility Economic Damage and Environmental Release Planning (FEDERAP). The framework allows to determine the impact of spills from waste storage and contaminated sites at regional scale and estimate the cost of remediation.

Finally, the works by Miura et al. and Barbier focus on the optimization of protection systems. Miura et al. report a methodology that aims at minimizing the overall expected losses within a prescribed budget. They consider human-made protective systems such as seawalls, barriers, artificial dunes, raising individual buildings, sealing parts of the infrastructure, strategic retreat, and insurance that could be activated over time and built throughout the sensitive area. The effectiveness of each solution and their spatio-temporal combination was evaluated under different SLR scenarios using the storm surge computational model GeoClawflood. The authors apply a proof-of-concept of the method to the urban area of Lower Manhattan in New York City (NY). Barbier analyzes the economics of protective systems based on natural estuarine and coastal ecosystems (ECE) such as marsh, mangroves, coral reefs, and sea grass meadow. He observes that ECEs do not only provide flood mitigation but also have environmental benefits related to long-term coastal restoration and protection, which should considered. Alone, or in combination with human-made structures, ECEs can significantly reduce the vulnerability of the coastal areas while providing critical habitats of the land-sea interface.

With this Research Topic we provide a platform for scientists and engineers that are interested in modeling and monitoring coastal flooding, the design of protection systems, and the human and environmental impact of coastal flooding. The excellent contributions to this Research Topic are a demonstration of a highly active research community in coastal science and engineering focused on assessment of coastal flooding impacts. Together they provide a detailed overview of the state-of-the-art of the subject and future research needs.

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