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Editorial

Climate Change, Coasts and Coastal Risk

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1. Introduction

Projected climate change driven variations in mean sea level (i.e., sea level rise), wave conditions, storm surge, and river flow will affect the coastal zone in many ways. The coastal zone is the most heavily populated and developed land zone in the world with rapid expansions in settlements, urbanization, infrastructure, economic activities and tourism.

The combination of coastal climate change impacts and their effects on the ever-increasing human utilization of the coastal zone will invariably result in increasing coastal risk in the coming decades. But, while the economic damage (potential consequence) that can be caused by Climate change driven coastal inundation and erosion (potential hazard) is likely to increase, foregoing land-use opportunities in coastal regions is also costly (opportunity cost). Thus, a 'zero risk'-policy could have severe economic consequences, while high risk policies could lead to risks that are unacceptable to society and individuals.

To avoid unacceptable future risks, due to coastal hazards and/or sub-optimal land use, it is imperative that risk informed and sustainable coastal planning/management strategies are implemented sooner rather than later. This requires comprehensive coastal risk assessments which combine state-of-the-art consequence (or damage) modelling and coastal hazard modelling. Apart from being of crucial importance to coastal managers/planners, this type of risk quantification will also be invaluable to the insurance and re-insurance industries for insurance pricing, which may have a follow-on effect on coastal property values. However, the present level of knowledge on generally applicable coastal hazard and risk assessment approaches, especially at local scale (~10 km) is rather limited. This Special Issue contains 13 papers that aim to address this knowledge gap.

2. Thematic Contributions

The 13 contributions have been organized around the following themes:

1. Climate change impacts on forcing and coastline change,
2. Socio-economic and environmental impacts of coastline change,
3. Probabilistic methods for analysing system reliability, and
4. Risk-informed decision making and probability-based economic optimization.

2.1. Climate Change Impacts on Forcing and Coastline Change

The papers of Watson [1], Helman & Tomlinson [2], Bigalbal et al. [3], Bamunawala et al. [4] and Kumbier et al. [5] aim to improve our understanding of the links between climate change, coastal forcing (SLR, storm surge, waves) and coastline change. Watson [1] and Helman & Tomlinson [2] look backward and discuss observed climate change impacts. Bigalbal et al. [3], Bamunawala et al. [4] and Kumbier et al. [5] look forward and discuss methods for modelling the impacts of climate change, presenting applications from around the world.

Watson [1] compares observed rates of sea-level rise from observational data records (tide gauges) against the ensemble mean of the model-projection products used in IPCC AR5 at 19 sites around the world over the period 2007–2016. Helman & Tomlinson [2] examine two centuries of observed climate and coastline response along the central east coast of Australia, between Fraser Island and Coffs Harbour. Looking backwards and describing historic trends and contrasting model predictions to actual behavior are essential for improving our understanding of relevant physical processes, improving models and quantifying model uncertainties.

The contributions of Bigalbal et al. [3], Bamunawala et al. [4] and Kumbier et al. [5] show that the impacts of climate change on coastal forcing and coastal change depend strongly on local circumstances, and that estimating these impacts requires physics-based extrapolations into an uncertain future. Bigalbal et al. [3] examine the potential impacts of sea level rise and marsh migration on the hydrodynamics and wave conditions within four natural protected areas of the Chesapeake Bay during storm surge events. The impacts of climate change are shown to be site-specific and suggest the presence of a critical limit for conservation. Kumbier et al. [5] present numerical simulations of coastal flooding under different sea-level scenarios for two Australian estuaries that are at different geomorphological evolutionary stages of infilling. The two estuaries display very different responses to sea level rise illustrating the limitations of applying simple rules of thumb. Bamunawala et al. [4] present reduced complexity modelling results for several small tidal inlets in Australia and Vietnam which show that human induced changes in fluvial sediment supply to the coast from e.g., urbanization or deforestation, should not be ignored when assessing the long-term behavior of such coastal systems in a changing climate.

2.2. The Socio-Economic and Environmental Impacts of Coastline Change

O'Neill et al. [6] and Erikson et al. [7] present the USGS's innovative Coastal Storm Modeling System (CoSMoS) for coastal zones affected by sea-level rise and changing coastal storms. CoSMoS allows coastal managers to not only quantify hazards but also to examine the associated socio-economic impacts on coastal communities. The contribution of O'Neill et al. [6] addresses the hazard quantification aspect, while the contribution by Erikson et al. [7] addresses the link between hazards and socio-economic consequences. The example applications in Southern California illustrate the inner workings of CosMoS and show that climate change may have considerable effects on the built environment. Moving from climate change impacts on the coastal zone built environment to the natural coastal environment, Mehvar et al. [8] examine environmental losses and present a methodology for valuing ecosystem services in monetary terms, allowing them to be included in economic assessments.

2.3. Probabilistic Methods for Analysing System Reliability

Because of the inherent and epistemic uncertainties related to coastal forcing, probabilistic methods for analyzing system reliability are increasingly gaining traction in coastal zone management circles. Oosterlo et al. [9] present a modular modelling framework for propagating the uncertainties related to forcing in wave overtopping assessments. The framework allows the computation of overtopping failure probabilities for sea dikes with shallow foreshores, as illustrated by a case study in southern Netherlands. Aguilar-López et al. [10] present a probabilistic method for assessing the resistance of grass covered dikes to overtopping and specifically examine the effect of roads on the crests of such dikes. Finally, on this theme, Ngo et al. [11] present a modelling approach to support probabilistic assessment of flood hazards at Cantho city in in the Mekong Delta, Vietnam.

2.4. Risk-Informed Decision Making and Probability-Based Economic Optimization

Probabilistic estimates of coastal change and the reliability of coastal defenses are indispensable for risk-informed decision making. Lowering the probability of socio-economic and/or environmental losses typically comes at a cost, turning coastal zone management into a balancing act. Economic optimization methods can be used for establishing economically optimal failure probabilities, to support risk-informed decision making. Along these lines, Galiatsatou et al. [12] present the economic optimization of measures to improve the reliability of a rubble mound breakwaters. In the Final paper of this issue, Dastgheib et al. [13] examine potential shoreline changes for sites in Sri Lanka using a probabilistic coastline recession model, and balance risk and reward to determine economically optimal setback lines.

3. Conclusions

This Special Issue provides an overview of the different types of research that are essential for responsibly managing the risks to coastal zones posed by climate change. The 13 contributions cover the physics of climate change driven shoreline change, associated impacts on communities and the environment, and methods for balancing risk and reward. Climate change poses a global challenge. Yet its impacts are felt locally. Risk management actions will therefore have to be tailored to local circumstances. As illustrated by studies from across the globe, the uniqueness of coastal zones does not permit convenient generalizations.

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