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Editorial: Large scale coastal processes and their interactions with changing coastal environments

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Editorial on the Research Topic
Large scale coastal processes and their interactions with changing coastal environments

Coastal areas are important ecosystems that contain and preserve high natural capital, host a variety of natural activities and are subject to natural forcing including tides, waves storms and sediment transports. Human activities, including land-use change and wider interactions, further contribute to the pressures on coastal ecosystems. Coastal areas maintain their importance as they are at the interface between marine and riverine environment and their preservation is paramount to maintain both the natural and community resilience, which is why they steadily attract the attention of researchers worldwide. The complexity of the physical processes in these areas remain largely unknown, particularly when examining phenomena at a large scale, both spatially and temporally, that play fundamental role to the observed changes.

The main objective of this Research Topic was to explore in more details some of the processes allowing authors to assess changes and interaction at regional and continental scales and for longer span of time and the potential impacts of future changing climates, to help understand and advanced the main base knowledge to build ecosystems that are more resilient.

Six papers have contributed to this Research Topic. Three of them explored morphological processes at various spatial and temporal scales and different regions, with two of them based on two large Chinese environment and one located in the Irish Sea. A fourth paper explored extreme water levels caused by surge and tide interaction in New Zealand waters. Finally, the last two papers explored dating of coastal dunes using optically simulated luminescence across the coast of Hainan Island, China, while the last explored benthic foraminiferal records to understand its potential to study the impact of climate change on salt marshes across a century long scale.

The research of Bunzel et al provides evidence for the vulnerability of coastal ecosystem under the combined effects of climate change and anthropogenic influences which amplifies the former. These results may be of considerable value in the way of designing nature-based protection measures, such as salt marshes. The Authors investigated the historical foraminiferal records of two sedimentary salt marsh archives in the Wadden Sea area, Germany, which had been modified by human activities over the last century. Salt marshes, crucial for coastal protection, are facing challenges from accelerated sea-level rise and increasing storm surges. The research focused on the response of salt marsh physico-chemical traits to storm tide inundation over the past century, assessing salt marsh stability and vulnerability. The study found an increase in abnormally grown tests of the salt marsh indicator species Entzia macrescens between 1950 CE and the late 1980s, suggesting heightened environmental stress due to increased salt marsh flooding. These trends aligned with amplified North Sea storm surges, suggesting that salt marsh ecosystems responded to changing climate conditions. The research concluded that intensively human-modified coastal wetland ecosystems were particularly vulnerable to amplified storm climate conditions. The findings highlight the importance of foraminiferal morphological abnormalities as biomarkers for assessing environmental stressors in coastal wetlands. The observed changes in E. macrescens provide insights into the ecological impacts of natural and anthropogenic factors on salt marsh ecosystems. Overall, the study underscores the significance of foraminifera in understanding the complex dynamics of coastal environments and their responses to environmental changes.

The second paper (Costa et al.) identified the importance of tide surge interaction TSI in demonstrating the dependency of surge interaction in order to predicts more accurately extreme events. It uses an extensive network of gages and spans across New Zealand coastal lines, and combing them with statistical and numerical simulations. In particular, the methodology of this study involved a dual approach: a regional analysis based on observed data and an investigation into Tide-Surge Interaction (TSI) and morphological effects through data and numerical modelling. The study utilized data from 36 tide gauges around New Zealand, spanning 6 to 87 years, and employed a multi-step data pre-processing method. It conducted a regional assessment of TSI, considering Non-Tidal Residual (NTR), skew-surge, and astronomical tide. The morphological impact on extreme water levels within estuaries, particularly in Manukau Harbour, was analysed through statistical methods and numerical modelling. Overall, the methodology involved a comprehensive combination of observational data analysis, statistical techniques, and numerical modelling to investigate TSI and its relation to estuarine morphology and other influencing factors in the New Zealand coastal context. The analysis revealed prevalent TSI, particularly influential in inner estuarine locations. Magnitude quantification ranged from -16 cm to +27 cm, highlighting the importance of accounting for TSI in water level estimates. Statistical independence challenges were found between highest skew-surges and associated astronomical tides, prompting further investigation. TSI significantly impacted the co-occurrence rate of extreme sea levels in estuaries. Estuarine morphology played a crucial role, correlating with astronomical tide, Non-Tidal Residual (NTR), and TSI. The study emphasized the urgency of investing in tide gauge networks for accurate hazard assessments and projections.

Zhou et al, discussed the use of Optical Simulated Luminescence (OSL) for dating large system of coastal dunes, for an extended time period. The importance of coastal dune is due to their capability to offer a buffer zone against natural hazard, and can provide highlights on coastal processes, environmental changes and extreme events. The work carried out on OSL was validated with environmental archaeological investigation, showing the consistency of the records. With this technique, the authors were also capable of dating the periods were some of the sample dunes were formed, showing at least three periods of coastal sand accumulation: >28-21 ka BP, 14-4 ka BP, and 3.0 ka -present, which occurred during the Last Glacial Maximum (LGM), late Pleistocene/early-mid Holocene, and late Holocene period. While difficulties may arise from impact of storm activities in dune formation, the analysis of the local dune has been successful in highlight the importance of dune in relation to paleoclimate changes.

The three morphological analyses explored several aspect of coastal dynamics, emphasizing the need for interdisciplinary approaches to comprehend the multifaceted interactions shaping these environments. Remote sensing emerges as a powerful tool, offering insights into temporal variations and contributing significantly to our understanding of coastal evolution, weather using localize sensors or satellite images. As coastal areas continue to face threats from climate change and human activities, the knowledge derived from these studies becomes crucial for informed decision-making and sustainable management of these vulnerable ecosystems.

Murphy et al. studied the implications of a high-resolution three-dimensional survey for assessing morphological changes in coastal areas and its advantages over traditional methods. In this paper, they used an established punctual nearshore radar-based monitoring system that can cover a 6km radius every 3 seconds. Combined with machine learning, the authors successfully studied short and long-term morphological trends and captured inter-beach movement within large-scale morphological changes, which could be missed in classical transect surveys. While spatial and temporal changes were monitored more accurately, the higher granularity approach during storm events could bring significant advantages. In particular, compared to waterline-based surveys, radar surveys can offer the possibility to capture intertidal phenomena. The radar system provides valuable, cost-effective monitoring of short-term beach morphology dynamics. The approach offers high-resolution coverage at a similar cost to traditional surveying techniques. Elevation tracking could aid coastal managers in identifying rapid erosion areas, informing intervention strategies. The data and methods presented could help optimize nourishment processes, targeting specific areas with net elevation loss, and could contribute to improved coastal management.

Kang et al. The paper explores the impact of reclamation projects on tidal flats in Tongzhou Bay, emphasizing the irreversible consequences on mudflat wetlands, using a combination of Landsat 8 and HJ-1A/B satellite images for waterline extraction and DEM creation, spanning an area of around 700 km. The methodology individuated a powerful toll for studying the changes by reducing manual labour through automatic delination of the water line. The analysis highlighted a significant reduction in mudflat area during its implementation (2014–2016). Post-project completion in 2017, the hydrodynamic environment stabilized, leading to sediment redistribution and siltation around the enclosure, particularly on the east side of the Yaosha polder. Examining historical reclamation activities from 1974 to 2018, the study reveals continuous advancement of coastal reclamation, reaching over 10 km seaward, totalling approximately 320 km2. Despite a pause in reclamation activities post-2014, the encroachment on tidal flat areas remains irreversible. The research also anticipates future trends, highlighting short-term disruptions in sediment transport and long-term macroscopic seabed deposition. Remote sensing images illustrate south-eastward movement of sand ridges over 40 years, attributed to tidal systems and human-induced coastal changes. The study acknowledges few limitations, including potential errors in DEM construction due to tidal gully oscillations and emphasizes the need for higher-resolution monitoring methods like LiDAR and UAV for detailed analysis (as in the Murphy et al. Study), and advanced satellite images and bathymetry inversion algorithms to enhance the accuracy of underwater topography evolution analysis.

Zhan et al. investigated the evolution of landscape patterns in historical subdeltas and coastal wetlands in the Yellow River Delta over the last 30 years using a geo-informatics approach. The study examines the recent impact of channel migration and coastline evolution across the Yellow River deltas and wetlands from 1989 to 2016. Diverse data sources, including historical maps, topographic maps, field surveys, and remote sensing images from 1989 to 2016, were utilized to investigate landscape changes in the Yellow River Delta (YRD). The data underwent extensive processing, involving georeferencing, vectorization, and image transformations. Landscape types were classified based on vegetation characteristics, and their centroids were analyzed for spatial changes. The research focused on the impact of Yellow River channel and coastline evolution on YRD landscapes, considering factors like soil salinization and vegetation community types. The study applied unsupervised classification, achieving high interpretation accuracy, and explored landscape pattern distributions over different periods.

After an extensive analysis, the main drivers for landscape pattern changes were broadly attributed to channel changes in the Yellow River channel and coast, storm surge, and human activity and policies. For two of the sub deltas, artificial landscapes were mainly affected by human activity, while in more natural landscapes, the Yellow River channel was observed to be the main driver. It is interesting to observe how some of the complex patterns observed gave rise to changes in industrial activity (salt industry, fishing, and shrimp ponds), which could potentially drive changes in the local population and community encroachment along the river. Considerable shifts in the landscape were observed in a short period of time, with migration towards the area under examination, especially in the case of artificial ponds, and to the east for more urbanized areas, thus generating a series of feedback on the natural migration of the Yellow River channels, with somewhat negative erosional effects on the southern part of the delta. The paper also highlights how human activities have destabilized the ecosystem over time and how more sustainable practices in the area could lead to a more favourable recovery of the natural environment and enhance carbon sink capacity.

From the papers published in this Research Topic, it emerges more than ever that combinations of various methodologies in a holistic approach could identify small and large-scale dynamics, weather natural or caused by human activities, while reducing the intense manual labour of local surveys. These surveys can still be instrumental for referencing, validation, and calibration. Innovative technologies and fossil-based analytical techniques can provide further insight into the analysis of recent and long-term changes and will be instrumental in the broader understanding of various impacts derived from human or natural activities and the impact we can generate on the environment and ecosystems and improving local decision-making process during the management of the costal environments.

Author contributions

IC: Writing – original draft, Writing – review & editing. ML: Writing – original draft, Writing – review & editing. NL: Writing – original draft, Writing – review & editing.

Conflict of interest

Publisher's note