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Editorial: Advances in monitoring and modelling spatial and temporal dynamics of estuarine ecosystems

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Editorial on the Research Topic
Advances in monitoring and modelling spatial and temporal dynamics of estuarine ecosystems

Estuarine systems rank among the world's most valuable and threatened ecosystems. In addition to being highly productive and sustaining a rich biodiversity, they also provide highly favourable conditions for the establishment of human settlements and the development of socio-economic activities. However, these activities are recognised to unbalance the ecosystem functioning and sustainability. The major threats to estuaries include the discharge of pollutants and nutrients, which impairs water quality, and changes in geomorphology (e.g., channels dredging, construction of dams and hydraulic structures). These alterations directly impact hydrodynamic conditions (e.g., current velocity, flooding patterns, residence time, salinity intrusion), posing a threat to numerous species that may not be able to adapt to survive in different conditions. Furthermore, the hydrodynamics of estuaries and the associated services are also being influenced by the impacts of climate change, including induced mean sea level rise, alterations in freshwater input, saltwater intrusion and an increase in air and water temperature.

The rapid degradation of estuarine ecosystems underscores the necessity for the development and implementation of comprehensive and intensive monitoring methods and tools capable of predicting their natural evolution, as well as assessing the impacts of escalating climate and anthropogenic threats. Monitoring estuaries through *in situ* or remote sensing methods and laboratory analysis has facilitated the timely identification of threats, providing crucial information to stakeholders and administrations responsible for their management. Additionally, numerical modelling of estuaries has advanced

considerably, contributing to a better understanding of estuarine processes and the effects of environmental changes on the ecosystems. The main objective of this Research Topic is to offer new insights into the monitoring and modelling of estuarine ecosystems. This aims to enhance our understanding of the physical processes that determine estuarine dynamics and the intricate interplay between physical and biological processes. This topic gathers 7 peer-reviewed studies reporting significant advances in this field.

He et al. investigated the nonlinear characteristics of freak waves propagating over the shoaling bathymetry through a combination experiments in a wave flume and spectral analysis. Their study contributes to a better understanding of how depth variations in shallow systems can generate freak waves.

The influence of density gradients and tidal forcing on the formation of a salt plug, as well as the lateral circulation within the salt-plug estuaries were investigated by Hosseini et al. through numerical modelling. The numerical experiments conducted in an idealized funnel-shaped basin showed that the spring-neap tidal cycle and the Coriolis effect exert control over the circulation in the estuary and establish the salinity patterns.

Chowdhury et al. developed an algorithm that derives water turbidity from Sentinel-2 satellite data, specifically focusing on highly turbid estuarine systems. The application of this algorithm to the Guadalquivir estuary in southern Spain demonstrates its efficacity as a valuable tool for continuous turbidity monitoring. Moreover, it could serve as an effective means for assessing the impact of both natural and human-induced activities on estuarine water quality.

Tavora et al. introduced the semi-supervised and spatially explicit algorithm PLUMES for detecting turbidity plumes in coastal waters using Landsat-8 satellite remote sensing data. The study, conducted in the Patos Lagoon, Brazil, demonstrated the algorithm's proficiency in distinguishing both low and high turbidity plumes from the surrounding waters. These promising results suggest the potential applicability of the PLUMES algorithm to estuarine systems globally.

A methodology combining *in situ* field observations with numerical modelling was developed by Deng et al., aiming to characterize the horizontal and vertical distributions of suspended particulate matter in the Pearl River Estuary, China, and to discuss the mechanisms influencing the observed patterns. The research emphasized that the intricate interplay between estuarine flows and coastal circulation plays a crucial role in determining the patterns of suspended particulate matter, offering valuable insights into the water quality status of the region.

Zhang et al. assessed the changes in the Yellow River Delta coastline from 2009 to 2019 using remote sensing data from Landsat-5 and Landsat-8 satellites. The study further utilised numerical modelling to investigate the influence of the tidal currents on the observed shoreline changes. Regions where the coastline had advanced and others where it had retreated were identified. The numerical results indicated a clear response to the sediment transport of the Yellow River, with residual currents playing a significant role in this process. This research underscores the importance of combining remote sensing with numerical modelling methods to enhance understanding and adaptation to future threats arising from climate and human activities, and to implement appropriate protection measures.

Xiao et al. assessed sediment transport processes during wet and dry seasons in Fitzroy Estuary - Keppel Bay, Australia, by integrating *in situ* field observations with numerical modelling. The observed data identified a region of maximum turbidity, while the model data highlighted the critical role of topography in trapping sediments. During the wet season, currents and tides were found to bring offshore material into the system, playing a major role in supplying sediment. Indeed, although sediments are discharged in the offshore zone during a flood, wind-driven, and wave-driven currents typically transport these river sediments back to the estuary. These results are of paramount importance to the Great Barrier Reef, as the Fitzroy Estuary - Keppel Bay serves as a significant source of sediment to the region. The presence of sediment can impact water clarity, thereby influencing ecosystem functioning.

In summary, various studies employ innovative approaches; including satellite remote sensing methods (Chowdhury et al.; Tavora et al.), a combination of *in situ* methods or satellite remote sensing with numerical modelling (Deng et al.; Xiao et al.; Zhang et al.), wave flume experiments (He et al.), and numerical modelling of idealized estuaries (Hosseini et al.). Collectively, these studies provide new insights to advance our understanding of estuarine systems dynamics and processes. Consequently, their finding should be of interest to a broad community of researchers and coastal managers worldwide.

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CL: Writing – original draft. VF: Writing – review & editing. AC: Writing – review & editing. JD: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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