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Editorial: Extreme weather events induced coastal environment changes under multiple anthropogenic impacts

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Editorial on the Research Topic
Extreme weather events induced coastal environment changes under multiple anthropogenic impacts

Coastal regions are prime areas that receive terrigenous materials and offer convenient marine areas for resource exploitation. These areas exhibit a complex hydrodynamic process, diverse ecological environments, and abundant fishery resources. On one hand, the implementation of sea farming and offshore wind power in coastal regions can alleviate food and energy scarcity. However, pollutants and man-made waste discharged into coastal oceans lead to deterioration of marine environment and decrease in fishery resources. Coastal environments are also vulnerable to various anthropogenic impacts as a result of human socio-economic development and extreme weather events related to the ongoing climate change. A thorough understanding of the processes and mechanisms associated with anthropogenic impacts and extreme weather events is a prerequisite for the effective utilization and management of coastal oceans.

Studies have shown an increase in the intensity and frequency of extreme weather events, including heavy rainfalls, river floods, storm surges, and marine heatwaves (MHWs) (Hirabayashi et al., 2013; Fischer and Knutti, 2015; Oliver et al., 2018; Leuven et al., 2019; IPCC, 2021; Alifu et al., 2022). It remains unclear how the evolution of the coastal ecological environment will be affected by these events, particularly in areas where increased human activity has compromised resilience. This Research Topic aims to address this question.

In this Research Topic, we collected 15 articles contributed by 69 authors, in which the majority focuses on extreme weather events. Yong et al. highlighted a notable increase in the frequency of atmospheric rivers (ARs) along with an eastward shift of AR plumes, which contribute to the rising trend of extreme precipitation amounts in the coastal regions surrounding the South China Sea. In another study, Sun et al. investigated the CO_2 absorption capacity of the entire Southern Indian Ocean and they found that it has been gradually increasing over the past 20 years, likely intensified by surface waves. This phenomenon can have a further impact on global carbon cycling and the process of global warming. Furthermore, Hamdeno and Alvera-Azcaráte identified that the Mediterranean Sea has experienced 96 marine heatwave (MHW) events, amounting to a total of 1495 MHW days, with more than half (54%) occurring in the last decade (2011-2020).

Extreme weather events interact with various coastal ocean processes, including waves, tides, ocean currents, and river runoff, at different temporal and spatial scales. As a result, these events may cause destabilization of artificial coastal structures. Yu et al. demonstrated that tropical cyclones (TCs) can significantly impact the evolution of beaches. Additionally, Sun et al. showed that winter gales can induce high-wave conditions, which result in enhanced alongshore currents that cause intense scouring in front of seawalls, leading to the destabilization of seawall structures. Furthermore, heavy rainfall-induced river floods may cause rapid morphological changes in mountain river estuaries, posing a threat to the stability of port infrastructures (Du et al.). Therefore, it is crucial to take steps to ensure the safety of coastal constructions. However, the impact of extreme weather events can result in uneven spatial changes, even in small-scale estuaries, beaches, and tidal flats (Yu et al.; Du et al.; Li et al.). For example, Yu et al. found that TCs passing through the west side of beaches may result in significant storm surge and seaward bottom current, leading to noteworthy beach profile changes, while TCs passing through the east side of beaches may result in negligible beach profile changes.

Consecutive occurrences of extreme weather events or their combination with long-term variations in air-sea interaction may have more severe impacts. Shen and Zhang observed that prolonged forcing time on intense positive wind stress curls induced by two sequential TCs can result in upwelling caused by Ekman response, culminating in pronounced surface cooling and increase in chlorophyll-a. Guo et al. found that TC-induced coastal flooding can lead to hazardous conditions in low-lying areas, which are expected to worsen due to sea level rise and changes in TC climatology associated with global warming. The most vulnerable areas, in this regard, are artificial surfaces and agricultural lands, which suggests a heightened risk of flooding in the future. Jacques-Coper et al. analyzed the high phytoplankton biomass events in the southern Inner Sea of Chiloé, which were influenced by a mid-latitude migratory anticyclone inducing persistent cloudless conditions, leading to an increase in photosynthetically active radiation and positive sea surface temperature anomalies, promoting the occurrence of MHWs. These phenomena were also modulated by the Madden-Julian Oscillation. Ishida et al. evaluated the accumulative carryover effects (ACEs, the effects of sequential events accumulating additively over time) of MHWs in rocky intertidal communities of southeastern Hokkaido, northern Japan. They found different ACEs in four major functional groups: macroalgae, sessile invertebrates, herbivorous invertebrates, and carnivorous invertebrates. Their results emphasized the importance of considering ACEs, as neglecting them would underestimate the response of marine organisms to MHWs.

On the other hand, coastal regions are significant areas for human socio-economic development, but they face multiple pressures from various human activities, such as land reclamation, damming, marine culture, fertilizer and wastewater emissions, garbage, and microplastics. For instance, Vörösmarty et al. and Nilsson et al. reported that 59% of the world's large river systems were impacted by human damming activities, with over 70% of these systems retaining more than 50% of their sediments in reservoirs. Jia and Yi, in this Research Topic, demonstrated that the water-sediment regulation scheme of the Yellow River could remove the previously deposited sediments in the river and reservoir beds in the lower reaches and transport a massive sediment plume to the estuary, modifying the delta's shape. Nevertheless, terrigenous sediment and nutrients carried by river runoffs altered the dietary structure of estuarine organisms, leading to a decrease in the trophic levels of major consumers, and the flow pulse with high sediment also intensified the spatial structure differences of the food webs (Yi et al.). Coastal sediments could accumulate organic and inorganic materials from land and marine environments, thereby providing diverse microbial niches. Li et al. revealed that crude oil contamination due to oil spills increased bacterial phyla abundance, causing partial replacement of microbial communities in water columns and sediments. Furthermore, Chen et al. discovered that microbial production rates and metabolic activities, represented by extracellular polymeric substances production, were significantly associated with the grain size of their bound sediments, indicating changes in microbial communities resulting from sediment disturbance across the bed-water interface generated by the abovementioned human activities or extreme weather events.

This Research Topic examines the interactive effects and nonlinear dynamics of extreme weather events and intensive human activities on coastal hydrodynamics (Sun et al.; Li et al.; Shen and Zhang), sedimentary dynamics (Du et al.; Jia and Yi; Yu et al.), and ecological dynamics (Chen et al.; Ishida et al.; Li et al.; Yi et al.). Studies involving analysis of *in situ* measurements, numerical modeling, and satellite remote sensing are included. Additionally, the trend of global climate change and extreme weather events have been investigated (Guo et al.; Hamdeno and Alvera-Azcaráte; Jacques-Coper et al.; Sun et al.; Yong et al.). However, current research faces significant challenges in identifying the critical points and resilience of adaptive changes in the coastal ecological environment to the compound impacts of extreme weather events and human activities. The consequences of these interactions can have severe impacts on coastal oceans globally. Therefore, there is a need for measures aimed at enhancing the resilience of coasts, which can be extended from a regional scale to a global scale.

Author contributions

All authors listed have made an equal contribution to the work and approved it for publication.

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Conflict of interest

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