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Editorial: Multi-scale air-sea variability and its application in Indo-Pacific regions

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Editorial on the Research Topic
Multi-scale air-sea variability and its application in Indo-Pacific regions

The Indo-Pacific region includes the tropical Indian and Pacific Oceans and straddles over the Asian coastal seas, accommodating the Indonesian seas that connects the two oceans. It is characterized by dynamic coastal and marine environmental variability associated with natural ocean and climate phenomena and affected by human activities. The regional climate is significantly affected by tropical climate variability such as the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), as they modulate the onset, intensity, and withdrawal of the Asian Monsoon. The region is also affected by extreme weather variations such as tropical cyclones (TCs). Severe impacts from long-term climate changes such as global warming are a growing concern, especially in coastal areas.

The basin-scale ocean observation networks in the Indian and Pacific Oceans, as represented by the TAO/TRITON buoy array (e.g., McPhaden et al., 1998; Ando et al., 2017) and international Argo program (Roemmich et al., 2009) as well as IndOOS-2 (Beal et al., 2020), is providing us with essential data for better understanding of ongoing climate and environmental variability/changes in the Indo-Pacific region. Improvements in high-resolution numerical simulations have also been made significantly since the 2000s (e.g., Masumoto et al., 2004). In addition, high-resolution (250 m−1 km) and high-frequency (about 1–3 days) remotely sensed satellite data covering the Asian coastal regions, such as those from Himawari 8/9 (Bessho et al., 2016) and the Global Change Observation Mission-Climate (GCOM-C) satellite (JAXA, 2018), have been available since the 2010s. These satellite data have enabled us to analyze environmental changes seamlessly from the coastal ocean to the open ocean. One of the challenging issues to be investigated is to clarify relations between these regional/local phenomena and larger-scale climate variations/changes under the global warming stresses. Thus long-term, continuous ocean observing and further improvements in numerical simulations are imperative.

To facilitate our understanding of these topics, we have organized an annual Workshop since 2017 on ocean circulation, climate variation, and environmental studies in the Indo-Pacific region. This Research Topic "*Multi-scale air-sea variability and its application in Indo-Pacific regions*" is based on the main findings obtained through and discussions conducted during these workshops and related collaborative works and provides the following research articles for the Indo-Pacific regions.

Developments in ocean observations and numerical simulations over the past two decades have enabled studies with higher spatio-temporal resolution. Kameyama et al. and Sasaki and Iwai utilized observation data collected by buoys and Argo floats in the Pacific. Kameyama et al. analyzed observation data of the Kuroshio Extension Observatory buoy and found that short-term mixed layer low-salinity signals with the passage of TCs. Based on observations of ocean temperature and salinity in the upper ocean, Sasaki and Iwai evaluated the subsurface ocean circulation in the South Pacific. They analyzed temperature and salinity anomalies (the spiciness anomalies) of water masses and revealed a detailed circulation for the relatively less-observed South Pacific. The TC activity and genesis were studied by Ogata and Baba. They analyzed planetary-scale convection and anomalous atmospheric circulations using state-of-the-art numerical simulations and found that atmospheric variability related to TC genesis in the western North Pacific with the updated convection scheme.

Leenawarat et al. and Genda et al. are examples of observational studies focusing on an Asian coastal area and the Indonesian seas. Leenawarat et al. used high-resolution satellite data for the Gulf of Thailand to investigate the seasonal chlorophyll-a variability and influences from ENSO. Their results improved our understanding of the changes in tropical marine ecosystems related to monsoon and ENSO variability. Genda et al. measured Sr/Ca and oxygen isotope ratios (δ18O) in coral samples and reconstructed sea surface temperature and sea surface salinity in the southern Lombok Strait over 50 years (1962–2012). Their results suggest that under the global warming, the possible warming trend in Indonesian seas was not as pronounced as in the surrounding areas, indicating that the response to climate change in the coastal area is a challenging issue due to the complicated circulation of the Indonesian throughflow (ITF). On the coastal ocean near the exit of the ITF, Horii et al. pointed out a long-term shift in coastal upwelling onset south of Java. They suggested that a regional warming trend west of Sumatra and long-term changes in the atmospheric circulation may have contributed to the observed early onset of the coastal upwelling.

Recent studies indicate that extreme events such as torrential rainfall may change more frequently in a warming climate (e.g., Westra et al., 2014). Manda et al. assessed the impact of the SST warming in the East China Sea (ECS) on a torrential rain event in Kyushu Island, Japan. Their numerical simulations showed that the ECS warming played an important role in the extreme event through the intensification of the convective systems which then increased the precipitation.

The ongoing development of ocean observing networks, satellite observations, and high-resolution simulations provides an excellent opportunity to study multi-scale atmospheric and ocean variability in the Indo-Pacific region. In addition to the findings in this Research Topic, further studies are desirable on teleconnections of atmospheric and oceanic variability between the two basins, including the connection through the ITF. In particular, understanding how the effects of global warming redistribute heat through ocean circulation and how it appears in coastal areas are remaining questions. Finally, these findings should be applied to realize effective environmental adaptation and disaster prevention in the Indo-Pacific region.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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.

Publisher's note

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