frontiers | Frontiers in Climate

TYPE Editorial
PUBLISHED 25 April 2023
DOI 10.3389/fclim.2023.1203977

OPEN ACCESS

EDITED AND REVIEWED BY
Matthew Collins,
University of Exeter, United Kingdom

*CORRESPONDENCE
Swadhin Kumar Behera
behera@jamstec.go.jp

RECEIVED 11 April 2023
ACCEPTED 13 April 2023
PUBLISHED 25 April 2023

CITATION
Behera SK and Luo J-J (2023) Editorial: Progresses in Indo-Pacific climate predictions. *Front. Clim.* 5:1203977. doi: 10.3389/fclim.2023.1203977

Editorial: Progresses in Indo-Pacific climate predictions

Swadhin Kumar Behera[1]* and Jing-Jia Luo[2]

[1]Application Laboratory, Research Institute for Value-Added-Information Generation (VAiG), Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan, [2]Institute for Climate and Application Research, Nanjing University of Information Science and Technology, Nanjing, China

KEYWORDS

Indo-Pacific, climate phenomena, ENSO, IOD, PDO, IPO, MJO, AI/ML

Editorial on the Research Topic
Progresses in Indo-Pacific climate predictions

The Indo-Pacific sector plays a crucial role in the global climate system due to its complex and dynamic ocean-atmosphere interactions. Climate variability in this sector is characterized by interannual to decadal scale changes in the coupled ocean-atmosphere system that occur across the Indian Ocean, Pacific Ocean, and their connecting regions. The El Niño/Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) are two of the most dominant modes of this variability, with significant impacts on the climate and weather patterns of the region and beyond. The Madden-Julian Oscillation (MJO), the Pacific Decadal Oscillation (PDO), and the Interdecadal Pacific Oscillation (IPO) are a few other modes of variability that need our attention while studying those two dominant modes of climate variability. Moreover, these modes of variability interact with each other and their combined effect on regional climate can vary depending on their phase and amplitude. Understanding and predicting the variability of the Indo-Pacific climate is important for climate adaptation and disaster risk reduction strategies in the region. As the world faces the challenges of global warming, the changes in the characteristics of the climate phenomena are a matter of concern, as more frequent and intense occurrences of these phenomena, especially the ENSO and the IOD, are already causing huge socio-economic damages.

The creation of effective mitigation and adaptation strategies depends critically on the improvement of ENSO and IOD understanding and predictions. Great progress has been made over the years in the modeling of ENSO and IOD by developing advanced ocean-atmosphere coupled models. These models realistically replicate ocean-atmosphere interactions, which are crucial for correctly forecasting ENSO and IOD behaviors, and hence are increasingly used in seasonal to interannual climate predictions. The coupled model predictions are helpful for scheduling agricultural activities, water management, and disaster response.

In the meantime, statistical climate predictions have greatly benefited from the application of artificial intelligence and machine learning (AI/ML) approaches. AI/ML methods are used for model initialization, ensemble averages, and other purposes used in climate predictions. These methods have made it possible to create climate models that are more precise and effective, which can help us better understand ENSO, IOD, and the effects they have on the ecosystem and environment. Another advantage of AI/ML techniques is that they can handle large volumes of data and identify complex patterns that may be missed by traditional statistical methods. This is especially useful for identifying precursors for ENSO and IOD, which are highly complex and non-linear phenomena that involve multiple interacting factors. AI/ML techniques can analyze these complex data sets and identify the key factors that influence ENSO and IOD, leading to more accurate predictions and projections.

Considering all these progresses in climate prediction, this special Research Topic on "*Progresses in Indo-Pacific climate predictions*" discusses some of the recent advances in climate prediction systems in the Indo-Pacific sector. The six articles published in this Research Topic addressed different aspects of those progresses. Ye and Tozuka explored the causal relationship between sea surface temperature (SST) and precipitation data using normalized Information Flow. They found that the ocean affects the atmosphere more in the tropics, while the atmosphere affects the ocean more in the extratropics, and that the local impact of SST on precipitation is dominant in almost all tropical regions. In another process study, Zhang and Mochizuki analyzed sea surface height (SSH) variations in the northwestern Indian Ocean during 1993–2016, finding that the Indian summer monsoon predominantly controls summertime SSH variations while wintertime SSH is strongly influenced by ENSO and IOD.

The global coupled model predictions are now able to resolve some of the regional variations in addition to the basin-scale variations such as those of ENSO and IOD. This was explored by Doi et al. by evaluating the skills of 1-month lead deterministic predictions of monthly surface air temperature anomalies over most of Japan using a large ensemble of the global climate model, SINTEX-F. The study reveals that September is the most predictable month in the model results, while December becomes skillful when the signal-to-noise ratio of the predictions is relatively high. The study also explored the signal-to-noise ratio and the inter-member co-variability to check how confident the individual prediction was as well as to find potential sources of predictability. In a related study, Ratnam et al. evaluated the skill of 120 predictions from SINTEX-F in predicting surface air temperature anomalies over Japan during the winter months. They found that an average of selected member predictions (SEM), based on their skill scores with the anomaly correlation coefficient, outperformed the average of all member predictions due to improved representation of geopotential height anomalies, suggesting SEM's usefulness in improving the climate prediction skill.

In a study to understand models' ability to capture seasonal temperature and precipitation variability over India, Salunke et al. explored ninety climate models from four consortiums: CMIP5, CMIP6, NEX-GDDP, and CORDEX. NEX-GDDP was found to be the best for surface air temperature for all seasons and CMIP6 for precipitation in certain seasons. The selected models suggest that temperatures will increase over the entire Indian landmass, particularly in the northwest region, and that precipitation will increase in specific areas during the monsoon and post-monsoon seasons.

In an attempt to develop an AI/ML-based ENSO prediction system, Patil et al. used the deep learning technique of convolutional neural networks (CNN) with heterogeneous CNN parameters for each season and a modified loss function. The AI/ML prediction system was used to predict ENSO at long-lead times of 18–24 months. The results are very encouraging as they show high skill in predicting extreme ENSO events by overcoming the spring barrier at such long lead times, beating the dynamical prediction system. Moreover, the study was able to identify various precursors to ENSO events using CNN heatmap analysis.

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