**AI-Based Global KARINA Model Skillfully Simulates Intraseasonal Tropical Variability: MJO, BSISO, and Associated Air-Sea Dynamics**

**Abstract:** The advancement of machine learning-based climate models has opened new pathways for improving the prediction and simulation of intraseasonal variability in the tropics. In this study, we assess the performance of the AI-based Global KARINA model in representing two critical modes of tropical variability: the Madden-Julian Oscillation (MJO) and the Boreal Summer Intraseasonal Oscillation (BSISO). Results demonstrate that the KARINA model exhibits high skill in capturing the spatial-temporal characteristics, propagation, and amplitude of both MJO and BSISO events, outperforming several conventional general circulation models (GCMs). Particularly, the model accurately replicates the eastward propagation of the MJO and the northwestward propagation of BSISO, consistent with observational datasets such as ERA5. A detailed analysis of the Moist Static Energy (MSE) budget reveals that the KARINA model adeptly balances horizontal advection and vertical moistening processes, which are pivotal for sustaining intraseasonal oscillations. Additionally, the model demonstrates realistic air-sea coupling, effectively capturing key feedbacks between skin temperature anomalies and atmospheric convection. Importantly, regional analysis highlights the model's skill in representing the sensitivity of atmospheric variables across the Arabian Sea (AS), Bay of Bengal (BoB), Western Indian Ocean (WIO), Eastern Indian Ocean (EIO), and Western North Pacific (WNP). In these regions, the KARINA model successfully captures critical interactions among low-level moisture convergence and convective processes, which significantly influence the strength and propagation characteristics of MJO and BSISO events. Moreover, the model exhibits notable predictive skill at higher lead times, maintaining coherent representations of MJO and BSISO phases and amplitudes beyond typical forecast windows, which is crucial for extended-range forecasting applications. Overall, the AI Global KARINA model stands as a promising tool for advancing our understanding of tropical intraseasonal variability. Its robust representation of the MSE budget, realistic air-sea interactions, sensitivity depiction across key ocean basins, and strong performance at higher lead times provide valuable insights for improving regional climate prediction and guiding future model development efforts.