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Bootstrapping Image Histogram for Simplifying Climate Snapshots: Exploring the Application to Indo-Pacific Warm Pool Expansion Research

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Thanks to the recent advancements in climate observation methods and numerical simulation performance, there has been a significant increase in the availability climate datasets, which offer finer resolutions and broader coverage of variables than ever before. In contrast to the past, when scientists faced challenges due to limited data, the challenge now lies in extracting meaningful information from high-dimensional climate data. In climate analyses, each timestep of data provides a snapshot of atmospheric/oceanic conditions, analogous to a photograph. In such sense, techniques from the field of computer vision can serve as valuable tools for analyzing these climate snapshots.

This presentation aims to introduce the concept of the Bootstrapping Image Histogram, a fundamental idea in computer vision, and demonstrate its usefulness in simplifying climate snapshots and reducing the dimensionality of climate data. Additionally, given the crucial role of the Indo-Pacific warm pool (IPWP) in driving the global climate system, this presentation also showcases two applications of the Bootstrapping Image Histogram approach to IPWP expansion research, as recently published.

(1) Recent observed weakening of IPWP seasonality: We find that the amplitude of seasonal cycle of the IPWP size has decreased significantly since 1950, despite the sea surface warming being rather uniform across seasons. Analysis results suggest that the climatological spatial pattern of sea surface temperature (SST) over the Indo-Pacific Ocean is the primary factor contributing to the weakening IPWP seasonality. (https://doi.org/10.1088/1748-9326/acabd5)

(2) Overestimated IPWP expansion under greenhouse warming: The IPWP drives the global climate system by consistently supporting and maintaining atmospheric deep convection. For this reason, the IPWP is defined as the region where the SST exceeds a pre-condition necessary to favor deep convection (σ_{conv}). Previous conclusions regarding the rapid expansion of the IPWP were based on

a constant σ_{conv} (typically 28°C). However, our analysis results reveal that σ_{conv} is indeed increasing under climate change, which corresponds to a slower IPWP expansion speed. This highlights the necessity of considering the response of the relationship between deep convection and SST to climate change when studying the long-term variability of the IPWP and its impacts on the climate system. (https://doi.org/10.1038/s41612-022-00315-w)