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Links between summer wet-bulb temperature variability and climate indices over East Asia

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The intensification of humid heatwaves in recent decades has elevated wet-bulb temperature (Tw) as a critical metric of combined thermal and moisture stress, drawing attention to its implications for human health and regional climate extremes. While previous studies have primarily examined Tw at local or national scales, the dominant modes of variability across East Asia and their governing mechanisms remain insufficiently explored. In this study, we apply empirical orthogonal function (EOF) analysis to ERA5 reanalysis data for summer (June–August) during 1979–2023 to identify the principal modes of Tw variability and to characterize their associated large-scale circulation patterns. The first mode reveals a basin-wide upward trend consistent with the influence of global warming. The second mode exhibits a north–south dipole pattern linked to anticyclonic anomalies over East Asia and cyclonic anomalies near the Philippine Sea, thereby channeling enhanced moisture inflow from South Asia and the western Pacific. The third mode displays an east–west dipole associated with wave activity emanating from western Siberia toward the Sea of Okhotsk, directing Pacific moisture transport into northern Japan. Correlation analysis highlights the Outgoing Longwave Radiation Index (OLRI), which enhances convection and strengthens the moisture inflow associated with the second mode. This suggests that EOF2 variability is closely tied to convective activity near the Philippine Sea and the resulting moisture transport into East Asia. For the third mode, the British–Baikal Corridor Index (BBCI) emerges as a key driver. It modulates the wave propagation from western Siberia toward the Sea of Okhotsk, and its influence becomes particularly strong during La Niña conditions, thereby shaping the moisture pathways linked to EOF3. These findings emphasize the importance of regional atmospheric circulation and moisture transport in shaping Tw variability.

Keywords: Wet-bulb temperature (Tw), East Asia, Empirical Orthogonal Function (EOF), Climate indices

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