



## Identification and Characterization of Compound Heatwaves in Kerala a Humid Tropical Region of India.

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High temperatures and heatwaves are among the most significant climate extremes, with well-documented effects on human health, including increased mortality rates. Heatwave impacts may arise from a single extreme variable, such as air temperature, or from compound conditions in which multiple variables jointly contribute to heat stress without all being individually extreme. In humid tropical regions, the co-occurrence of high temperature and humidity substantially amplifies physiological heat stress. India is a major global heatwave hotspot, particularly during the pre-monsoon season.

In this study, we identify and characterize compound heatwave events over Kerala, India, using a multi-variable framework that integrates air temperature and Wet-Bulb Globe Temperature (WBGT) a humidity-sensitive indicator of physiological heat stress. Heatwaves are classified into dry and humid categories based on percentile-based thresholds and the duration of event. Dry heatwaves are defined using the 90<sup>th</sup> percentile and a minimum three-day duration of daily maximum air temperature from the India Meteorological Department, while humid heatwaves are identified using the 90<sup>th</sup> percentile and three-day persistence of WBGT.

Our results indicate that compound heatwave events are increasingly frequent over Kerala, with heat stress intensifying as atmospheric humidity increases. These compound heatwaves impose a substantially higher heat stress burden than dry heatwaves, highlighting the limitations of temperature-only indices and highlighting the importance of incorporating humidity-sensitive metrics for improved heatwave monitoring, early warning, and risk assessment in humid tropical regions.