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The Role of Rainfall in Humid Heat Extremes across the Global Tropics

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Extreme humid heat poses a serious risk to human health, reducing the body's ability to cool itself through sweating. The impact on humans will increase under climate change, particularly in tropical regions, such as the Indian subcontinent, that are highly populated and already hot and humid. Whilst there is a growing body of research on dry-bulb temperature extremes, there is limited understanding of the meteorological drivers of humid heat extremes, particularly the role of moisture transport, rainfall, and evaporation of moisture from the Earth's surface.

In this study, we use ERA5 data to identify and analyse extreme humid heat events in the global tropics during 1993-2022. In particular, we focus on the relationship between rainfall and the occurrence of humid heat and use extremes in wet-bulb temperatures to define the humid heat events.

We find that rainfall is a key driver of humid heat extremes across much of the global tropics. In monsoon regions, dry-bulb temperature extremes typically occur in the pre-monsoon period whereas wet-bulb extremes occur more frequently during the monsoon season. The role of rainfall varies between humid heat events characterised by extremes in dry-bulb temperature versus those characterised by extremes in humidity. In much of the global tropics, rainfall followed by a few days of dry clear weather primes the surface and boundary layer climates for the initiation of humid heat events. These events typically have extremes in dry-bulb temperatures accompanied by what we characterise as a sufficiently high level of humidity. In arid regions, away from irrigated areas, rainfall is critical for the initiation of humid heat and frequently occurs locally on the first day of humid heat events. These events typically have extremes in humidity whereas dry-bulb temperatures are less likely to be extreme.

These findings are a step towards greater understanding of the meteorological drivers of humid heat extremes at the regional scale. They will be valuable in the evaluation of weather and climate models, will aid the use and interpretation of climate model projections, and ultimately inform the design of much needed early warning systems for humid heat extremes.