Seasonal variations in the dynamic and thermodynamic response of precipitation extremes in the Indian subcontinent

Supplementary Material

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Abstract

Precipitation extremes are a major impact-relevant implication of climate change. Rising temperatures increase the moisture holding capacity at a rate of $\boldsymbol{\approx 7\% K^{-1}}$, called the Clausius-Claypeyron (CC) scaling, which can lead to intense precipitation which last for short duration. At a regional level, the scaling of extremes deviates from this expected scaling rate. Large scale circulation dynamics and local variability in thermodynamic influences are suspected to cause these deviation, but these drivers differ across seasons. In the present study, we use ERA5 reanalysis to evaluate the seasonal changes in precipitation-temperature scaling rates over the Indian subcontinent. We further determine the deviations from the expected CC scaling rate, and the precipitation extremes are decomposed to their dynamic and thermodynamic contribution across different seasons. It is found that significant seasonal contrast exists in the dynamic and thermodynamic contributions, with the latter dominating during the Indian summer monsoon season, while the former being higher during the pre-monsoon and post-monsoon season. Further analysis highlights that the lower dynamic contribution is attributed to drop in dew point temperatures and Convective Available Potential Energy during extremes. The primary drivers causing the extremes in different seasons are also pointed out, further improving the understanding of how the intensity and frequency of precipitation extremes changes spatially across different seasons, and what are the physical drivers causing these changes.

Keywords: Precipitation extremes, CC scaling, Dynamic and Thermodynamic processes, ERA5

Supplementary Figures

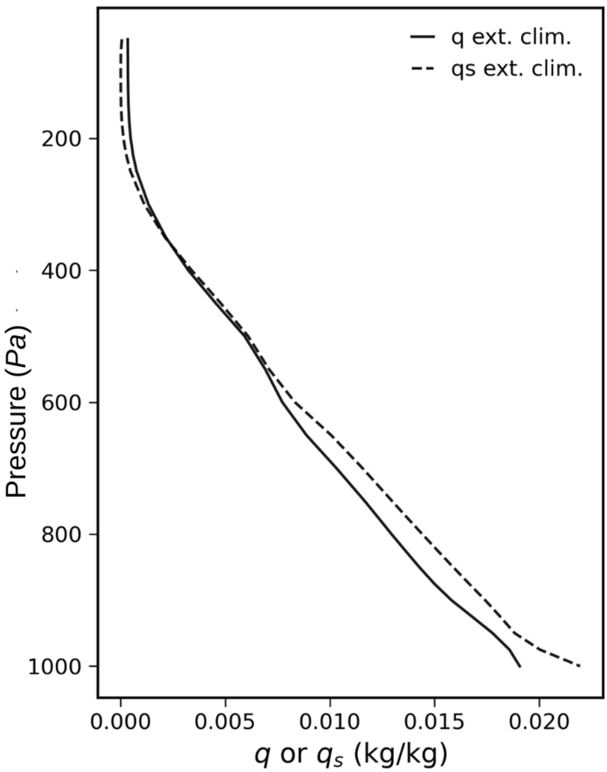

Figure S 1 Vertical profile of the composite mean of specific humidity (q) and saturation specific humidity (q_s) associated with daily precipitation extremes events, for a single grid point (19^oN and 72^oE)

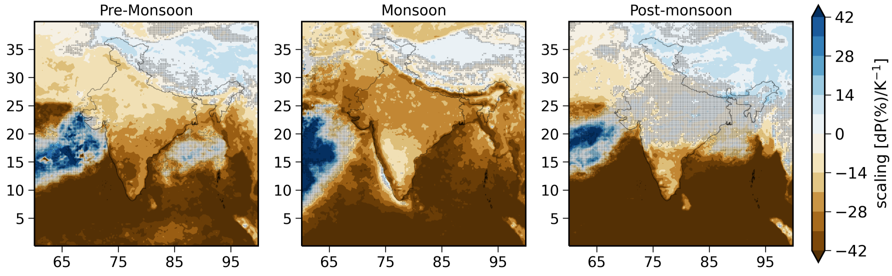

Figure S 2 Seasonal variations in apparent scaling rates of ERA5 daily P95 precipitation against SAT as a covariate. The stippling indicates grid-points without a 95% statistical significance. Here, x-axis represents longitude (^{o}E) and y-axis represents latitude (^{o}N).

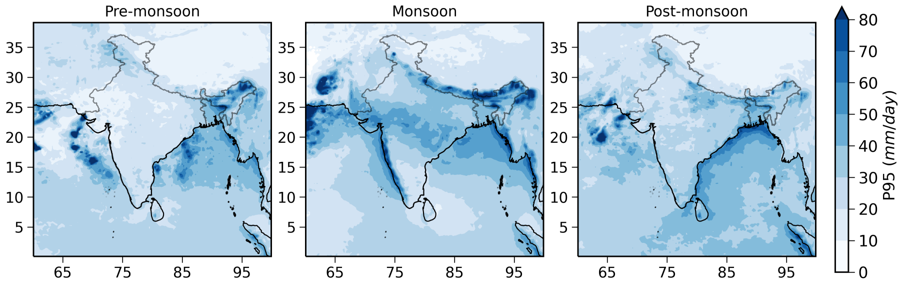

Figure S 3 Seasonal variations in the 95th percentile of precipitation (P95). Here, x-axis represents longitude (^{o}E) and y-axis represents latitude (^{o}N).

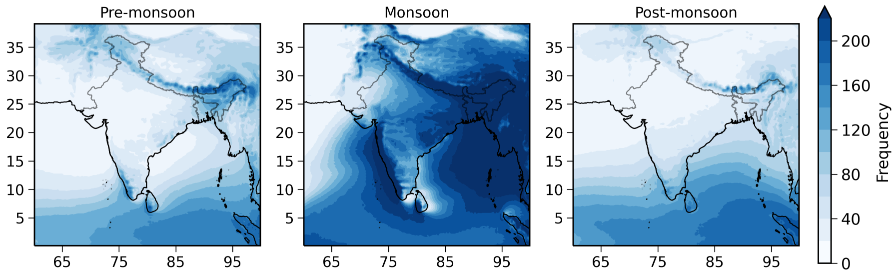

Figure S 4 Seasonal variations in the frequency of precipitation extremes i.e. all daily precipitation events exceeding the P95 threshold. Here, x-axis represents longitude (^{o}E) and y-axis represents latitude (^{o}N).

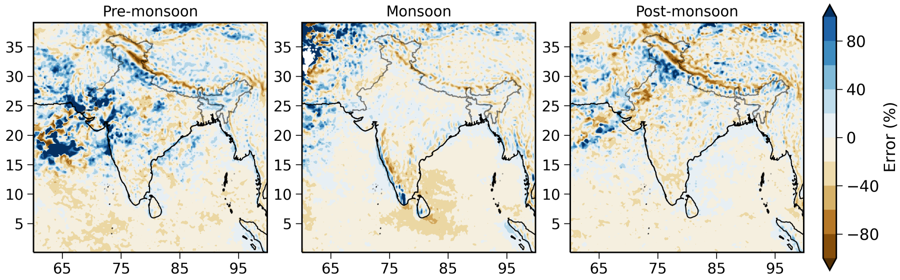

Figure S 5 Percentage bias in Precipitation estimate. Here, x-axis represents longitude (^{o}E) and y-axis represents latitude (^{o}N).

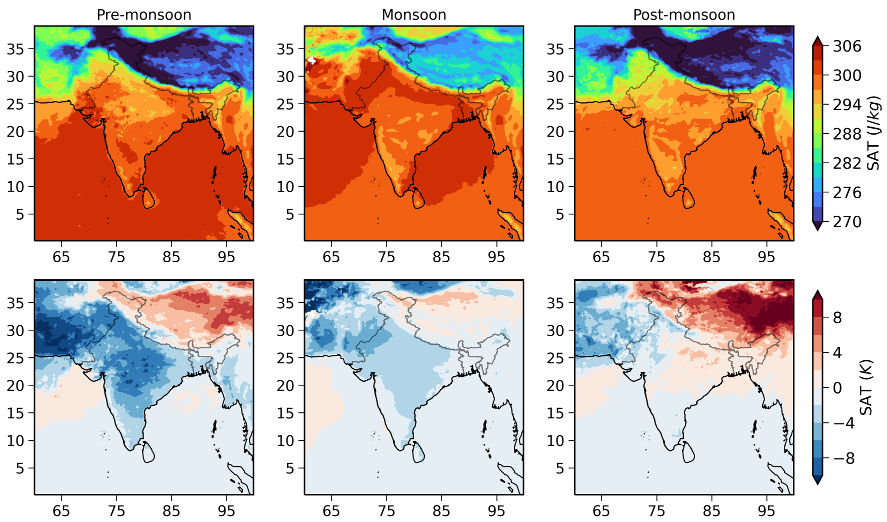

Figure S 6 Top: Composites of daily SAT associated with extremes and, Bottom: Composite anomaly of SAT against the climatology of SAT on wet days (precipitation > 1 mm/day). Here, x-axis represents longitude (^{o}E) and y-axis represents latitude (^{o}N).

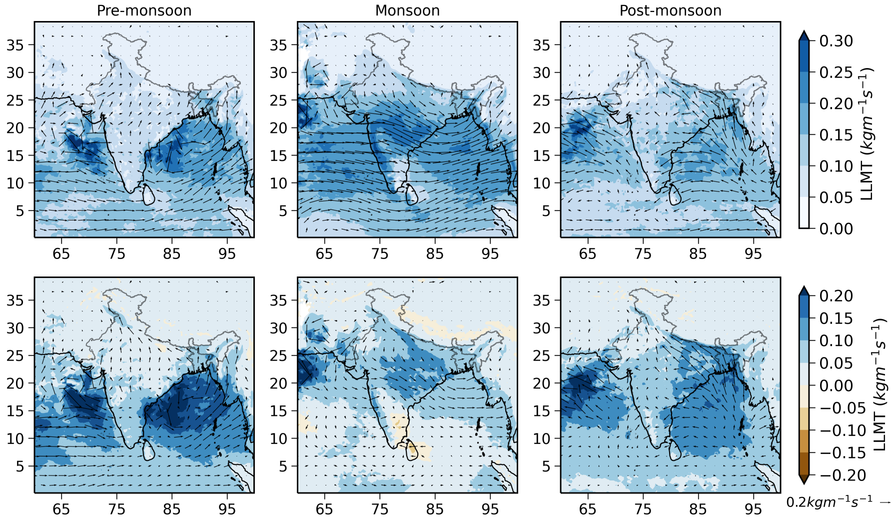

Figure S 7 Top: Composites of daily LLMT associated with extremes and, Bottom: Composite anomaly of LLMT against the climatology of LLMT on wet days (precipitation > 1 mm/day). Here, x-axis represents longitude (^{o}E) and y-axis represents latitude (^{o}N).

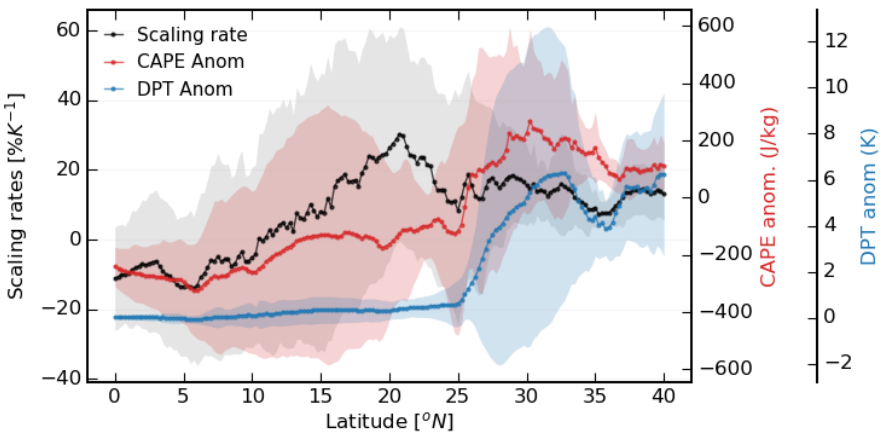

Figure S 8 Meridional variation of apparent scaling rates, CAPE anomalies, and DPT anomalies during precipitation extremes over the Indian subcontinent, during the Indian summer monsoon season. The shaded regions represent the standard deviations associated with spatial distribution.