Compounding Risk of Heat Stress-Rain Induced Floods in Urban India

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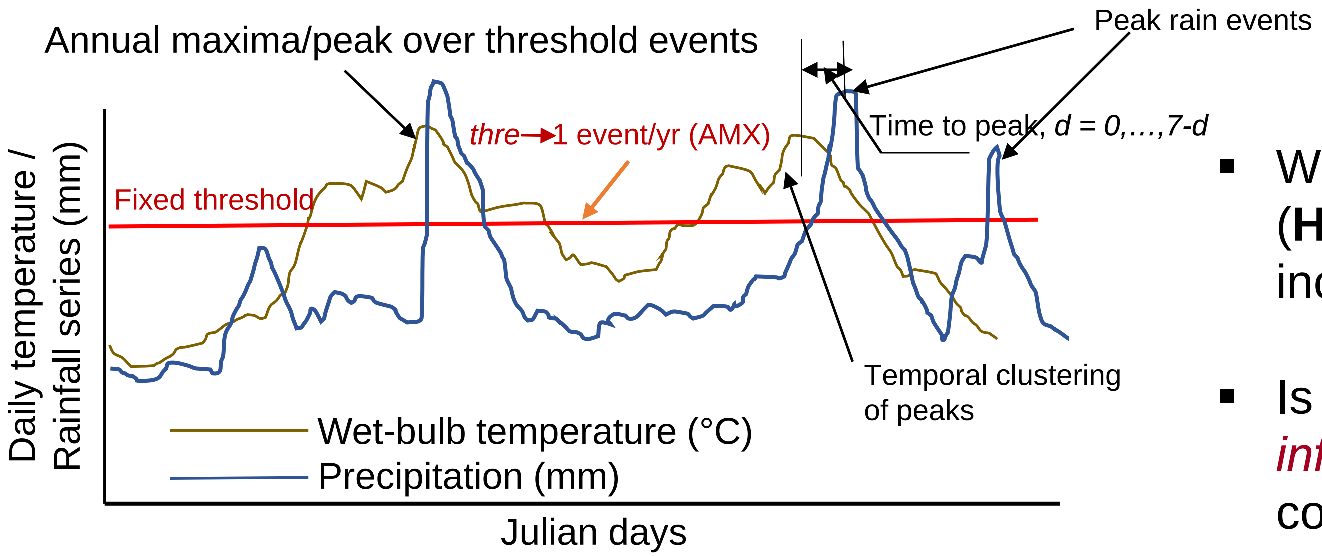
November 25, 2022

Abstract

The Indian subcontinent is one of the hotspots of deadly heat stress. Several attribution studies have shown increasing trends in heatwaves and its linkage with dry spells over South Asia. However, very few studies have investigated concurrent or successive (lagged d-day) occurrence of humid heat stress (high temperature compounded by humidity) and precipitation extremes within a short time window. Using gauge-based observation records of the last five decades, we have analyzed the concurrence of extreme wet bulb temperature, T_w and peak rain events in 9 urban locations of India, distributed over climatologically heterogeneous regions. We find a larger fraction of the population is exposed to a significant increase (more than 1% and up to 2.5%/decade) in mean and extreme T_w (around 1%/decade) in several sites than solely accounting dry-bulb temperature trends. This prompted us to analyze the compound hazard associated with storm events preceded by extreme T_w (assessed through [?] $95 - 98.5^{th}$ percentile exceedances and annual maxima series) up to a week of occurrence of the event. Considering synchronicity between two drivers (extreme T_w and peak rain), we demonstrate cities located across the western half of the country showed positive dependence, whereas those located over the eastern half show negative dependence. While negative correlation suggests the concurrence of dry and hot episodes, the positive correlation suggests robust amplification in precipitation extremes. This is confirmed by the large upper tail distributions of peak rain events during the core monsoon season (June – September) to locations showing positive dependence. Based on extreme T_w-precipitation sensitivity, we propose compound heat stress – rain-induced flood hazard model for densely populated areas. Understanding drivers of peak runoff responses would benefit risk management, insurance, and flash flood forecast, devising flood resilience under climate change.

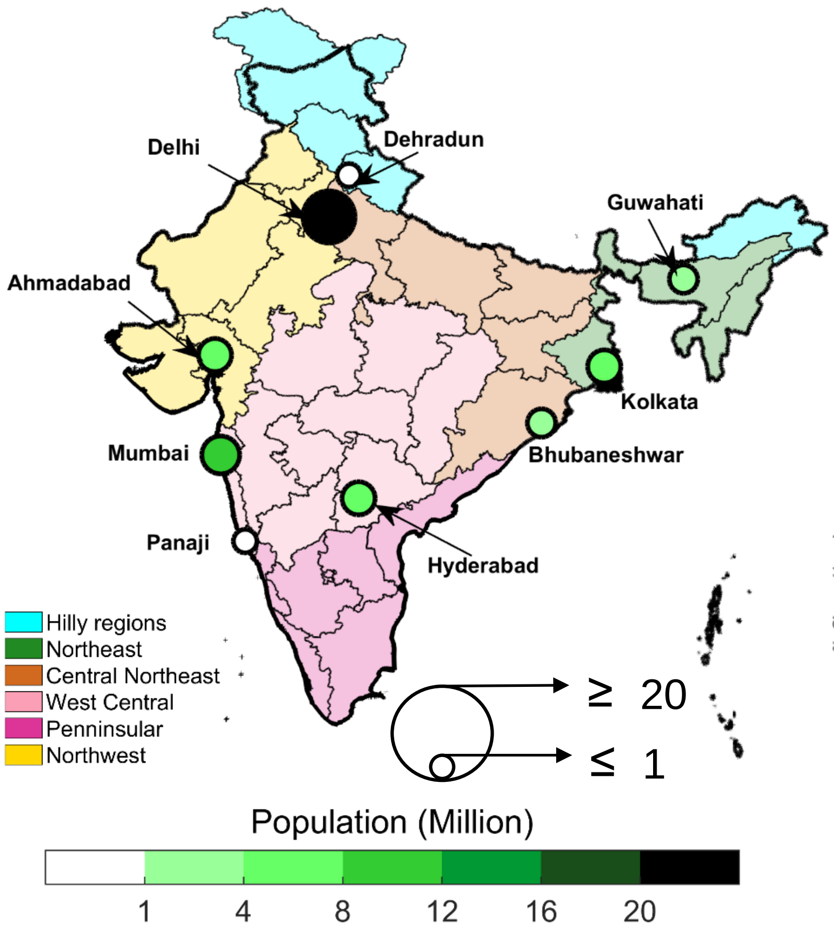
Research Questions

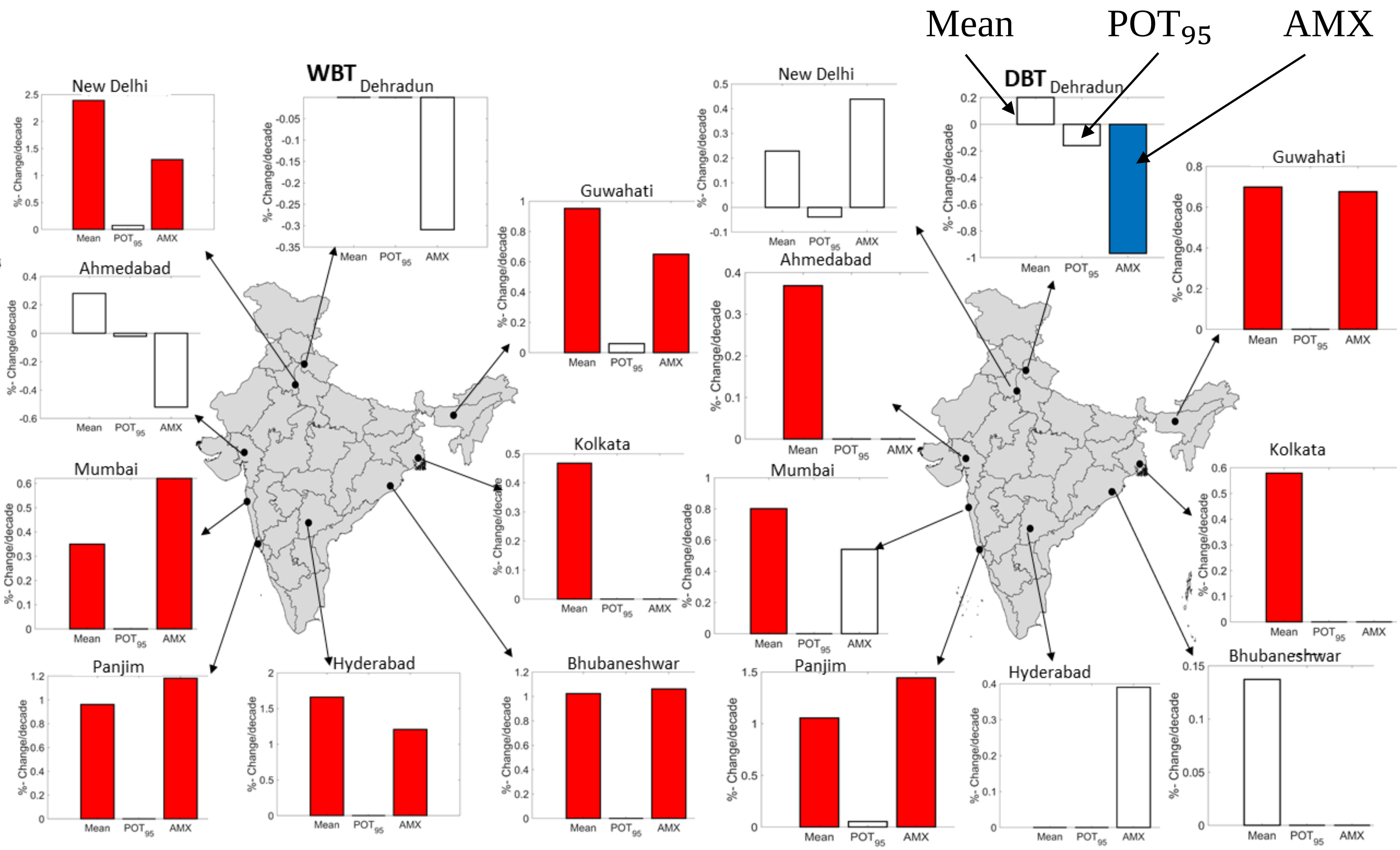


- Whether high temperature ***compounded*** by humidity (**H**umid **h**eat **s**tress: *HHS*) impact subsequent/co-incidence of *heavy rain events*?
- Is there any potential for developing a 1st-order *climate-informed pluvial flood risk model* considering *HHS* as a covariate?

Investigation of hazard cascade – *HHS* has potential to collapse critical infrastructure (e.g., power grid failure), whereas co-incidence of heavy rain endanger storm water drainage system (Rosenzweig, 2018)

Trends in Mean & Extreme Dry- vs Wet-Bulb Temperature



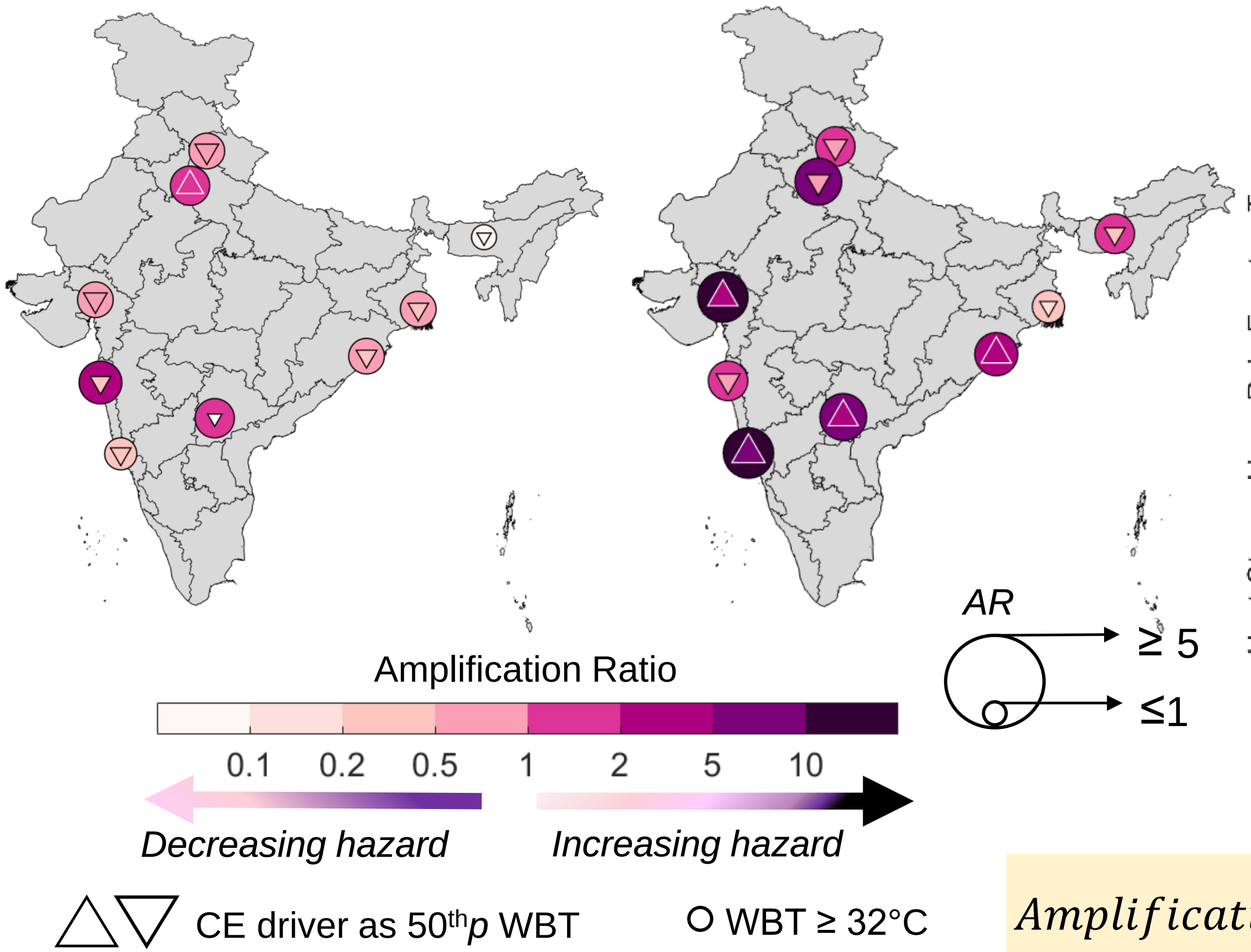


More number of sites show increasing trends in humid heat than the sensible heat stress

Cities are at *Near 'Tipping Point'* with Increase in Humid Heat-Stress

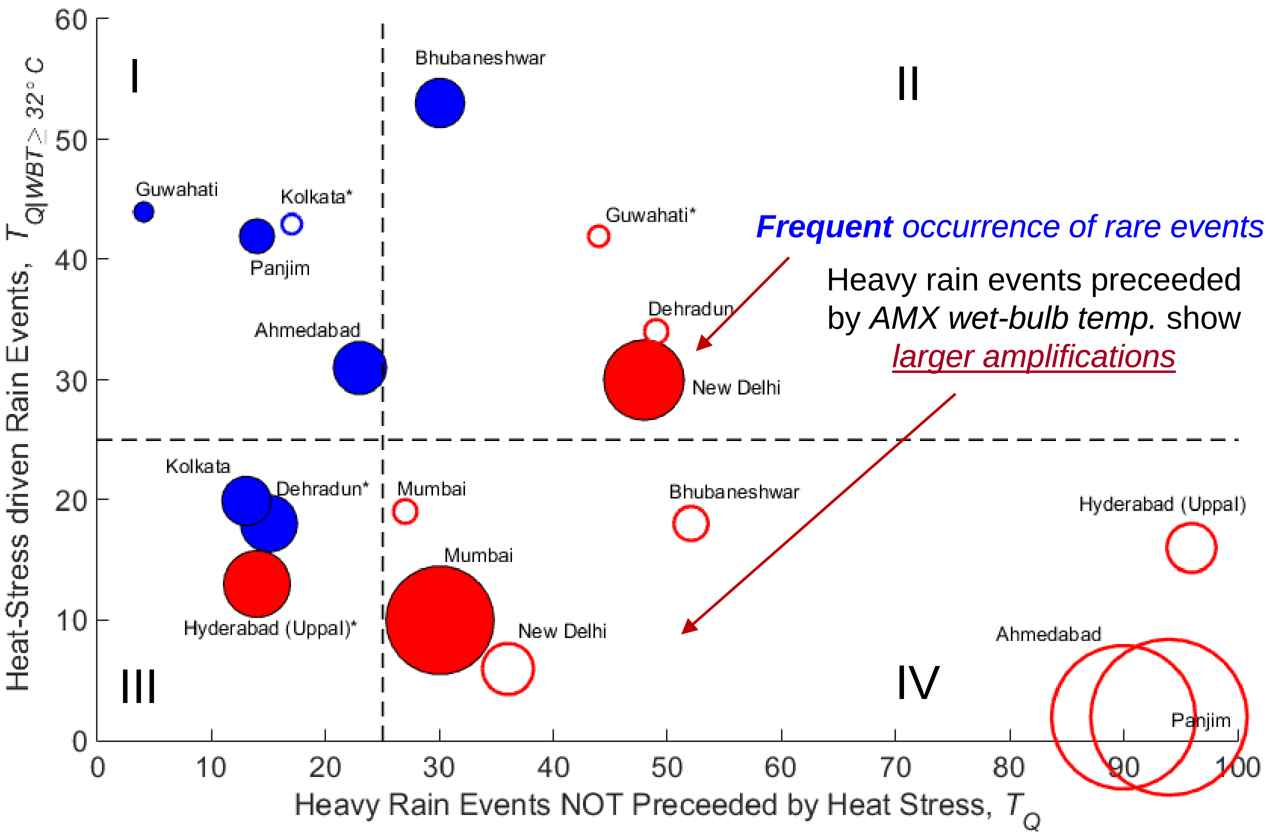
Case I: *POT 96.5p wet-bulb temp. & peak rain*

Case II: *AMX wet-bulb temp. & peak rain*



Cities at Risk

* Significant dependence, *pvalue* < 0.10



$$Amplification\ Ratio[AR] = \frac{Peak\ Rain\ Events\ Preceeded\ by\ HHS}{Peak\ Rain\ Events\ NOT\ Preceeded\ by\ HHS}$$