When do Indians feel hot?

Regional Internet Search Frequencies depict thermal discomfort

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Background

The Intergovernmental Panel on Climate Change has declared heat stress as one of the key health risks in Asia. While the majority of studies identify thresholds for the most extreme impact of heat stress – when people die - it remains unclear when people start to experience thermal (dis)comfort, which is not only a potential health hazard, but also lowers productivity, and satisfaction e.g. at home or at work. To understand how humans will react to global warming it is important to understand their ability to adapt to heat, which involves physiological, behavioural and psychological factors.

Objective

By analysing heat thresholds, i.e. location-specific outdoor temperatures at which internet users across India start searching for air conditioning (AC), and relating those to local climate, we explore whether there is a relationship between thermal discomfort and local climate, which would signal adaptation potential (e.g. through culture, clothing, housing design, cooling devices, or acclimatisation) in a warming world.

Methods

We formulated a simple mechanistic heat threshold model in R, which describes weekly Regional Internet Search Frequencies (RISF) of 'AC' as a function of temperature and a heat threshold for 2011 - 2015. A saturation function was introduced, based on the data observation that RISF peak when the threshold value is reached, but search volumes go down when it is hot for a consecutive period of time: in the meantime people might have purchased what they needed, searched for a cooling device out of an impulse trigger or may even have gotten acclimatised.

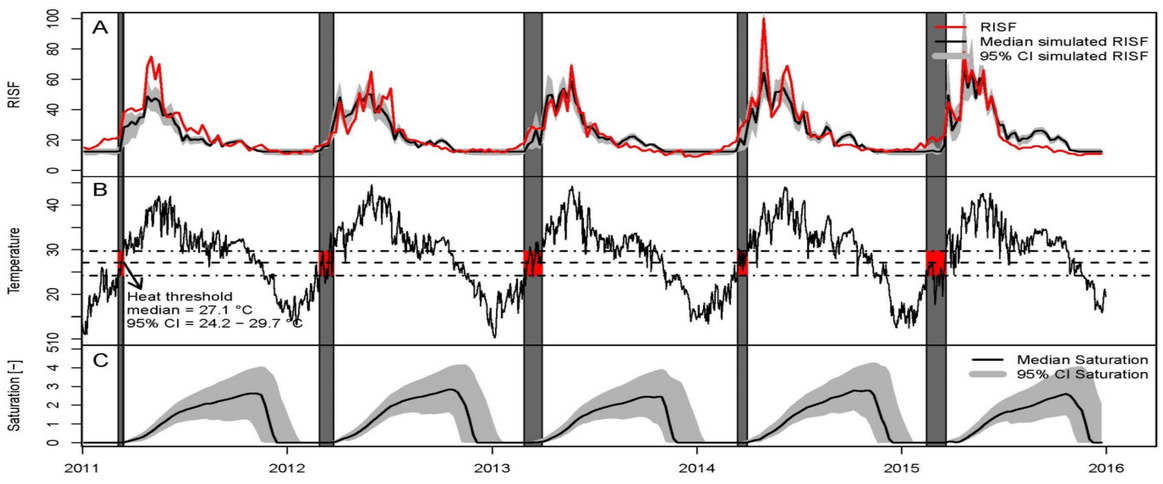

Figure 1. RISF model for Delhi. Simulated and actual RISF (A), temperature (B) and saturation function (C). The RISF unit represents a relative number of searches between 0 - 100, where 100 represents the maximum fraction of internet searches on the search term; R^2 = 0.86

Results

Simulated RISF follow actual RISF well for all states. The heat thresholds range from 25.9 °C (Madhya Pradesh) to 31.0 °C (Orissa). They tend to be higher towards the more hotter south-west when contrasted against northern states. Intra-annual temperature range (i.e. mean temperature of the warmest – coldest month) significantly predicted heat threshold in °C, β= -0.266, t (15) = -5.040, p < .001. It explained a significant proportion of variance in heat thresholds, $\boldsymbol{R^2}$ = .63, F (1, 15) = 24.182, BCa CI [-0.363, -0.212], p <.001. For each degree (°C) increase in intra-annual temperature differences the heat threshold **decreased** by 0.27 °C. Mean temperature significantly predicted heat threshold in °C, β= 1.099, t (15) = 3.467, p <.005, $\boldsymbol{R^2}$ = .45, F (1, 15) = 12.018, BCa CI [0.680, 1.768], p <.005. For each degree (°C) increase in the mean monthly temperature the heat threshold **increased** by 1.1 °C.

Conclusion

- Heat discomfort thresholds are variable across India and depend on local adaptation to the prevalent climate.
- There is potential within India to adapt to warmer temperatures, but a large intra-annual temperature range strongly reduces this potential to adapt on a short-term to hot temperature during the warmest months due to a "reset" mechanism triggered during the winter. Depending how climate change will affect not only the maximum temperatures, but also temperatures during the winter months will therefore determine human adaptability to a changing climate.
- These findings contribute to a better understanding of local heat thresholds and people's adaptive capacity, which can support the design of local thermal comfort standards and early heat warning systems and the development of projections including adaptation.

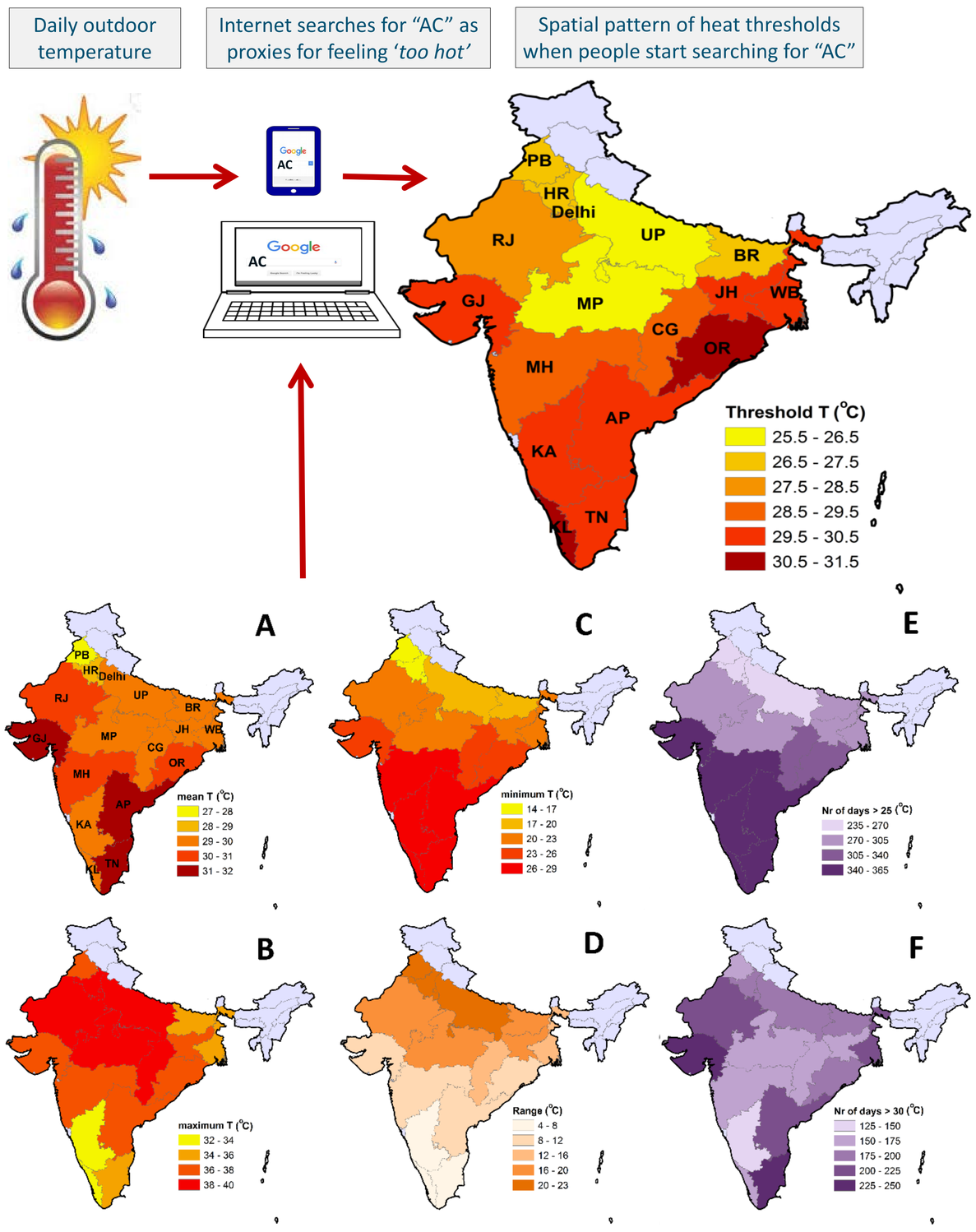

Figure 2. Graphical summary of results. The graph depicts how daily temperature (12:00 PM) and local climate drive Regional Internet Research Frequencies (RISF) for "AC" and above which heat threshold an increase in internet searches for AC across different states in India can be observed (top right graph). Mean daytime temperature (A), mean daytime temperature of the warmest (B) and coldest month (C), and the average daytime temperature difference between the warmest and coldest month (D) for India for 2011-2015 in °C; number of days (Nr of days) daytime temperature exceeds 25 °C (E) and 30 °C (F) on average within a year for 2011 - 2015.

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