Refined assessment of urban residents' exposure to extreme temperatures across the United States

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Extreme temperatures during heat and cold waves are severe health hazards for humans. Residents' exposure controls the susceptibility of the urban population to these hazards, yet the spatiotemporal population dynamics has been long overlooked in assessing the risk. In this study, we conducted comparative analysis over 16 major urban habitats under three massive heat waves and one cold wave across the contiguous United States. Incorporating WRF weather simulations with commute-adjusted population profiles, we found that the interaction between population dynamics and urban heat islands makes residents exposed to higher temperatures under extreme weather. After accounting for diurnal population movement, urban residents' exposure to heat waves is intensified by $2.0 \pm 0.8 \, ^\circ C$ (mean ± standard deviation among cities), and their exposure to cold wave is attenuated by $0.4 \pm 0.8 \, ^\circ C$. The aggravated exposure to extreme heat is more than half of the heat wave hazard (temperature anomaly $3.7 \pm 1.5 \, ^\circ C$). The underestimated exposure to extreme heat needs to be taken into serious consideration, especially in nighttime given the evident trend of observed nocturnal warming. Results suggest that the major driver for modified exposure to heat waves is the spatial temperature variability, i.e., residents' exposure is more likely to be underestimated in a spread-out city. The current release of warnings for hazardous extreme weather is usually at the weather forecast zone level, and our analysis demonstrates that such service can be improved through considering spatiotemporal population dynamics. The essential role of population dynamics should also be emphasized in temperature-related climate adaptation strategies for effective and successful interventions.