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A public database of future heat stress in 140 cities to examine the potential for heat reduction via climate-smart urban development

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Heatwaves are becoming more frequent because of climate change, and this trend is exacerbated in cities due to the urban heat island effect. With more than half of the world's population living in cities, it is essential to quantify the future evolution of heat stress and develop smart adaptation strategies to counter its impacts. This requires the capturing of fine-grained variations in heat-related hazards within the urban fabric. However, the coarse resolutions of Earth System Models makes it difficult to model urban areas explicitly. Moreover, high-resolution modelling of future climate conditions in cities is often conducted for select cities only, in very focused studies or by private companies, thus limiting the availability of its results in the public domain. Additionally, there is limited understanding of the potential of climate-smart urban development for reducing heat stress.

In the H2020 PROVIDE project, we use the urban boundary layer climate model UrbClim to generate projections of urban heat stress at a 100-meter resolution, for about 20 indicators in 140 urban centres across the world. UrbClim consists of a land surface scheme with simplified urban physics coupled to a 3-D atmospheric boundary layer module, and can represent the effect of varying land cover conditions on local climate. We consider three emission scenarios: 1) compatible with the 1.5°C goal of the Paris Agreement, 2) representative of the trend from current policies, and 3) an intermediary scenario. The forcing data corresponding to these scenarios is generated by coupling the emulator for Global Mean Temperature FaIR, with the Earth System Model emulator with spatially explicit representation MESMER. This allows us to account for uncertainties in the forcing data arising from both the response of Global Mean Temperature (GMT) to emissions, and the response of large-scale climate conditions above each city included in

the study to rising GMT.

The resulting database is integrated into the PROVIDE climate risk dashboard, an open-access and user-friendly online tool that allows visualization of global-to-local future climate impacts depending on mitigation outcomes. The dashboard also contains a module that allows its users to first select a critical heat stress level of their choice, and then get information about the emission scenarios that would enable to avoid exceeding that level in their city of interest. This more impact-centered perspective on the UrbClim results provides information on future heat stress in a way that better reflect how climate impact information is accounted for in local adaptation processes.

Furthermore, we explore the potential for urban greening plans co-developed by urban planners and city-level stakeholders to reduce heat stress by running UrbClim at very high resolution (down to 1 meter) for the cities of Lisbon (Portugal), Bodø (Norway), Islamabad (Pakistan), and Berlin (Germany). These new results will eventually also be made available in the PROVIDE climate risk dashboard. Together with the insights from the urban planners and stakeholders' needs, they offer more practical and policy-relevant insights for adaptation practitioners at the municipal level on the potential for climate-smart urban development to reduce heat stress.