HEat Robustness In relation To AGEing cities (HERITAGE) Program: First observations

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Abstract.

The HERITAGE research program intends to develop a high-tech sensing and design system aiming at detection, reduction and prevention (by monitoring and design) of urban heat-stress occurring due to ageing of built environmental settings and buildings in cities, through socio-technical solutions. This integral system will detect and forecast spatiotemporal patterns of heat stress at unprecedented resolutions (1m scale), aiming at technological solutions to reduce and mitigate indoor and outdoor heat stress through developing urban design guidelines and connecting the energy transition, housing demands, repurposing areas, climate adaptation and digitalization.

The HERITAGE system necessitates a multi-disciplinary approach involving earth observation, urban hydro-meteorology and climatology, urban design and sustainable infrastructural energy systems. Therefore, parallel to the sensing, long-term research lines are rolled out on robust hydro-meteorological, design and energy solutions, at multiple spatiotemporal scales and forms. Concretely, these research lines fill knowledge gaps in climate policies through innovative techniques for analysis, simulation, development and experimental testing of newly designed multiscale urban heritage canopy layer schemes for climate models, multiscale form-microclimatic relationships and sustainable energy systems, suited for application in aged neighborhoods and buildings.

Reflected and emitted solar and thermal radiation can be considered the main drivers for turbulent and radiative heat exchange and thus for urban heat. However, their use from remote sensing observations in urban areas is still in its infancy and rather simplistic in its modelling approach. The above-mentioned multiscale schemes and relationships will be developed in the cities of Amsterdam, Rotterdam, Eindhoven, Delft and Enschede, where we collect ground-based, air- and space-borne radiative observations and heat-exchanges at matching scales. We cover space-time resolutions from submeter to kilometer and from 100 Hz to hours, monitoring the exchange processes at the relevant scales. The observations will be employed to develop scale-dependent heat-exchange parameterizations, suitable for 3D city models at building-, street-, and neighborhood-level. In this contribution the first observations are presented.

Keywords: Urban heat, remote sensing, spatiotemporal modelling, building energy system, urban design

HEat Robustness In relation To AGEing cities (HERITAGE): First simulations

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Abstract.

Due to ongoing climate change and urbanization, societies face challenges concerning environmental quality, energy management and citizens' health. While many past observational and modelling studies concentrated on understanding urban microclimate and how humans experience this, focus has been on relatively modern infrastructure ("street canyons") regarding modelling and observational efforts which showed less success over historical districts. Many cities have a significant share of aged and historical buildings with unique and different street profiles from modern infrastructure, which raises additional challenges in the energy transition due to low energy-efficiency and restrictions to required interventions.

Within the HERITAGE research program we are developing a sensing system aiming at detection, reduction and prevention (by monitoring and design) of urban heat-stress in a realistic setting, where we aim at detecting (observations) and forecasting (simulations) spatiotemporal patterns of heat stress at resolutions down to 1 meter. This requires an observational modelling approach which ideally should utilize routinely collected urban hydro-meteorological observations and earth observation data that is operationally available. Utilizing our local urban observational infrastructure (in the city of Enschede), consisting of microwave and scintillometers, 4-component radiometer and turbulent flux (H2O, CO2 and heat) eddy-correlation sensors next to a spatially distributed urban micro-meteorological sensor network, we will develop such an approach.

Objective and generic determination of urban heat stress comes down to the determination of energy budgets. Calculating the energy budget at high resolutions depends on accurate representation building properties such as albedo, emissivity, and thermal capacity. The energy budgets relate to externally exposed thermal stresses on the human body by radiative, conductive and turbulent energy fluxes. The most relevant flux herein is the radiative flux, by emission and reflection, which can for a large part be provided by remote sensing. Future satellite missions, such as LSTM, CHIME, SBG and TRISHNA, have a more suitable temporal and spatial resolution for urban heat stress detection than current satellite constellations. Most urban climate simulations use generic values for building properties which are not representative of the realistic conditions, this gap can be bridged with inputs from remote sensing. In preparation thereof, quasi-synthetic simulations (employing the PALM4U model) of urban heat stress as experienced by humans, were performed over the city of Enschede, Netherlands to explore potential improvements. Results are shown for typically different Local Climate Zones, where use has been made of the above-mentioned observational infrastructure combined with readily available high-resolution imagery.

Keywords: Urban heat, remote sensing, spatiotemporal modelling, urban simulations