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Application of Machine Learning for spatio-temporal mapping of the air temperature in Warsaw

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Mapping the spatio-temporal distribution of near-surface urban air temperature is crucial to our understanding of climate-sensitive epidemiology, indoor-outdoor thermal comfort, urban biodiversity, and interactive impacts of climate change and urbanity. Urban-scale decision-making in face of future climatic uncertainties requires detailed information on near-surface air temperature at high spatio-temporal resolutions. However, reaching such fine resolutions cannot be currently realised by traditional observation networks, or even by regional or global climate models (Hamdi et al. 2020). Given the complexity of the processes affecting air temperature at the urban scale to the regional scale, here we apply Machine Learning (ML) algorithms, in particular, XGBoost gradient boosting method to build predictive models of near surface air temperature (Ta at 2-meter height). These predictive models establish data-driven relations between crowd-sourced measured Ta (data produced by citizens' sensors) and a set of spatial and spatio-temporal predictors, primarily derived from Earth Observation satellite data including Modis Aqua/Landsat 8 Land Surface Temperature (LST), Modis Terra vegetative indices, and Sentinel-2 water vapour product. We use our models to predict sub-daily (at Modis Aqua satellite passing times) variation in urban scale Ta in city of Warsaw, Poland at spatial resolution of 1 km for the months July-September and the years 2016 to 2021. A 10-fold cross-validation of the developed models shows a root mean square error between 0.97 and 1.02 °C and a coefficient of determination between 0.96 and 0.98, which are satisfactory according to the literature (Taheri-Shahraiyni and Sodoudi 2017). The resulting maps allow us to identify regions of Warsaw that are vulnerable to heat stress. The strength of the method used here is that it can be easily replicated in other EU cities to achieve high resolution maps due to the accessibility and open-sourced nature of the training and predictor data. Contingent on data availability, the predictive framework developed also can be used for monitoring and downscaling of other urban governing climatic parameters such as relative humidity in the context of future climate uncertainties.

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