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High Spatiotemporal Resolution Determination of the Urban Heat Island in Rome Using Satellite LST Measurements and In Situ Air Temperature Data

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Air temperature (T_a) plays a crucial role in numerous applications, including studies on physical stress conditions and understanding phenomena such as urban heat island (UHI). Due to the increasing frequency of summer heat waves caused by climate change, the UHI, which in itself leads to a significant rise in nighttime temperatures in cities, can cause extreme physical discomfort for humans, especially during these periods. These heat waves, like heavy rains and strong winds, belong to the category of extreme weather phenomena, and combined with the UHI, they can lead to critical conditions in cities during the summer. For this reason, it is necessary to study and accurately characterize the UHI phenomenon. This study employs innovative techniques to achieve this goal, also with a view to studying mitigation strategies to address increasingly critical summer conditions in cities.

T_a measurements, acquired from in situ sensors often distributed unevenly, are limited in describing the spatial temperature field pattern. On the other hand, land surface temperature measurements (LST) obtained from geostationary satellites provide a more detailed spatial overview, but represent a different variable. In this work, a method based on machine learning algorithms is presented for converting LST detected from geostationary satellites MSG, into air temperature. To perform the conversion, a gradient boosting algorithm, which is part of the tree-structured family of machine learning algorithms, was implemented. The method is applied to LST and T_a data available for the city of Rome (Italy) during the summers of 2019 and 2020. The T_a data are sourced from 17 weather stations, predominantly consisting of amateur stations whose quality has been verified. Using predictive variables such as instantaneous LST and with delays ranging from 1 to 4 hours, along with other parameters like altitude, imperviousness, land cover, tree cover, grassland, NDVI, and temporal parameters such as time of day, T_a was estimated, designated as the target variable, at points where no in situ measurement sensors are available. The T_a predicted by the model exhibits an average error of 1.2°C during the daytime and 0.8°C at night. This model output has improved the accuracy and spatial resolution of temperature pattern analysis across the city of Rome, compared to analyses based solely on in situ measurements. Furthermore, the spatiotemporal pattern of the UHI, which can now be measured at high resolution, aligns well with the expected pattern.