Mapping of Urban Micro-Climate in Lyon (France) by Integrating Complementary Predictors at Different Scales into Multiple Linear Regression Models

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Abstract : The characterizations of urban heat island (UHI) and their interactions with climate change and urban climates are the main research and public health issue, due to the increasing urbanization of the population. These solutions require a better knowledge of the UHI and micro-climate in urban areas, by combining measurements and modelling. This study is part of this topic by evaluating microclimatic conditions in dense urban areas in the Lyon Metropolitan Area (France) using a combination of data traditionally used such as topography, but also from LiDAR (Light Detection And Ranging) data, Landsat 8 satellite observation and Sentinel and ground measurements by bike. These bicycle-dependent weather data collections are used to build the database of the variable to be modelled, the air temperature, over Lyon's hyper-center. This study aims to model the air temperature, measured during 6 mobile campaigns in Lyon in clear weather, using multiple linear regressions based on 33 explanatory variables. They are of various categories such as meteorological parameters from remote sensing, topographic variables, vegetation indices, the presence of water, humidity, bare soil, buildings, radiation, urban morphology or proximity and density to various land uses (water surfaces, vegetation, bare soil, etc.). The acquisition sources are multiple and come from the Landsat 8 and Sentinel satellites, LiDAR points, and cartographic products downloaded from an open data platform in Greater Lyon. Regarding the presence of low, medium, and high vegetation, the presence of buildings and ground, several buffers close to these factors were tested (5, 10, 20, 25, 50, 100, 200 and 500m). The buffers with the best linear correlations with air temperature for ground are 5m around the measurement points, for low and medium vegetation, and for building 50m and for high vegetation is 100m. The explanatory model of the dependent variable is obtained by multiple linear regression of the remaining explanatory variables (Pearson correlation matrix with a $|r| < 0.7$ and VIF with < 5) by integrating a stepwise sorting algorithm. Moreover, holdout cross-validation is performed, due to its ability to detect over-fitting of multiple regression, although multiple regression provides internal validation and randomization (80% training, 20% testing). Multiple linear regression explained, on average, 72% of the variance for the study days, with an average RMSE of only 0.20°C. The impact on the model of surface temperature in the estimation of air temperature is the most important variable. Other variables are recurrent such as distance to subway stations, distance to water areas, NDVI, digital elevation model, sky view factor, average vegetation density, or building density. Changing urban morphology influences the city's thermal patterns. The thermal atmosphere in dense urban areas can only be analysed on a microscale to be able to consider the local impact of trees, streets, and buildings. There is currently no network of fixed weather stations sufficiently deployed in central Lyon and most major urban areas. Therefore, it is necessary to use mobile measurements, followed by modelling to characterize the city's multiple thermal environments.