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Towards an Effective Approach for Modelling near Surface Air Temperature Combining Weather and Satellite Data

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Abstract : The urban environment affects local-to-global climate and, in turn, suffers global warming phenomena, with worrying impacts on human well-being, health, social and economic activities. Physic-morphological features of the built-up space affect urban air temperature, locally, causing the urban environment to be warmer compared to surrounding rural. This occurrence, typically known as the Urban Heat Island (UHI), is normally assessed by means of air temperature from fixed weather stations and/or traverse observations or based on remotely sensed Land Surface Temperatures (LST). The information provided by ground weather stations is key for assessing local air temperature. However, the spatial coverage is normally limited due to low density and uneven distribution of the stations. Although different interpolation techniques such as Inverse Distance Weighting (IDW), Ordinary Kriging (OK), or Multiple Linear Regression (MLR) are used to estimate air temperature from observed points, such an approach may not effectively reflect the real climatic conditions of an interpolated point. Quantifying local UHI for extensive areas based on weather stations' observations only is not practicable. Alternatively, the use of thermal remote sensing has been widely investigated based on LST. Data from Landsat, ASTER, or MODIS have been extensively used. Indeed, LST has an indirect but significant influence on air temperatures. However, high-resolution near-surface air temperature (NSAT) is currently difficult to retrieve. Here we have experimented Geographically Weighted Regression (GWR) as an effective approach to enable NSAT estimation by accounting for spatial non-stationarity of the phenomenon. The model combines on-site measurements of air temperature, from fixed weather stations and satellite-derived LST. The approach is structured upon two main steps. First, a GWR model has been set to estimate NSAT at low resolution, by combining air temperature from discrete observations retrieved by weather stations (dependent variable) and the LST from satellite observations (predictor). At this step, MODIS data, from Terra satellite, at 1 kilometer of spatial resolution have been employed. Two time periods are considered according to satellite revisit period, i.e. 10:30 am and 9:30 pm. Afterward, the results have been downscaled at 30 meters of spatial resolution by setting a GWR model between the previously retrieved near-surface air temperature (dependent variable), the multispectral information as provided by the Landsat mission, in particular the albedo, and Digital Elevation Model (DEM) from the Shuttle Radar Topography Mission (SRTM), both at 30 meters. Albedo and DEM are now the predictors. The area under investigation is the Metropolitan City of Milan, which covers an area of approximately 1,575 km2 and encompasses a population of over 3 million inhabitants. Both models, low- (1 km) and high-resolution (30 meters), have been validated according to a cross-validation that relies on indicators such as R2, Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE). All the employed indicators give evidence of highly efficient models. In addition, an alternative network of weather stations, available for the City of Milano only, has been employed for testing the accuracy of the predicted temperatures, giving and RMSE of 0.6 and 0.7 for daytime and night-time, respectively.

Keywords : urban climate, urban heat island, geographically weighted regression, remote sensing
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