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A cost-efficient method for deriving spatially continuous urban air temperatures using Landsat 8 and open land use - land cover data

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We present a cost-efficient method for retrieving spatially continuous air temperature information in urban environments. The study area is the middle-sized coastal city of Turku in SW Finland (60°27'N, 22°16'E, 190 000 inhabitants). Landsat 8 thermal band 10 data from July, August, October and December in 2015 were used to extract the land surface temperature (LST) for each pixel. For calculating the LST, an accurate atmospheric and emissivity correction for different land use–land cover (LULC) types will be necessary. Two open source LULC classifications were employed for retrieving the emissivity information: 1) CORINE (Coordination of Information on the Environment), which is a Europe-wide nationally produced LULC classification with 48 classes and 20 m spatial resolution, and 2) SLICES (Separated Land Use/Land Cover Information System), which is a Finnish national classification incorporating 46 classes and 10 m grid size. The emissivity values for different LULC classes were assigned with the aid of MODIS and ASTER emissivity libraries. The Landsat thermal data were resampled to match the SLICES and CORINE grids of 10 and 20 m grid size, respectively. The Landsat-based LST information was retrieved by applying the atmospheric correction and the emissivity correction for all existing LULC classes to the satellite-derived blackbody radiation.

The extracted satellite based, emissivity corrected LSTs were compared with simultaneous in situ air temperature observations by the Turku Urban Climate Research Group (TURCLIM) of the Department of Geography and Geology at the University of Turku. The network consists of 75 Hobo U23-001 Pro T/RH data loggers at 3-meter elevation, and three Vaisala MAWS automatic weather stations.

Seasonally, the results indicate statistically a very significant correlation during summer months (July, August). In October, the correlation was significant, while in December, the correlation between the Landsat-based LST and air temperature at 3 m elevation was non-significant.

Spatially, relatively high surface and air temperatures were found near public buildings and on asphalt roads whereas the coolest places were among or near vegetation and water bodies. These results emphasize the importance of green spaces and green infrastructure in relieving extreme high temperatures by evapotranspiration and latent heat.

Our results demonstrate that it is possible to reliably estimate air temperatures from remote sensing data at least during summer months if LULC data are available for emissivity corrections. The Finnish national SLICES data were found better suited for studying urban environments than the European CORINE as SLICES has more urban classes for emissivity correction compared to CORINE, which has more rural classes.