A Cost-efficient Method for Deriving Spatially Continuous Urban Air Temperatures using Landsat 8 and Open LULC data

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Main findings

- **We produced a model for resolving high spatial resolution urban air temperatures (AT) with the aid of openly available remotely sensed surface temperatures (ST) and land use / land cover (LULC) data**
- **The approach allows estimating urban temperature distribution in the absence of in-situ observations**
- **The model accuracy is at its best during summer months, with R^2 of 0.33**

Introduction

The availability of consistent air temperature (AT) data is fundamental for studying urban climates. Traditionally, these data are collected using in situ devices with the limitations of discontinuous spatial coverage and high expense. Resolving continuous AT through remotely sensed (RS) land surface temperature (LST) using thermal infra-red band would be a viable approach. There are, however, challenges in resolving accurate RS-based air temperatures, such as the availability of suitable thermal data and land cover information for accurate surface emissivity assessment. The current study provides a reliable approach for resolving air temperature. Our study area is the coastal city of Turku (60°27′N 022°16′E) on the SW coast of Finland (Figure 1).

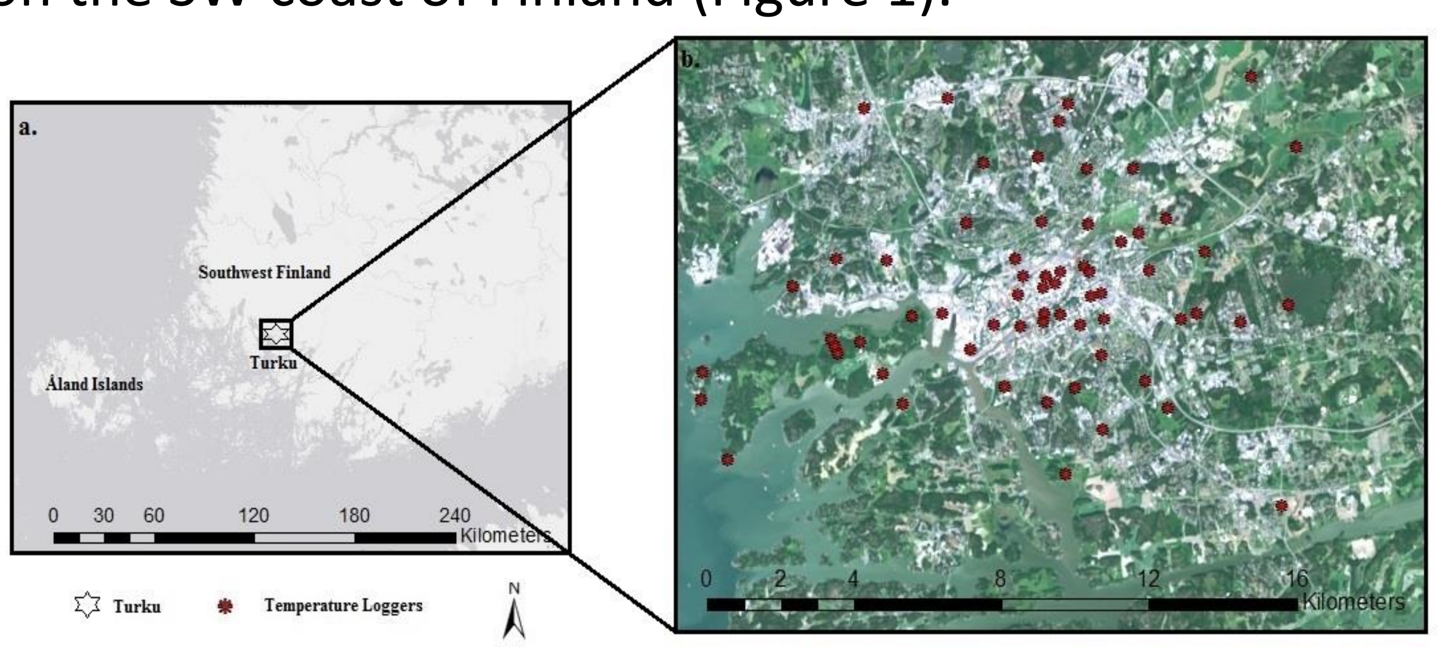

Fig. 1: *The study area in southwest Finland. (a) Turku city with the extensive archipelago. (b) Landsat 8 image of 3 July 2015 (RGB band combination 4 3 2) with red asterisks indicating the air temperature logger sites. Coordinate system EUREF-FIN- TM35FIN.*

Objectives

- To build a model for predicting high spatial resolution urban air temperatures with the aid of remotely sensed surface temperatures.
- To compare different land use / land cover data (CORINE and SLICES) in their ability to offer accurate emission values for extracting reliable land surface temperature.

Data and methods

The data included Landsat 8 band 10 data for different seasons of 2015, plus CORINE (2012) and SLICES (2010) LULC data. Emissivity data were generated by assigning the emissivity values from MODIS and ASTER spectral libraries for different land cover types. LSTs were extracted after atmospheric and emissivity correction of Landsat 8 band 10 using radiative transfer equation. The reference data consisted of in-situ air temperature measurements from the Turku Urban Climate Research Group (TURCLIM) logger network. LSTs were compared with TURCLIM using Spearman's rank correlation and ATs were resolved using linear regression model.

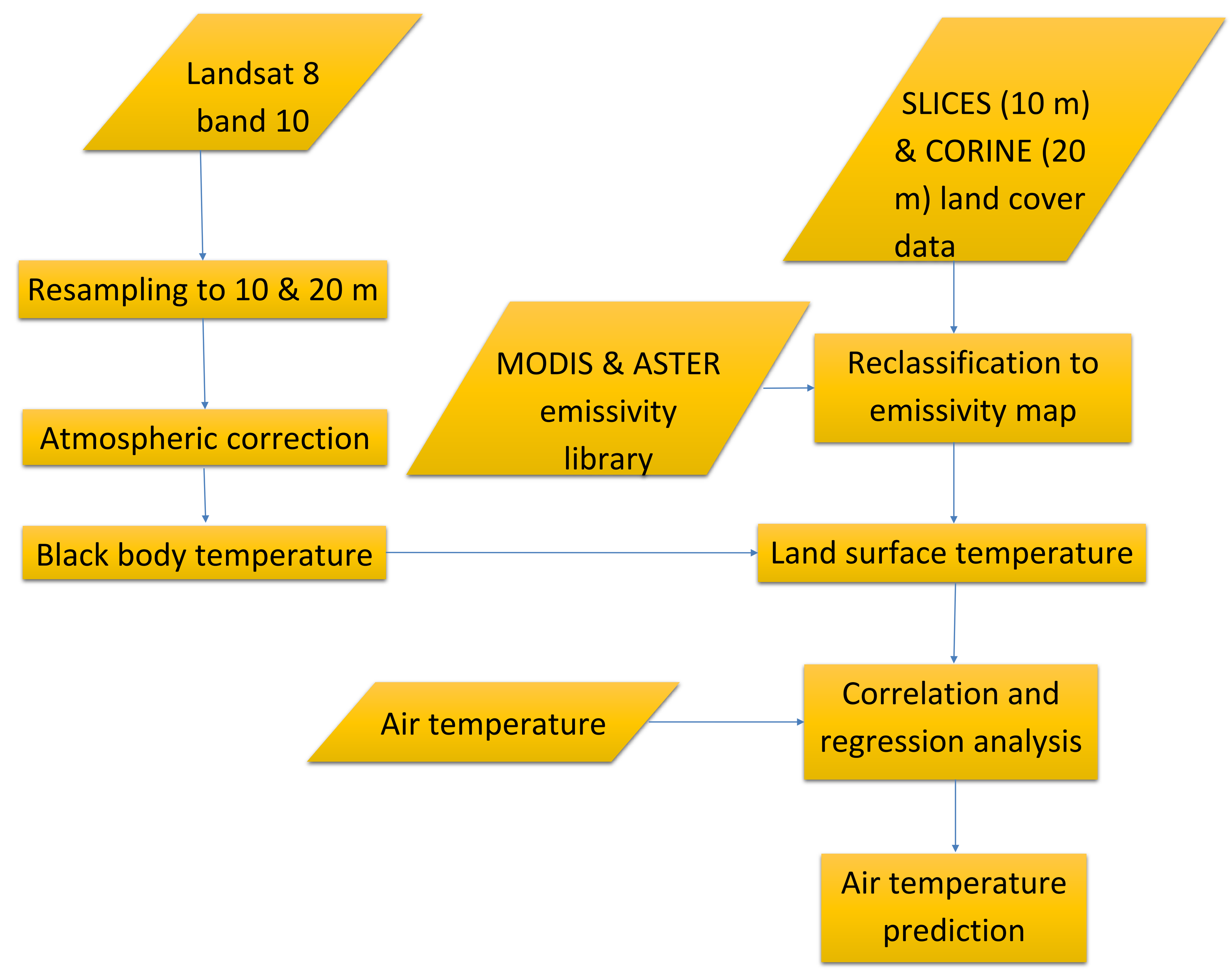

Fig. 2: *Schematic diagram presenting the research flow.*

Results

Significant correlation between observed air temperatures and remotely sensed surface temperatures was detected during summer season (in July and August, correlation coefficients 0.49 and 0.44, respectively [n = 61]). In October, the correlation was significant (0.398, n = 62), while in December, the correlation between LST and air temperature at 3 m elevation was non-significant (0.147). Linear regression showed an R^2 of 0.33 in July and 0.28 in August. In fall and winter, the R^2 was somewhat lower: 0.20 in October and 0.04 in December. Urban heat island hotspots were observed in disperse pattern in urban areas.

SLICES data offered somewhat more accurate estimates for temperature than CORINE, due to better spatial resolution and more appropriate classification. Relatively high surface and air temperatures were found at densely built areas and paved surfaces, whereas the coolest places were among or near vegetation and water bodies.

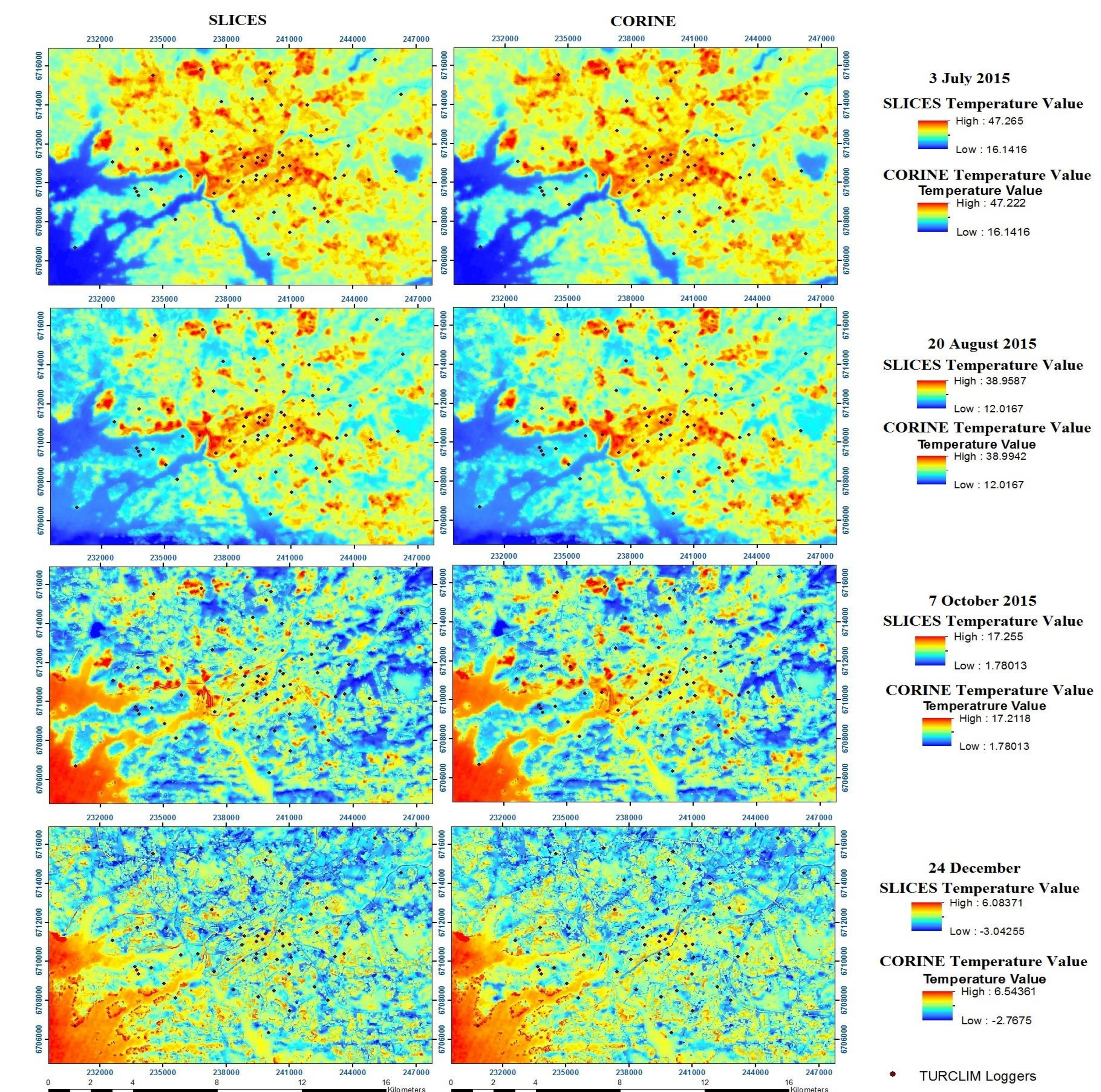

Fig. 3: *Landsat 8 band 10 (10.60-11.19 µm) derived land surface temperatures for different seasons using emissivity values based on SLICES land use data (left column) and CORINE land cover data (right column).*

Conclusions

This research demonstrates that it is possible to reliably estimate urban air temperatures using open remote sensing data. The importance of green spaces and green infrastructure in relieving extreme high temperatures by evapotranspiration and latent heat is demonstrated by the relatively cool temperatures among vegetation and near water bodies.

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