Downscaling urban Land Surface Temperature variations across different land cover types using high-resolution satellite imagery

Liliia Hebryn Baidy & Gareth Rees
Scott Polar Research Institute, University of Cambridge

Figure 1. Panorama Tromsø, Norway was taken by Gareth Rees during ASSW 2022

Introduction

Over the past fifty years, anthropogenic influences have caused an increase in global temperatures that exceeds natural fluctuations. To mitigate the effect of UHI, it is necessary to thoroughly study the factors influencing the interaction of solar radiation with urban surfaces. The rise in climate change and urbanization demands an in-depth analysis of heat stress in cities. Using high-resolution satellite imagery allows detailed downscaling of LST variations in urban settings across different land cover types, providing critical data on LULC changes and surface urban heat island effects.

Objective

The aim of this research is to apply a methodology for calculating urban LST by integrating a solar radiation model with a digital surface model (DSM) derived from LiDAR data. By utilizing high-resolution satellite imagery, we seek to downscale LST variations across different land cover types within urban environments in the high-latitude urban environment of Tromsø, Norway.

Methodology

The Heat Balance Equation based on the Stefan-Boltzmann Law and Newton`s iteration method constructed the downscale LST (d LST).
Random Forest algorithm, based on PCA, was used for LULC classification.
Linear regression models to estimate the relationship between dLST and Landsat-based LST.

Data & software

DSM from LiDAR data 25 cm (Høydedata)
Planet Scope 3 m
Landsat 8 dataset 30 m
Google Earth Engine
ArcGis Pro, Raster Solar Radiation Tool

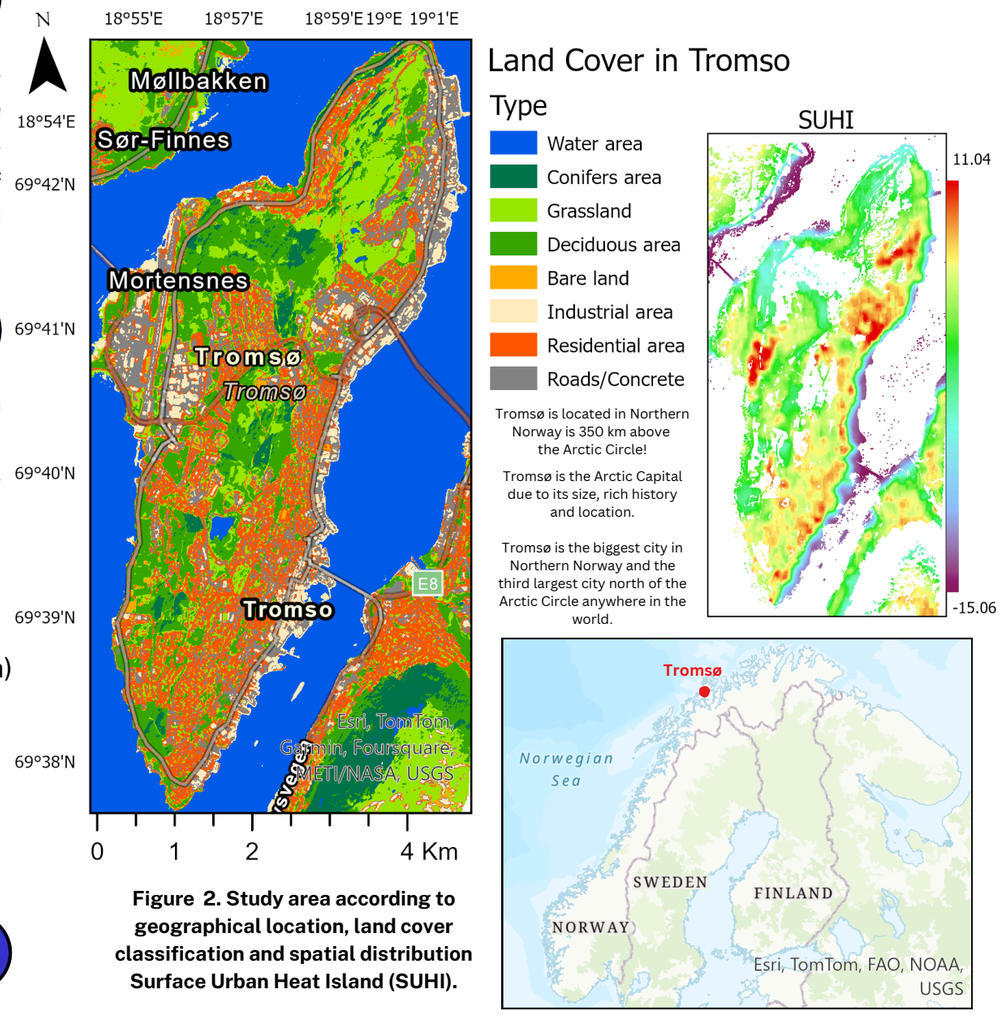
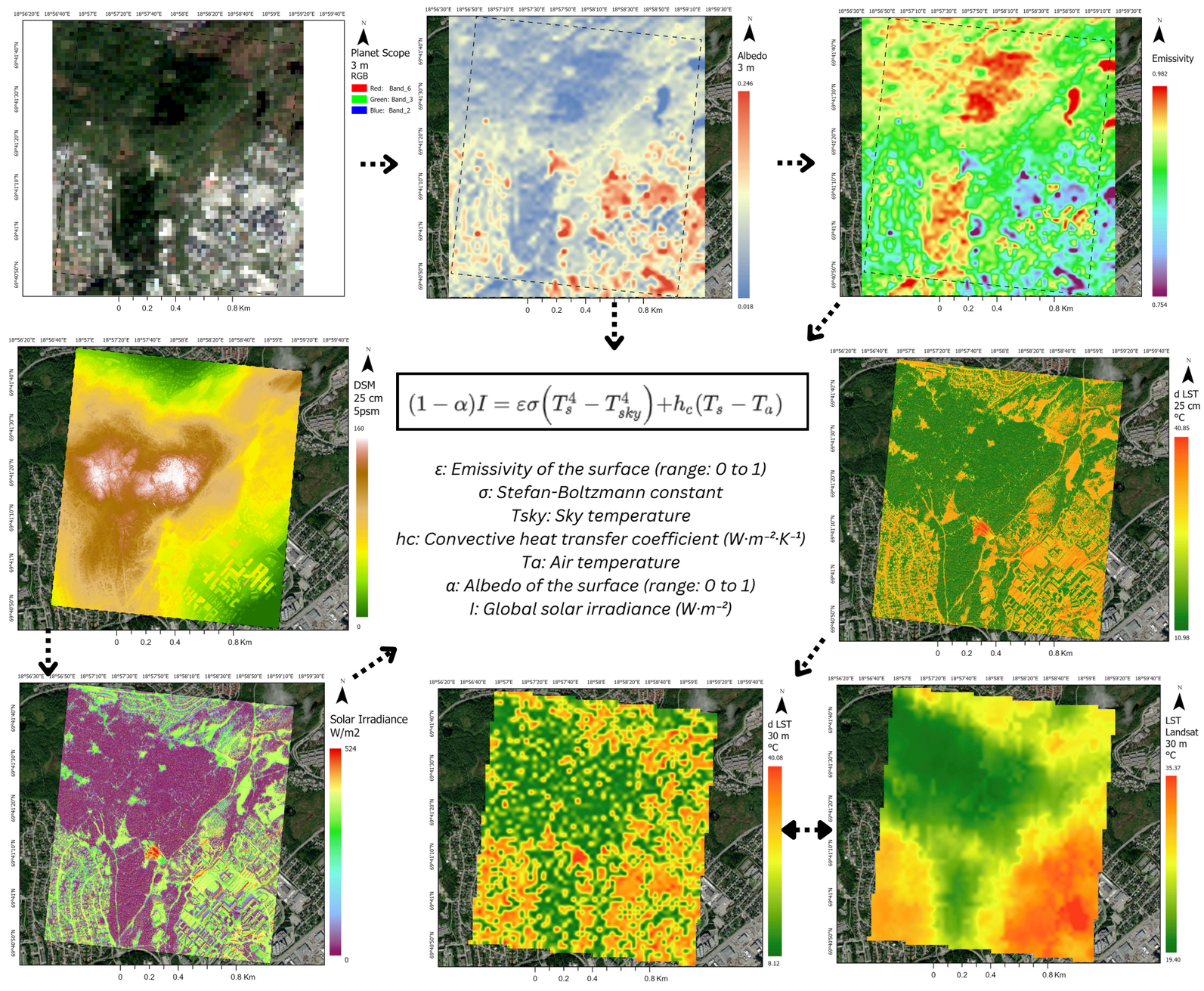
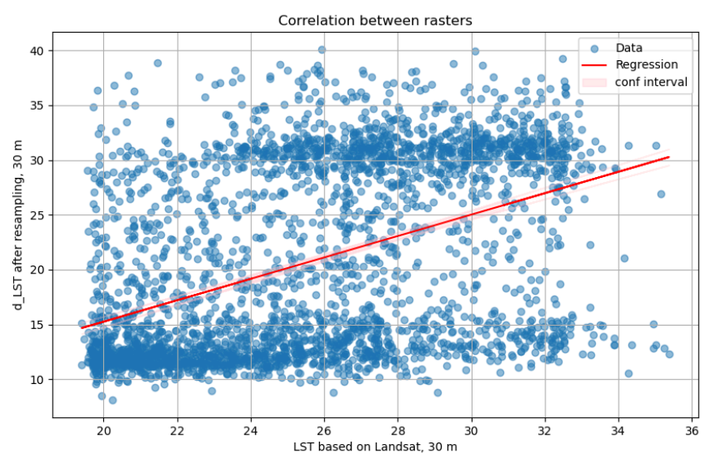


Figure 2. Study area according to geographical location, land cover classification and spatial distribution Surface Urban Heat Island (SUHI).



Conclusions / Limits / Futher research

LST modeling is crucial for analyzing UHIs, especially in complex urban environments like high-latitude cities. In this research, we applied a methodology to calculate urban LST by integrating a solar radiation model with a DSM derived from LiDAR data in Tromsø, Norway. Utilizing high-resolution satellite imagery allowed us to downscale LST variations across different land cover types within the urban environment.
Limitations of our study include the uncertainty of input variables such as convective heat transfer coefficients, as well as the failure to account for the accumulated heat flux in urban surface materials, which may affect the accuracy of the model.
Future research should focus on validating our results with ground-based studies.



y=−4.2771+0.9766x
R: 0.44, R²: 0.19

N = 3095
P>|t| [0.025;0.975]

REFERENCE

- Hofierka, J., Gallay, M., Onačillová, K., Hofierka, J. Physically-based land surface temperature modeling in urban areas using a 3-D city model and multispectral satellite data, Urban Climate, 31, 2020. https://doi.org/10.1016/j.uclim.2019.100566.

we will be happy to answer all your questions lh825@cam.ac.uk