Impact of green roofs on surface urban heat island using random forest regression: A case study in Liege, Belgium

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Introduction

Abundance of impervious surfaces like building roofs in the densely populated cities makes green roofs a suitable solution for surface urban heat island (UHI) mitigation. Here, we employ random forest (RF) regression approach to identify the impact of green roofs on the surface UHI in Liege, Belgium. Figure 1 shows the study area. Figure 2 describes the methodology used in the study.

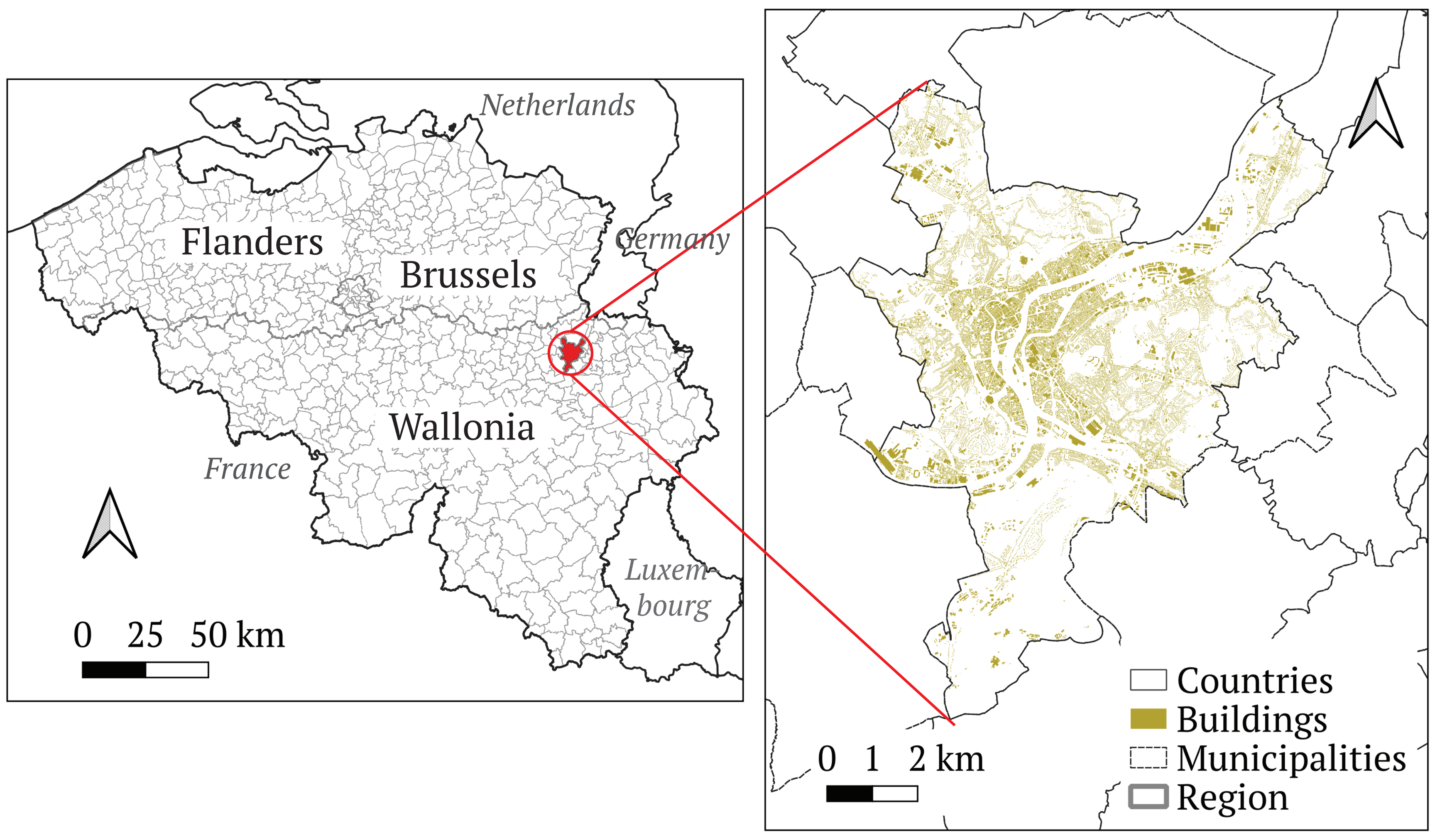

Figure 1. Study area, Liege, Belgium

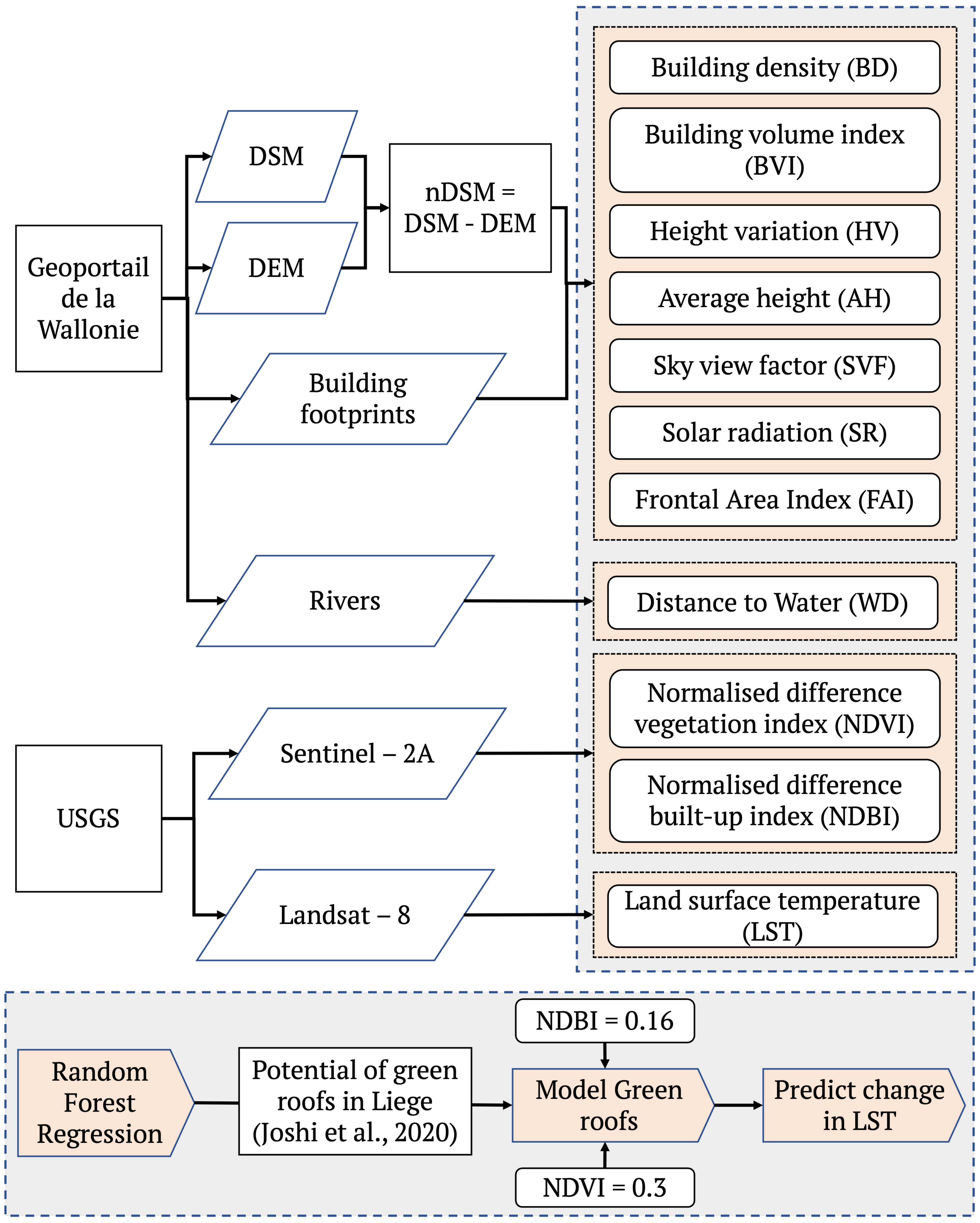

Figure 2. Methodology

Results

- We tuned the hyperparameters of number of trees (*ntree*) and maximum features to consider at every split (*mtry*) to optimize the model based on root mean squared errror (RMSE) (Figure 3).
- Optimized model observed at mtry = 5 and ntree = 5000.
- Figure 4 indicates the feature importance of variables in the model.

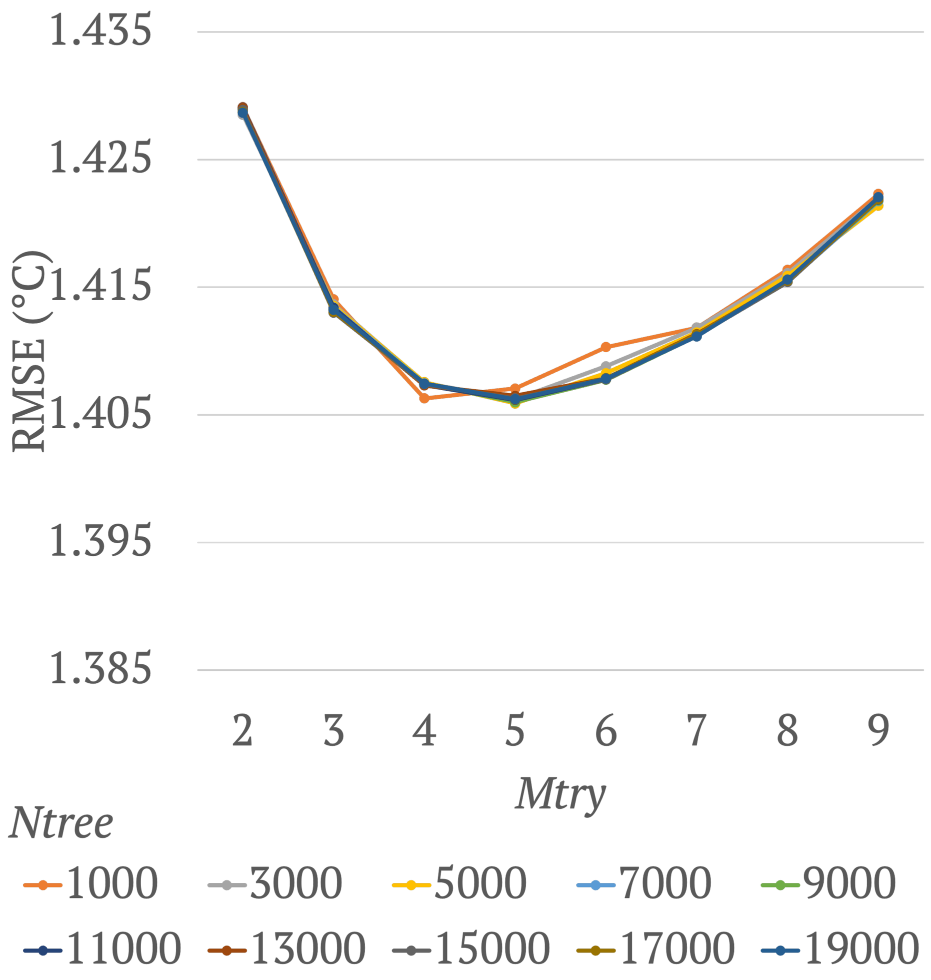

Figure 3. Optimisation of hyperparameters

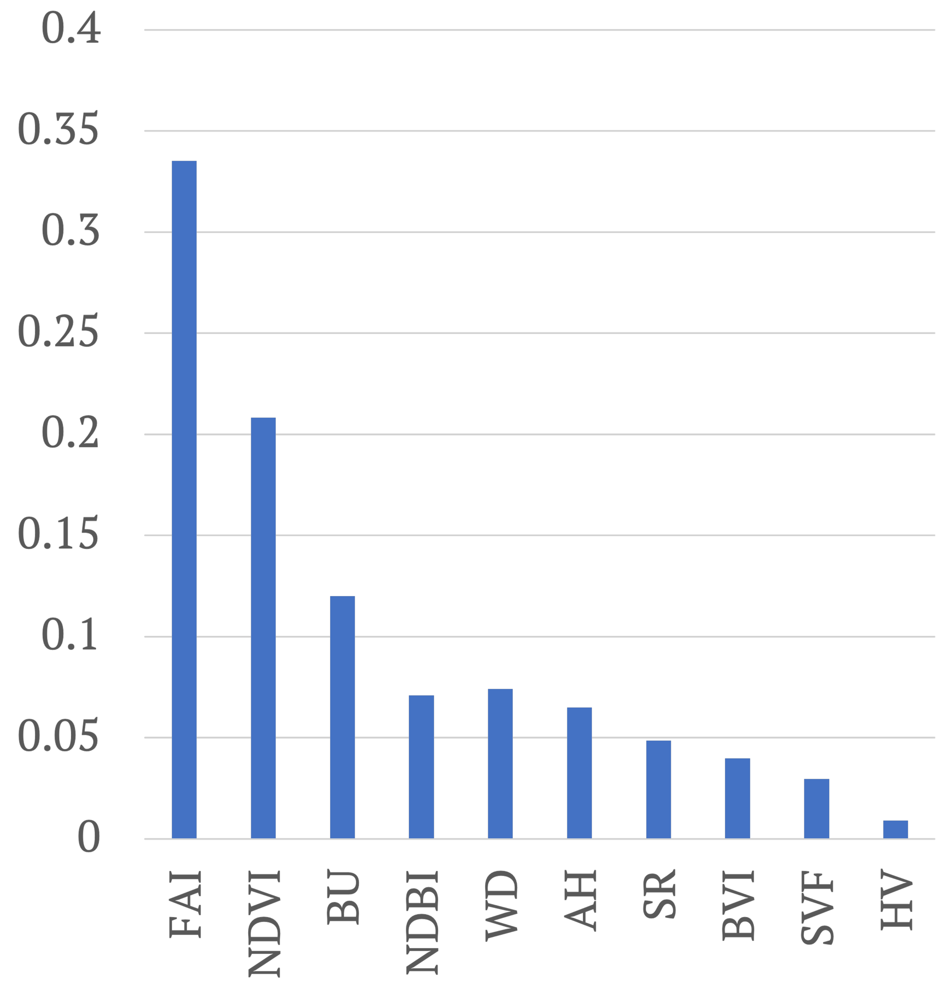

Figure 4. Variable importance

Prediction

- LST range has narrowed from 16.42 – 35.7 °C to 17.5 – 28.68 °C.
- Maximum LST reduced from 35.7 °C to 28.7 °C, the average LST of Liege reduced by 0.5 °C from 24.07 °C to 23.47 °C. (Figure 5)
- Most pixels in the city had LST greater than 26 °C before green roofs. After introducing green roofs, the pixels of LST that were greater than 26 °C are reduced considerably (Figure 6).
- However, the minimum value of LST has increased by 1 °C, indicating the need for improvement in the model

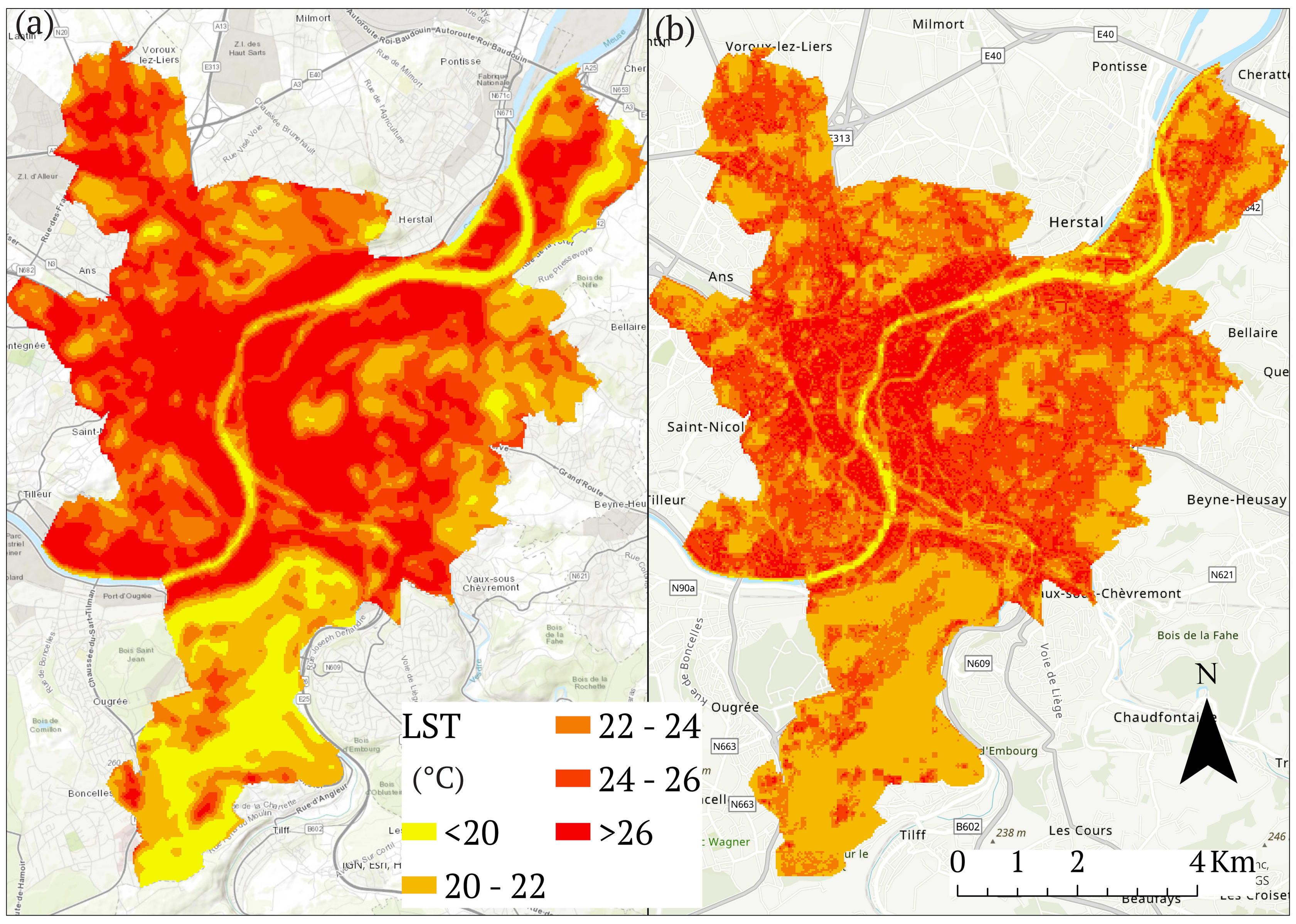

Figure 5. Spatial variation of LST (a) before green roofs (b) after green roofs

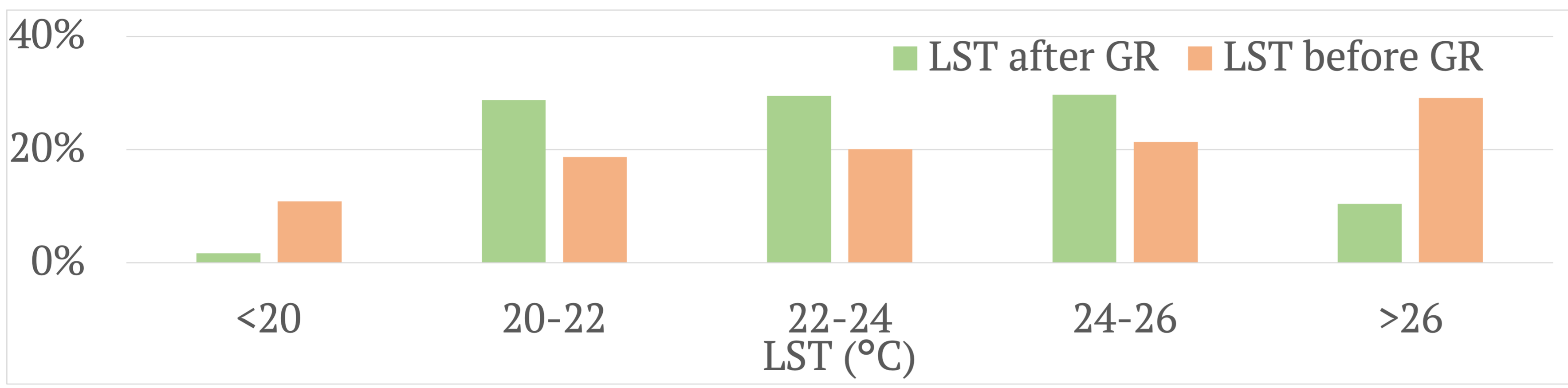

Figure 6. Distribution of proportion of pixels in LST ranges

Data Processing

We compute all the layers at 30 m spatial resolution.

- For BD, BVI, AH, and HV building height is obtained from nDSM, followed by transforming the layers to raster, with 1 m spatial resolution. Subsequently, we aggregated the rasters by summing, averaging or using standard deviation to 30 m resolution.
- For computing SVF, we use Relief Visualisation Toolbox of QGIS 3 (Kokalj & Somrak, 2019; Zakšek et al., 2011), with search radius of 100m and 16 directions (Dirksen et al., 2019).
- We use solar radiation tool of ArcGIS to calculate SR.
- We compute FAI using the methodology of H. Li et al. (2021). The method involves rasterization of the building height and area and computing the FAI at 100 m resolution. The FAI is only calculated for northerly/easterly winds.

Conclusions and further research

- Model suggests reduction of LST after adding green roofs to potential roofs in Liege.
- Model needs further tuning considering trise in LST in some regions that were cooler before.
- Additional parameters such as surface albedo and energy balance of the surfaces can enhance the analysis.

References

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