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Biophysical Parameters

Vegetation & Urban Indices for Urban Heat Island Analysis

Analysis & Modelling (Remote Sensing)
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Outline

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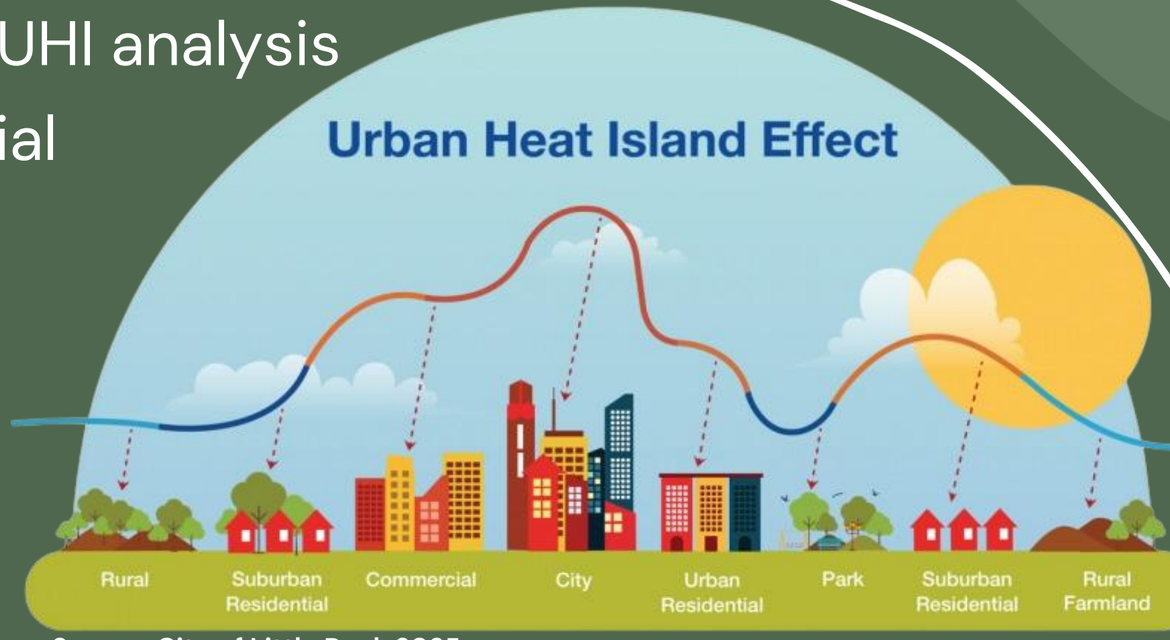
Introduction

Urban Heat Islands (UHIs): Higher temperatures in urban areas compared to surrounding rural areas

→ Driven by surface properties
→ Biophysical parameters as measures for UHI analysis
→ Remote Sensing provides extensive spatial coverage & temporal monitoring



Source: City of Little Rock,2025

Vegetation Biophysical Indices

1. Normalized Difference Vegetation Index (**NDVI**)

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

2. Soil-adjusted Vegetation Index (**SAVI**)

$$SAVI = \frac{NIR - Red}{NIR + Red + L} * (1 + L)$$

Additional Vegetation Indices: Greenness, Leaf Area Index (LAI)

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Urban Biophysical Indices

1. Normalized Difference Built-Up Index (**NDBI**)

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

2. **Albedo**

$$\propto_{short} = 0.356 \propto_1 + 0.130 \propto_3 + 0.373 \propto_4 + 0.085 \propto_5 + 0.072 \propto_7 - 0.0018$$

Additional Urban Indices: Dry Built-Up Index (DBI), Normalized Difference Bareness Index (NDBaI)

Land Surface Temperature (LST)

- Use of **thermal infrared bands** (e.g. Landsat 8 – band 10)
- Acquiring images with low atmospheric water vapor content

Methods: Radiative transfer equation, single window algorithm, split window algorithm

→ based on Planck blackbody radiation formula

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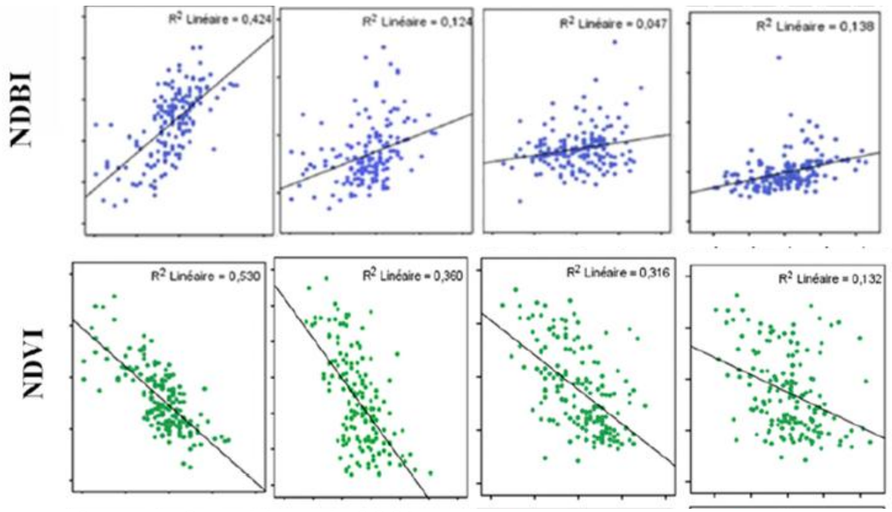
Correlation between LST & Biophysical Indices

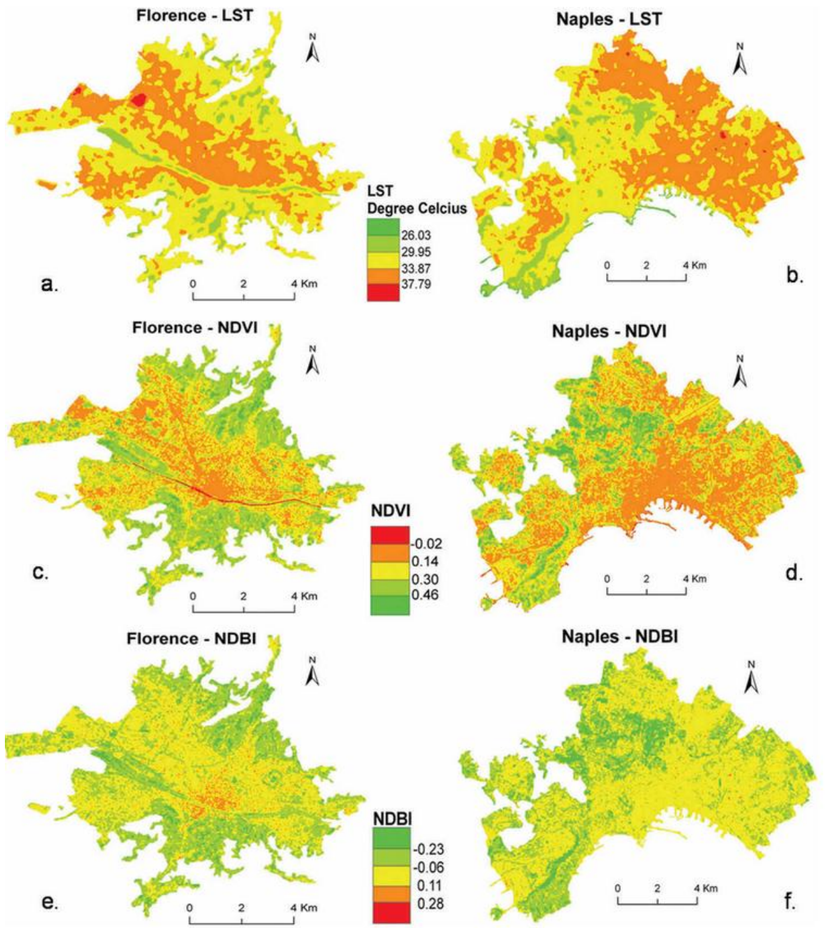
→ **Negative** correlation between LST & vegetation biophysical indices

→ **Positive** correlation between LST & urban biophysical indices



Source: Guechi et al., 2021

Correlation between LST & biophysical indices in Guelma, Algeria



Biophysical parameters for Florence & Naples for July 2016

Source: Guha et al., 2018

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Hands-on

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Research Questions

1. What is the **spatial distribution of LST** across **Vienna** & how can it be used to identify UHIs?
2. What is the **relationship** between urban & vegetation biophysical parameters and LST in Vienna?
3. How does LST correlate with **NDVI** and **NDBI**?

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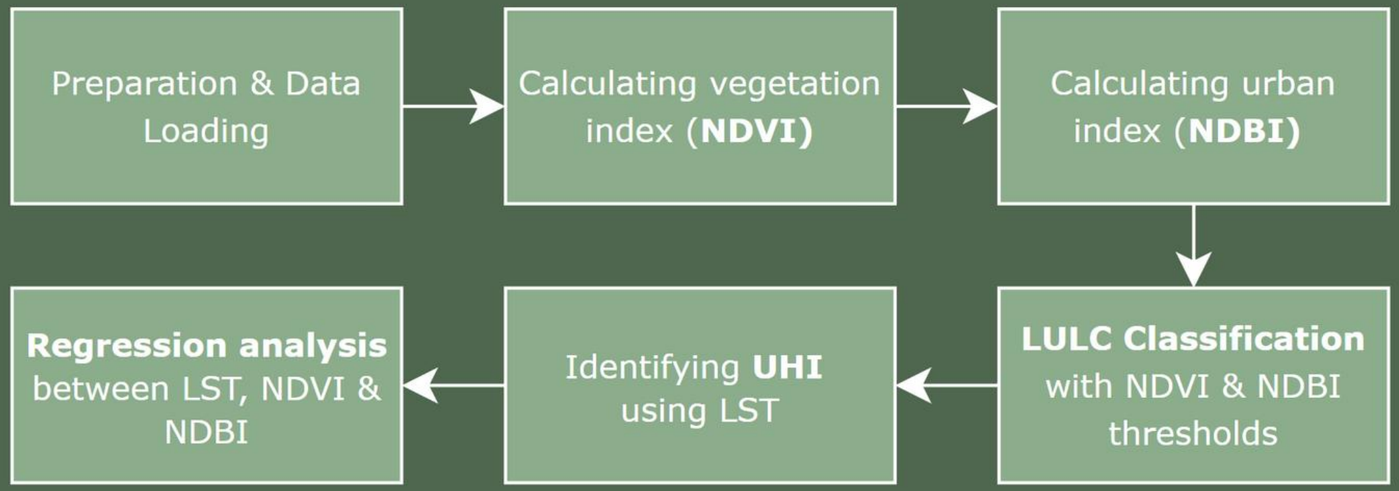
Data

Landsat Collection 2 Level-2

- Landsat 9 OLI (Surface Reflectance)
- Landsat 9 TIRS (Surface Temperature in K)

→ Acquisition date: 27.07.2024

Methodology



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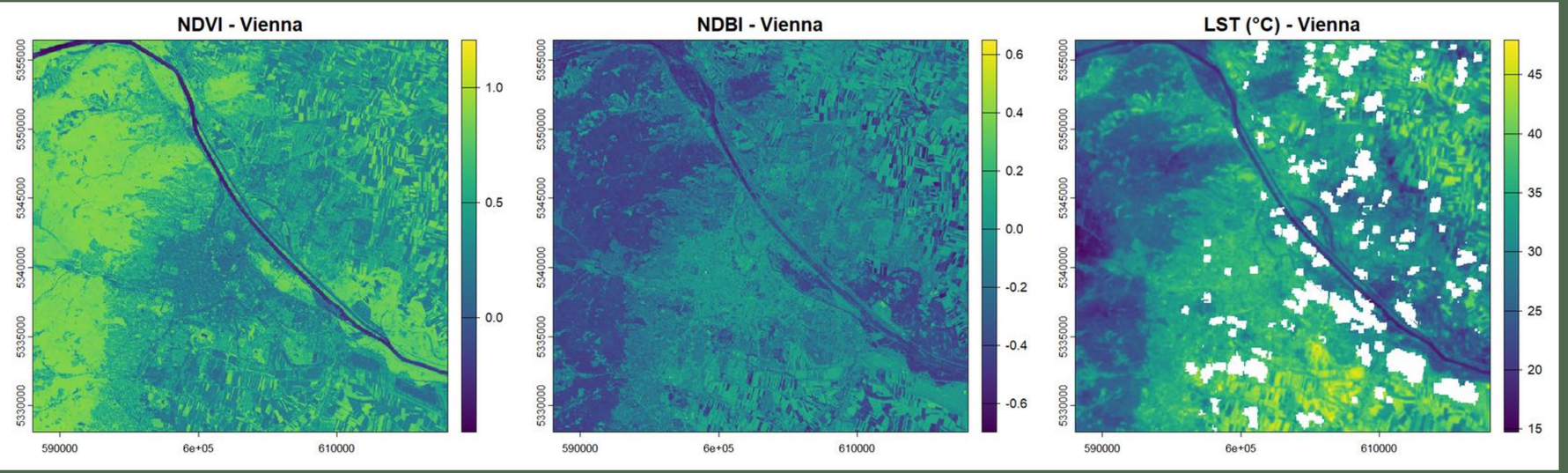
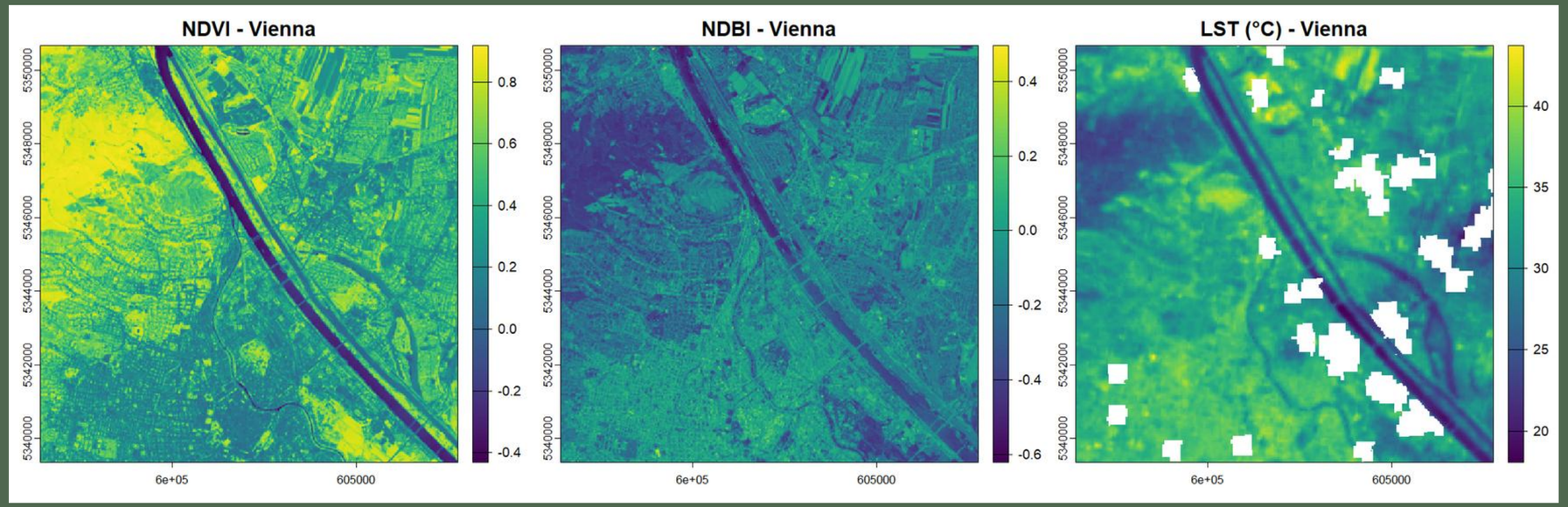
Results

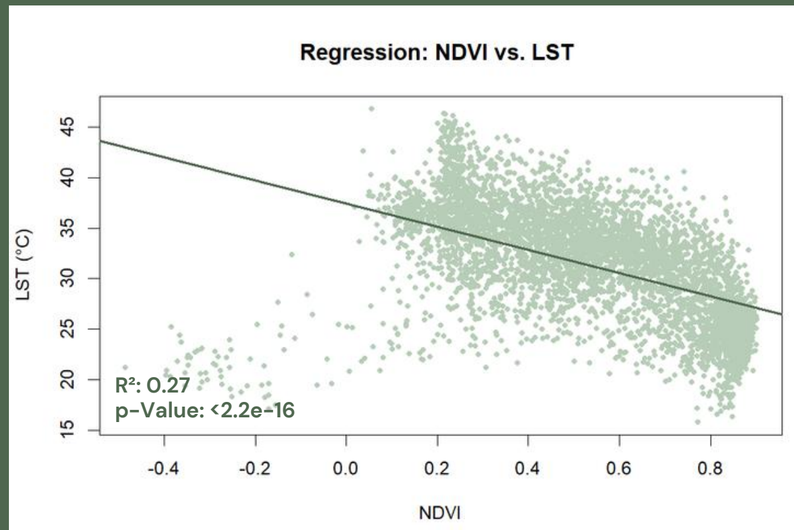


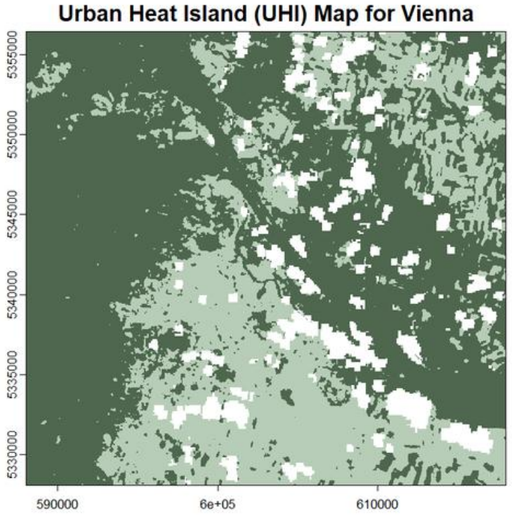
Urban Area Analysis

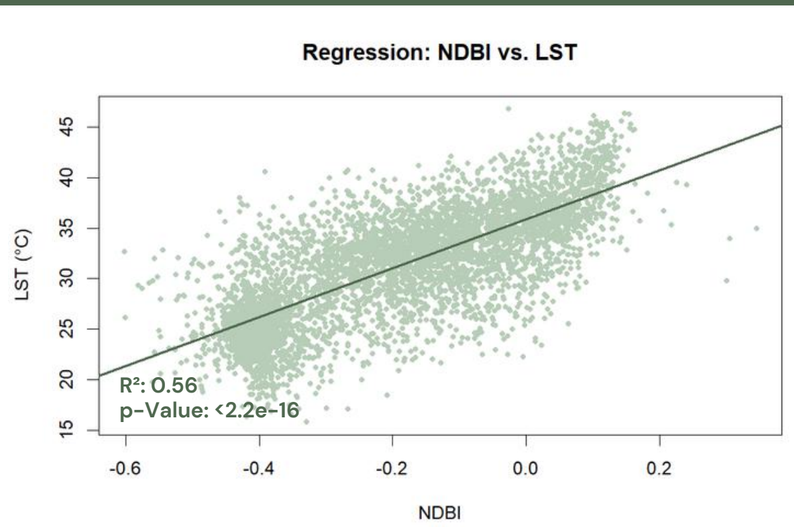


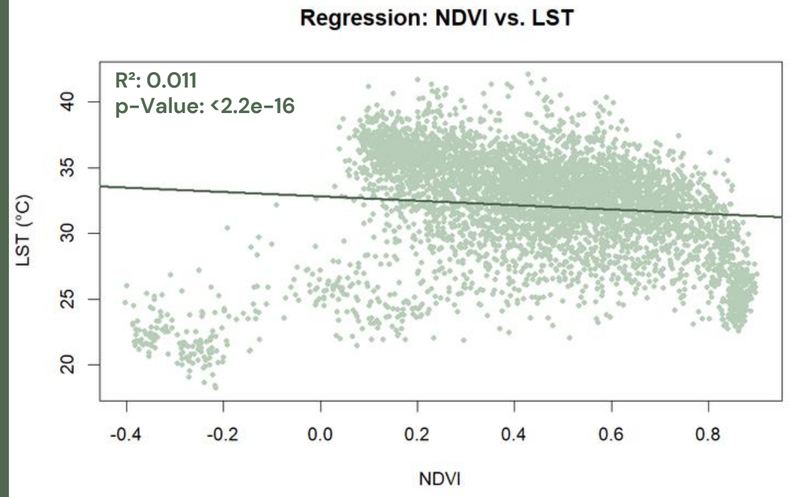
Citywide Analysis

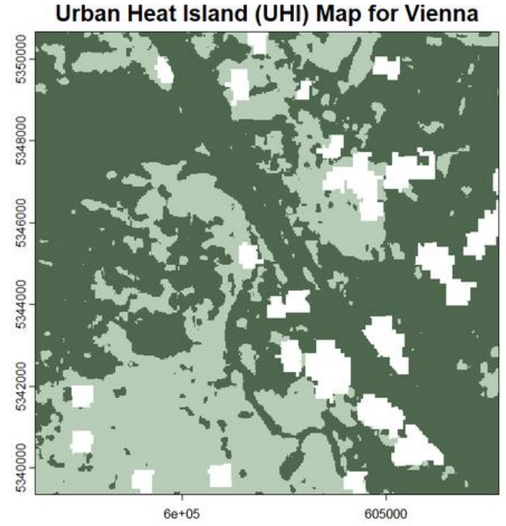
Results

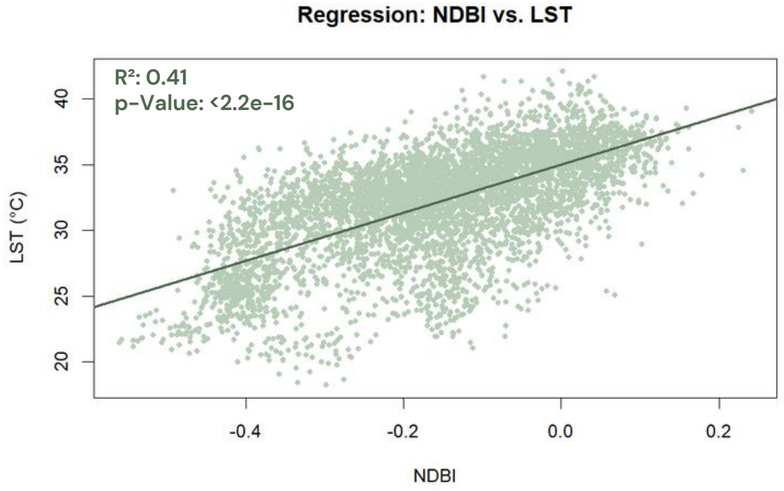

Regression: NDVI vs. LST
LST (°C)
NDVI
R²: 0.27
p-Value: <2.2e-16


Urban Heat Island (UHI) Map for Vienna


Regression: NDBI vs. LST
LST (°C)
NDBI
R²: 0.56
p-Value: <2.2e-16


Regression: NDVI vs. LST
LST (°C)
NDVI
R²: 0.011
p-Value: <2.2e-16


Urban Heat Island (UHI) Map for Vienna


Regression: NDBI vs. LST
LST (°C)
NDBI
R²: 0.41
p-Value: <2.2e-16

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Conclusion & Outlook

- Biophysical parameters provide valuable insights into UHI by analyzing correlation between indices & LST
- Detect spatial pattern of urban heat distribution effectively

Limitations: Inaccuracies due to varying land cover types, spatial scales & sensor limitations

→ Incorporating advanced approaches such as neighboring pixels analysis & OBIA

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Thank you for your attention!