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Introduction

Urban Heat Islands are a phenomena where the temperature within a city is significantly higher within an urban area, compared to the temperature of the surrounding rural area.

- **Goal:** Detection of UHIs using Remote Sensing Satellite Data
- **Why** Measure impact of different factors over time
 - land cover change
 - temperature change
- **Output** Output factors and Indices of these factors on UHI severity and size

Urban Heat Islands

- **Urban Heat Islands (UHIs)** → surface and air temperature within a city is higher than the average temperature of the surrounding
- **Consequences** → Major health impact, increased pollution, reduced well-being
- **Measuring** → Remote Sensing data and local weather station measurements

Processing Chain

The Image Processing Pipeline can be separated in these steps:

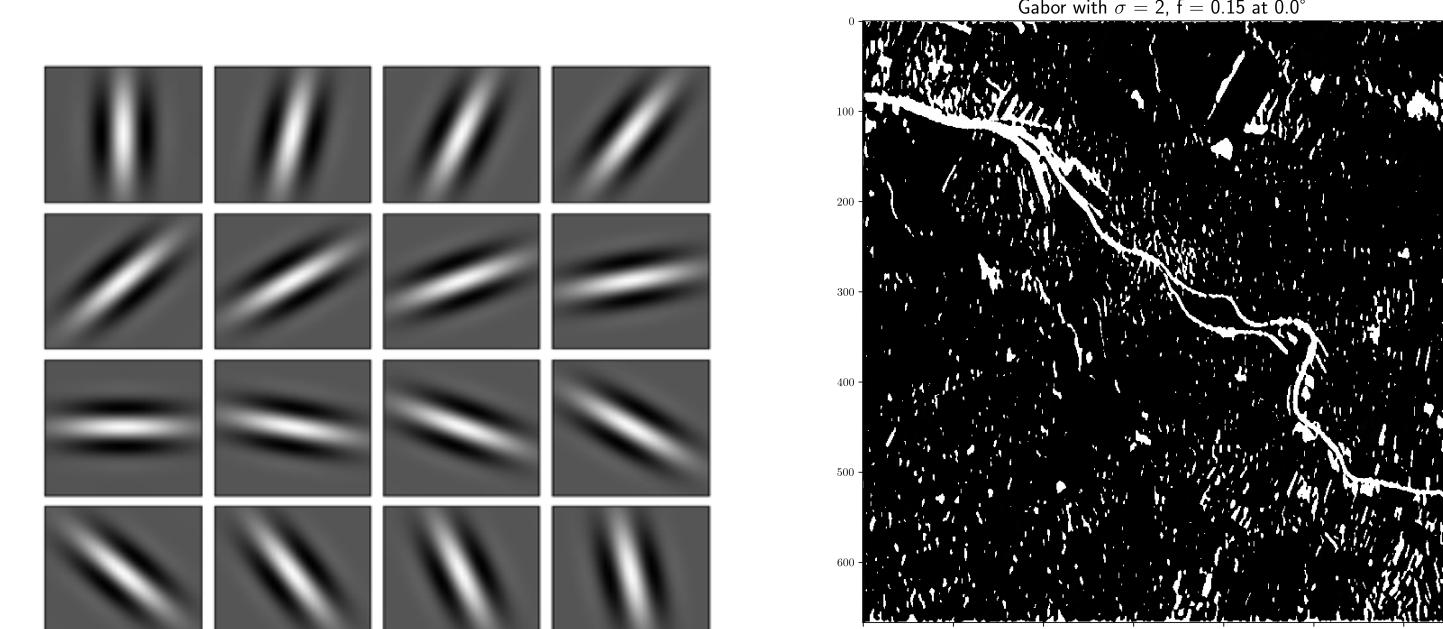
1. **Preprocessing** Cutting the image area to the Area of Interested
2. **Feature Engineering** A Gabor filter bank of rotated Gabor kernels is used to enrich pixels with information about their place in larger structures of the image
3. **Image Classification** The pixels are classified using a random forest machine learning model that was trained using k-means based classification.
4. **Urban Area Detection** Classes indicating Urban Areas are identified and the buffer zones are built up around the areas to calculate a reference temperature.
5. **Peri-Urban Area Clean-up** Larger settlement structures are masked away in the surrounding areas
6. **Detection of Urban Heat Islands** use thermal infrared channels to detect UHIs within the Urban Area
7. **Statistical Analysis of UHIs** Pixel within the UHI are evaluated using land surface type, NDVI and NDBI indices
8. **Timeline Creation** Repetition of the pipeline for different images of the same area over multiple years:
 - change in size of UHIs
 - statistical composition of UHIs
9. **Climate Change Impact** Estimation of the impact of rising average temperatures:
 - subtracting impact of metrological factors on size and intensity of UHIs
 - subtracting impact of surface change on size and intensity of UHIs
10. **Result** Correlating of UHI with climate and land use change

Feature Engineering

For adding information of surrounding larger scale structures to each pixels, for each image band the same bank of Gabor-filters was used.

- **Gabor filter** → convolution of a sinusoid and a gaussian.
- **parameter variation** σ of gaussian, ν , λ and ϕ of sine
- **Output** Detection of patterns, structures and textures in different orientations and sizes
- **Additional information** one binary marker if pixel is part of larger structure

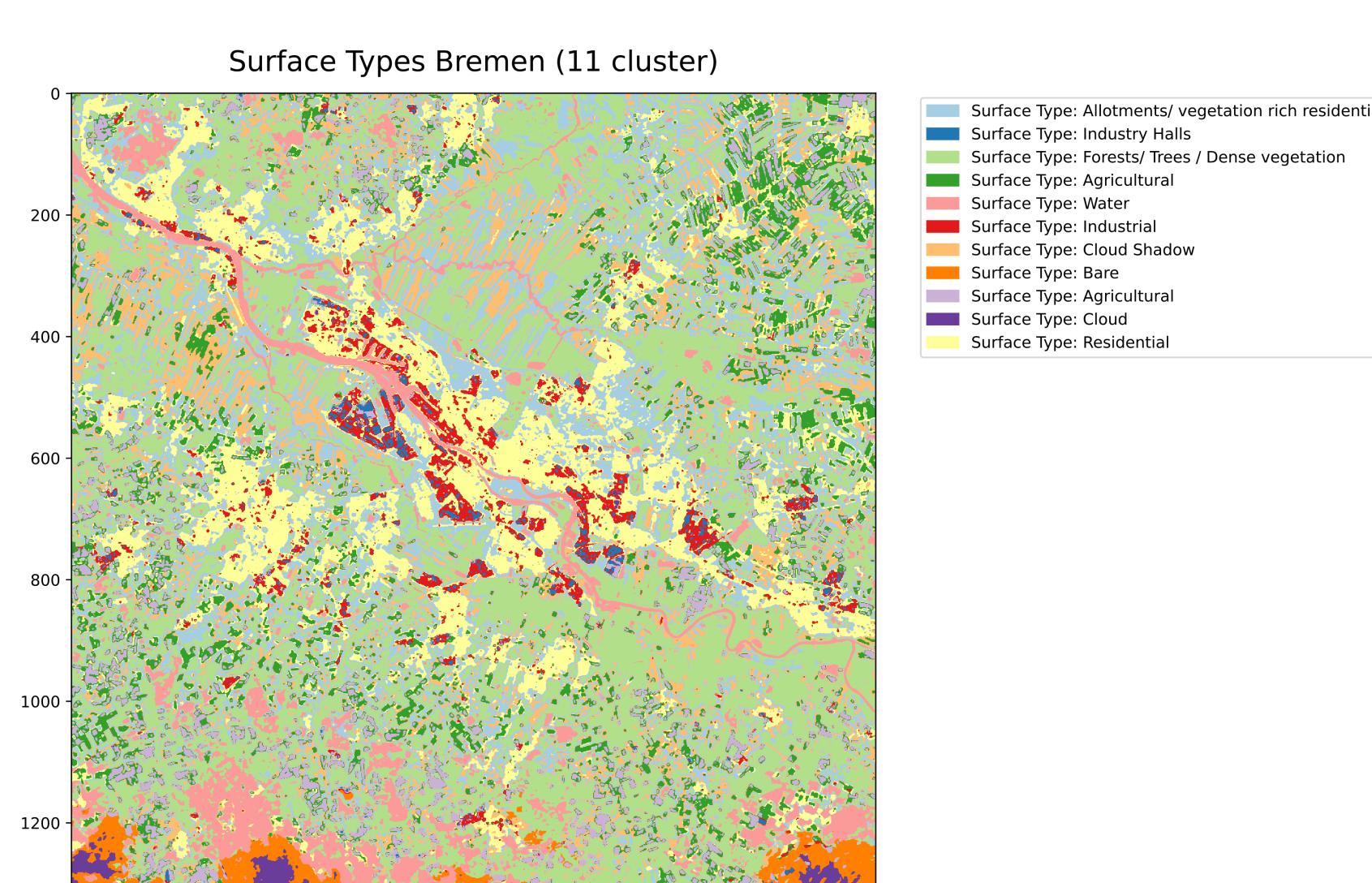
The filter used in fig. 1b was rotated 5 times. Increasing the data from 8 color bands to 144 color and feature bands.



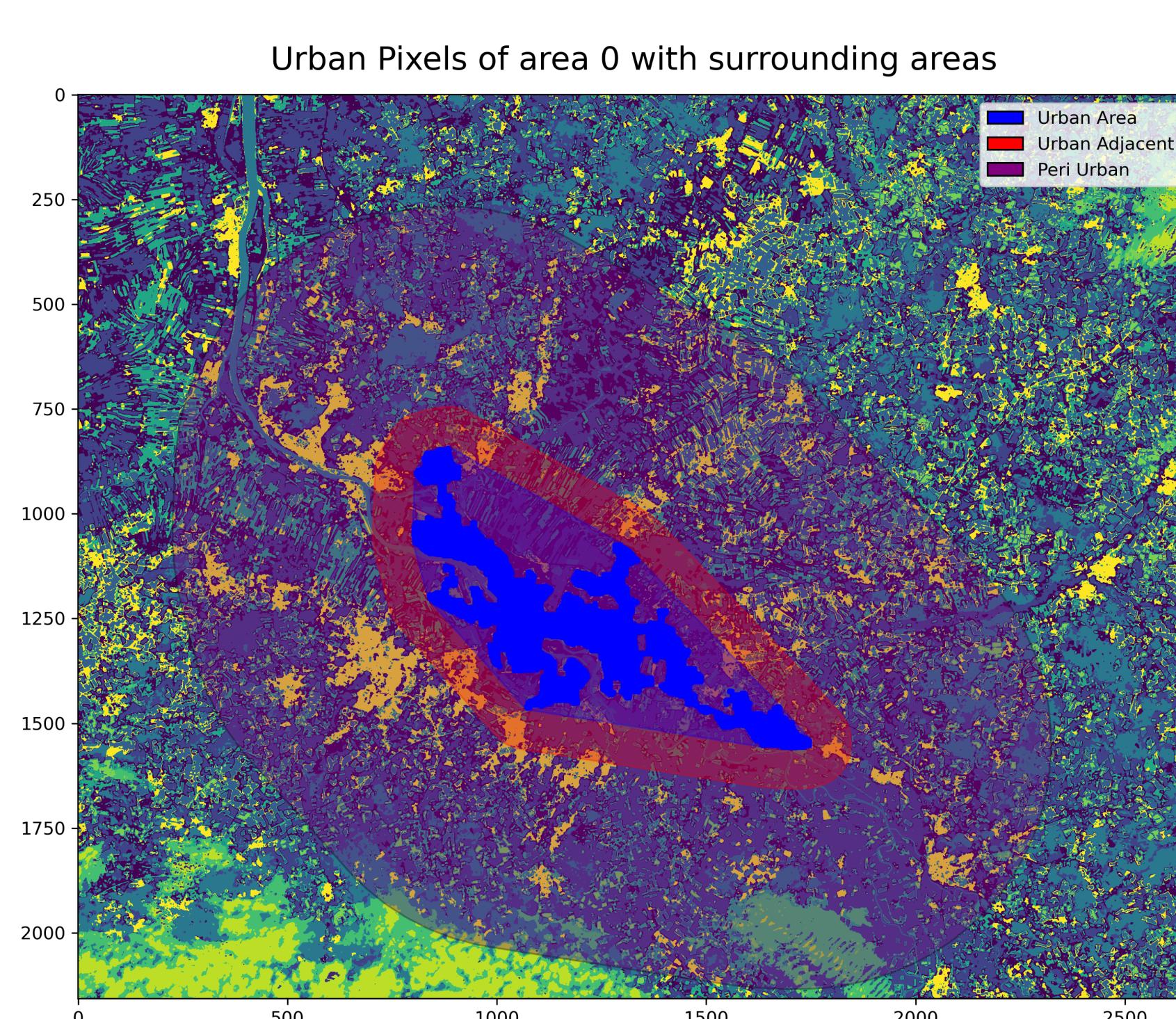
(a) Example filter bank of 16 rotated Gabor-kernels [Sha18] (b) Features extracted from an image of the city of Bremen

Surface Classification

Using K means the surface classes seen in fig. 2a were determined.



(a) Surface type classification of Bremen and the surrounding area



(b) Bremen urban area and the rural buffer zones

The Urban pixels were merged into a urban area with buffer and suburban zones (fig. 2b).

UHI Detection

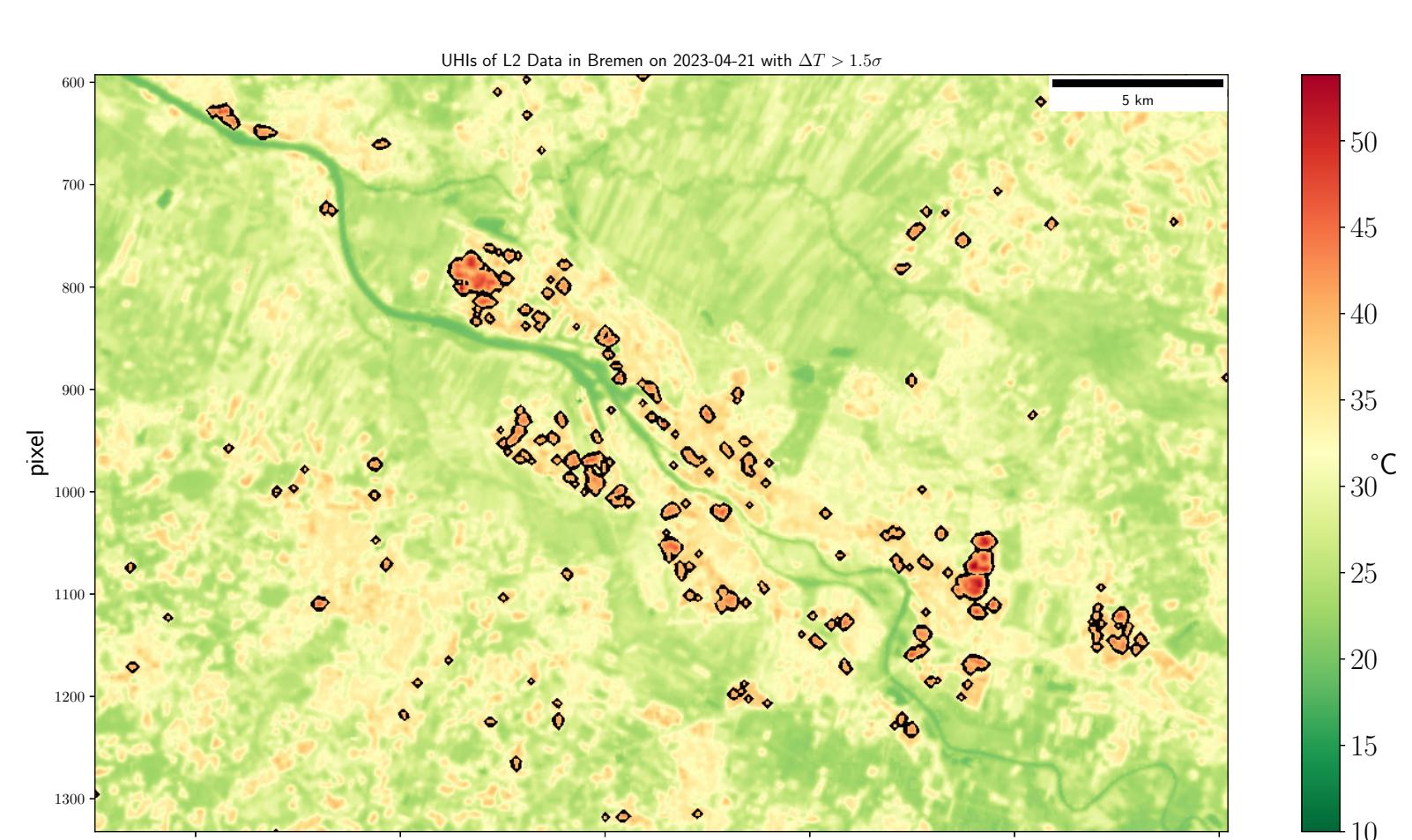


Figure 3. Urban Heat Islands detected in Bremen (more than 1.5 σ above average temp)

Analysis and Results

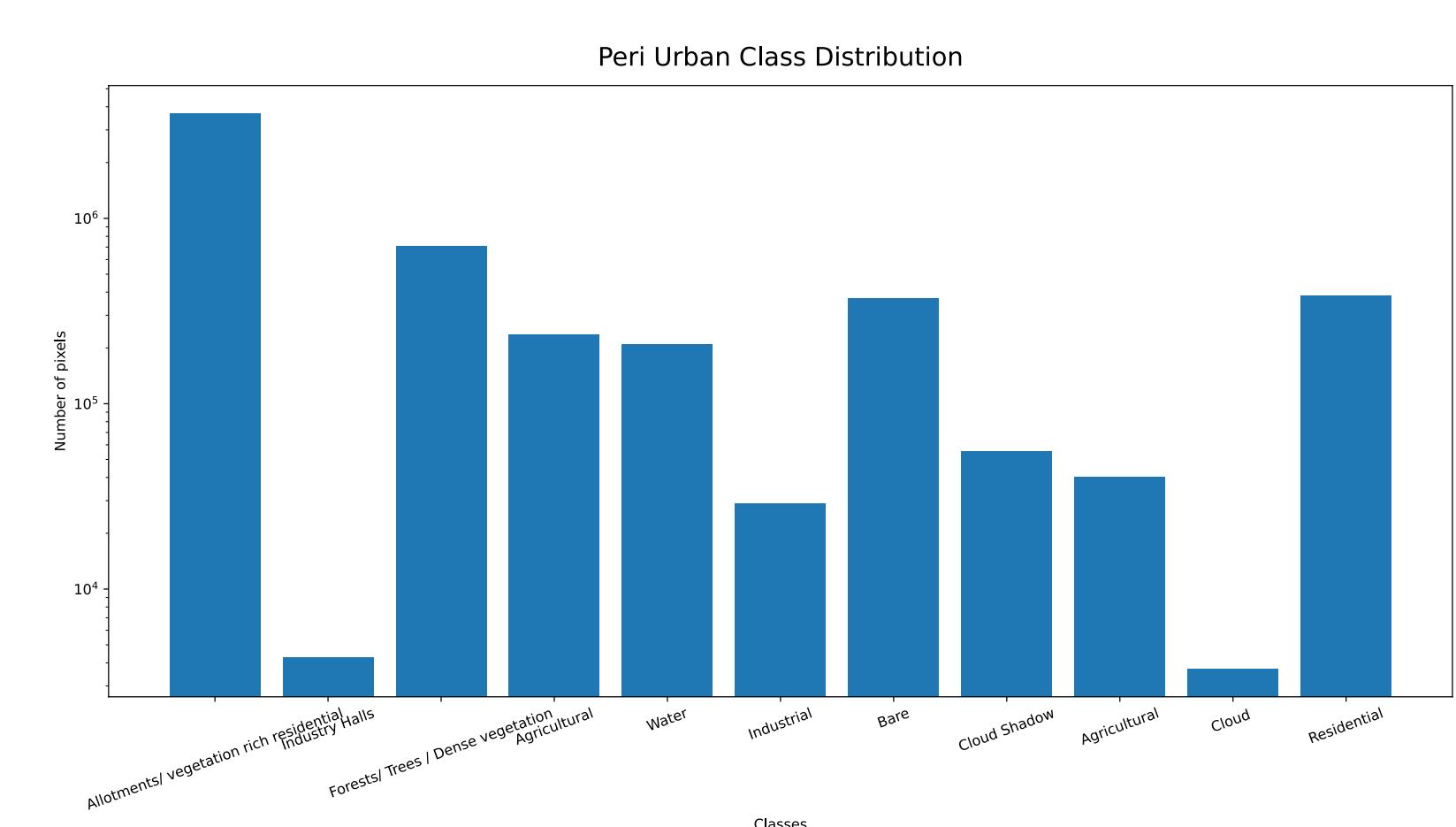


Figure 4. Statistical analysis of the Bremen surface type distribution within the peri urban area

- City area classification works well with a combined approach
- Detecting Surface UHIs works well in different latitudes using Landsat 8 Satellite Images
- Severity depends highly on surface type and weather
- Climate Change and timeline analysis are currently a Work in Process (master thesis)

TL;DR:

Summary

- Remote Sensing Data can Help with detection and monitoring of UHIs
- UHIs pose a severe health risk
- UHIs pose a severe environmental risk
- Impact on humans will get worse with increased average temperatures
- Mitigation needs multidisciplinary approach

References

- [Sha18] Anuj Shah. Through The Eyes of Gabor Filter. 2018. URL: https://scribe.rip/%5C%40anuj_shah/through-the-eyes-of-gabor-filter-17d1fdb3ac97.