Land Use Change and Climate Change Impact on Urban Heat Islands Development

Linus Andrae[1]

[1]Institute for Environmental Physics, University of Bremen

Introduction

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

- **Goal:** Detection and Analysis of UHIs using Landsat 8 & 9 Satellite Data:
- **Why** Find influencing factors on size and impact of urbanisation and climate change of UHIs
- **Output** Find factors that influence UHI severity and size. Determine what indices are useful for judging impact of UHI on human health

Urban Heat Islands

- **Urban Heat Islands** (UHIs) → Surface and air temperature within a city is higher than the average temperature of the surrounding area.
- **Consequences** → Major health impact, increased pollution, reduced well-being
- **Measurement Technique** → Remote sensing data for Surface UHIs and local weather station measurements for Atmospheric UHIs

Processing Chain

The Image Processing Pipeline can be separated in these steps:

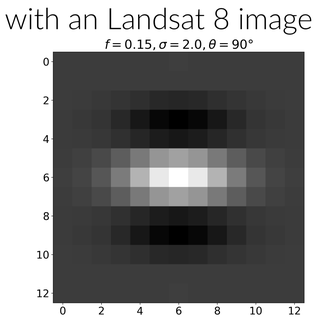
1. **Preprocessing** Cutting the image area to the area of interested
2. **Feature Engineering** A Gabor filter bank of rotated Gabor kernels is used to enrich pixels with information about surrounding pixel and larger structures.
3. **Image Classification** The pixels are classified using a k-means based classification.
4. **Urban Area Detection** Classes indicating urban areas are identified and the buffer zones are build 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** using thermal infrared images 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 as well as LST values
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. **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 sinosoid 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 result of the convolution of the filter in Figure 1a with an Landsat 8 image is shown in Figure 1b.



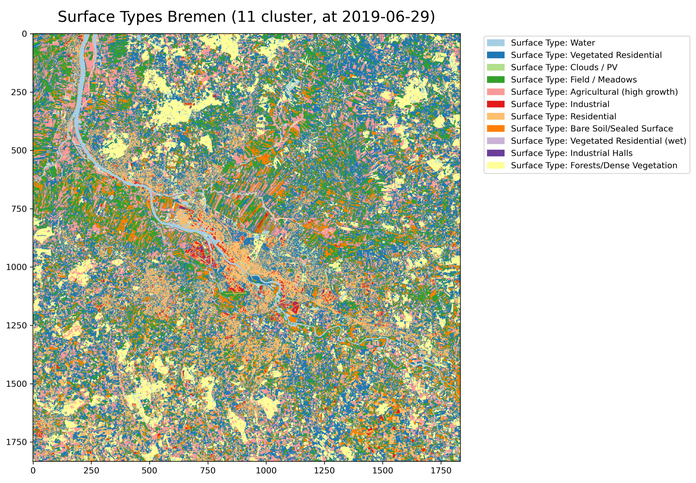
(a) Example filter bank of 90° rotated Gabor-kernel with $\sigma = 2$, $f = 0.15$

(b) Features extracted from an image of the city of Bremen

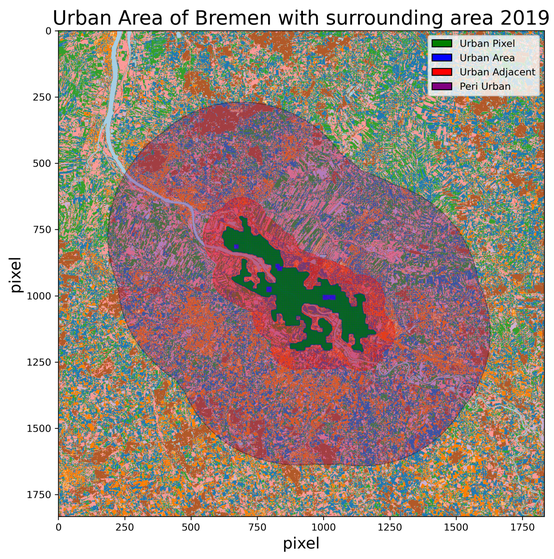
Figure 1. Gabor Filter kernels and convoluted image

Surface Classification

Using k-means the surface classes seen in Figure 2a were determined.



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



(b) Bremen urban area and the rural buffer zones

Figure 2. Classification and urban area detection results

The urban pixels were merged into a continuous urban area with suburban and rural influence zones (Figure 2b).

UHI Detection

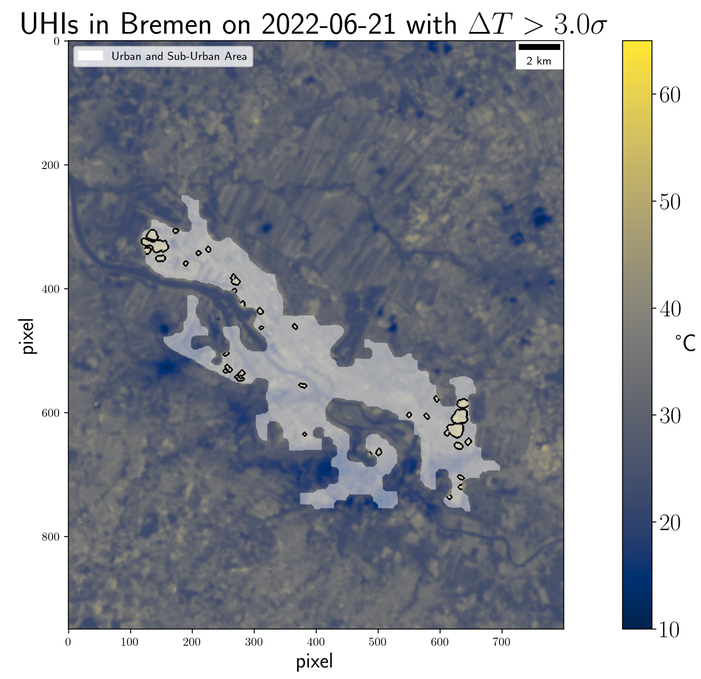


Figure 3. Urban Heat Islands detected in Bremen (more then 3 σ above average temp)

Analysis and Results

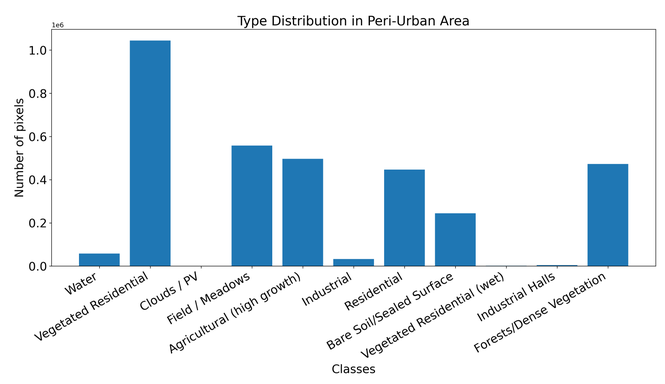


Figure 4. Statistical analysis of the Bremen surface type distribution within the peri urban area

- 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)

Summery

- 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

Read the full work here:

The online version of this Poster: https://github.com/paradx/PresT-Poster/blob/main/poster.pdf?raw=true

PresT Winter Semester 2023/2024
University Bremen

contact: landrae@uni-bremen.de