**Urban heat islands - Topic: Climate adaptation of German cities**

Munich is the most densely populated city in Germany and the one with the most sealed surfaces. Due to the increasingly noticeable climate change, this is a major problem. Large cities in particular need to adapt against increasing temperatures and droughts: for example, with more open and green spaces, roofs and facades, and with loose, unsealed soils that absorb rainwater and cool the city on hot days through evaporation. But making densely populated cities like Munich climate resilient is not easy, because space for new buildings is urgently needed.

Yet, time is pressing: if adaptations to climate change fail, life in the city will become increasingly dangerous. One of the most important reasons for this are heat islands. These are areas that are warmer than their surroundings. Especially in larger cities, there are zones that are significantly warmer than other parts of the city and than the surrounding countryside.   
The reason for this is that concrete, steel and glass heat up more strongly and for longer periods than vegetation. For Bavaria, some analyses assume a nightly temperature difference of up to 10 degrees. This has a variety of consequences: Study results make it clear that more and more people are dying in Germany due to heat - currently 20,000 a year.

An effective remedy could be more green spaces and, in particular, large and old trees. Concepts for climate impact adaptation also call for more floodplains, bogs and swamps in urban areas. Vegetation and unsealed soils act like sponges for water storage. Such "urban wetlands" simultaneously protect against heat and flooding and help to support urban sewage systems.

*Using current and historical satellite data, we can show where heat islands are located in (i) Munich and in (ii) Germany and how (sealed) surfaces, vegetation and soil moisture have changed in specific regions.*

**Work order and steps:**

**Data**: Landsat data (as those go back to min. 1995), possibly in combination with Sentinel-2 (as these optical data are better resolved).

1.) **Evaluation of data sources:**

(a.) use Landsat data for (A) surface temperature, (B) vegetation, (C) soil moisture

(b.) Combination (as of 2015) with corresponding Sentinel-2 data possible? Could be useful because of its better spatial resolution?

c.) Which observation period is realistic? Target: 1995 (Landsat-5)

2.) **Evaluation of surface temperature, vegetation and soil moisture at first for a spatially limited area, e. g. Munich:**

a.) Practical use of thermal infrared, a suitable vegetation index (NDVI, EVI etc.) and a way to measure surface moisture (e.g. Normalized Difference Moisture Index (NDMI)).

b.) Visualization oft he above indicators over time (i.e. since 1995)

c.) Statistical analysis of changes oft he above indicators over time (using histograms etc.)

**3.) Scaling:**

(a.) We would like to evaluate not only Munich but all of Germany (minimum goal: all of Bavaria + all major German cities).

4.) **Develop an algorithm that locates where change occurred and when:**

a.) classification of meaningful surface categories (e. g. machine learning, see sources for possible training data)

b.) Definition of meaningful spatial units that can be used to determine changes on a minimal spatial scale (preferably, that spatial unit is flexible).

c.) This spatial unit should be used to write one/multiple algorithms that detect changes (i) from vegetation to buildings, roadsor other built-up urban surfaces an (ii) vice versa (one should be able to determine if a park has become a settlement and so on)

d.) When did changes in a specific region occur?

e.) Are there correlations with heat islands that are located in close proximity to the detected change?

f.) Are there correlations with soil moisture measurements for those specific regions?

5.) **What is the data format of the output and how can the results be visualized?**

a.) Implementation of useful geotagging

1. \* Use the surface classification algorithm to calculate what material are cities (like Munich) consisting of and how the material composition changed over time
2. \* Can you use your tools to show whether Vienna’s strategies for climate resilience (implemented in Summer 2019) where successful?

* Note: There is no perfect correlation between surface and air temperature but surface temperature can be used as an indicator for urban heat load

**Useful sources:**

Urban Heat Islands with Landsat:

<https://www.sciencedirect.com/science/article/pii/S0198971514000866>

<https://www.mdpi.com/2072-4292/11/1/48>

Urban Heat Islands in European Cities

<https://www.sciencedirect.com/science/article/abs/pii/S1618866717304806>

Overview Urban Heat Islands in Europe: <https://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation>

Surface Classification, Example for Training Data <https://link.springer.com/article/10.1007%2Fs00103-020-03177-w>

Heat in Vienna: <https://www.zamg.ac.at/cms/de/klima/news/neues-computermodell-zur-untersuchung-von-hitze-in-staedten>

Example Heat Islands/Vegetation in Thüringen: <https://tlubn.thueringen.de/klima/klimaagentur/projekte/cokap>

Overview Heat islands, satellites an public health (in German): <https://www.atlas-digitale-gesundheitswirtschaft.de/aufgeheizte-staedte-als-gesundheitsrisiko-intelligenter-umgang-dank-satellitendaten/>