Methodology Development for the Local Climate Regulation Ecosystem Service

Land Monitoring

Online training

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REPUBLIC OF ESTONIA ENVIRONMENT AGENCY
STATISTICS ESTONIA
eurostat
PROGRAMME OF THE EUROPEAN UNION
Copernicus Europe's eyes on Earth
Implemented by European Environment Agency
European Commission

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Overview:

- **Project background:** Local Climate Regulation funded by the Eurostat
- **Motivation:** urban heat island effect and trees create cooling effect in their surroundings
- **Data:** 3 largest urban areas in Estonia, Land Surface Temperature (LST), Google Earth Engine Evapotranspiration and **Copernicus Tree Cover Density (TCD)**
- **Method:** linear regression models
- **Results:** Tallinn, Tartu, Narva
- **Challenges**
- **Conclusions**

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Project background:

- **Project:** Development of the forestry, environmental subsidies and ecosystem accounts (Eurostat Grant Agreement 101113157 — 2022-EE-EGD)
- This project is **funded by the Eurostat**
- Collaboration between Estonian Environment Agency, Tallinn University of Technology and Statistics Estonia
- **Local Climate Regulation** defined as the way urban vegetation helps cool cities and improve living conditions. Measured as the cooling effect of urban vegetation on days hotter than 25 degrees Celsius.

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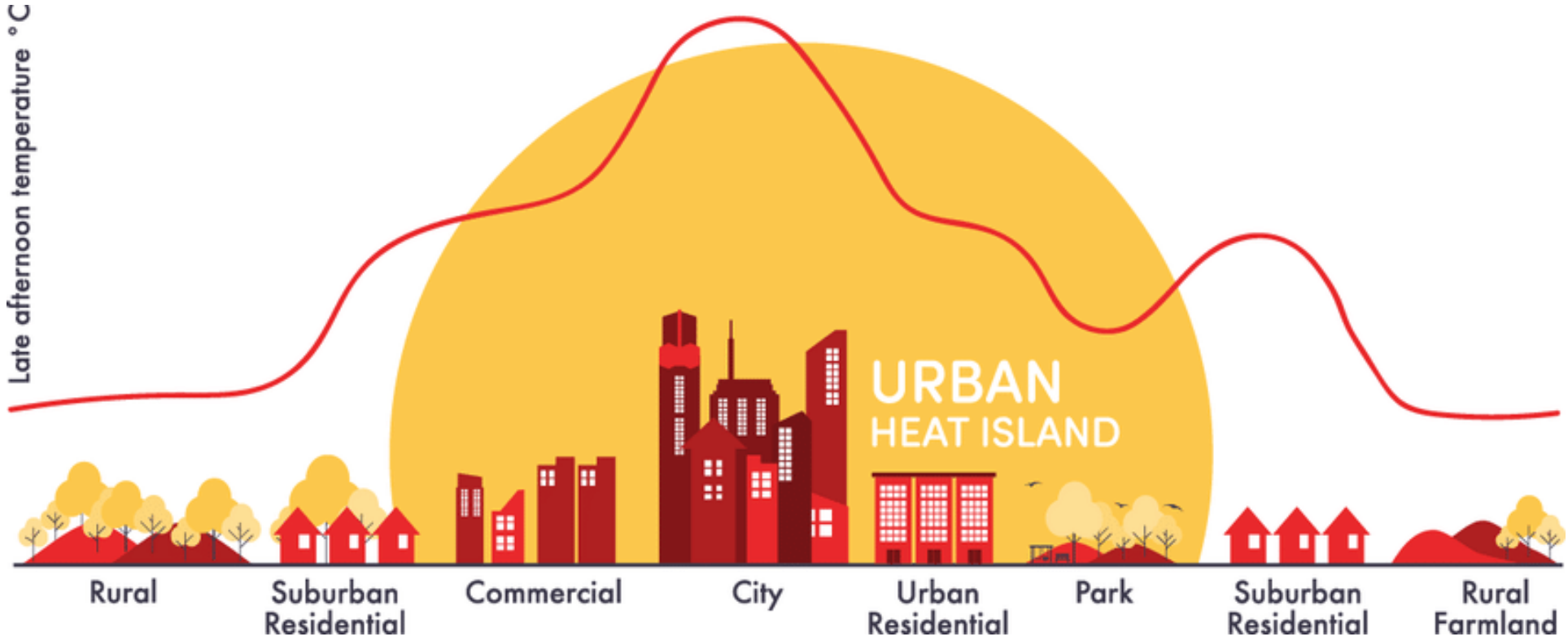
Motivation: urban heat island effect

Urban areas are significantly warmer than surrounding rural areas



Source: http://coolparramatta.com.au/about_us

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Motivation: Urban heat island effect

Contributing factors:

1. Loss of evaporative cooling
2. Increase in impervious surfaces.
3. Waste Heat
4. Radiative trapping

Brian Stone. Source: Dey et al. 2024, CC BY-ND

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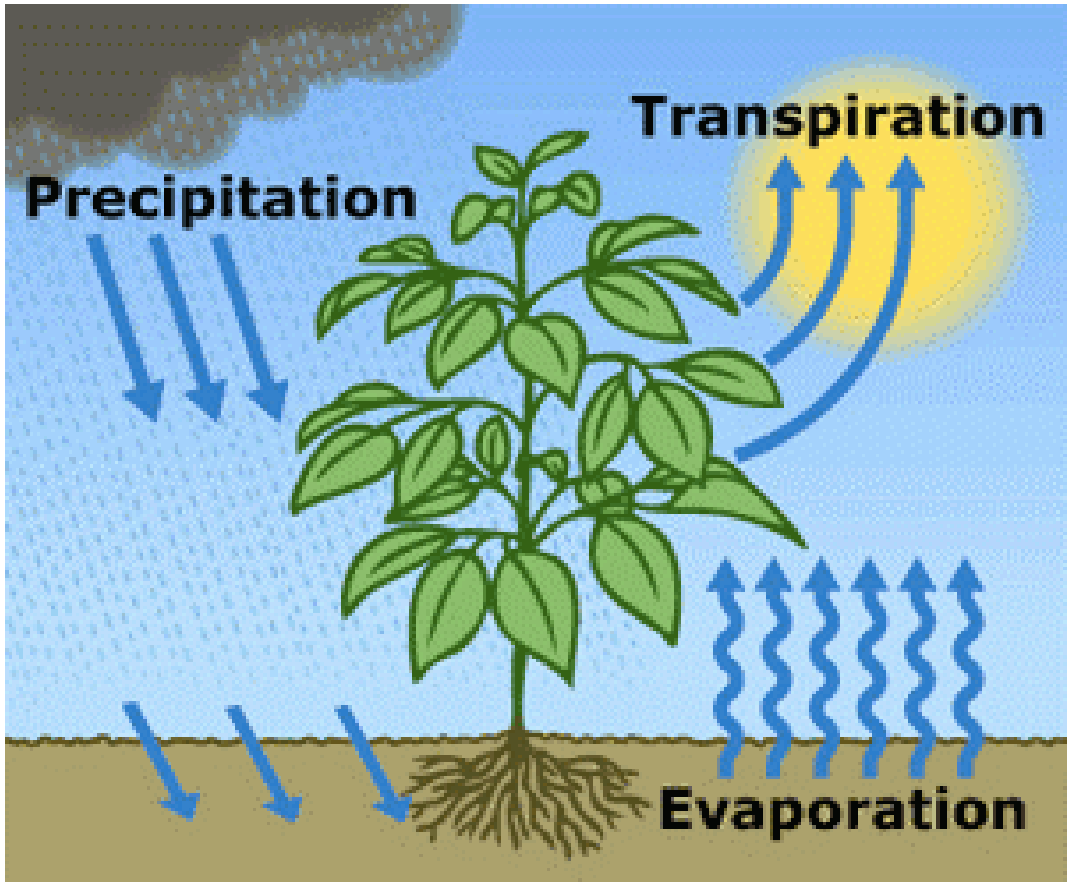
Motivation: evapotranspiration

- Evapotranspiration product from Google Earth Engine
- Through evapotranspiration trees and vegetation help cool the surrounding environment
- Evapotranspiration is considered as sum of transpiration (Ec) and precipitation interception (Ei)

*Soil evaporation and evaporation from water bodies are not included in this analysis.



(Credit: U.S. Geological Survey)

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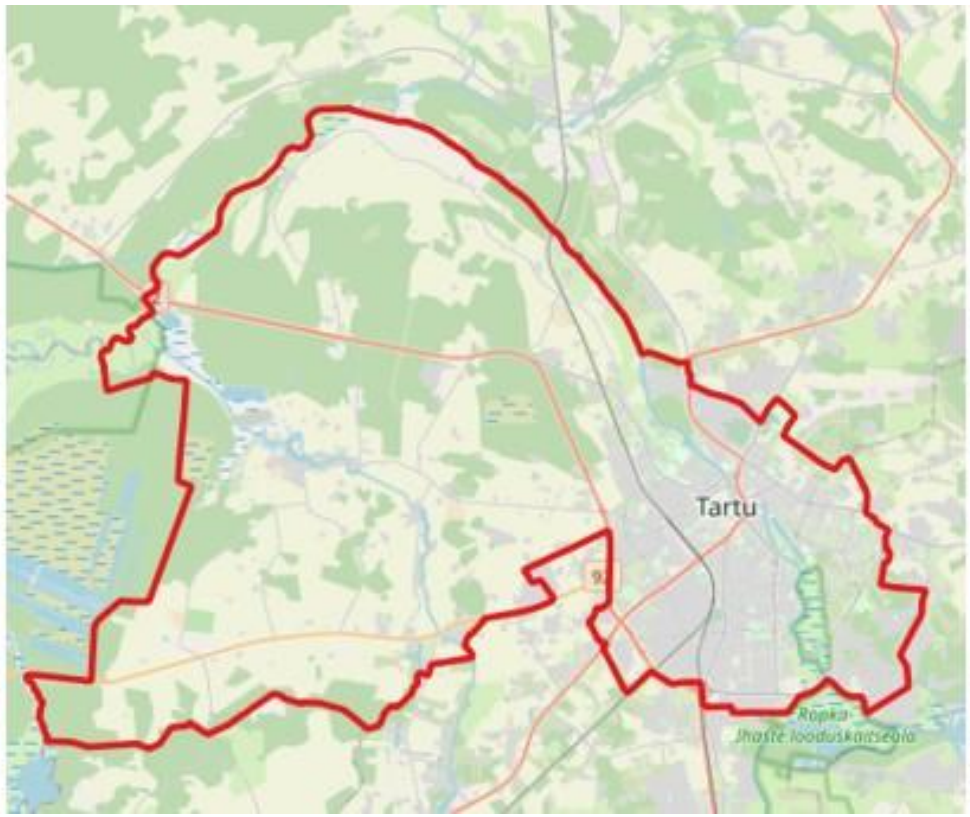
3 largest urban area in Estonia

Tallinn

Tartu



Narva

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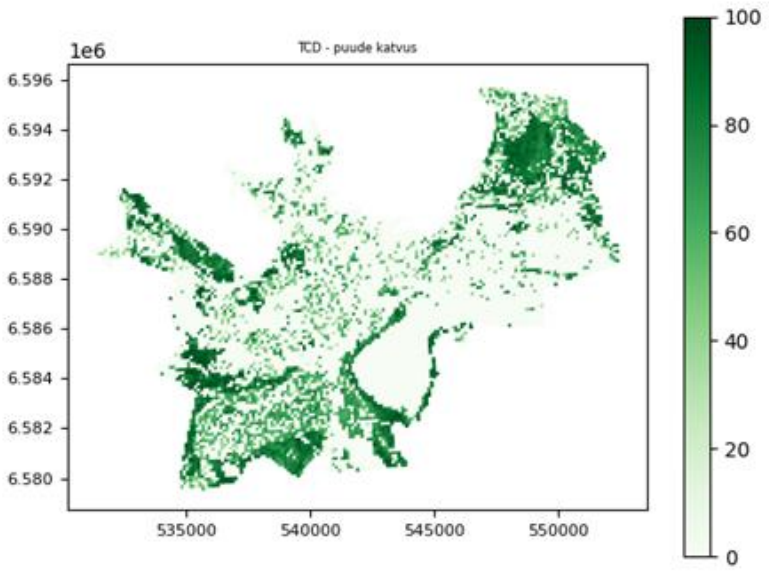
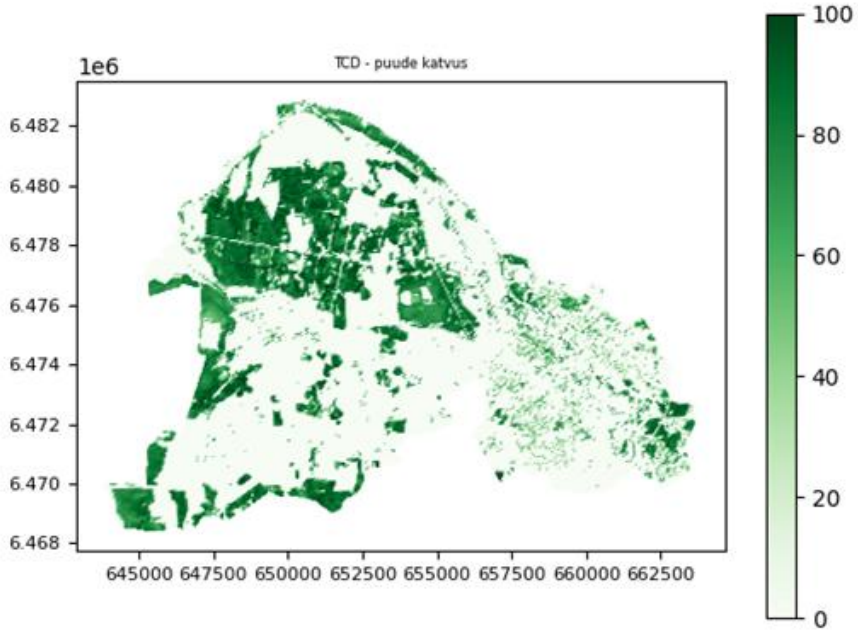
Tree Cover Density % (TCD)

Tree Cover Density product 2018, derived from the Copernicus High Resolution Layer, shows, which part of area is covered by trees, values 0 to 100 %

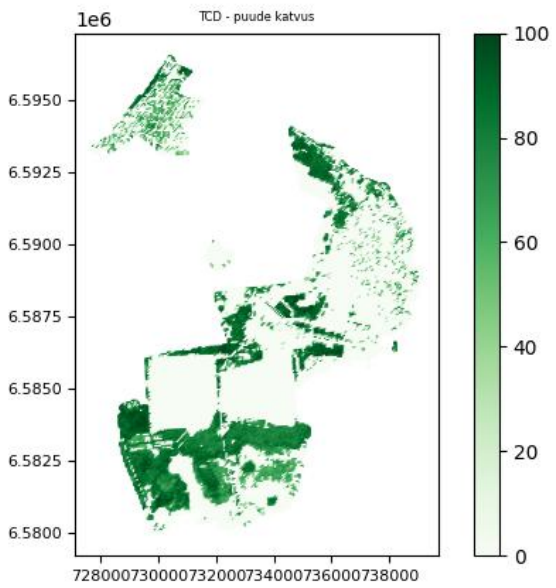
Tallinn TCD 0-100%



Tartu TCD 0-100%



Narva TCD 0-100%



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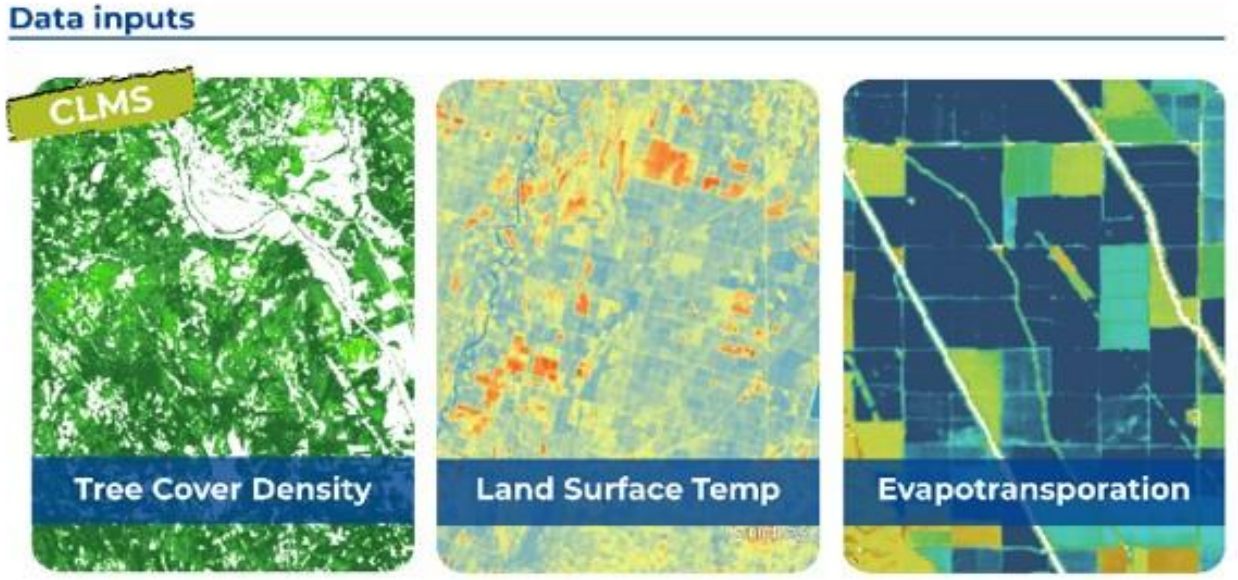
Datasets

- 3 largest Estonian cities: Tallinn, Tartu, Narva
- Tree Cover Density (TCD) - Copernicus Land Monitoring Service (CLMS)
- Land surface temperature (LST), Landsat 8/9
- Evapotranspiration (Google Earth Engine)



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Datasets for cooling effect calculation:

1. Tree Cover Density % (TCD) – data from Copernicus Land Monitoring Service (CLMS) (2018)
2. Land Surface Temperature (LST)
3. Evapotranspiration (ET) – dataset from product „PML_V2 0.1.8: Coupled Evapotranspiration and Gross Primary Product (GPP)“ of Google Earth Engine Data Catalog (2022, 2023)
4. Ecosystems map – dataset from Statistics Estonia, which shows territorial distribution of different ecosystem types.
5. Maps of administrative units – datasets of borders of municipalities and settlements from Estonian Land and Spatial Development Board

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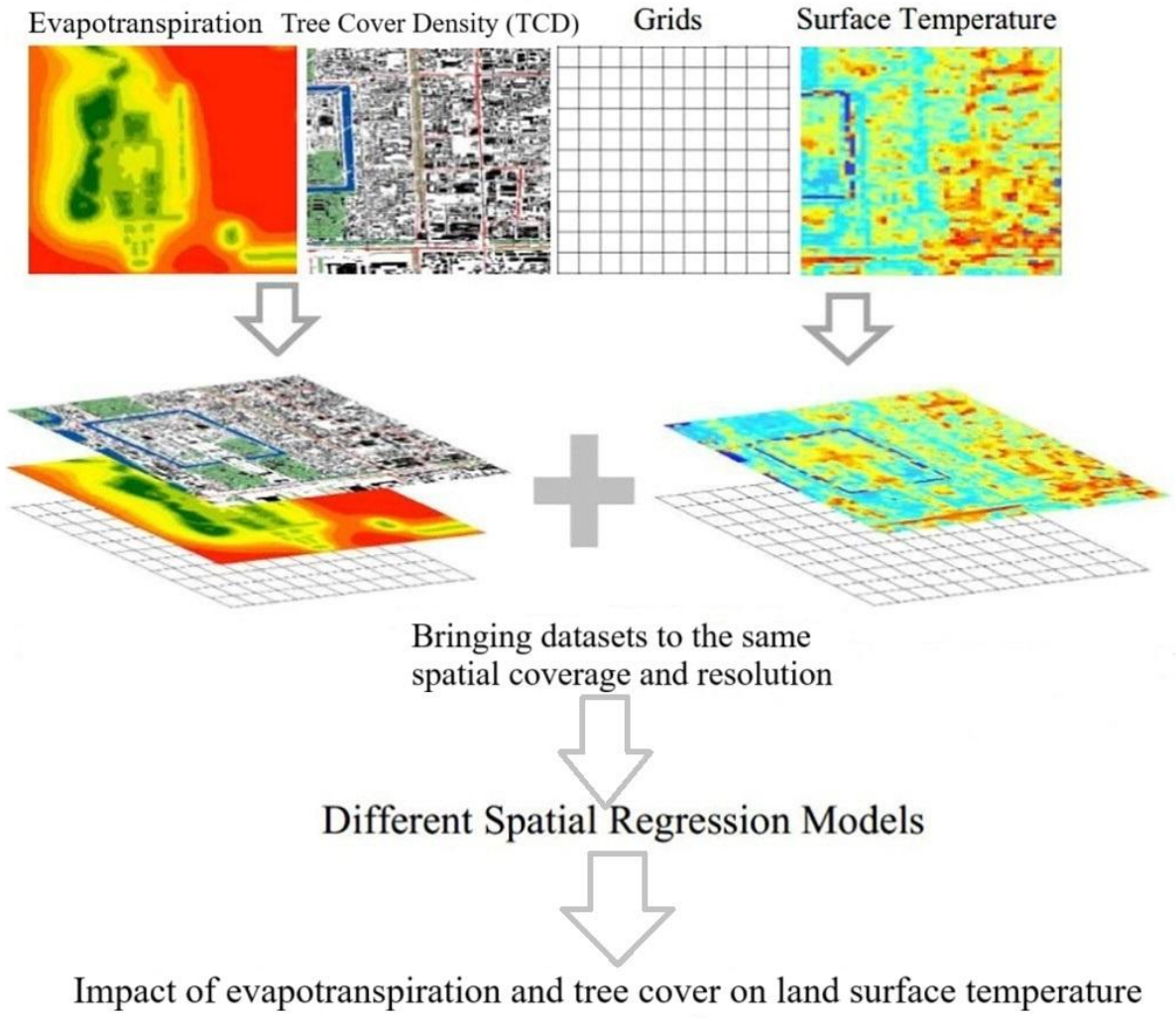
Method

- It is crucial to bring all datasets to the same spatial coverage and resolution 30 meters
- The calculations of vegetation cooling effect was calculated using linear regression models
- The programs are designed to work in Linux environment
- Python version 3.7.12 was used



Modified figure from: Zhaoxin Dai, Jean-Michel Guldmann, Yunfeng Hu. Spatial regression models of park and land-use impacts on the urban heat island in central Beijing, 2018.

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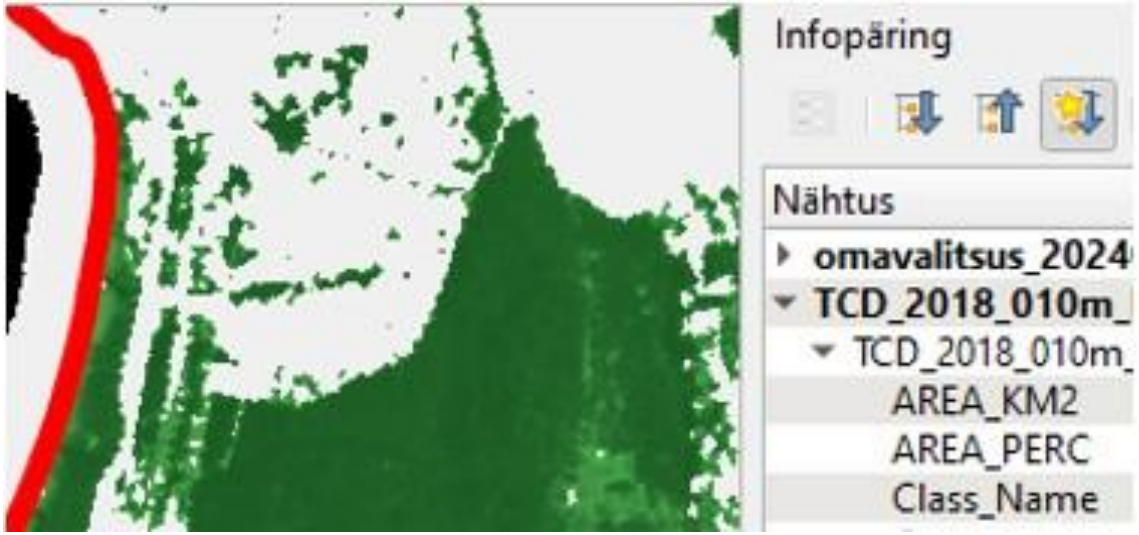
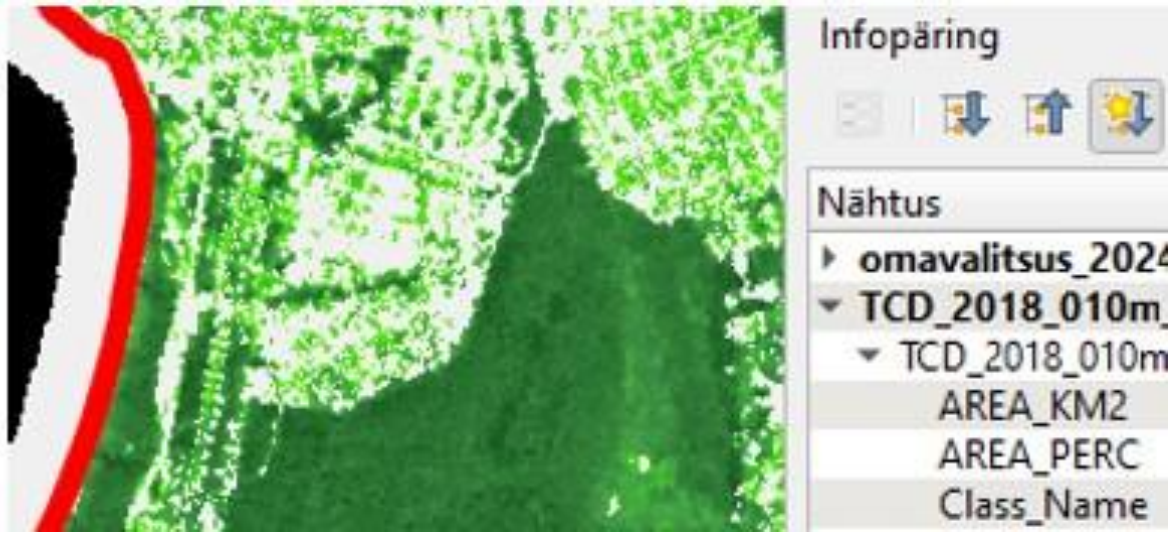
Challenges

- TCD from newly downloaded 2018-year dataset (left) and earlier downloaded data year 2018 (right)
- Newly downloaded datasets do not represent sparse tree cover in residential area. Dataset of year 2021 has the same peculiarity
- In context of the present survey, the vegetation located in residential areas is very important, so its neglection in unacceptable. Due to that older dataset of year 2018 was selected for the calculations





Results

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		Tallinn			Tartu			Narva		
		Relative area, %	Cooling within the class, °C	Area-weighted cooling of the class, °C	Relative area, %	Cooling within the class, °C	Area-weighted cooling of the class, °C	Relative area, %	Cooling within the class, °C	Area-weighted cooling of the class, °C
1	*Settlements and other artificial areas*	43,9	-1,06	-0,47	17,5	-1,86	-0,33	21,6	-1,12	-0,24
2	*Cropland*	0,1	-2,54	0	30,8	-3,77	-1,16	1,9	-0,99	-0,02
3	*Grassland*	16,5	-2,87	-0,47	12,9	-3,95	-0,51	10,3	-1,93	-0,2
4	*Forest and woodland*	6,9	-3,9	-0,27	27,3	-5,78	-1,58	15,9	-2,89	-0,46
5	*Heathland and shrub*	8,2	-1,61	-0,13	2,8	-3,64	-0,1	18,2	-0,68	-0,12
6	*Sparsely vegetated ecosystems*	15,2	-0,69	-0,11	4,4	-2,77	-0,12	7,5	-0,58	-0,04
7	*Inland wetlands*	0,5	-2,44	-0,01	1,7	-4,08	-0,07	16,8	-1,97	-0,33
8	*Rivers and canals*	0,4	-2,6	-0,01	1,6	-3,99	-0,06	1,2	-1,1	-0,01
9	*Lakes and reservoirs*	8,1	-0,39	-0,03	1	-2,7	-0,03	6,6	-0,5	-0,03
10	*Marine inlets and transitional waters*	0	0	0	0	0	0	0	0	0
11	*Coastal beaches; dunes and wetlands*	0,1	-0,83	0	0	0	0	0	0	0
12	*Marine ecosystems*	0,1	-0,43	0	0	0	0	0	0	0
				-1,5			**-3,96**			**-1,45**

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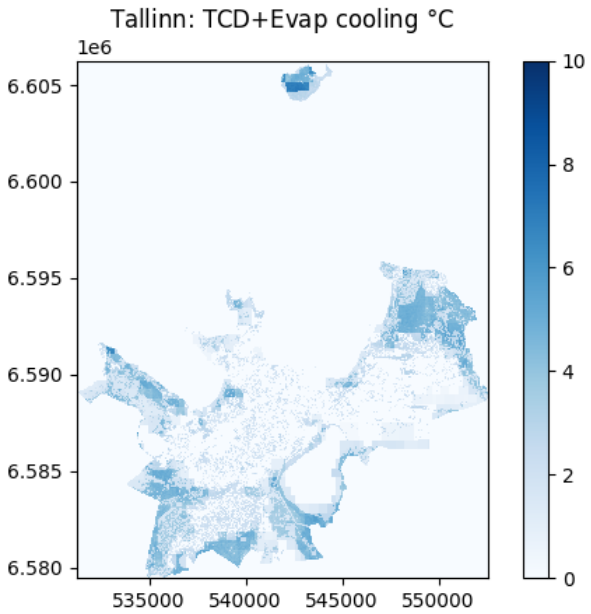
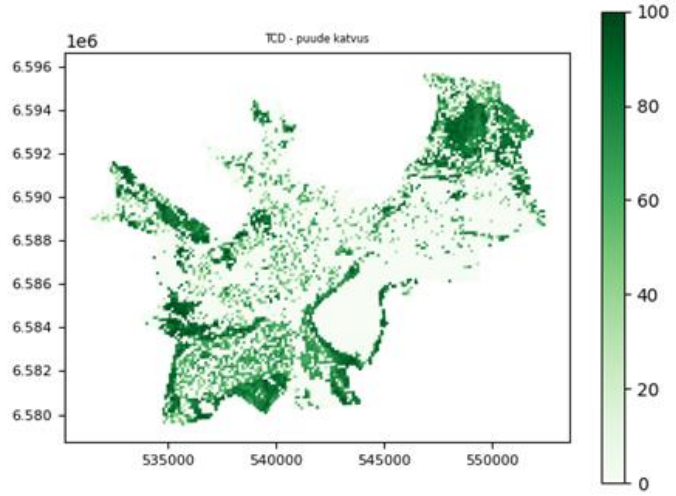
Results: Tallinn

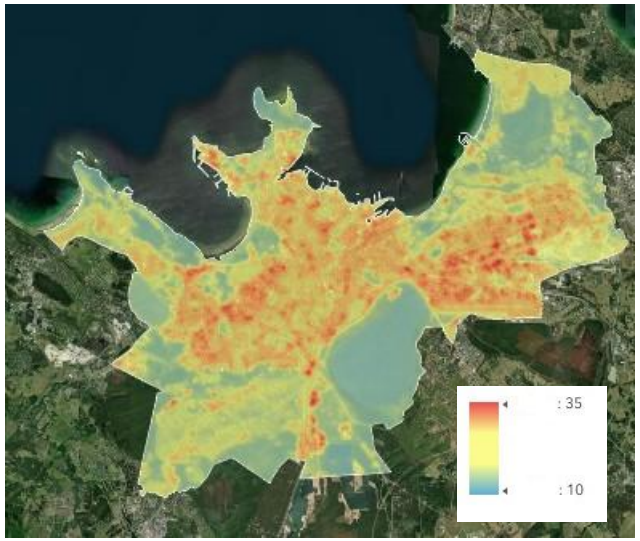
TDC + Evapotranspiration cooling



Copernicus Tree Cover Density (TCD) 0-100%



Land Surface Temperature (LST)



Results: Tartu

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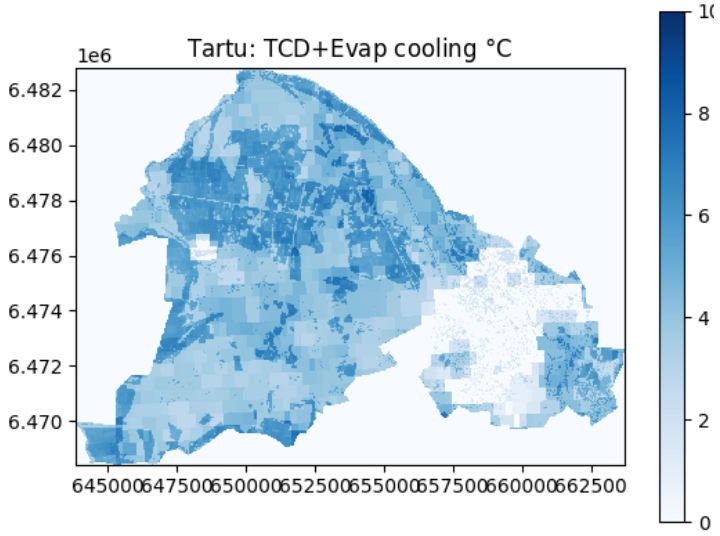
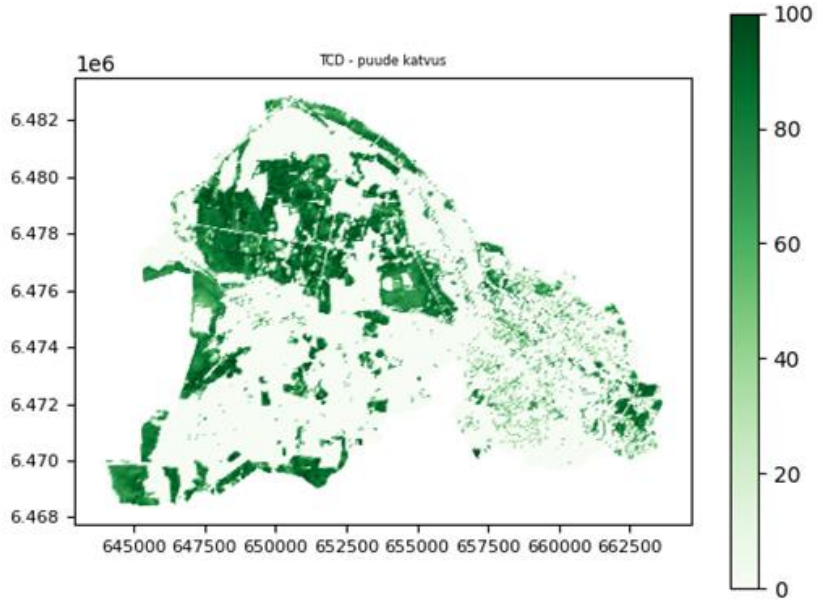
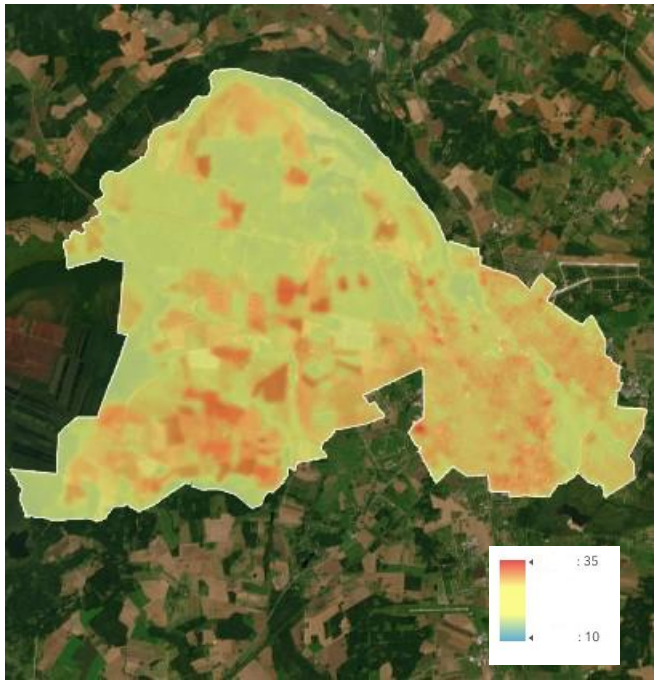
TDC + Evapotranspiration cooling



Copernicus Tree Cover Density (TCD) 0-100%



Land Surface Temperature (LST)



Results: Narva

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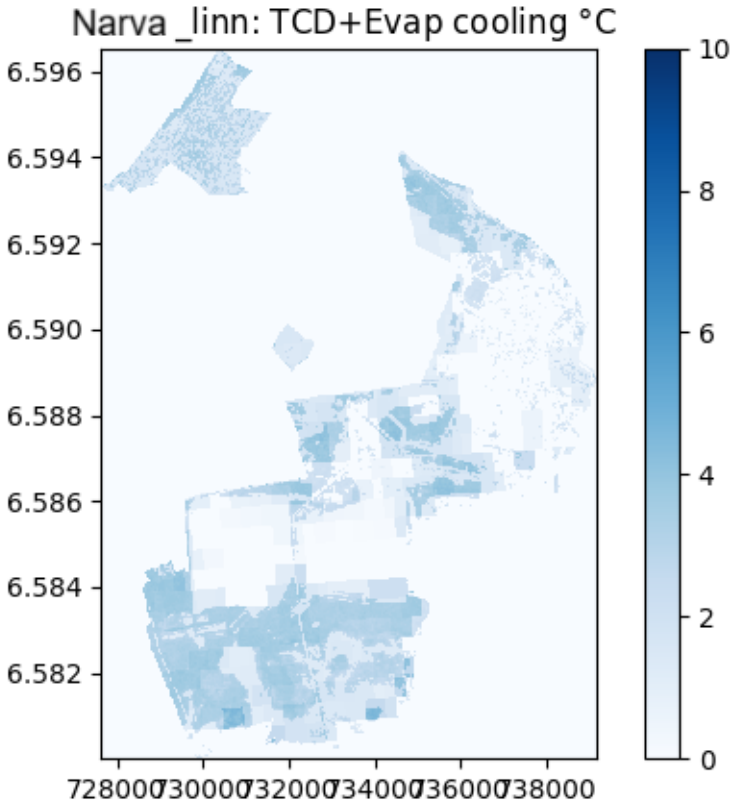
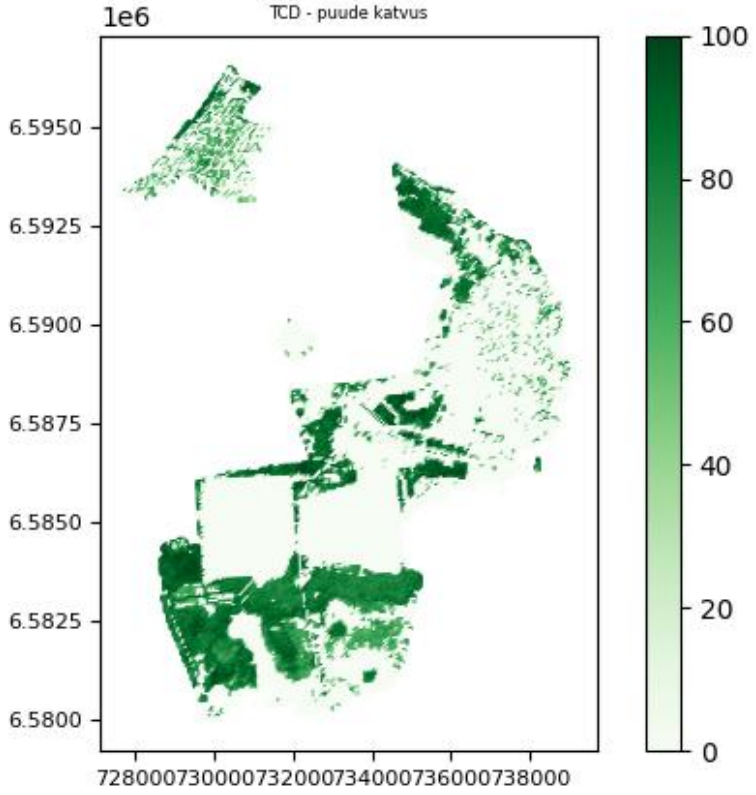
TDC + Evapotranspiration cooling



Copernicus Tree Cover Density (TCD) 0-100%



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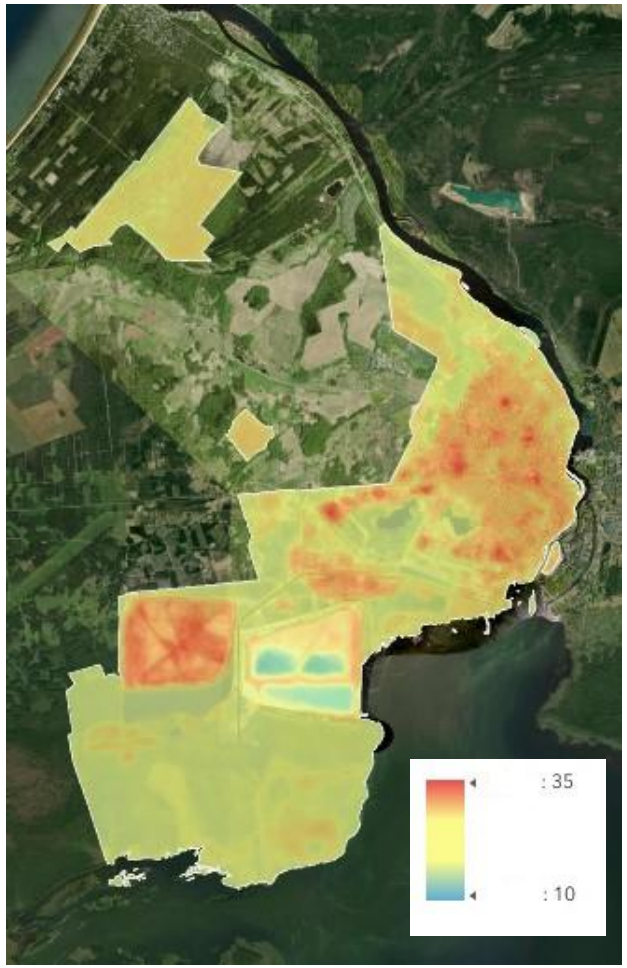

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Conclusion

Copernicus tree cover data provided valuable insights for our project, though we found some challenges with resolution and update frequency. Overall, it's a powerful tool for environmental monitoring and for urban climate regulation Ecosystem Service.

Thank you!

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