Urban Multi-scale Environmental Predictor

Abstract

UMEP (Urban Multi-scale Environmental Predictor), a city-based climate service tool, combines models and tools essential for climate simulations. Applications are presented to illustrate UMEP's potential in the identification of heat waves and cold waves; the impact of green infrastructure on runoff; the effects of buildings on human thermal stress; solar energy production; and the impact of human activities on heat emissions. UMEP has broad utility for applications related to outdoor thermal comfort, wind, urban energy consumption and climate change mitigation. It includes tools to enable users to input atmospheric and surface data from multiple sources, to characterise the urban environment, to prepare meteorological data for use in cities, to undertake simulations and consider scenarios, and to compare and visualise different combinations of climate indicators. An open-source tool, UMEP is designed to be easily updated as new data and tools are developed, and to be accessible to researchers, decision-makers and practitioners.

https://www.sciencedirect.com/science/article/pii/S1364815217304140

Organized with pre-processor, processors and post processors

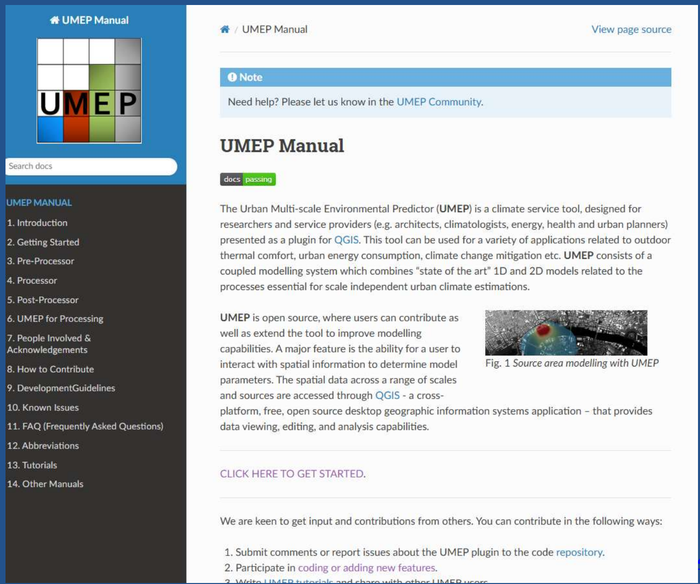
- Pre-processors are used to prepare and create the required data.
- Processors are the main models for the calculations. (SOLWEIG)
- Post-processors provide a quick analysis based on the model's outputs.

There is a tutorial here (for Goteborg) with the data to download. Could be a good exercice to see how it works.

- Web site manual
- Web site tutorial
- YouTube channel

UMEP

A GIS-based climate planning tool for researcher and practitioners.



UMEP Manual

UMEP

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UMEP MANUAL

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/ UMEP Manual

View page source

Note

Need help? Please let us know in the UMEP Community.

UMEP Manual

docs passing

The Urban Multi-scale Environmental Predictor (**UMEP**) is a climate service tool, designed for researchers and service providers (e.g. architects, climatologists, energy, health and urban planners) presented as a plugin for QGIS. This tool can be used for a variety of applications related to outdoor thermal comfort, urban energy consumption, climate change mitigation etc. **UMEP** consists of a coupled modelling system which combines "state of the art" 1D and 2D models related to the processes essential for scale independent urban climate estimations.

UMEP is open source, where users can contribute as well as extend the tool to improve modelling capabilities. A major feature is the ability for a user to interact with spatial information to determine model parameters. The spatial data across a range of scales and sources are accessed through QGIS - a cross-platform, free, open source desktop geographic information systems application – that provides data viewing, editing, and analysis capabilities.

Fig. 1 *Source area modelling with UMEP*

CLICK HERE TO GET STARTED.

We are keen to get input and contributions from others. You can contribute in the following ways:

1. Submit comments or report issues about the UMEP plugin to the code repository.
2. Participate in coding or adding new features.

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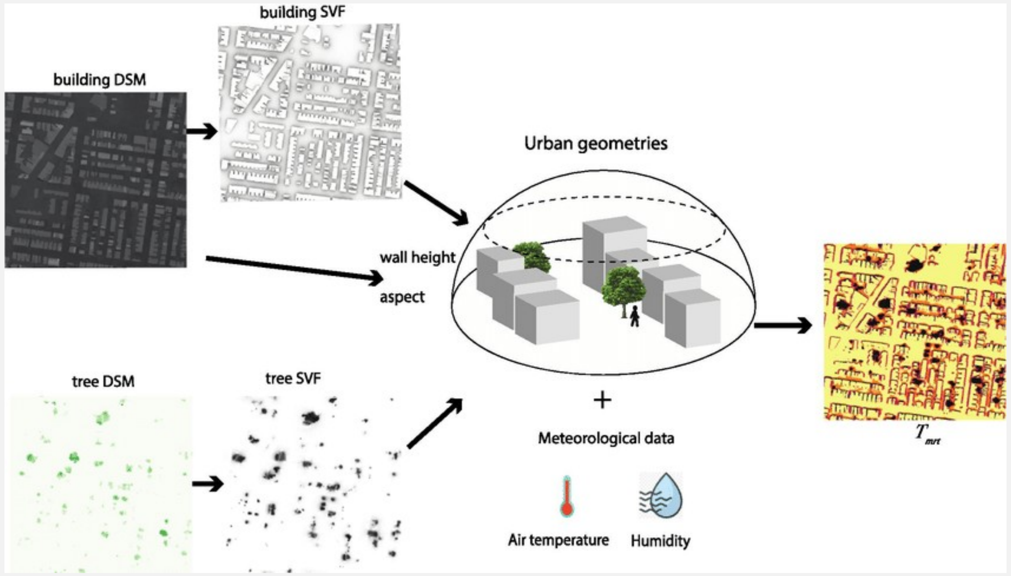
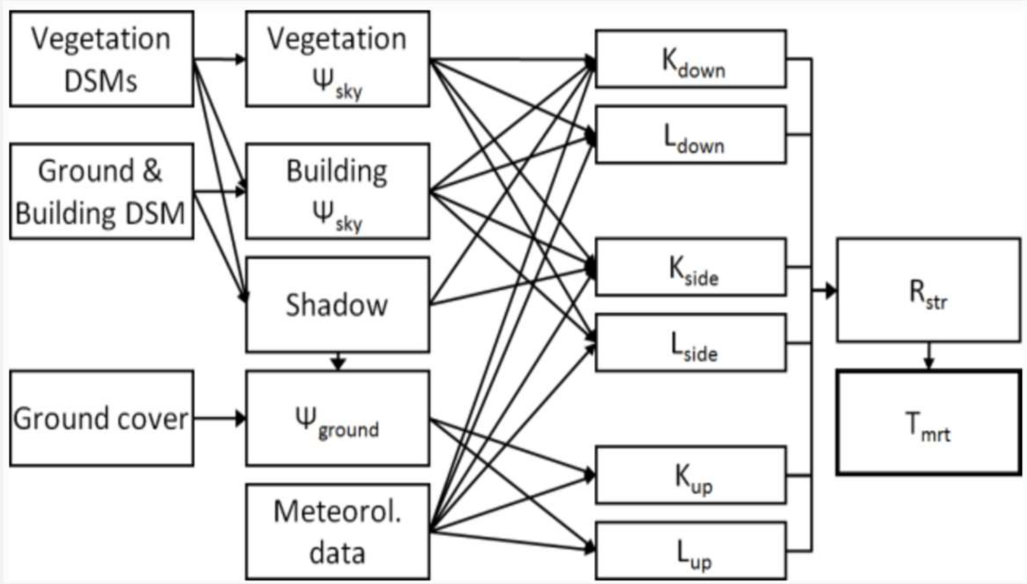
SOLWEIG

SOLWEIG models solar and thermal radiation in urban areas to estimate human thermal stress.

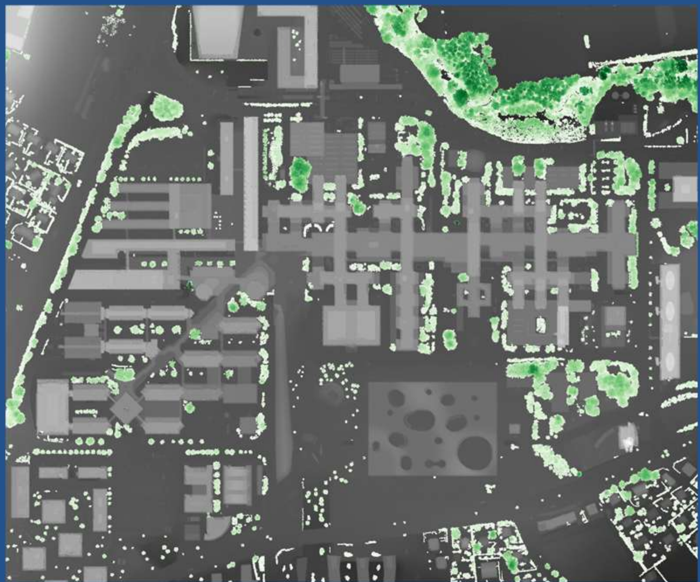


SOlar and LongWave Environmental Irradiance Geometry model



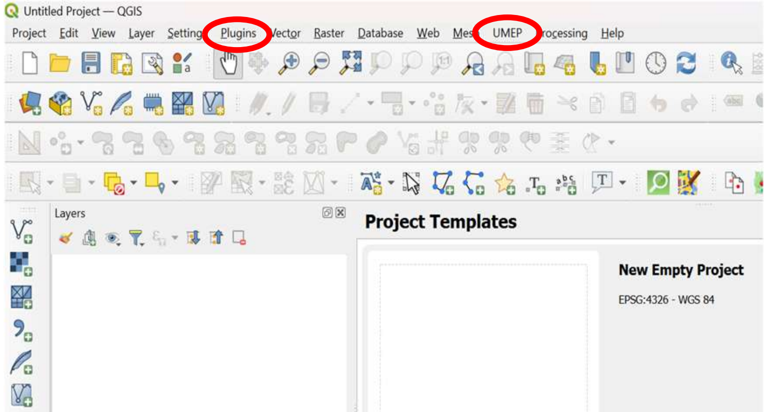
The main objective is to compute the spatial variation of the *mean radiant temperature* based on the radiation fluxes (shortwave and longwave).

Works for pedestrian level!

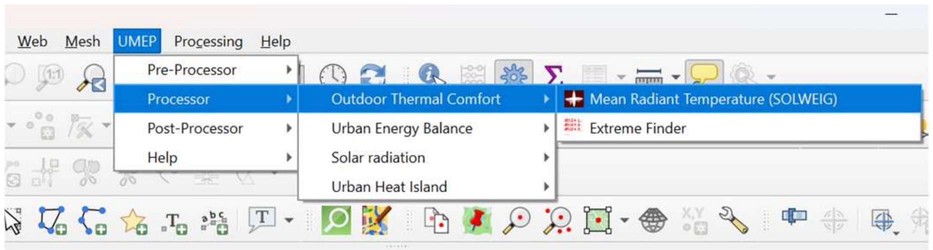


How to use it

SOLWEIG is a processor of UMEP plugin **in QGIS**.



To download UMEP:
1. open the *Plugins* menu → *Manage and Install Plugins*
2. Install UMEP and UMEP for processing plugins
3. A UMEP menu should appear



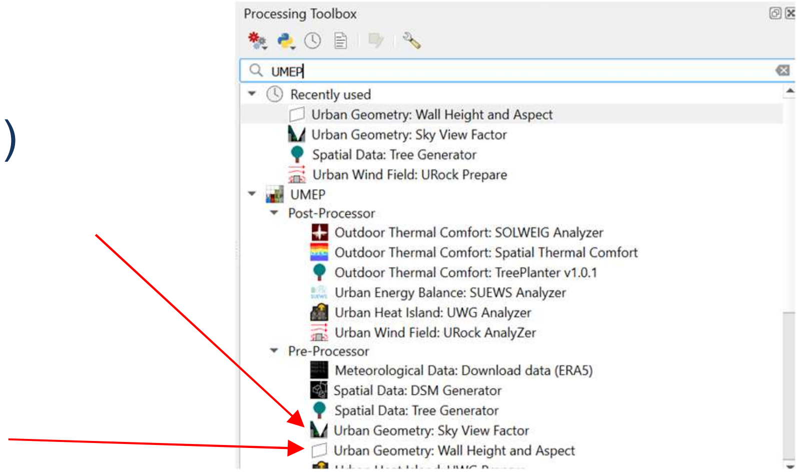
To use SOLWEIG:
1. Open the UMEP menu
2. SOLWEIG is a processor
3. But SOLWEIG needs pre-processors…

Pre-processors

In the *Processing Toolbox* (Processing → Toolbox) search for *UMEP*

1. Sky View Factor (mandatory)
   Provided for the initial conditions
   Has to be run for the project spatial changes (DSM & CDSM)
   Could take time to run for large spatial extent ⚠

2. Wall Height and Aspect (mandatory)
   Provided for the initial conditions
   Has to be run for the project spatial changes (DSM)



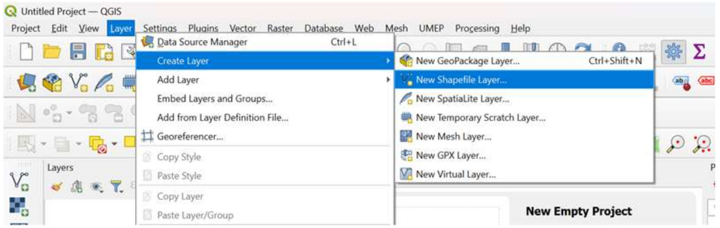
3. Others pre-processors can be useful (TreeGenerator, Meteorological Data, Land Cover Reclassifier…).

Points Of Interest

POIs can be placed in specific location to analyse with multiple parameters the evolution during the time period.

A POI layer should be created:

1. Open *Layer → Create Layer → New Shapefile Layer*
2. Geometry type: Point
3. Each POI must have unique ID

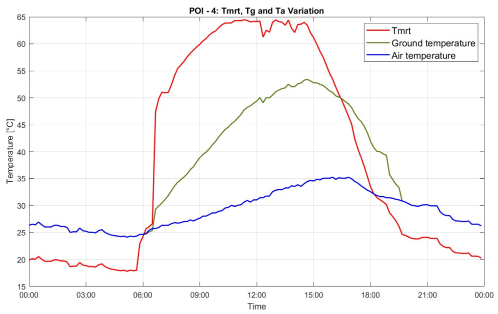


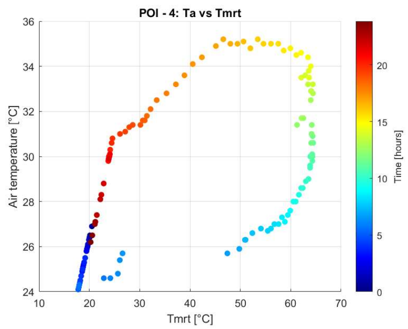
To add POIs to the layer:

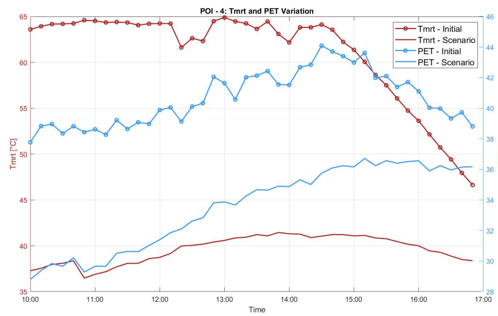
1. *Toggle Editing* 
2. *Add Point Feature* and clic on the location of interest

Example of use:

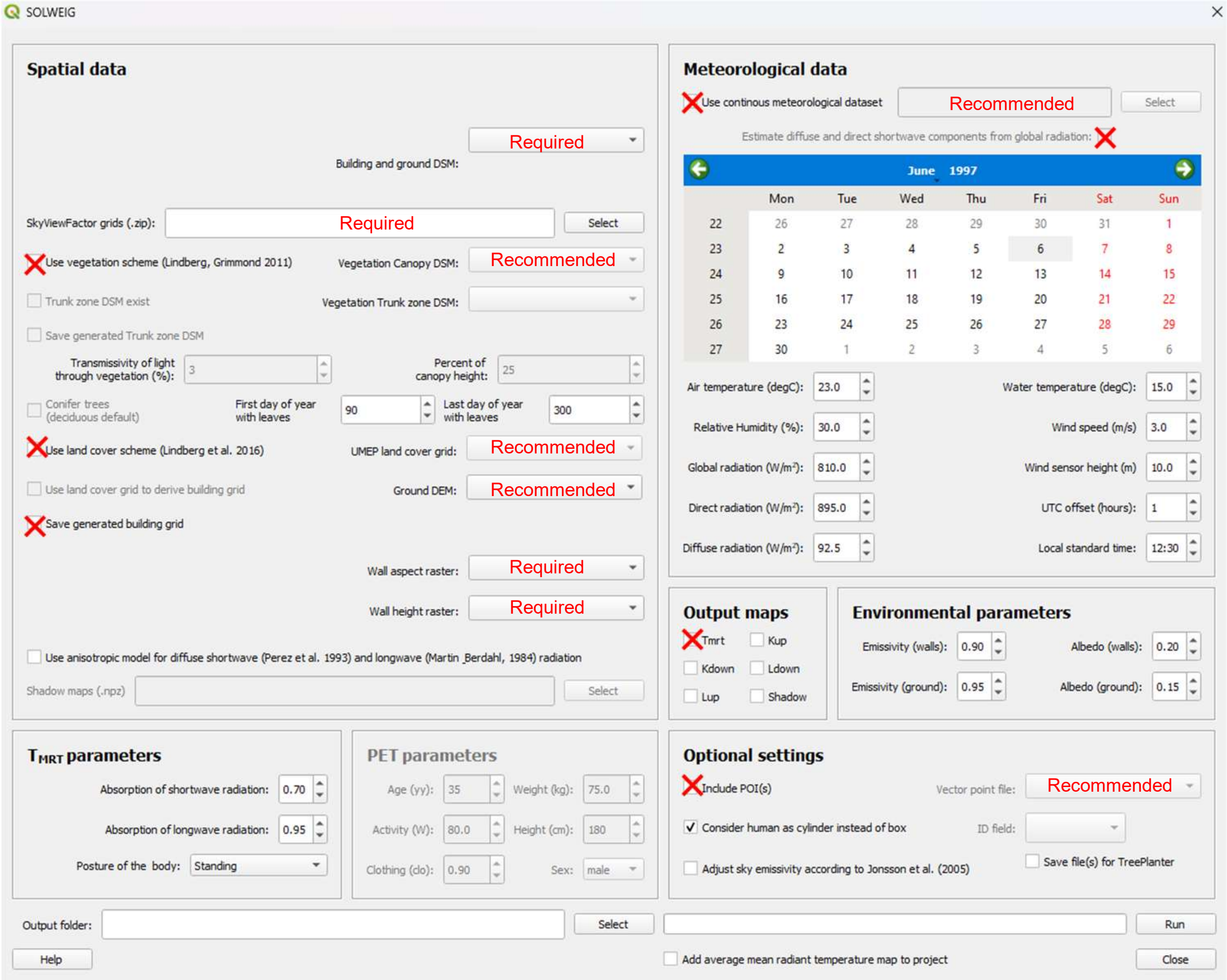
(After running SOLWEIG, With MATLAB)







Interface



- Additionnal default values and ticking are not required.
- All spatial and Meteorological initial data is given. You can modify it, for the project, in QGIS or MATLAB/PYTHON…
- PET (Physiological equivalent temperature) works including POI
- Running time depends on the length of the meteorological dataset and spatial extent. (Advice: First run for one iteration and small spatial extent)
- Building grid is then used in Post-processor to exclude roofs as the model works for pedestrian level.

Outputs:

- Saved in a folder
- A map for each timestep and selected Output maps
- A building grid
- A text file for each POI

Ideas

- Create scenarios:
  Spatial; changing landcover, adding trees (TreeGenerator), green walls, buildings, sun protection building…

  Meteorological; variation of the parameters, creation of dataset for different time period and seasons…

  Values; comparing/selecting shapes of trees (height, trunk, diameter, transmissivity…), shapes of buildings/streets, human parameters (Tmrt, PET)…

- Analyse:
  Coding (MATLAB/PYTHON…); POIs, evolution, maximum values, thresholds (litterature review), contributions…

  In QGIS; Post-processor (SOLWEIG Analyser), spatial statistics (mean, median, max…), contributions, spatial analysis (critical areas), overviews (qualitative and quantitative)…

Good to know:
Mean radiant temperature is based on mean radiation fluxes depending on several factors. To better understand the contribution, one can read the research in the references section here.

YouTube playlist on how to use SOLWEIG with project research questions here.

The following slides are ideas with graphics and maps

Contributions

$$Mean\ Radiant\ Temperature = Tmrt = \sqrt[4]{\frac{S_{str}}{\varepsilon_p \sigma}} - 273.15$$

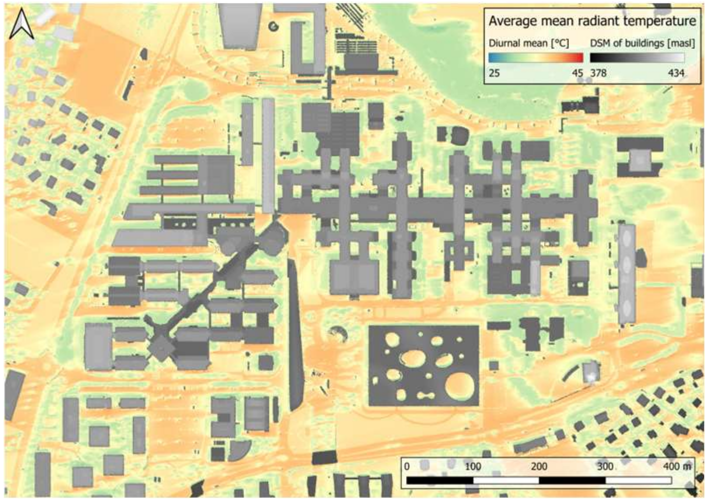
Where ε_p is the emissivity of human body, σ is the Stefan Boltzmann constant and S_{str} the mean radiation fluxes.

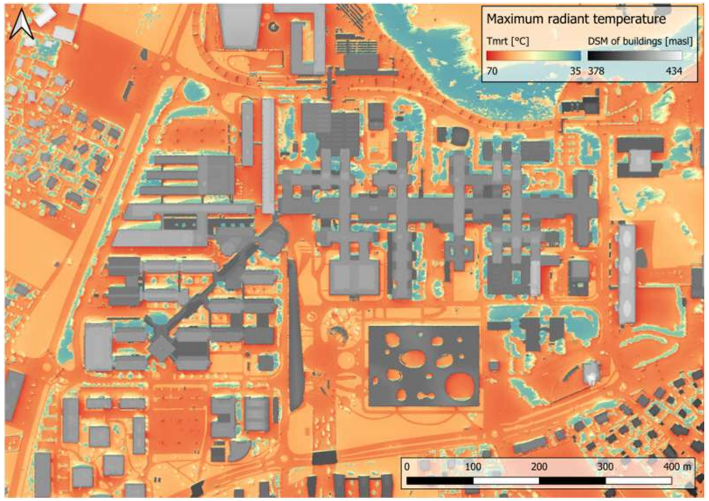
$$S_{str} = \alpha_k \left[0.28K_{dir\rightarrow} + 0.06(K_{\uparrow} + K_{\downarrow}) + 0.88K_{diff\rightarrow}\right] + \varepsilon_p [0.88L_{\rightarrow avg} + 0.06(L_{\uparrow} + L_{\downarrow})]$$

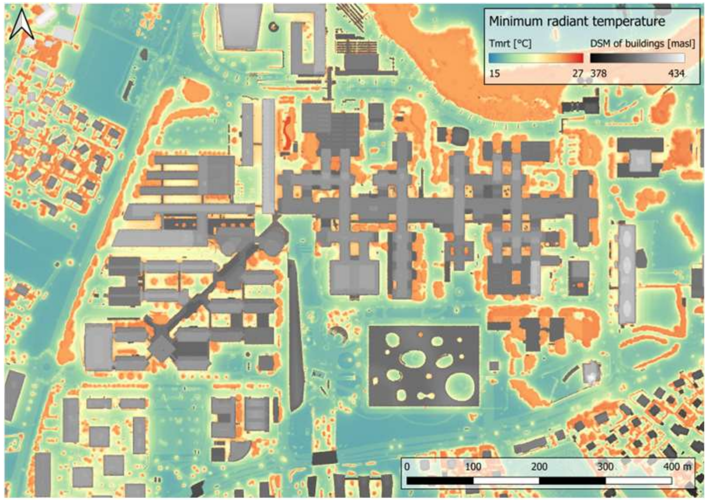
Radiation fluxes estimated with the incoming radiation, air temperature, relative humidity, sky/ground view factor, sun's position, shadow, emissivities and albedos.

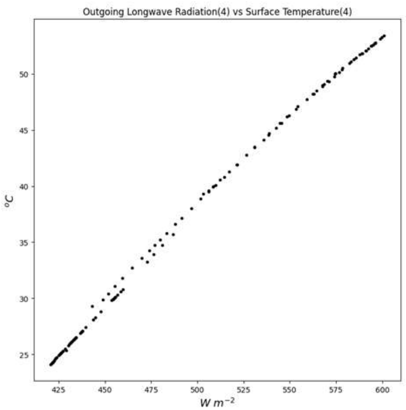
For more details check the research documents on SOLWEIG.

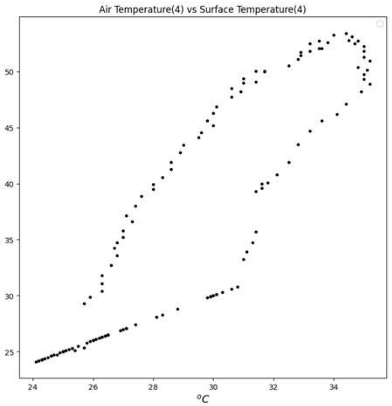
Post-processor



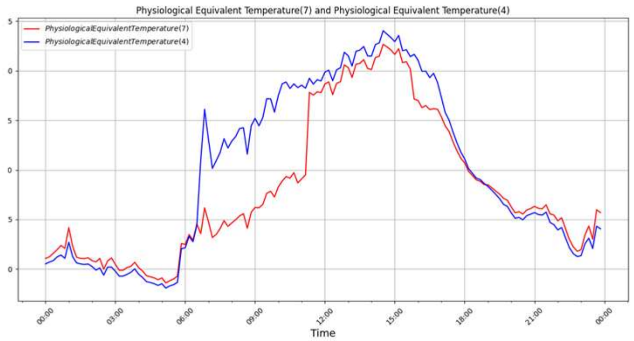


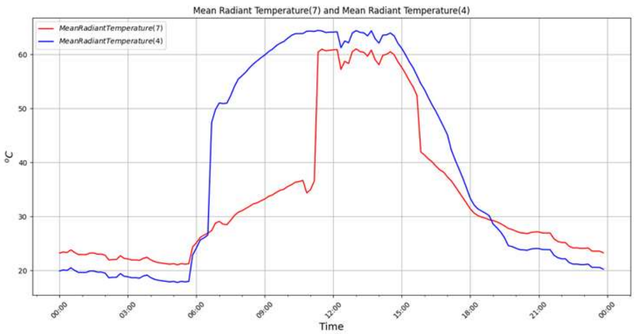






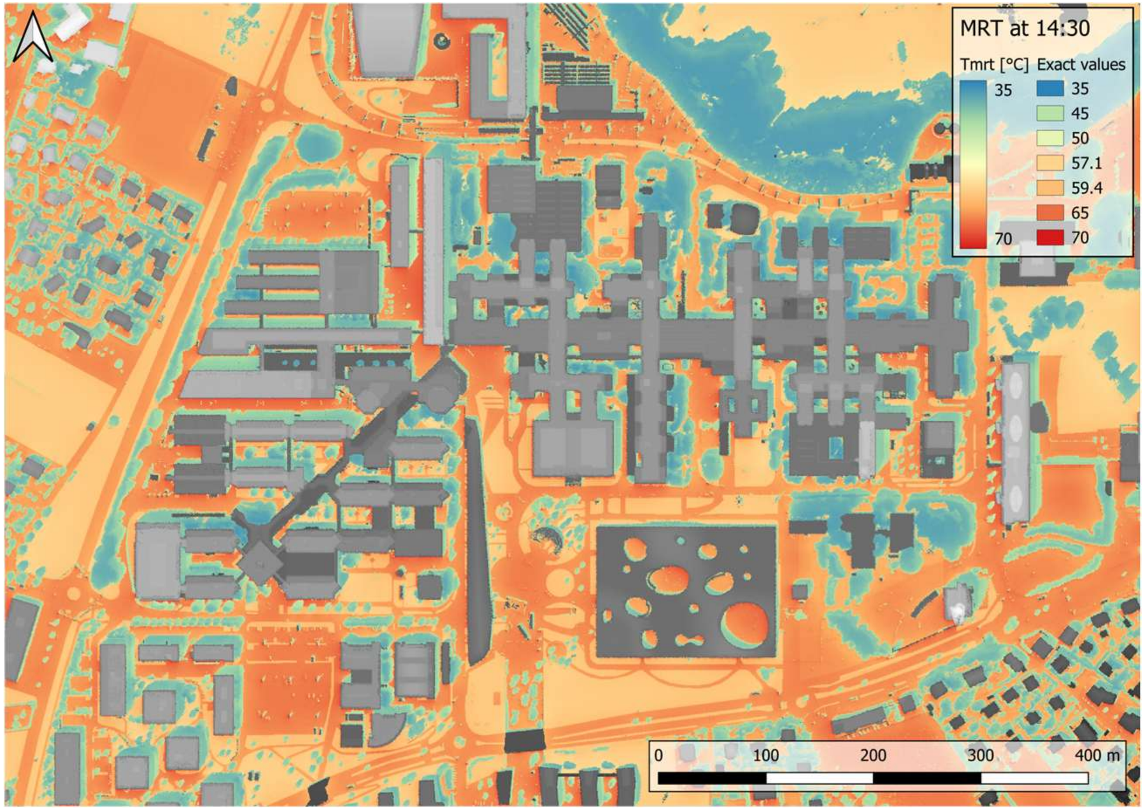
POI - 4

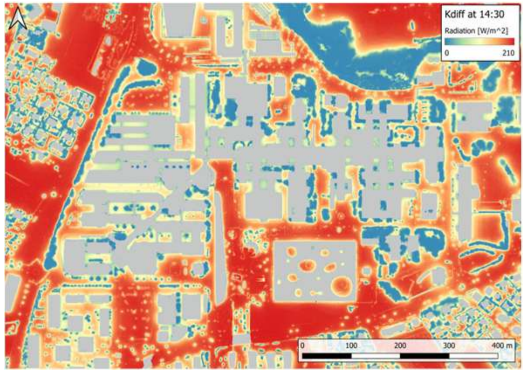


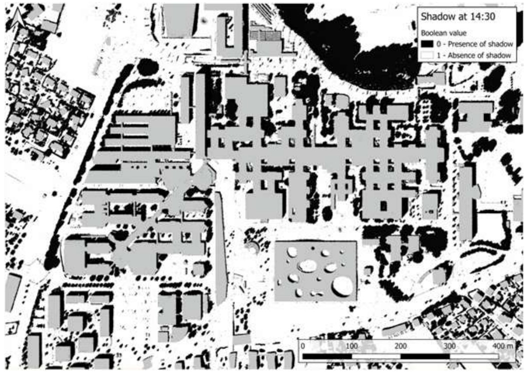


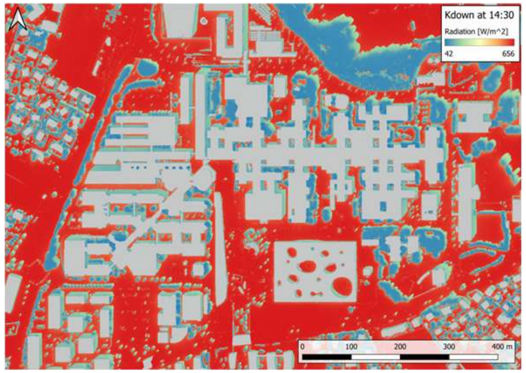
POI – 4 & POI -7

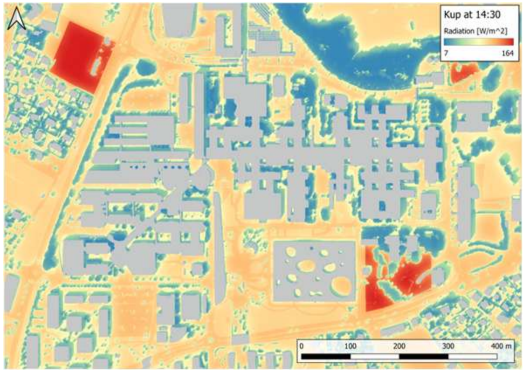
Analysing the radiations at 14:30

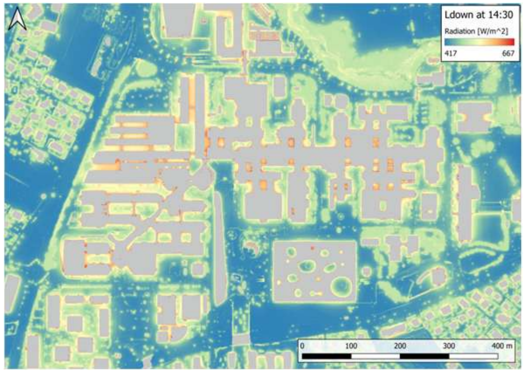


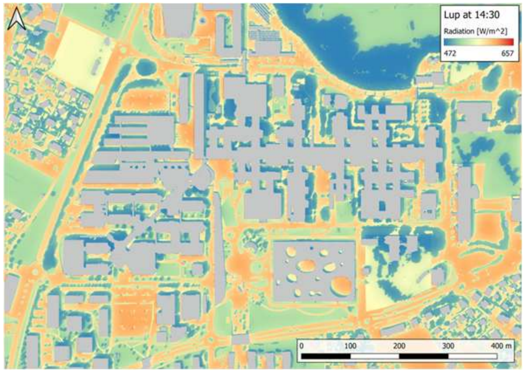




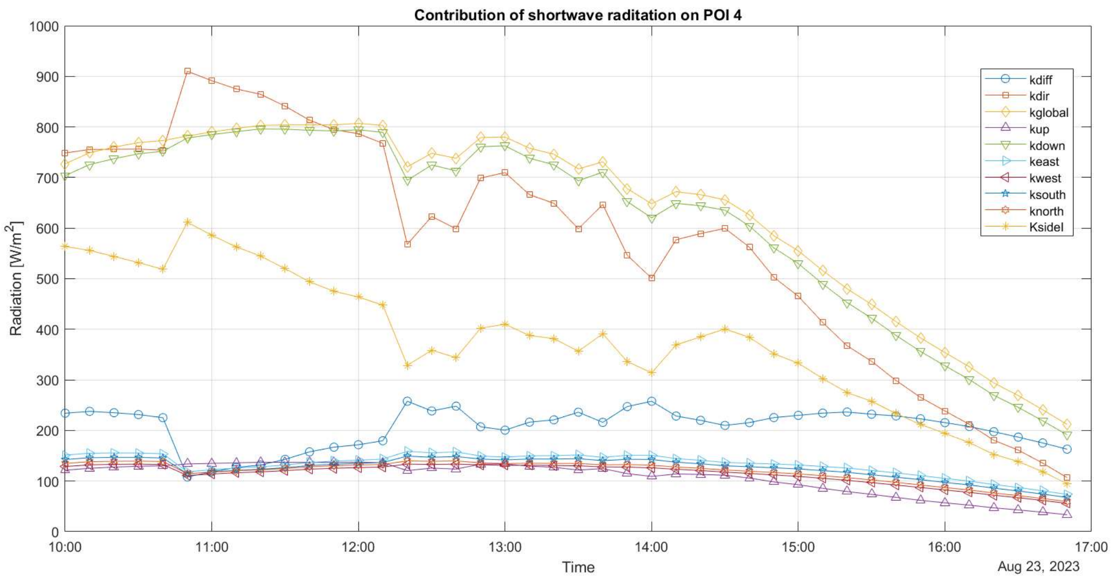


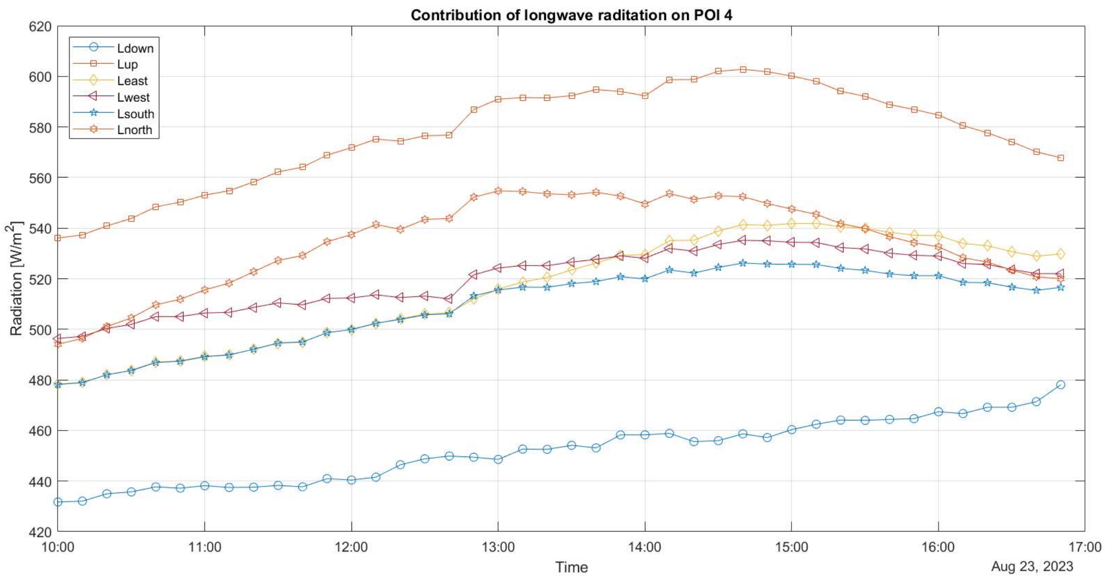




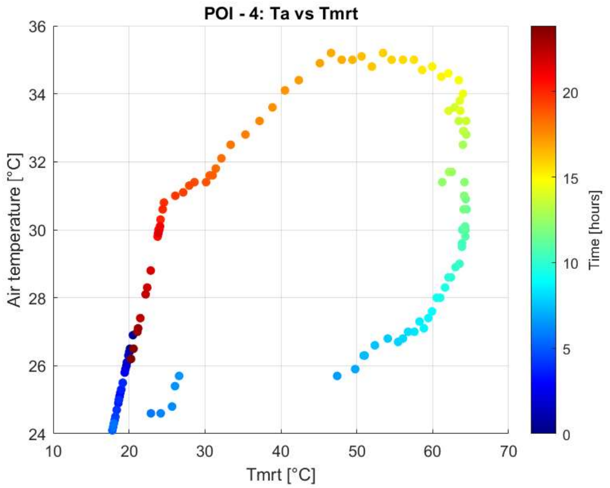


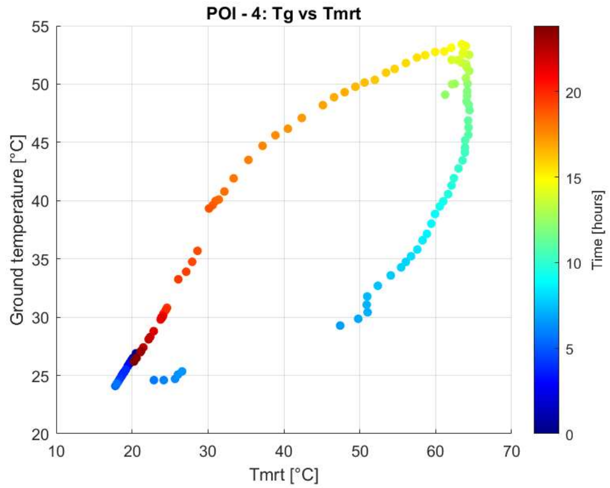
Analysing the radiations with MATLAB

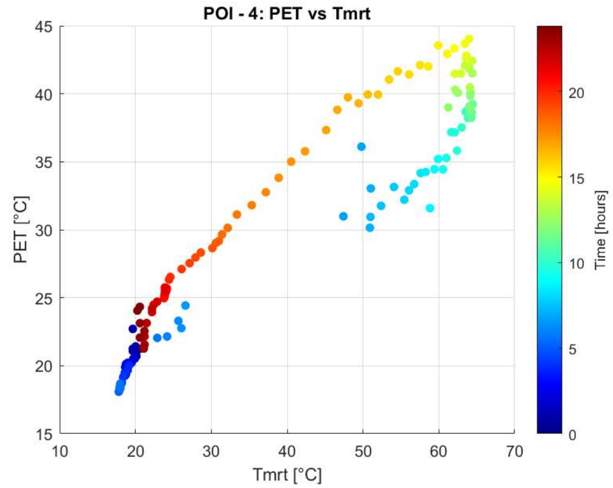


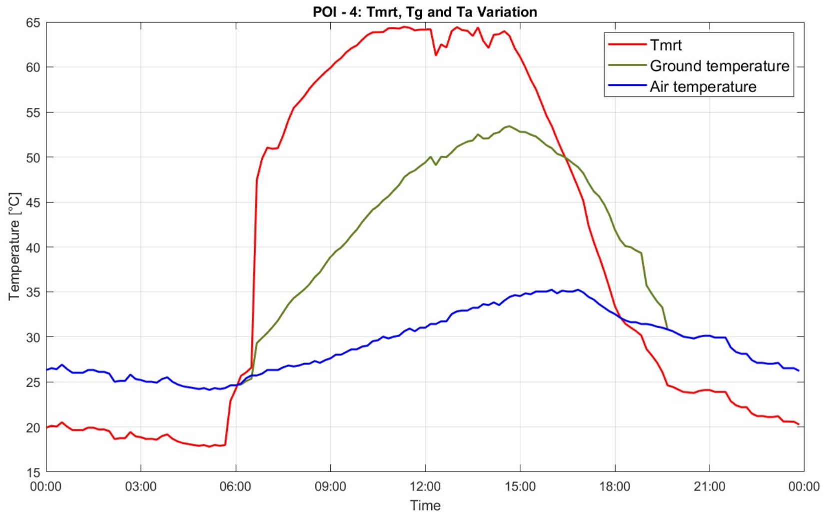


Analysing with MATLAB







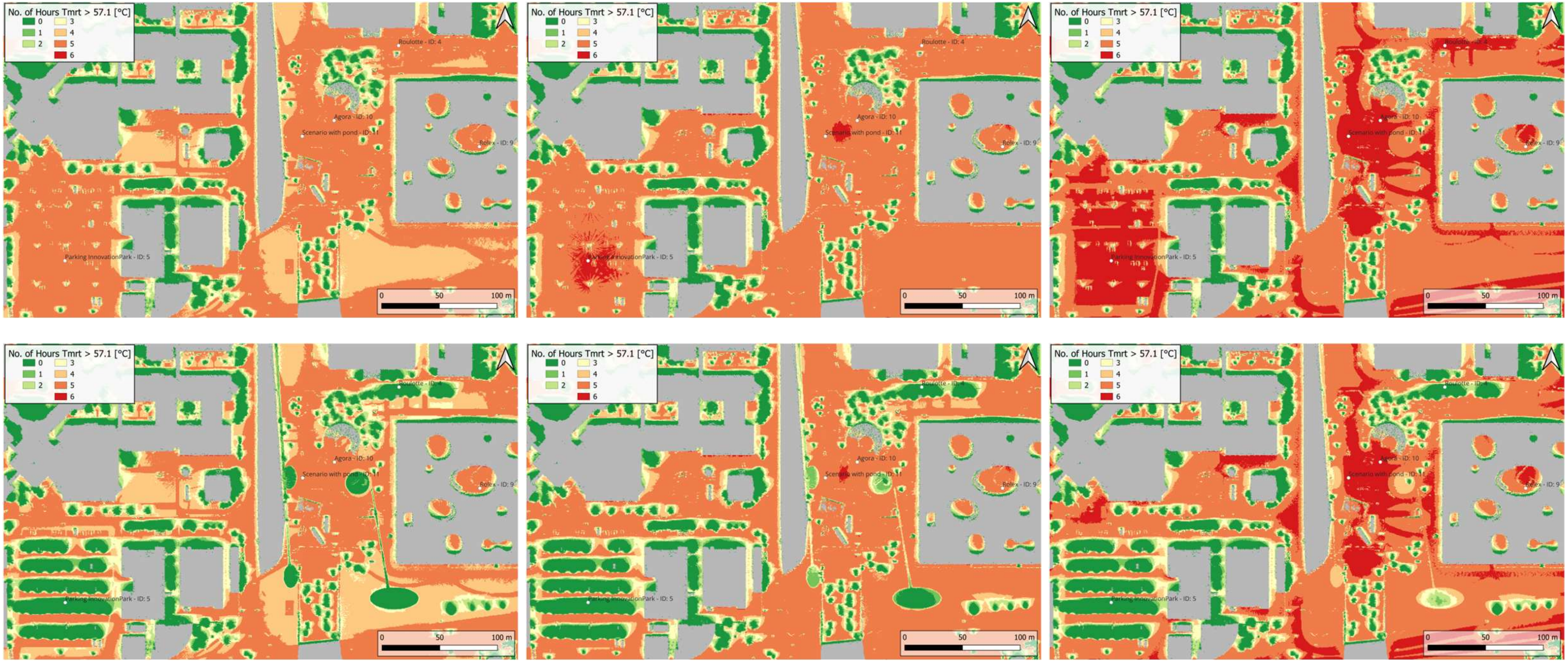


Analysing with scenarios

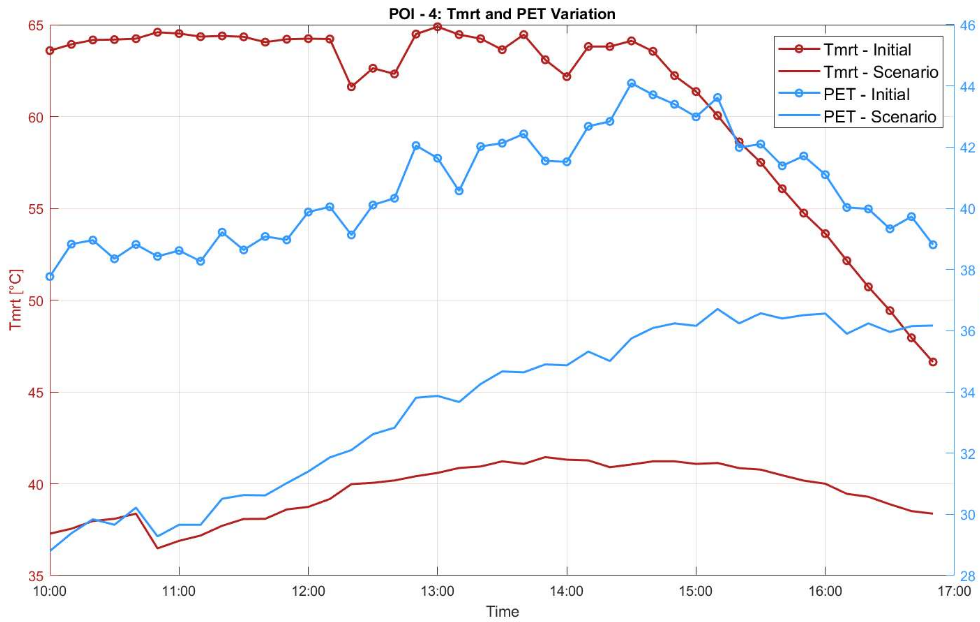
Initial conditions | +1.5 °C | + 3°C

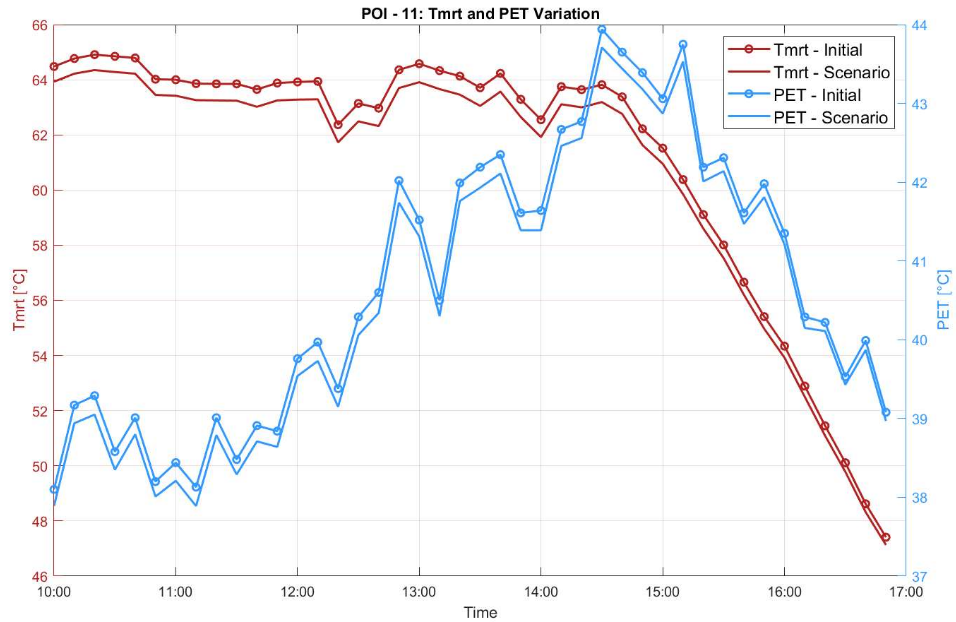
1)

2)



Analysing with MATLAB





Comparing with Ville de Lausanne