Supplementary material: Evaluating Green Roof Heat Mitigation Potential in a Changing Climate

Giovan Battista Cavadini[a,b], Livio Bächtold[a], Trang Nguyen[a] , Gabriele Manoli[c], Lauren Cook[a]

[a]Eawag, Urban Water Management Department, Switzerland

[b]Instititute of Environmental Engineering, ETH Zürich, Switzerland

[c]Laboratory of Urban and Environmental Systems, EPFL Lausanne, Switzerland

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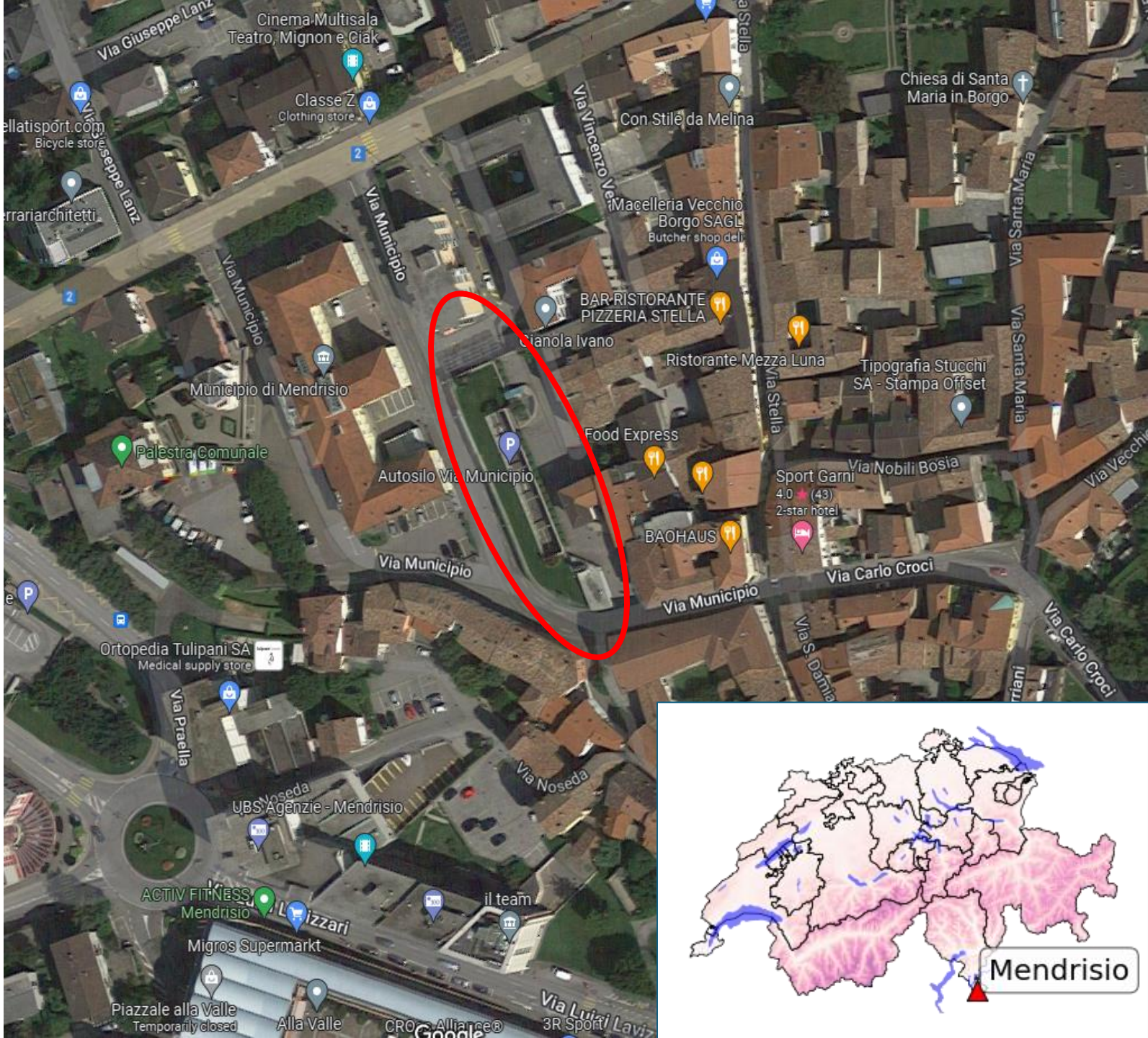
Green Roof in Mendrisio

Challenging environment for BGI:

- Hot and dry climate
- Strong precipitation events

SUPSI

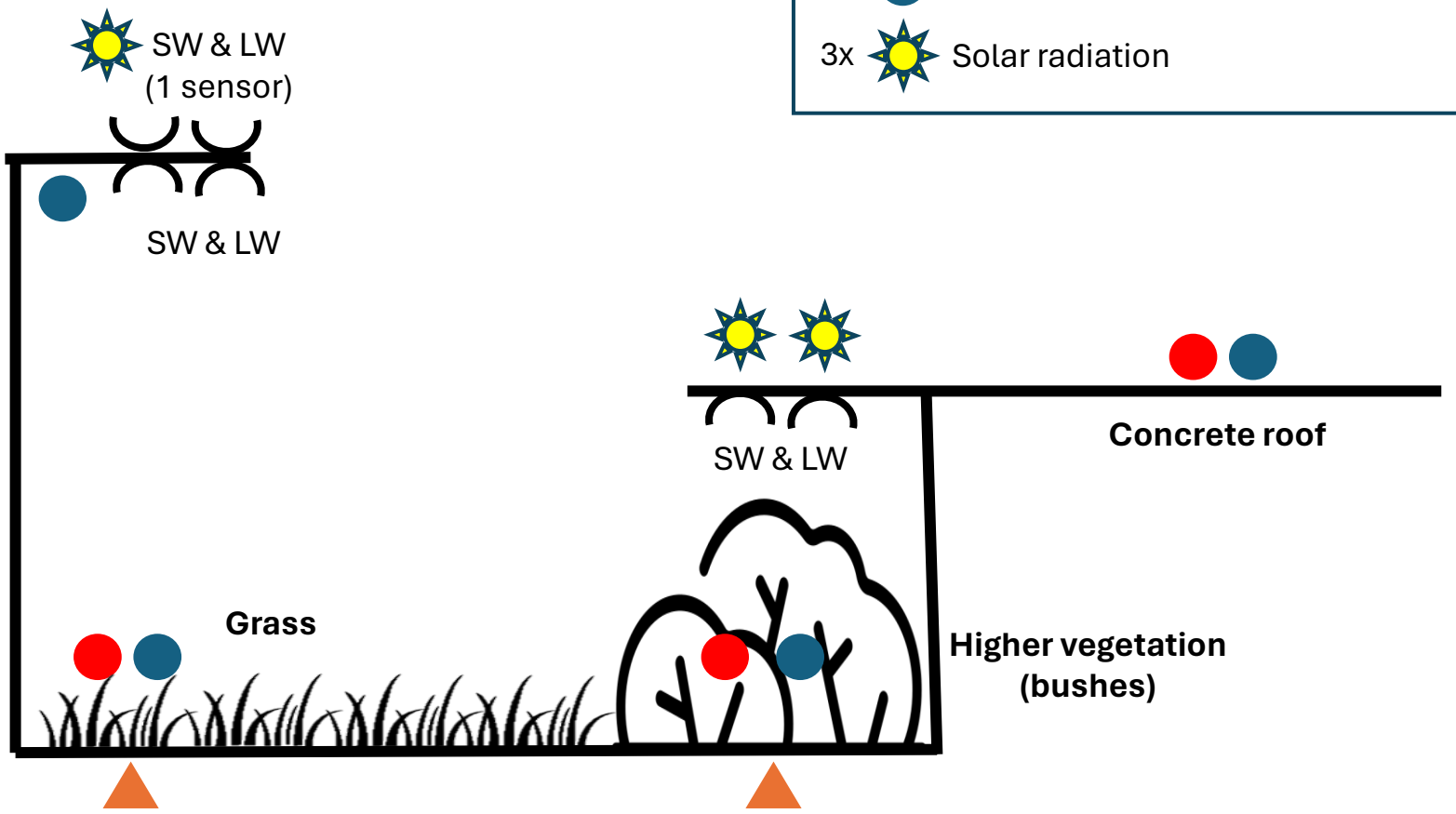
Città di Mendrisio



Green roof characteristics

- Located on a parking lot (canyon elevation 3.5 m)
- Dimensions: ca. 60 x 10 m
- Vegetation: grass
- Substrate depth: 30 cm
- Irrigated twice a week (during summer)
- Publicly owned (municipality of Mendrisio)

Sensor Placement



Sensor placement

3x Surface temperature
4x Air temperature
3x Global radiation (SW + LW)
4x Soil moisture + temperature

Concrete roof

LoraWan

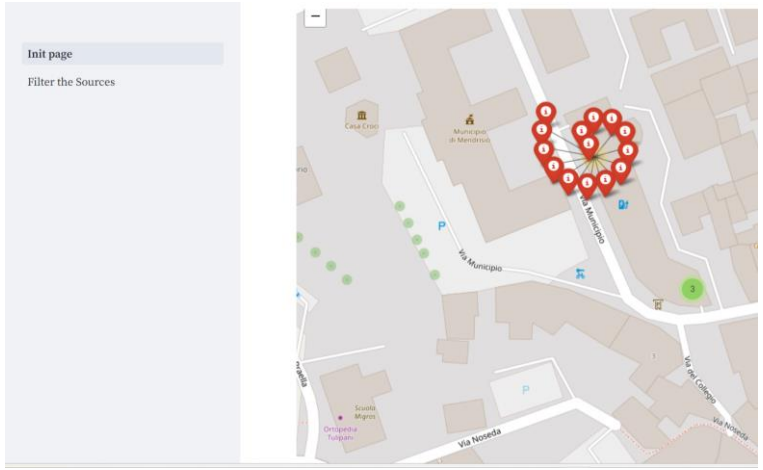
On higher vegetation

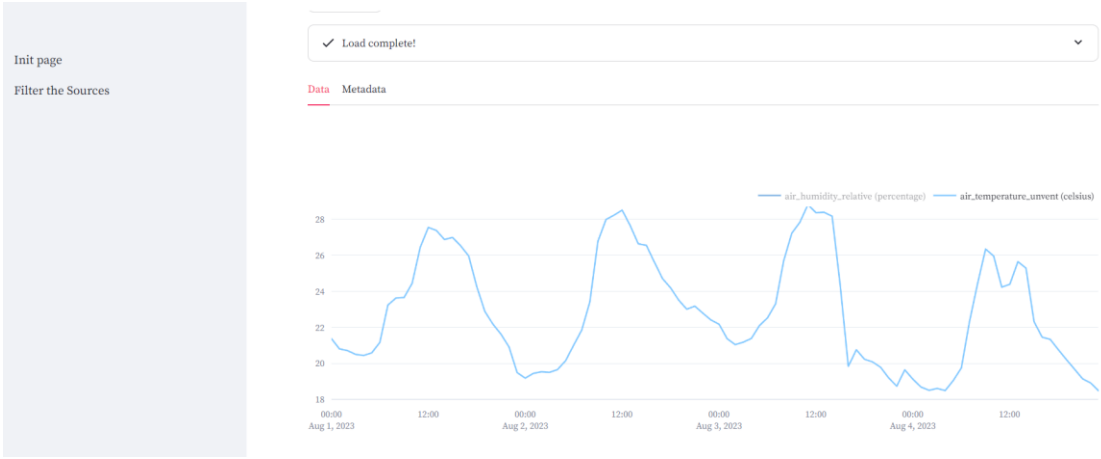
Roof Runoff

On the pole (2m), pointing grass

Data visualization tool

1. Select the sensor
2. Choose the desired time-period and the aggregation interval
3. Visualize the data





Check the data!
http://86.119.41.169:8501/

Calibration measurements

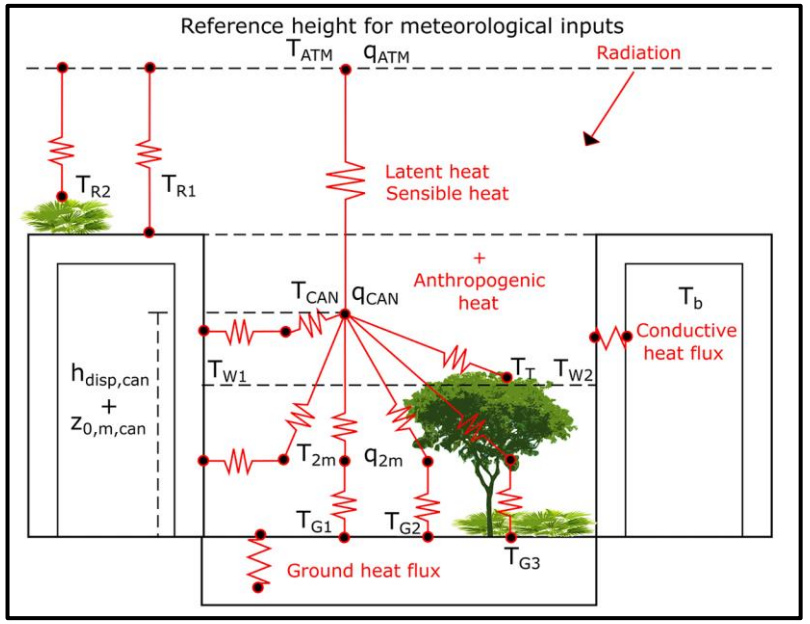
- Infrared surface temperature sensor: Optris Csmicro_LT_LTH
- Selected period: June-July-August 2023
- Data aggregated hourly

Grass

Concrete

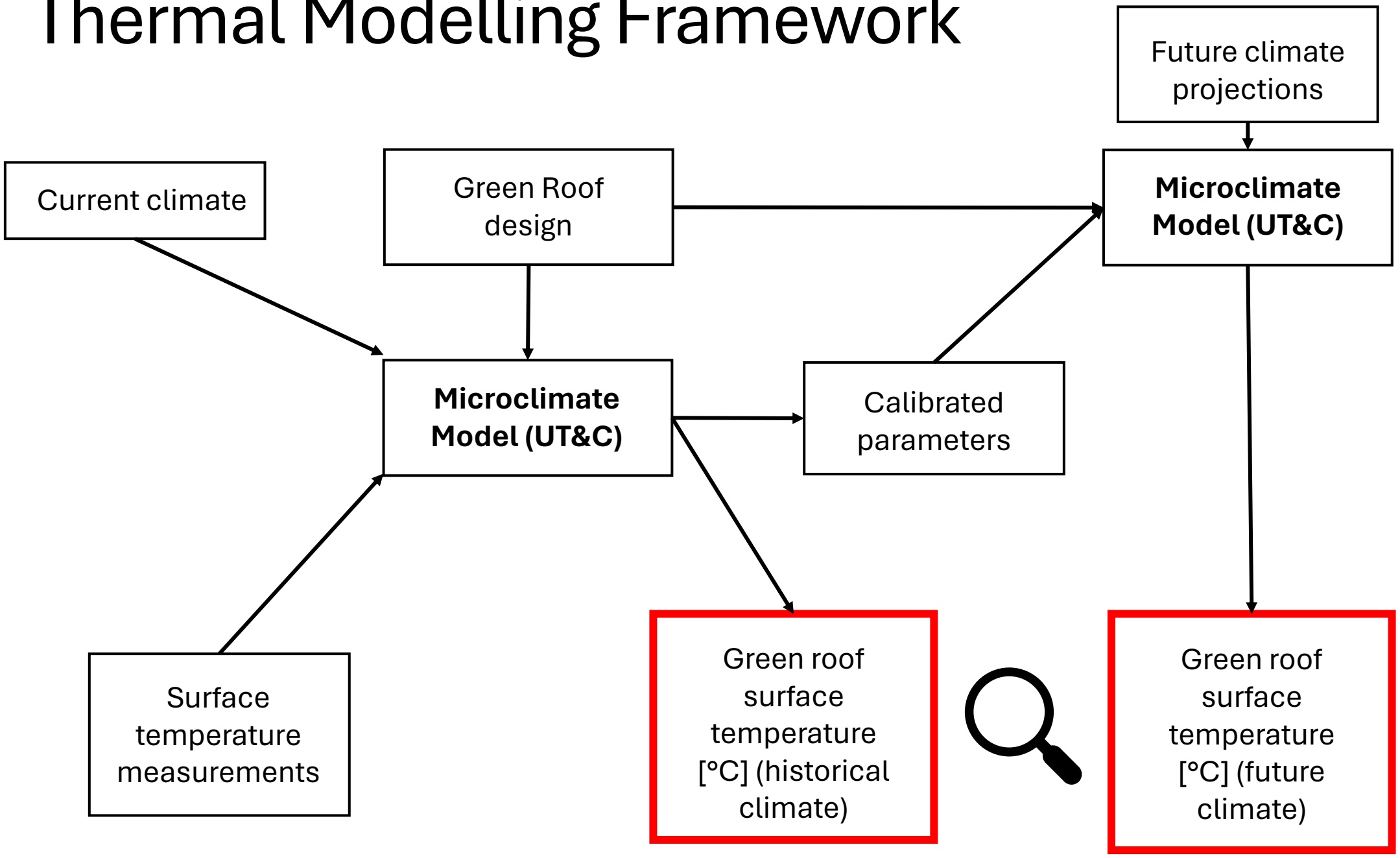
Why Urban Tethys-Chloris (UT&C) model?

- One of the first urban canyon parameterizations to include eco-hydrology
- Low computational demand allows for multiple years analyses
- Calculates 2 m air temperature, 2 m humidity, and surface temperatures
- Surface temperature on vegetated surfaces on the ground is considered as a proxy for the surface temperature on the roof



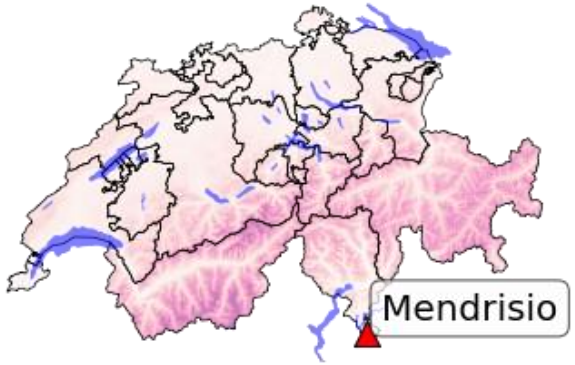
Meili, N. et al. "An Urban Ecohydrological Model to Quantify the Effect of Vegetation on Urban Climate and Hydrology (UT&C v1.0)." *Geoscientific Model Development* (2020)

Thermal Modelling Framework

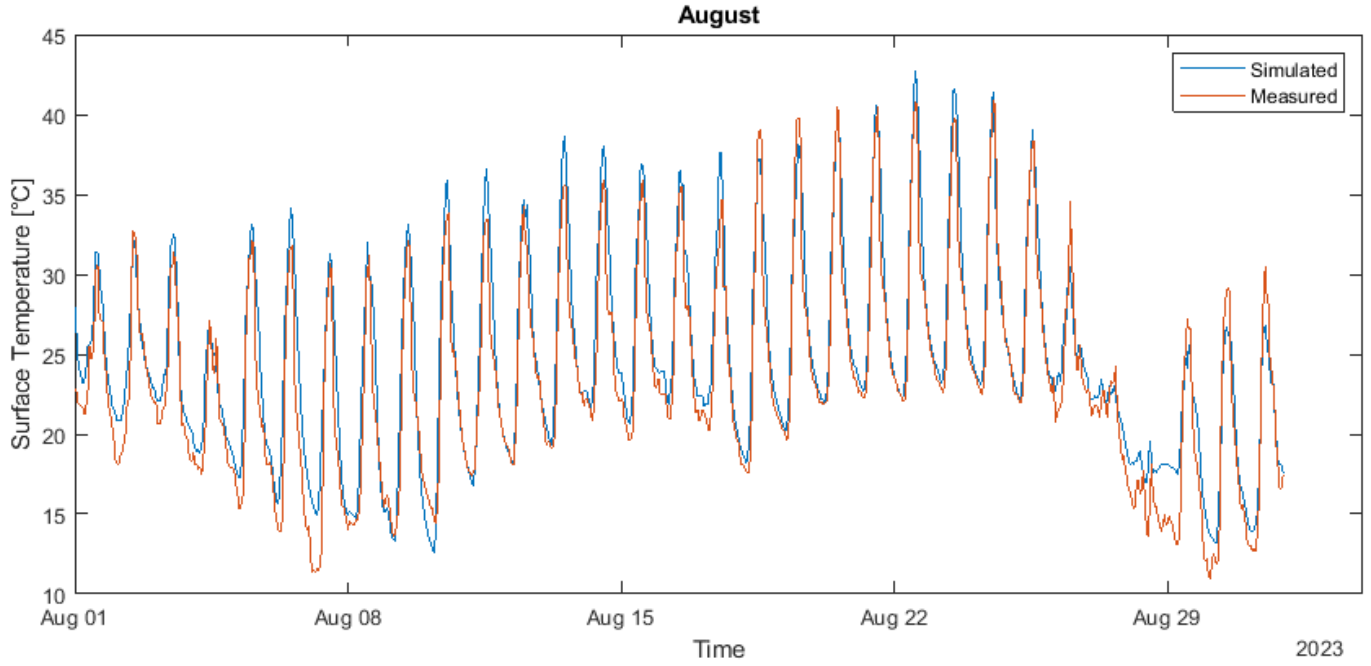


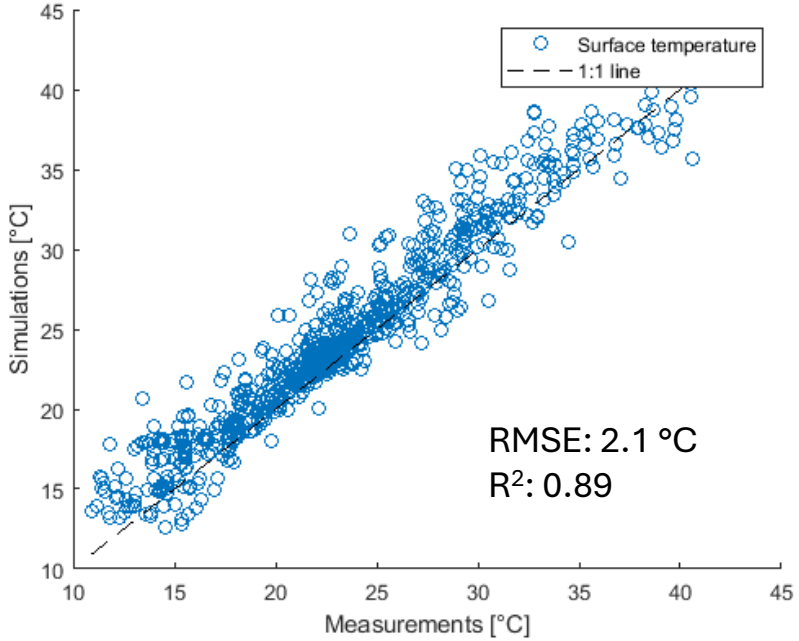
Metereological input current climate

- Source: MeteoSwiss weather station in Stabio (due to better data quality)
- Hourly aggregated values:
  - Air temperature at 2 meters [°C]
  - Relative humidity [-]
  - Atmospheric pressure [Pa]
  - Wind velocity [m s^{-1}]
  - Precipitation [mm]
  - Global horizontal radiation [W m^{-2}]
  - Incoming longwave radiation [W m^{-2}]



Calibration: August





- Simulations slightly overestimate surface temperature peaks and night temperature, however it replicates the observations well

Parameter	Unit	Calibrated value
Thermal conductivity	W m^{-1} K^{-1}	0.9
Volumetric heat capacity	J m^{-3} K^{-1}	1’700’000
Leaf area index	-	2
Albedo	-	0.23

Future climate projection

Global Circulation Model (GCM)	Regional Climate Model (RCM)	RCP	Future time period	Spatial resolution [km]	Temporal resolution [minutes]	Bias-correction method	Data source
MPI-M-MPI-ESM-LR	COSMO-crCLIM-v1-1	8.5	2079-2088	2.2	6	Quantile mapping [1]	C2SM [2, 3]

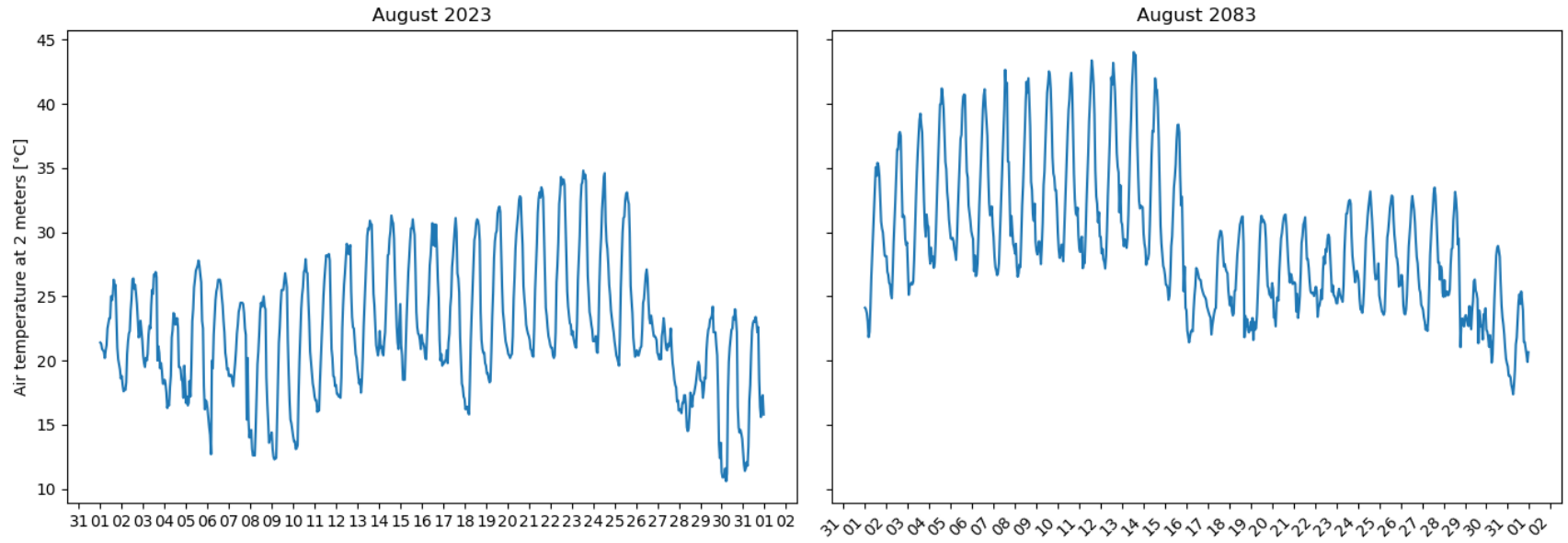
- The convection-permitting model enables higher temporal and spatial resolution, leading to better predictions of convective events.
- Only the year 2083 is presented in the results (preliminary analysis; the investigation will be extended to cover the available 10 years).
- The data are aggregated at an hourly timescale after bias correction.

[1] Cannon et al. «Bias Correction of GCM Precipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantiles and Extremes?» *Journal of Climate* (2015)
[2] Ban et al. «Evaluation of the Convection-Resolving Regional Climate Modeling Approach in Decade-Long Simulations». *Journal of Geophysical Research: Atmospheres* (2014)
[3] Leutwyler et al. «Evaluation of the Convection-Resolving Climate Modeling Approach on Continental Scales». *Journal of Geophysical Research: Atmospheres* (2017)

Future climate projection is notably hotter than historical values

Air temperature	Historical	Projection (RCP 8.5)
Average	22.0	29.0
95˚-percentile	30.2	39.5

Average increase in green roof surface temperature = 7.3 °C ~ average increase in air temperature



- Future analysis will include more 10 years to include interannual variability

Sensitivity analysis

- A simplified sensitivity analysis was conducted by varying one parameter range at a time to identify potential variations in surface temperature due to these parameters.
- The simulations considered only the minimum and maximum values of each parameter range.
- Values were derived from previous literature analyses to encompass the entire potential parameter range [4][5].

	Unit	Minimum	Maximum	Calibrated
Leaf area index	-	1.5	3	2
Maximum rubisco capacity	mol CO_2 m^{-2} s^{-1}	20	120	58
Albedo	-	0.1	0.4	0.23

[4] Meili et al. “An Urban Ecohydrological Model to Quantify the Effect of Vegetation on Urban Climate and Hydrology (UT&C v1.0).” *Geoscientific Model Development* (2020)
[5] Meili et al. «Vegetation cover and plant-trait effects on outdoor thermal comfort in a tropical city». *Building and Environment* (2021)

Acknowledgments

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