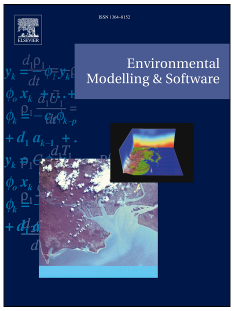

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# An open-source GIS user interface for the TARGET climate model in the Urban Multi-scale Environmental Predictor (UMEP) tool

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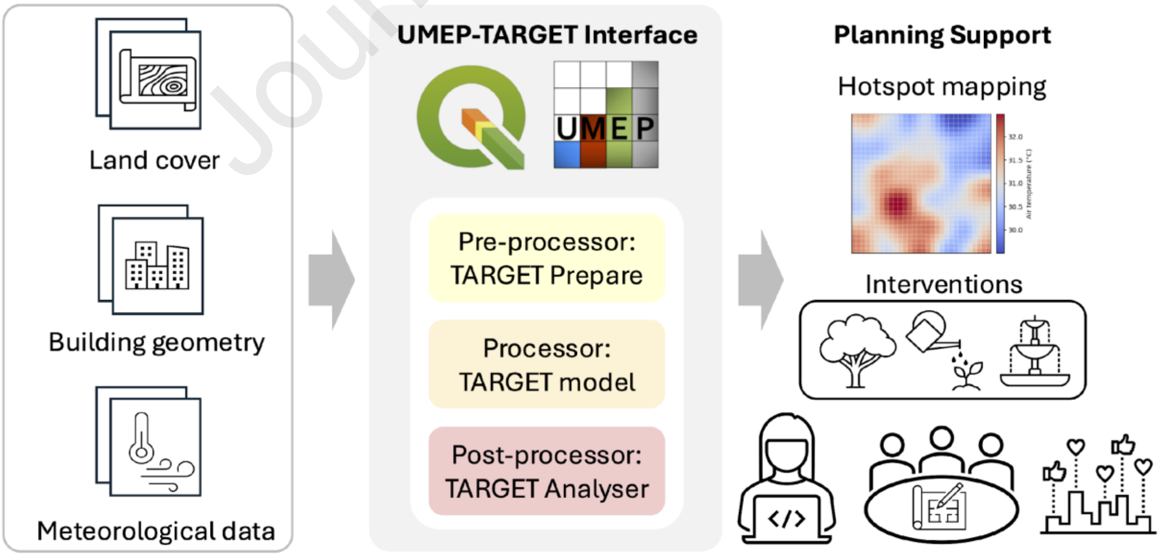
# An open-source GIS user interface for the TARGET climate model in the Urban Multi-scale Environmental Predictor (UMEP) tool

## Abstract

The Air-temperature Response to Green/blue-infrastructure Evaluation Tool (TARGET) is a compact urban climate model designed to predict intra-urban temperatures and assess city cooling strategies. Until now, the lack of a user interface has limited its broader adoption. This study presents an open-source interface for TARGET, integrated within the Urban Multi-scale Environmental Predictor (UMEP) tool in QGIS. The interface supports a complete workflow, including input data preparation, simulation, and output visualisation. Its applicability is demonstrated through a case study in Zurich, Switzerland, where it identified thermal hotspots and quantified the cooling benefits of targeted interventions. By lowering technical barriers, UMEP-TARGET enhances the accessibility of physically based urban temperature modelling for both the scientific community and practitioners, supporting evidence-based planning for climate adaptation.

## Graphical abstract



**Highlights**

- Integration of TARGET urban climate model into the UMEP QGIS plugin
- Developed user-friendly full workflow for data preparation, simulation, and visualisation
- Case study in Zurich shows hotspot mapping and cooling intervention scenario analysis
- Tool lowers technical barriers, enabling broader research and planning use
- Open-source interface supports future extensions and community development

**Keywords**: urban climate; urban heat; modelling; UMEP; TARGET; QGIS plugin; Python

## 1. Introduction

Cities worldwide are facing increasing challenges from extreme heat events, driven by the combined effects of global climate change and urbanisation (IPCC, 2023; Oke et al., 2017). High temperatures in densely built environments exacerbate heat stress (Kovats & Hajat, 2008), elevate risks to public health (Watts et al., 2018), and intensify energy demand for cooling (Santamouris, 2014). Urban heat is therefore not only an environmental concern but also a socio-economic and planning challenge (Stone, 2012). Developing effective mitigation strategies, such as expanding tree cover (Marando et al., 2022), irrigating green spaces (Cheung et al., 2022), or introducing water features (Jandaghian & Colombo, 2024), requires a quantitative understanding of the spatial and temporal variability of urban thermal conditions. Modelling tools capable of resolving intra-urban temperature patterns at fine spatial scales have thus become essential for evidence-based urban climate adaptation (Oke et al., 2017).

High-resolution models, such as computational fluid dynamics (CFD)-based ENVI-met (Bruse & Fleer, 1998) or large-eddy-simulation frameworks like PALM-4U (Maronga et al., 2019), provide detailed representations of microclimate processes. However, their computational intensity and high expertise requirements make them less suitable for city-scale scenario testing. Mesoscale models such as Weather Research and Forecasting (WRF) (Skamarock et al., 2008) face similar challenges. Despite offering comprehensive meteorological capabilities, these models require substantial computational resources and specialised expertise and are often too coarse for intra-urban analysis. The Air-temperature Response to Green/blue-infrastructure Evaluation Tool (TARGET) (Broadbent et al., 2019) was designed to fill this gap by balancing physical realism with computational efficiency, making it accessible to practitioners who need timely information for planning decisions.

TARGET simulates energy fluxes for key land cover types, including buildings, paved surfaces, vegetation, and water, while accounting for local canyon morphology and meteorological forcing. Its computational efficiency makes it particularly suitable for scenario testing at neighbourhood to city scales, where users may wish to compare baseline conditions with alternative land cover configurations. The model has been successfully applied in both research and policy contexts to assess the cooling benefits of blue-green infrastructure (BGI), evaluate urban morphology effects, and explore adaptation strategies under heatwave conditions (Broadbent et al., 2019; Chen et al., 2024, 2025; Demuzere & Nice, 2025; Gupta et al., 2025; Nice et al. 2024; Urich & Harold, 2020). These studies have demonstrated TARGET's ability to capture urban thermal contrasts and to provide robust insights into heat mitigation potential.

Despite these strengths, the practical use of TARGET has remained limited. An early prototype of the model was implemented in Python, but the original release was provided as stand-alone Java code (Nice, 2019; Broadbent et al., 2019). Running simulations requires users to handle input preparation, parameter configuration, and output processing within a coding environment. Because the process demands substantial technical expertise to format inputs and interpret outputs, the model's accessibility has been restricted to a small group of expert users. Urban planners, environmental consultants, and practitioners, who could directly benefit from applying TARGET in real-world decision-making, often lack the technical capacity to operate such stand-alone models. The earlier Python version of TARGET was subsequently updated to include new functionalities and parameterisations from the Java implementation (Chen et al., 2024). Despite facilitating integration with geospatial workflows, this earlier version still requires command-line execution and programming skills. In contrast, models such as ENVI-met (Bruse & Fleer, 1998) have achieved widespread adoption in both research and practice, largely because they offer a graphical user interface that lowers the entry barrier for non-specialists. Such discrepancies illustrate a broader challenge in environmental modelling, where the transition from academic models to general use is often hindered by the complexity of setup, execution, and analysis. A major barrier is therefore not the availability of suitable models, but rather the absence of user-friendly interfaces that reduce the entry barrier for urban climate modelling non-specialists.

Geographic Information Systems (GIS) (Longley et al., 2015) offer a natural solution to this barrier, as they provide an environment where spatial data, model workflows, and visualisation tools can be combined. Previous work has demonstrated that such interfaces substantially improve usability by simplifying data preparation for model applications (Aloui et al., 2023). Among the available options, QGIS (QGIS.org, 2025) has become one of the most widely used open-source platforms, offering cross-platform compatibility (Linux, MacOS, Windows), extensive community support, and flexibility through plugin development. The Urban Multi-scale Environmental Predictor (UMEP) builds on this ecosystem, functioning as a QGIS plugin that integrates tools for pre-processing meteorological and surface data, running urban climate models, and post-processing results (Lindberg et al., 2018). By providing a modular framework and an accessible graphical user interface, UMEP bridges disciplinary boundaries between urban climatology and planning.

Here, we introduce an open-source interface for the TARGET model within the UMEP plugin for QGIS. The integration is designed to support the full modelling workflow, from data preparation to simulation execution and visualisation of results. By leveraging existing UMEP modules for land cover classification, urban morphology calculation, and meteorological pre-processing, the new interface minimises user effort and ensures compatibility with widely available datasets. Dedicated visualisation tools were added to facilitate hotspot identification and scenario comparison, enabling users to evaluate the cooling potential of targeted interventions. Extending this framework to include TARGET therefore represents an opportunity to expand the UMEP toolset and make fast intra-urban temperature modelling directly usable by a wider audience.

To demonstrate the applicability of the UMEP-TARGET interface, we apply it to a case study in Zurich, Switzerland. The case illustrates the end-to-end workflow, from input preparation to the assessment of mitigation strategies during a heatwave. We show how the tool can identify thermal hotspots, design interventions such as greening and irrigation, and quantify the resulting cooling benefits. The example highlights the value of integrating TARGET into UMEP for both research and practice. By improving accessibility and functionality, the UMEP-TARGET interface has the potential to expand the use of physically-based urban climate modelling, supporting evidence-based planning for climate-resilient cities.

## 2. Methods

### 2.1. TARGET overview

The TARGET model is a computationally efficient model designed to estimate surface and 2 m above-ground air temperatures in heterogeneous urban environments, with a specific focus on evaluating the impacts of BGI. TARGET can be implemented at individual locations or across a spatial grid with configurable resolution. The recommended highest resolutions are 30 m for surface temperature and 100 m for air temperature. It requires three main categories of input: (i) land cover fractions (roofs, concrete, asphalt, dry grass, irrigated grass, trees, and water), (ii) building geometry describing urban canyon morphology, and (iii) meteorological forcing data representative of local background conditions, including incoming shortwave and longwave (optional) radiation, air temperature, relative humidity, wind speed, and barometric pressure. This meteorological data can be sourced from nearby weather stations or reanalysis products like ERA5 (Hersbach et al. 2020).

TARGET operates through several interconnected sub-models that calculate radiation balance, energy balance, and ultimately surface temperature for each land cover type. Building forms and vegetation density are generalised into a sky view factor, which determines the net radiation reaching urban surfaces. This net energy is partitioned into sensible heat, latent heat, and ground storage fluxes, with the latter estimated using an adapted version of the Objective Hysteresis Model (OHM) (Grimmond & Oke, 2002). For each grid cell, surface energy balances are aggregated by land cover composition to derive aggregated canyon-average surface and air temperatures, which together form spatially distributed 2D temperature maps, when the model is applied over a domain.

TARGET combines this physically based energy balance framework with high computational efficiency, enabling rapid testing of BGI interventions at neighbourhood to city scales. However, processes such as horizontal advection and anthropogenic heat fluxes are not yet explicitly accounted for. Comprehensive details on the model equations, parameter values, and evaluation results are provided in Broadbent et al. (2019).

### 2.2. UMEP overview

The Urban Multi-scale Environmental Predictor (UMEP) is an open-source plugin for QGIS that integrates a suite of urban climate models and supporting tools (Lindberg et al., 2018). Structurally, UMEP relies on three core components: the pre-processor, which handles meteorological and surface input data; the processor, which serves as the main modelling system; and the post-processor, which provides analysis tools for the outputs.

UMEP includes a number of dedicated pre-processing tools, such as land cover fraction calculators, morphometric and sky view factor estimators, and meteorological pre-processors, which can be combined into workflows suited to different modelling applications. A key strength of UMEP lies in its ability to connect standard geographic datasets, such as land cover maps, digital elevation models, and building morphology data, with urban climate models, facilitating both input preparation and output interpretation at spatial scales relevant for urban planners.

In its initial release, UMEP included three main models: the SOlar and LongWave Environmental Irradiance Geometry model (SOLWEIG) for radiation and outdoor thermal comfort (Lindberg et al. 2008, Lindberg & Grimmond, 2011), Surface Urban Energy and Water Balance Scheme (SUEWS) for coupled surface energy and water balance (Järvi et al., 2011), and Solar Energy on Building Envelopes (SEBE) for solar energy assessments on building envelopes (Lindberg et al., 2015). Since then, the platform has been gradually expanded to include additional capabilities, including the Urban Weather Generator (UWG) (Bueno et al., 2013), and the URock wind model for pedestrian-level airflow simulations (Bernard et al., 2023).

Supported by extensive tutorials and documentation that make the tool accessible to both researchers and practitioners, UMEP has been widely applied in studies of radiation and energy exchange, outdoor thermal comfort, and scenario-based urban climate analysis (e.g., Evola et al., 2021; Guerri et al., 2023; Jiang & Menz, 2025; Lopez-Ordoñez et al., 2025; Zou et al., 2024). Its combination of modularity, extensibility, and community-driven development provides a suitable framework for hosting additional climate models, such as TARGET, whose integration adds a dedicated capability to assess urban heat mitigation strategies.

### 2.3. Technical implementation

The integration of TARGET into UMEP is designed to provide an accessible interface while remaining consistent with the structure of the original model. Within the plugin architecture, TARGET is implemented as a dedicated module that follows the established pre-processor, processor, and post-processor framework. The model is distributed as a Python package (PyPI), which ensures consistency with the reference implementation and allows straightforward updates through dependency management.

Input preparation relies on UMEP's existing pre-processing tools with targeted adaptations. The Land Cover Fraction (LCF) Calculator was extended to include the additional categories required by TARGET, which differ from the default UMEP classification. Building geometry is derived using the Morphometric Calculator, while meteorological forcing can be prepared either from local observations or retrieved directly from ERA5 via UMEP's data access functions.

Simulation outputs can be visualised in UMEP using additional tools developed specifically for TARGET, enabling users to generate spatial maps and time-series plots directly in the QGIS environment.

## 2.4. Workflow

The resulting integration enables a structured workflow from data preparation to analysis, as illustrated in Figure 1. Users first process the required input datasets, then run simulations using the integrated TARGET module, and finally visualise the results using the post-processing tools.

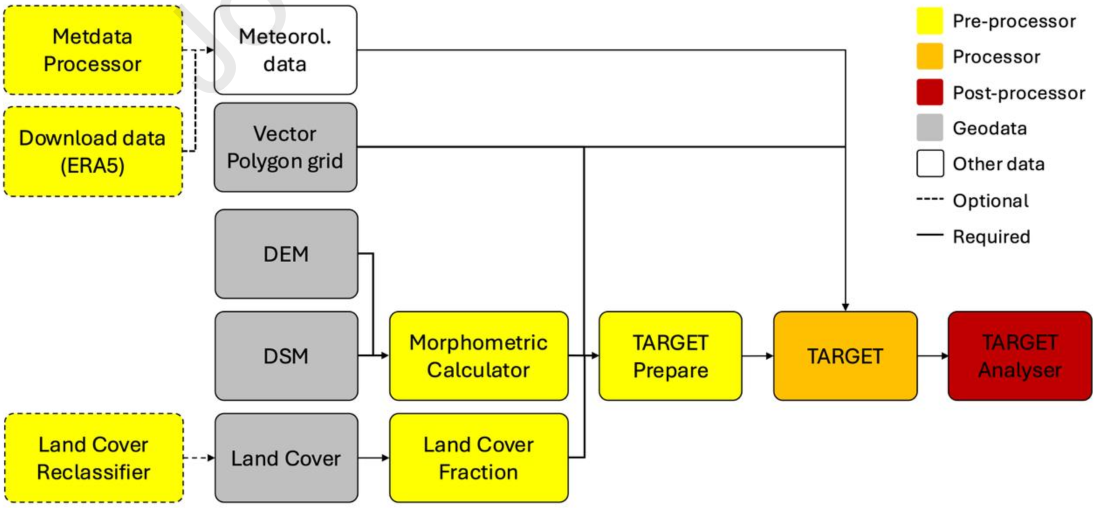


*Figure 1. Workflow and data for analysing urban heat using the TARGET model in UMEP. DEM – digital elevation model, DSM – digital surface model.*

In the initial phase of the workflow, users must prepare three essential input datasets: land cover information, building geometry, and meteorological data. All spatial inputs need to be provided as raster datasets. There is no strict requirement for the resolution of the input datasets, but to capture the relevant processes, the pixel resolution of the raster datasets should be fine enough to distinguish between ground (street) and objects (buildings). Accordingly, the first step is to generate a polygon grid at the chosen resolution, which defines the simulation domain. Following the recommendations of Broadbent et al. (2019), a minimum grid size of 100 m is advised for air temperature simulations and 30 m for surface temperature. Each grid cell represents a model unit where land cover fractions and building morphology are aggregated, providing the spatial framework for all subsequent TARGET calculations. Examples of the input geodata required are shown in Figure 2.

For land cover, users can either classify their dataset directly into TARGET categories using the *Land Cover Reclassifier* tool or make necessary adjustments later within the TARGET Prepare tool (e.g. allocating part of paved surfaces to concrete), if only UMEP's default classes are available. After reclassification, the Land Cover Fraction tool calculates the fractional coverage of each land cover type within each grid cell. The resulting file containing the land cover fractions for each grid cell is then provided to the TARGET Prepare tool later.

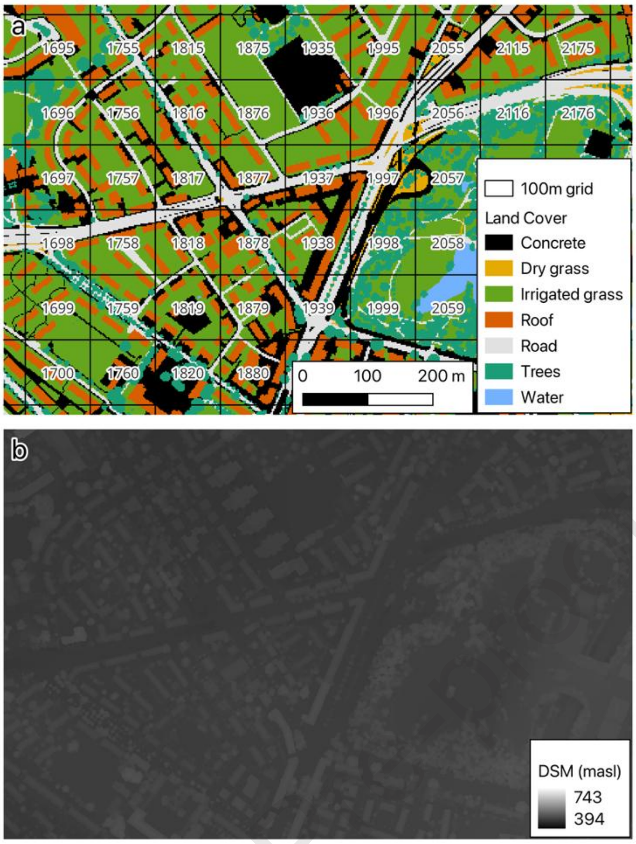
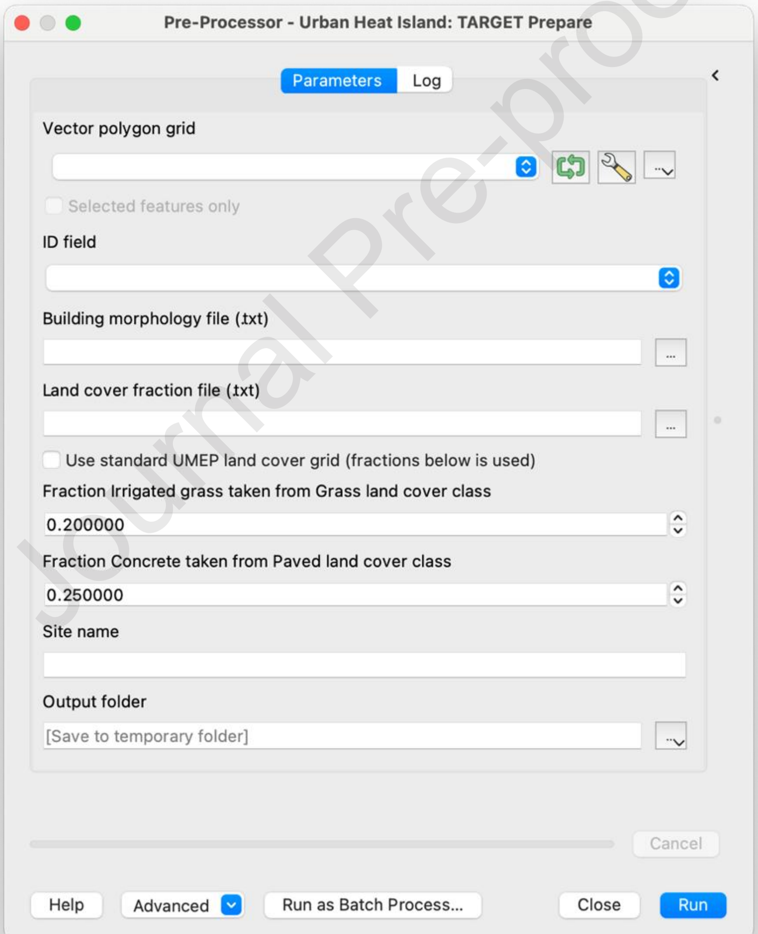


*Figure 2. Examples of input spatial data required to apply TARGET for Zurich: (a) land cover (2 m resolution) overlain with a polygon grid for aggregation (square grid created in QGIS, using Vector -> Research Tools -> create grid); (b) digital surface model (DSM, 0.5 m resolution in metres above sea level) including ground, vegetation and buildings.*

Building geometry preparation uses the *Morphometric Calculator* in UMEP, which requires a Digital Surface Model (DSM) and a Digital Elevation Model (DEM) as inputs. The resulting outputs are later used to calculate average building heights and canyon widths in TARGET Prepare.

For meteorological data, the *Metdata processor (UMEP -> Pre-Processor -> Meteorological Data -> Prepare Existing Data)* formats standard observations and supports both common weather data services and CSV files. UMEP also provides a dedicated tool for downloading ERA5 reanalysis data, which can be used when local observations are unavailable. For TARGET simulations, required data includes incoming shortwave radiation [W $m^{-2}$], wind speed [m $s^{-1}$], air temperature [°C], relative humidity [%], barometric pressure [kPa], and, if available, incoming longwave radiation [W $m^{-2}$].

Once all inputs are prepared, the *TARGET Prepare* tool generates the configuration folder required to run the model. During this phase, the tool organises the input datasets, creates the necessary configuration files, and ensures that the *TARGET Processor* can execute simulations consistently within UMEP. Figure 3 shows the *TARGET Prepare* interface, where users specify the polygon grid and ID field, link land cover and building morphology files, and define the output directory. Optional controls allow the splitting of irrigated grass and concrete fractions from the standard land cover classes.



☐ Selected features only

☐ Use standard UMEP land cover grid (fractions below is used)

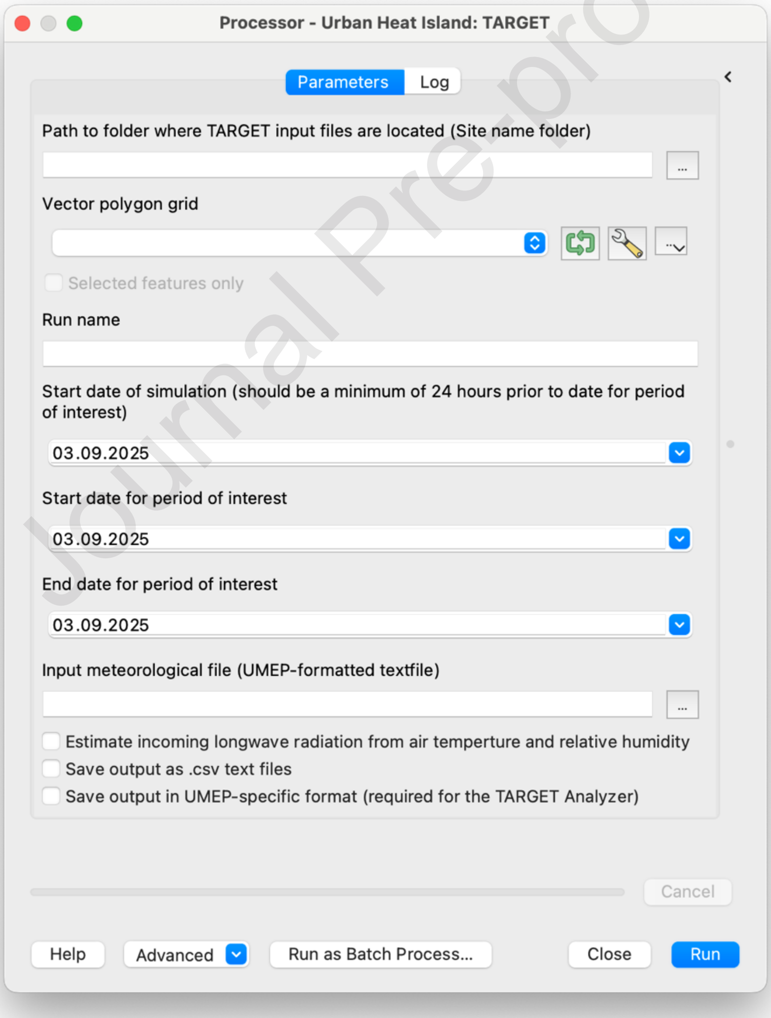
Fraction Irrigated grass taken from Grass land cover class: 0.200000

Fraction Concrete taken from Paved land cover class: 0.250000

Output folder: [Save to temporary folder]

*Figure 3. Graphical user interface (GUI) of TARGET Prepare.*

With inputs prepared, the *TARGET Processor* is used to execute the simulations. Figure 4 shows the TARGET Processor interface. Users load the configuration folder generated in the previous step, select the polygon grid, define the run name and the simulation period (including a user-defined spin-up period), and provide meteorological forcing. If incoming longwave radiation is unavailable, the interface offers an option to estimate it from air temperature and relative humidity, following Loridan et al. (2011). Additional checkboxes control whether outputs are saved as CSV tables or in the UMEP-specific format required for the TARGET Analyser.



Path to folder where TARGET input files are located (Site name folder)

Vector polygon grid

☐ Selected features only

Run name

Start date of simulation (should be a minimum of 24 hours prior to date for period of interest)
03.09.2025

Start date for period of interest
03.09.2025

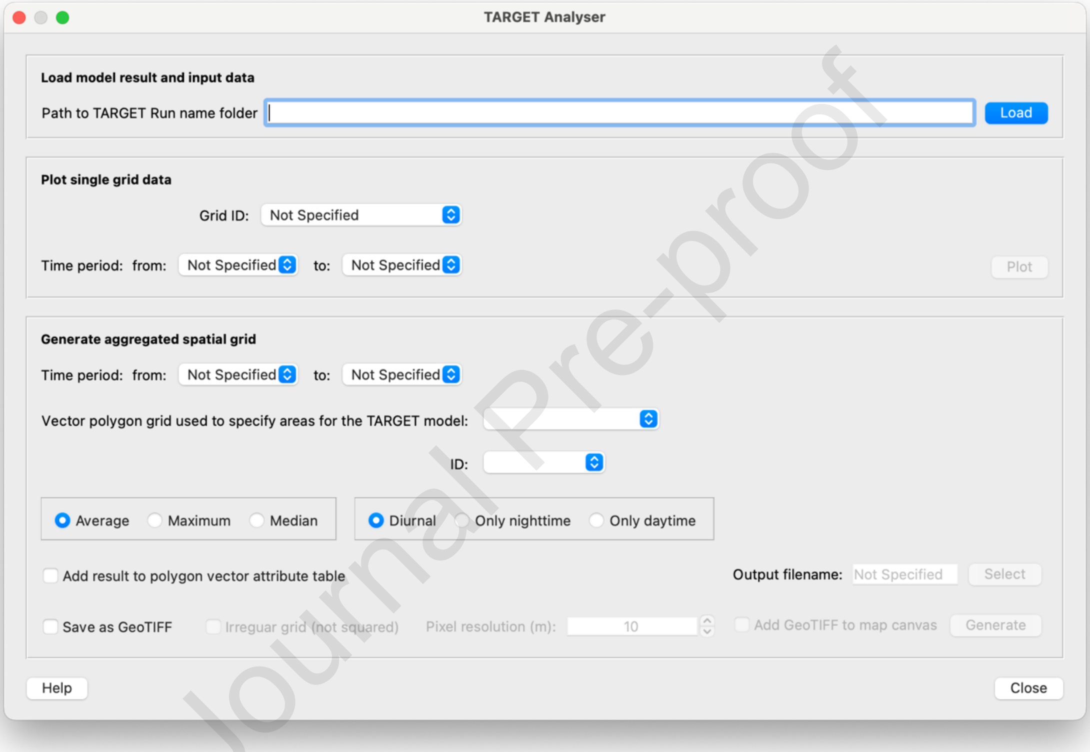
End date for period of interest
03.09.2025

Input meteorological file (UMEP-formatted textfile)

☐ Estimate incoming longwave radiation from air temperture and relative humidity
☐ Save output as .csv text files
☐ Save output in UMEP-specific format (required for the TARGET Analyzer)

*Figure 4. Graphical user interface (GUI) of TARGET Processor.*

The *TARGET Analyser* provides tools for exploring and visualising model outputs (Figure 5). Users can generate temporal plots for individual grid cells over a selected period, displaying simulated time series of urban and rural conditions. They can also create aggregated spatial maps, such as average, maximum, or median values across daytime, nighttime, or the full diurnal cycle. Results can be exported as GeoTIFFs or linked to polygon attributes in QGIS.



Path to TARGET Run name folder:

Grid ID: Not Specified

Time period: from: Not Specified to: Not Specified

Time period: from: Not Specified to: Not Specified

Vector polygon grid used to specify areas for the TARGET model:

ID:

● Average ○ Maximum ○ Median

● Diurnal ○ Only nighttime ○ Only daytime

☐ Add result to polygon vector attribute table

Output filename: Not Specified

☐ Save as GeoTIFF ☐ Irreguar grid (not squared) Pixel resolution (m): 10 ☐ Add GeoTIFF to map canvas

*Figure 5. Graphical user interface (GUI) of TARGET Analyser.*

## 3. Case study: Zurich, Switzerland

Zurich was selected as a demonstration site because it combines dense built-up areas with abundant green and blue spaces and offers high-quality official datasets. The study domain covers 28.8 km² in the city centre, encompassing a mix of residential, commercial, and industrial land uses, as well as a river corridor and large vegetated areas. All TARGET land cover classes are represented, with concrete, roof, and irrigated grass being the most prevalent. TARGET has previously been validated against observations in Zurich using the same input sources (Chen et al., 2024), which provides confidence in the reliability of the model outputs. The present case study, therefore, focuses on demonstrating the new interface rather than further model evaluation.

### 3.1. Input data preparation and initial setup

The simulation was conducted on a 100 m resolution polygon grid. Land cover information was derived from official planning authority vector data (ARE, 2019), which were reclassified into the seven TARGET categories and subsequently converted to raster format (2 m resolution) for model input. Building geometry was obtained from swissALTI3D (swisstopo, 2020) and swissSURFACE3D (swisstopo, 2018) datasets, representing the national digital terrain model (bare-earth DEM) and DSM, respectively, both available at a spatial resolution of 0.5 m.

To align with the intended use of TARGET for short episodes such as heatwaves, we selected a four-day period in July 2023 with daily maximum temperatures above 30 °C. The first day was used as spin-up and excluded from analysis. Meteorological forcing was provided by the nearby Fluntern station (556 m a.s.l.) (MeteoSwiss, 2023), including shortwave and longwave radiation, air temperature, relative humidity, wind speed, and pressure, recorded as 10-minute averages. The dataset covered four days (06/07/2023 – 09/07/2023), with the first day used as spin-up and excluded from the analysis. Unless otherwise noted, all results presented in the following sections are aggregated over the second simulation day (08/07/2023).

All input datasets were processed directly within the UMEP plugin, which integrates data preparation and model setup in the same environment. This allowed the simulation to be configured efficiently in QGIS without switching between different software or coding steps.

### 3.2. Hotspot identification and scenario design

As an initial analysis step, TARGET was run for the heatwave period using the baseline input data. Figure 6(a) shows the land cover distribution of the study domain. The *Analyser* was used to generate a spatial map of the average diurnal urban-rural temperature difference, shown in Figure 6(b). We selected this metric as it provides a straightforward representation of urban overheating patterns across the city. Positive values in the resulting map, indicating urban areas warmer than the rural reference, were identified as hotspots and are indicated in purple in Figure 6(a). The resulting pattern shows elevated air temperatures concentrated in dense built-up areas, particularly along the urban core and major transport corridors, while vegetated and river-adjacent zones consistently exhibited lower temperatures.

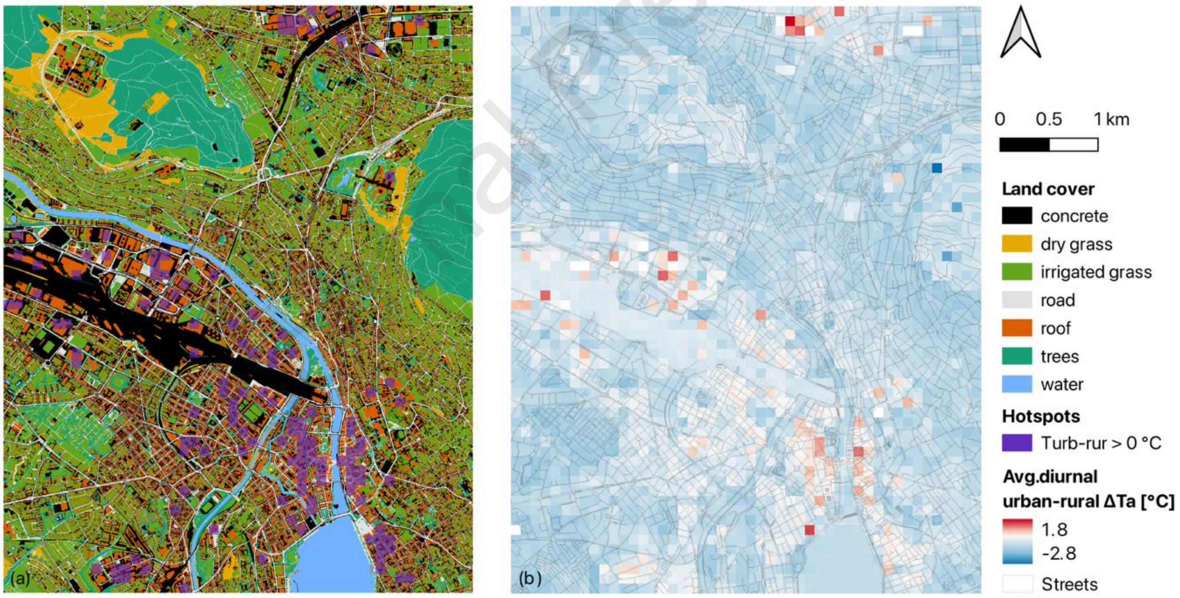


*Figure 6. (a) Land cover distribution of the study domain, with hotspot grid cells (in purple) derived from UMEP-TARGET outputs within QGIS; and (b) corresponding mean diurnal urban-rural temperature difference during the heatwave period, generated directly from the UMEP-TARGET interface. Positive values in the temperature difference map (b) were classified as hotspots in (a). In (b), white corresponds to a value of zero.*

Three scenarios were designed to assess the comparative cooling potential of different BGI strategies within the identified hotspot cells. In all scenarios, pixels classified as concrete or dry grass within hotspot cells were replaced with the target cover type, while all other pixels remained unchanged. Roof fractions were not modified, as interventions on rooftops are not represented in the current version of TARGET. As this case study serves as a demonstration of the tool's scenario-comparison capability, a full 100% replacement was applied for simplicity. The three scenarios were:

i. Greening and irrigation: concrete and dry grass replaced with irrigated grass, representing strategies such as new parks or irrigated planting beds;
ii. Tree cover expansion: concrete and dry grass replaced with trees, representing strategies such as street tree planting or urban forest expansion;
iii. Water features: concrete and dry grass replaced with water, representing the introduction of water features such as ponds or fountains.

For each scenario, the modified land cover raster was re-processed through the LCF tool to generate updated land cover fraction inputs, and TARGET was re-run using identical meteorological forcing and building geometry as the baseline. Figure 7 provides an example of a zoomed-in view of part of the study area, illustrating the original land cover and the modified configuration after intervention. As the current UMEP-TARGET interface does not support manual adjustment of land cover parameters, all land cover types were assigned their default values as defined in the TARGET model (Broadbent et al., 2019).

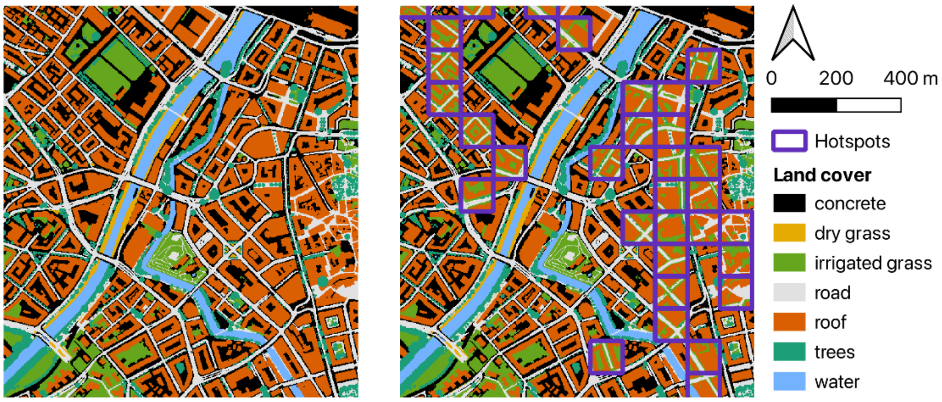


*Figure 7. Example of local-scale intervention design, created within QGIS. Original land cover for a selected neighbourhood (left) and modified land cover after hotspot mapping (right), where impervious and dry grass surfaces were replaced with irrigated grass to simulate a greening and irrigation strategy.*

To enable quantitative comparison across scenarios, three cooling metrics were computed for each hotspot cell. The scenario air temperature reduction (ΔT) was defined as the difference in average diurnal urban-rural temperature between the baseline and intervention simulations; since the rural reference is identical across runs, this simplifies to the reduction in urban air temperature attributable to the intervention. The three metrics derived are:

- Simple mean ΔT: the unweighted spatial average of this reduction across hotspot cells;
- Land cover-weighted mean ΔT: a metric that scale each cell's cooling by the fraction of concrete and dry grass available for replacement, providing a measure of cooling efficiency per unit of intervention.
- Severity-weighted mean ΔT: a calculation that weights each cell's cooling by its baseline urban-rural temperature difference, giving greater influence to cells where the pre-existing heat problem was most severe.

### 3.3. Results

The three intervention scenarios produce notably different cooling outcomes, as summarised in Table 1 and illustrated in Figure 8. Tree cover expansion is the most effective strategy, reducing hotspot cells by 83% (from 125 to 21) and achieving the highest cooling across all metrics. Interestingly, its severity-weighted mean ΔT (-0.76 °C) is higher than its simple mean (-0.60 °C), indicating that trees provide disproportionately greater cooling in the most severely overheated cells. Greening and irrigation achieves a moderate hotspot reduction of 57%, with a mean ΔT of -0.27 °C and a maximum reduction of 0.64 °C. Water features are the least effective at 46%, with a mean ΔT of -0.19 °C and a maximum reduction of 0.31 °C. These results are consistent with Chen et al. (2024), who found trees to be approximately twice as effective as irrigated grass and water in reducing peak air temperatures in Zurich, based on a multiple linear regression of land cover fractions against modelled temperatures.

The absolute cooling magnitudes across all scenarios reflect the limited fraction of replaceable surface available within hotspot cells. Although a full 100% replacement of concrete and dry grass was applied, these surface types represent only a portion of the total cell area, with roofs, roads, existing vegetation and water remaining unchanged. The effective land cover change per cell is therefore constrained by the baseline composition, which limits the achievable cooling even under idealised intervention conditions. This constraint is particularly pronounced in the densest urban districts. Across all three scenarios, the remaining hotspots are almost exclusively located in such areas where large-scale land cover modification is difficult to implement. In such settings, more active cooling strategies such as pavement watering (Chen et al., 2025; Hendel et al., 2016), misting systems (Huang et al., 2025), or the provision of artificial shading (Middel et al., 2021; Ouyang et al., 2024) may be required to achieve substantial cooling effects. Of these, only pavement watering can currently be modelled with an extended version of TARGET (Chen et al., 2025), though this capability is not yet integrated into the UMEP-TARGET interface.

*Table 1 Comparative cooling performance of the three intervention scenarios across the 125 baseline hotspot cells. ΔT is defined as the reduction in average diurnal air temperature relative to the baseline. LC-weighted mean ΔT is weighted by the fraction of concrete and dry grass available for replacement in each cell; severity-weighted mean ΔT is weighted by the baseline urban-rural temperature difference of each cell.*

| Scenario | Baseline | Greening and irrigation | Tree cover expansion | Water features |
|---|---|---|---|---|
| Hotspots remaining [-] | 125 | 54 | 21 | 67 |
| Reduction [%] | - | 57 | 83 | 46 |
| Range ΔT [°C] | - | -0.03 ~ -0.64 | -0.06 ~ -1.60 | -0.02 ~ -0.31 |

| | | | | |
|---|---|---|---|---|
| Mean ΔT [°C] | - | -0.27 | -0.6 | -0.19 |
| LC-weighted mean ΔT [°C] | - | -0.3 | -0.66 | -0.22 |
| Severity-weighted mean ΔT [°C] | - | -0.28 | -0.76 | -0.19 |

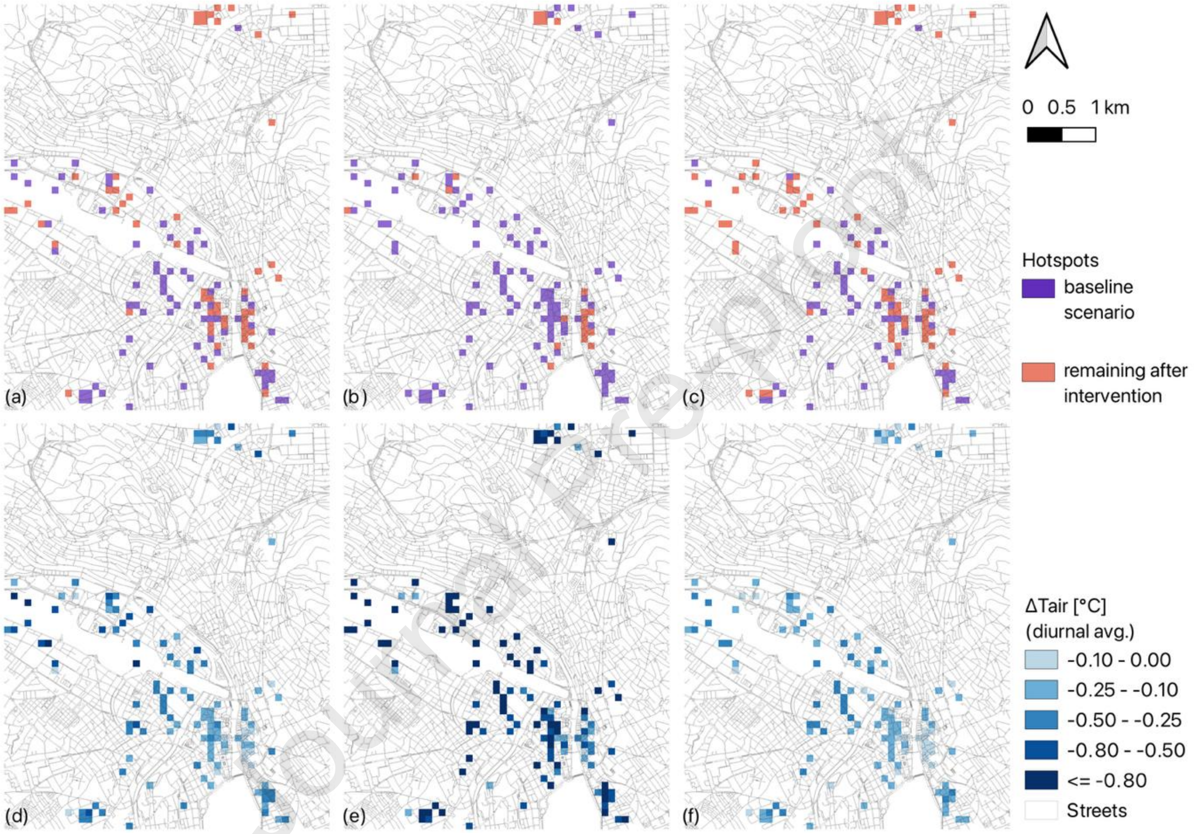


*Figure 8. Cooling benefits of the three intervention scenarios applied within the identified hotspot cells. Top row: spatial distribution of hotspot grid cells before intervention (baseline scenario, in purple) and those remaining after (in orange) for (a) greening and irrigation, (b) tree cover expansion, and (c) water features. Bottom row: corresponding spatial distribution of average diurnal air temperature reduction (ΔT) relative to the baseline for (d) greening and irrigation, (e) tree cover expansion, and (f) water features. All outputs were derived from UMEP-TARGET simulations and visualised within QGIS.*

Overall, the case study demonstrates that the entire workflow, from input preparation and model execution to hotspot mapping, intervention design, and scenario comparison, can be completed within the QGIS environment. This integrated process highlights the usability of the UMEP-TARGET interface and its potential to make TARGET accessible for both research and planning applications.

## 4. Discussion

### 4.1. Integration into UMEP and positioning among planning support tools

The integration of TARGET into UMEP improves the accessibility of lightweight urban climate models for a broader user community. TARGET has previously been demonstrated as a computationally efficient tool for estimating intra-urban air temperatures, but its use has largely been confined to technical experts. Embedding the model within the QGIS environment via UMEP makes the modelling process more approachable: users can prepare input data, configure simulations, and visualise outputs within a single interface, removing the need for extensive data pre-processing and input format verification. This lowers the barrier to entry for practitioners such as urban planners, consultants, and local authorities who may not have advanced programming skills but could benefit from applying these models in practice.

A key advantage of the UMEP-TARGET interface is its integration with existing UMEP and QGIS components. Pre-processing modules for land cover fraction and urban morphology help align input requirements with commonly available spatial datasets. The meteorological pre-processor enables the use of standard weather station or reanalysis data, allowing model runs even where extensive observational networks are unavailable. The post-processing functions provide outputs that can be readily interpreted in a planning context. Taken together, these features make UMEP-TARGET function as a coherent workflow within QGIS rather than as a stand-alone model, improving usability and practical relevance.

Compared to other GUI-based urban climate modelling tools, UMEP-TARGET occupies a distinct niche. ENVI-met is a notable example of how a graphical interface can drive broad adoption, though its microscale CFD-based approach makes city-scale BGI scenario testing impractical. Within UMEP itself, SOLWEIG supports radiation and outdoor thermal comfort assessment, SUEWS addresses surface energy and water balance modelling, and UWG focuses on urban heat island estimation and building energy interactions. None of these tools is designed for rapid, city-scale comparative evaluation of BGI interventions with respect to intra-urban air temperature, which is the primary purpose of TARGET. More broadly, GUI-based planning-support tools with city-scale, fast scenario-testing capabilities have emerged in adjacent fields. UrbanBEATS (Bach et al., 2020), for example, provides a comparable workflow for water-sensitive urban design and stormwater management (Coutts et al., 2013), but an equivalent tool specifically oriented towards assessing the air temperature benefits of heat mitigation measures has been lacking. UMEP-TARGET addresses this gap by combining the accessibility of a GIS-integrated interface with the computational efficiency required for systematic, city-scale evaluation of BGI strategies.

### 4.2. Scenario analysis and case study insights

The Zurich case study illustrates the tool's potential in practice. By combining baseline simulations with targeted land cover modifications, the interface enabled the identification of thermal hotspots and the evaluation of mitigation benefits. For example, a simulated greening and irrigation intervention reduced the hotspot extent by approximately two-thirds. Such results demonstrate the capacity of UMEP-TARGET to quantify the impacts of blue-green infrastructure strategies in a manner directly relevant to planning. The workflow moves beyond scientific analysis to support scenario-based decision making, illustrating how climate models can be embedded in urban design processes. Ultimately, embedding these models into daily workflows fulfills TARGET's original intent: to enable practical application by planners and practitioners.

However, several limitations of the current scenario analysis must be acknowledged. The interventions tested represent idealised land cover modifications, applying full replacement of concrete and dry grass within identified hotspot cells. Consequently, the resulting cooling estimates represent upper bounds on what could realistically be achieved. In reality, physical, financial, and institutional constraints will inevitably limit the extent of actual land cover change (O'Donnell et al., 2017). The quantitative outcomes are also specific to the Zurich context, reflecting local urban morphology, land cover composition, and the meteorological conditions during the selected heatwave period. Cooling magnitudes in other cities will vary accordingly, and results should not be directly transferred without recalibration to local conditions.

### 4.3. Appropriate use of UMEP-TARGET

The appropriate use of UMEP-TARGET is best understood in relation to its design envelope. For comparative scenario testing of BGI interventions at neighbourhood to city scales, where the goal is to identify thermal hotspots, rank intervention strategies, or provide rapid planning-support evidence during early-stage decision making, UMEP-TARGET serves as an ideal framework. Its computational efficiency makes it particularly valuable when multiple scenarios must be evaluated iteratively, or when modelling capacity is limited. The tool is most reliable for short-term analyses such as heatwave episodes of days to weeks under clear-sky conditions, consistent with the intended application of the underlying TARGET model (Broadbent et al., 2019). However, the tool is less appropriate when precise absolute temperature predictions are required or where building-resolving microscale processes are of primary interest. It also struggles in environments where anthropogenic heat fluxes or horizontal advection play a dominant role, such as in highly heterogeneous dense urban cores or coastal settings with strong sea breezes. In such cases, more detailed energy balance models such as SUEWS (Järvi et al., 2011) or the Town Energy Balance model (TEB; Masson, 2000), or high-resolution CFD frameworks such as ENVI-met (Bruse & Fleer, 1998) or PALM-4U (Maronga et al., 2019), remain more suitable depending on the application.

Rather than competing with these tools, UMEP-TARGET is best seen as a complementary first-order screening tool: its outputs can guide where more detailed and computationally intensive modelling efforts should subsequently be focused. In the Zurich case study, a complete four-day simulation could be completed in less than an hour on a standard desktop computer. This simulation included both data pre-processing using input rasters at up to 0.5 m resolution and model execution at 100 m grid spacing. These rapid processing times highlight the workflow's computational efficiency compared to conventional microscale or mesoscale urban climate models. The UMEP-TARGET interface is therefore most useful for municipal planning departments, environmental consultancies, and researchers who require rapid scenario evaluation, with more detailed microscale models subsequently applied at critical locations identified by TARGET.

### 4.4. Limitations of UMEP-TARGET

The accuracy of TARGET simulations remains dependent on the quality of input datasets. In Zurich, high-resolution digital surface models, building footprints, and official land cover maps were available. In many cities, such detailed data may be lacking or inconsistent, which could constrain model performance. This challenge is not unique to TARGET but reflects a broader issue in urban climate research (Hamdi et al., 2020).

To maintain computational efficiency, the model incorporates several physical simplifications that users should be aware of. For instance, urban morphology is represented using simplified canyon geometry, and vegetation is treated without explicit vertical structure. Horizontal advection and anthropogenic heat fluxes are not modelled, and the water sub-model does not fully represent evaporative dynamics over natural water surfaces. While these simplifications are consistent with TARGET's design philosophy, they impose clear bounds on the physical processes the model can represent (Broadbent et al., 2019). At present, UMEP-TARGET lacks a dedicated point-and-click tool for scenario design. Consequently, users must rely on the QGIS Raster Calculator for manual raster editing. Although straightforward to execute within QGIS, such an extra step may be unfamiliar to non-technical users. To overcome this hurdle, future development could integrate automated scenario generation directly into the interface.

## 5. Conclusions and outlook

To address the technical barriers of urban climate modelling, we developed an open-source QGIS interface that integrates the TARGET model into the UMEP framework. By combining data preparation, model execution, and result visualisation into a single workflow, the interface substantially streamlines the modelling process. Consequently, physically based urban temperature modelling is now more accessible to practitioners beyond the research community, including planners, consultants, and municipal agencies.

Through the Zurich case study, the interface demonstrated a clear capacity to identify thermal hotspots and evaluate the cooling benefits of targeted blue-green infrastructure interventions. Tree cover expansion proved to be the most effective strategy, reducing hotspot extent by 83% and achieving air temperature reductions of up to 1.6 °C. Other interventions also yielded significant benefits, with greening and irrigation reducing hotspots by 57% and water features at 46%. By embedding scientifically robust modelling capabilities within an accessible platform, the tool bridges the gap between climate research and decision-making.

Several limitations should be acknowledged, such as the model's dependence on high-quality input datasets, its simplified representation of urban morphology and vegetation, and its intended scale of application. Nevertheless, these constraints are consistent with the design philosophy of TARGET, which prioritises computational efficiency and comparative scenario analysis over microscale detail.

Looking forward, the open-source nature of UMEP-TARGET provides opportunities for community-driven development. Future enhancements to the interface may include automated scenario generation, expanded visualisation options, and coupling with models for energy use or human thermal comfort. Further development of the TARGET model itself, such as integration with URock to include advection processes, additional surface types, and extended outputs such as mean radiant temperature ($T_{mrt}$) and the universal thermal climate index (UTCI), is also envisaged. Users are encouraged to report bugs or request new features through the UMEP GitHub repository, which provides an open channel for community feedback and support. As urban areas worldwide face increasing challenges from heat stress, UMEP-TARGET offers a timely and valuable contribution to the growing field of city-based climate services, supporting more climate-responsive planning and design.

**Software availability**

Name of software: TARGET in UMEP

Developers: Fredrik Lindberg, Nils Wallenberg, Jixuan Chen, Kerry A. Nice, Matthias Demuzere, João P. Leitão, Peter M. Bach

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Year first available: 2025

Hardware required: NA

Software required: QGIS 3.40 or higher

Operation system required: OS independent

Program language: Python

Program size (full UMEP plugin): ~3.3 Mb (compressed), ~17.7 Mb (uncompressed)

Availability and cost: Open source (no cost)

License: GNU General Public Licence v3

Repository: https://github.com/UMEP-dev/UMEP/

Manual: https://umep-docs.readthedocs.io/

Tutorials: https://umep-docs.readthedocs.io/projects/tutorial/

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## References

Aloui, S., Mazzoni, A., Elomri, A., Aouissi, J., Boufekane, A., & Zghibi, A. (2023). A review of Soil and Water Assessment Tool (SWAT) studies of Mediterranean catchments: Applications, feasibility, and future directions. *Journal of Environmental Management*, *326*, 116799. https://doi.org/10.1016/j.jenvman.2022.116799

ARE. (2019). *Arealstatistik Schweiz – Bodennutzung und Bodenbedeckung (BNB) / Swiss Land Use and Land Cover Statistics*. Swiss Federal Office for Spatial Development (ARE). https://www.are.admin.ch

Bach, P. M., Kuller, M., McCarthy, D. T., & Deletic, A. (2020). A spatial planning-support system for generating decentralised urban stormwater management schemes. *Science of The Total Environment*, *726*, 138282. https://doi.org/10.1016/j.scitotenv.2020.138282

Bernard, J., Lindberg, F., & Oswald, S. (2023). URock 2023a: An open-source GIS-based wind model for complex urban settings. *Geoscientific Model Development*, *16*(20), 5703–5727. https://doi.org/10.5194/gmd-16-5703-2023

Broadbent, A. M., Coutts, A. M., Nice, K. A., Demuzere, M., Krayenhoff, E. S., Tapper, N. J., & Wouters, H. (2019). The Air-temperature Response to Green/blue-infrastructure Evaluation Tool (TARGET v1.0): An efficient and user-friendly model of city cooling. *Geoscientific Model Development*, *12*(2), 785–803. https://doi.org/10.5194/gmd-12-785-2019

Bruse, M., & Fleer, H. (1998). Simulating surface–plant–air interactions inside urban environments with a three dimensional numerical model. *Environmental Modelling & Software*, *13*(3–4), 373–384. https://doi.org/10.1016/S1364-8152(98)00042-5

Bueno, B., Norford, L., Hidalgo, J., & Pigeon, G. (2013). The urban weather generator. *Journal of Building Performance Simulation*, *6*(4), 269–281. https://doi.org/10.1080/19401493.2012.718797

Chen, J., Bach, P. M., & Leitão, J. P. (2025). Modelling pavement watering effects on urban heat mitigation with a fast urban climate model. *Sustainable Cities and Society*, *124*, 106313. https://doi.org/10.1016/j.scs.2025.106313

Chen, J., Bach, P. M., Nice, K. A., & Leitão, J. P. (2024). Investigating the efficacy of a fast urban climate model for spatial planning of green and blue spaces for heat mitigation. *Science of The Total Environment*, *955*, 176925. https://doi.org/10.1016/j.scitotenv.2024.176925

Cheung, P. K., Nice, K. A., & Livesley, S. J. (2022). Irrigating urban green space for cooling benefits: The mechanisms and management considerations. *Environmental Research: Climate*, *1*(1), 015001. https://doi.org/10.1088/2752-5295/ac6e7c

Coutts, A. M., Tapper, N. J., Beringer, J., Loughnan, M., & Demuzere, M. (2013). Watering our cities: The capacity for water sensitive urban design to support urban cooling and improve human thermal comfort in the Australian context. *Progress in Physical Geography*, *37*(1), 2–28. https://doi.org/10.1177/0309133312461032

Demuzere, M., & Nice, K. (2025). *Urban heat modeling & NBS scenario analysis*. B-Kode Technical Report. https://www.adpc.net/urbanheat/wp-content/uploads/2025/06/B-Kode_Technical_report_Final.pdf

Evola, G., Costanzo, V., Marletta, L., Nocera, F., Detommaso, M., & Urso, A. (2021). An investigation on the radiant heat balance for different urban tissues in Mediterranean climate: A case study. *Journal of Physics: Conference Series*, *2042*(1), 012046. https://doi.org/10.1088/1742-6596/2042/1/012046

Grimmond, C. S. B., & Oke, T. R. (2002). Turbulent Heat Fluxes in Urban Areas: Observations and a Local-Scale Urban Meteorological Parameterization Scheme (LUMPS). *Journal of Applied Meteorology*, *41*(7), 792–810. https://doi.org/10.1175/1520-0450(2002)041<0792:THFIUA>2.0.CO;2

Guerri, G., Crisci, A., & Morabito, M. (2023). Urban microclimate simulations based on GIS data to mitigate thermal hot-spots: Tree design scenarios in an industrial area of Florence. *BUILDING AND ENVIRONMENT*, *245*. https://doi.org/10.1016/j.buildenv.2023.110854

Gupta, D. N., Bhatia, A., Dutta, D. R., Senaka, D., Hammer, S., Demuzere, D. M., & Nice, K. (2025). *Urban Heat Resilience: Bridging Science, Policy, and Sustainable Design, Flagship Report*.

Hamdi, R., Kusaka, H., Doan, Q.-V., Cai, P., He, H., Luo, G., Kuang, W., Caluwaerts, S., Duchêne, F., Van Schaeybroek, B., & Termonia, P. (2020). The State-of-the-Art of Urban Climate Change Modeling and Observations. *Earth Systems and Environment*, *4*(4), 631–646. https://doi.org/10.1007/s41748-020-00193-3

Hendel, M., Gutierrez, P., Colombert, M., Diab, Y., & Royon, L. (2016). Measuring the effects of urban heat island mitigation techniques in the field: Application to the case of pavement-watering in Paris. *Urban Climate*, *16*, 43–58. https://doi.org/10.1016/j.uclim.2016.02.003

Huang, X., Bou-Zeid, E., Vanos, J. K., Middel, A., & Ramamurthy, P. (2025). Urban heat mitigation through misting, and its role in broader blue infrastructure portfolios. *Landscape and Urban Planning*, *256*, 105290. https://doi.org/10.1016/j.landurbplan.2024.105290

IPCC (Ed.). (2023). *Climate Change 2022 - Mitigation of Climate Change: Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (1st ed.). Cambridge University Press. https://doi.org/10.1017/9781009157926

Jacobs, A. F. G., Heusinkveld, B. G., & Berkowicz, S. M. (2000). Force-restore technique for ground surface temperature and moisture content in a dry desert system. *Water Resources Research*, *36*(5), 1261–1268. https://doi.org/10.1029/2000WR900016

Jandaghian, Z., & Colombo, A. (2024). The Role of Water Bodies in Climate Regulation: Insights from Recent Studies on Urban Heat Island Mitigation. *BUILDINGS*, *14*(9). https://doi.org/10.3390/buildings14092945

Järvi, L., Grimmond, C. S. B., & Christen, A. (2011). The Surface Urban Energy and Water Balance Scheme (SUEWS): Evaluation in Los Angeles and Vancouver. *Journal of Hydrology*, *411*(3–4), 219–237. https://doi.org/10.1016/j.jhydrol.2011.10.001

Jiang, Y., & Menz, S. (2025). Urban Densification and Outdoor Thermal Comfort: Scenario-Based Analysis in Zurich's Altstetten–Albisrieden District. *Land*, *14*(8), 1516. https://doi.org/10.3390/land14081516

Kovats, R. S., & Hajat, S. (2008). Heat Stress and Public Health: A Critical Review. *Annual Review of Public Health*, *29*(1), 41–55. https://doi.org/10.1146/annurev.publhealth.29.020907.090843

Lindberg, F., Holmer, B., & Thorsson, S. (2008). SOLWEIG 1.0 – Modelling spatial variations of 3D radiant fluxes and mean radiant temperature in complex urban settings. *International Journal of Biometeorology*, *52*(7), 697–713. https://doi.org/10.1007/s00484-008-0162-7

Lindberg, F., & Grimmond, C. S. B. (2011). The influence of vegetation and building morphology on shadow patterns and mean radiant temperatures in urban areas: Model development and evaluation. *Theoretical and Applied Climatology*, *105*(3–4), 311–323. https://doi.org/10.1007/s00704-010-0382-8

Lindberg, F., Grimmond, C. S. B., Gabey, A., Huang, B., Kent, C. W., Sun, T., Theeuwes, N. E., Järvi, L., Ward, H. C., Capel-Timms, I., Chang, Y., Jonsson, P., Krave, N., Liu, D., Meyer, D., Olofson, K. F. G., Tan, J., Wästberg, D., Xue, L., & Zhang, Z. (2018). Urban Multi-scale Environmental Predictor (UMEP): An integrated tool for city-based climate services. *Environmental Modelling & Software*, *99*, 70–87. https://doi.org/10.1016/j.envsoft.2017.09.020

Lindberg, F., Jonsson, P., Honjo, T., & Wästberg, D. (2015). Solar energy on building envelopes – 3D modelling in a 2D environment. *Solar Energy*, *115*, 369–378. https://doi.org/10.1016/j.solener.2015.03.001

Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). *Geographic Information Science and Systems* (4th Edition). Wiley.

Lopez-Ordoñez, C., Garcia-Nevado, E., Coch Roura, H., & Morganti, M. (2025). Heat stress in social housing districts: Tree cover–built form interaction. *Buildings and Cities*, *6*(1), 415–432. Scopus. https://doi.org/10.5334/bc.598

Loridan, T., Grimmond, C. S. B., Offerle, B. D., Young, D. T., Smith, T. E. L., Järvi, L., & Lindberg, F. (2011). Local-Scale Urban Meteorological Parameterization Scheme (LUMPS): Longwave Radiation Parameterization and Seasonality-Related Developments. https://doi.org/10.1175/2010JAMC2474.1

Marando, F., Heris, M. P., Zulian, G., Udías, A., Mentaschi, L., Chrysoulakis, N., Parastatidis, D., & Maes, J. (2022). Urban heat island mitigation by green infrastructure in European Functional Urban Areas. *Sustainable Cities and Society*, *77*. Scopus. https://doi.org/10.1016/j.scs.2021.103564

Maronga, B., Gross, G., Raasch, S., Banzhaf, S., Forkel, R., Heldens, W., Kanani-Sühring, F., Matzarakis, A., Mauder, M., Pavlik, D., Pfafferott, J., Schubert, S., Seckmeyer, G., Sieker, H., & Winderlich, K. (2019). Development of a new urban climate model based on the model PALM – Project overview, planned work, and first achievements. *Meteorologische Zeitschrift*, *28*(2), 105–119. https://doi.org/10.1127/metz/2019/0909

Masson, V. (2000). A physically-based scheme for the urban energy budget in atmospheric models. *Boundary-Layer Meteorology*, *94*(3), 357–397. https://doi.org/10.1023/A:1002463829265

MeteoSwiss. (2023). *Automatic weather station data: Zürich-Fluntern.* [Dataset]. https://www.meteoswiss.admin.ch

Middel, A., AlKhaled, S., Schneider, F. A., Hagen, B., & Coseo, P. (2021). 50 Grades of Shade. *Bulletin of the American Meteorological Society*, *102*(9), E1805–E1820. https://doi.org/10.1175/BAMS-D-20-0193.1

Molina Martínez, J. M., Martínez Alvarez, V., González-Real, M. M., & Baille, A. (2006). A simulation model for predicting hourly pan evaporation from meteorological data. *Journal of Hydrology*, *318*(1–4), 250–261. https://doi.org/10.1016/j.jhydrol.2005.06.016

Nice, K.A., 2019. *TARGET (The Air-temperature Response to Green/blue-infrastructure Evaluation Tool) – Java implementation* [Software]. Bitbucket repository: https://bitbucket.org/mothlight/target_java/src/master/

Nice, K. A., Demuzere, M., Coutts, A. M., & Tapper, N. (2024). Present day and future urban cooling enabled by integrated water management. *Frontiers in Sustainable Cities*, *6*. https://doi.org/10.3389/frsc.2024.1337449

O'Donnell, E. C., Lamond, J. E., & Thorne, C. R. (2017). Recognising barriers to implementation of blue-green infrastructure: A Newcastle case study. *Urban Water Journal, 14*(9), 964–971. https://doi.org/10.1080/1573062X.2017.1279190

Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). *Urban Climates*. Cambridge University Press. https://doi.org/10.1017/9781139016476

Ouyang, W., Ren, G., Tan, Z., Li, Y., & Ren, C. (2024). Natural shading vs. artificial shading: A comparative analysis of their cooling efficacy in extreme hot weather. *Urban Climate, 55*, 101870. https://doi.org/10.1016/j.uclim.2024.101870

QGIS.org. (2025). *QGIS Geographic Information System*. http://www.qgis.org

Santamouris, M. (2014). Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments. *Solar Energy, 103*, 682–703. https://doi.org/10.1016/j.solener.2012.07.003

Skamarock, W. C., Klemp, J. B., Dudhia, J., Gill, D. O., Barker, D. M., Duda, M. G., Huang, X.-Y., Wang, W., & Powers, J. G. (2008). A Description of the Advanced Research WRF Version 3. *University Corporation for Atmospheric Research*. https://doi.org/10.5065/D68S4MVH

Sparrow, E. M., Cess, R. D., Sparrow, E. M., & Cess, R. D. (1978). *Radiation heat transfer* (Augmented ed). Hemisphere Publ. [u. a.].

Stone, J., Brian. (2012). *The City and the Coming Climate: Climate Change in the Places We Live*. Cambridge University Press; Cambridge Core. https://doi.org/10.1017/CBO9781139061353

swisstopo. (2018). *swissSURFACE3D* [Dataset]. https://www.swisstopo.admin.ch/en/height-model-swisssurface3d

swisstopo. (2020). *swissALTI3D* [Dataset]. https://www.swisstopo.admin.ch/en/height-model-swissalti3d

Urich, C., & Harold, T. (2020). *WSC scenario tool: TARGET* [Industry note]. Cooperative Research Centre for Water Sensitive Cities, Melbourne, Australia.

Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Berry, H., Bouley, T., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D., Chambers, J., Daly, M., Dasandi, N., Davies, M., Depoux, A., Dominguez-Salas, P., Drummond, P., Ebi, K. L., … Costello, A. (2018). The 2018 report of the Lancet Countdown on health and climate change: Shaping the health of nations for centuries to come. *The Lancet*, *392*(10163), 2479–2514. https://doi.org/10.1016/S0140-6736(18)32594-7

Zou, Y., Chen, J., & Zong, H. (2024). Is shading a better way to cool down? Evaluation and comparison of the cooling capacity of blue-green spaces and urban shade. *Ecological Indicators*, *167*, 112688. https://doi.org/10.1016/j.ecolind.2024.112688

**Highlights**

- Integration of TARGET urban climate model into the UMEP QGIS plugin
- Developed user-friendly full workflow for data preparation, simulation, and visualisation
- Case study in Zurich shows hotspot mapping and cooling intervention scenario analysis
- Tool lowers technical barriers, enabling broader research and planning use
- Open-source interface supports future extensions and community development

**Declaration of interests**

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: