World Bank City Resilience Program's

Urban Heat Hackathon

Notes on input data

ICUC12 @ Rotterdam

8 July 2025

During this hackathon, you can explore and apply a range of urban climate and energy models - including TARGET, SOLWEIG, and EnergyPlus - to better understand and address urban heat challenges. Each model requires specific input data reflecting different spatial and temporal scales, from detailed land cover and surface geometry to building characteristics, and weather data. Below, we provide an overview of the core input data sources used to develop the required inputs for each of these models.

1. **Land cover**

In order to describe the surface characteristics of the cities of interest, in a language the tools understand, the following open-access resources are used:

- MERIT DEM: Multi-Error-Removed Improved-Terrain DEM (Yamazaki et al., 2017)
- ESA WorldCover 10m v200 (Zanaga et al., 2022)
- Overture maps - Buildings, water, and segment (transportation)
- World Settlement Footprint 3D data (Esch et al., 2022)
- High Resolution Canopy Height Maps (Tolan et al., 2024)

For TARGET, this data is first combined on a UTM-based 2x2m^2 to obtain the land cover fractions TARGET understands (paved-asphalt, paved-concrete, buildings, trees, grass, irrigated grass, water). Note that, since Timbuktu has large areas covered in bare soil / sand, a land cover class that does not exist in TARGET, the non-existent paved-concrete class is tricked into being bare soil/sand by changing its corresponding radiative and thermal parameters. Once these rasters are available, the data is aggregated on the hexagon level (each hexagon representing an area of ~ 0.1km^2.

For SOLWEIG, a similar procedure is followed, but for a UTM-based 1x1m^2, and for land cover classes (paved, buildings, grass, bare soil, and water). In addition, SOLWEIG also requires a DEM (High resolution surface model of the ground), a DSM (a high resolution surface model of ground and building heights), and a CDSM (a high resolution surface model of 3D vegetation). See this SOLWEIG tutorial for more information.

Notes:

- Be mindful that for several input layers, multiple open-access, globally available datasets are available, each with their own strengths, limitations, and uncertainties.
- Generating the high-resolution grids required for modeling involves a series of assumptions and processing steps, particularly in data-scarce or complex environments. For instance, the land cover layer is created using a hierarchical approach: starting with building footprints and heights (are all building footprints there?), followed by water bodies (note that Overture's water layer may also include subsurface drains), then ESA's grass layer, trees (can trees overhang buildings? What is the land cover below trees?

Are trees in the right place?), paved - asphalt, and finally, filling remaining pixels with bare soil / sand (for Timbuktu) or paved - concrete (for Davao).
- Due to the limited time available during the hackathon, the exercise has been kept relatively simple. Only short time periods are modeled, and limited attention is given to the detailed parameterization of the underlying physical schemes.

Additional geospatial data layers that are often used as drivers for urban overheating, are pre-processed and made available for the qualitative hotspot mapping tool. These rasters are available on a 100x100m^2 grid and including the following information:

Band Name	Unit	Explanation
BareCoverFraction	%	Percent vegetation cover for bare-sparse-vegetation land cover class, from the Copernicus Global Land Cover fractions (Buchhorn et al., 2020).
BuiltUpFraction	[0–1]	Fraction of built-up area based on WSF2019, representing buildings only (no roads) (Marconcini et al., 2020).
BuildingHeight	m	Building height from the World Settlement Footprint 3D dataset (WSF3D) (Esch et al., 2022).
NDVI	[-1, 1]	50th percentile of all available NDVI values from Sentinel-2, using a cloud cover filter of <50%.
LST	°C	50th percentile of Land Surface Temperature from Landsat 8/9 observations.
TreeCoverFraction	[0–1]	Fraction of the grid cell covered by tree canopy (Tolan et al., 2024).
PopulationDensity	# people / ha	Number of people per grid cell, expressed as people per hectare (Schiavina et al., 2023).
DEM	m	Elevation from the Copernicus FABDEM digital elevation model (Hawker et al., 2022).
AHF	W/m^2	Mean annual anthropogenic heat flux, from Varguez et al. (2021).

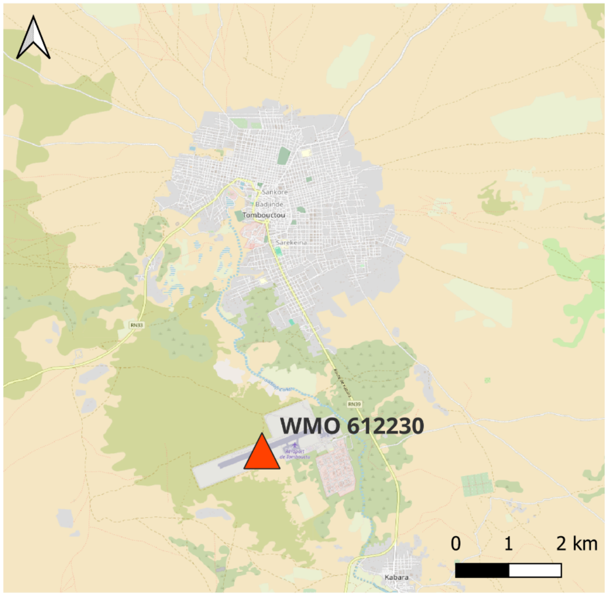
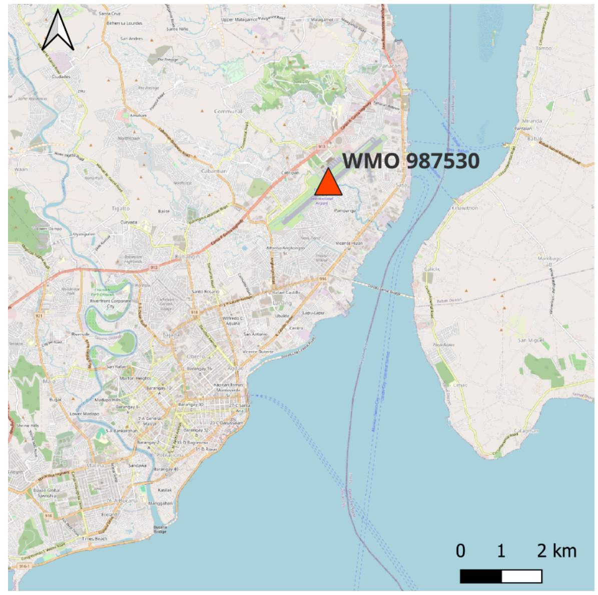
LowVegetationFraction	%	Combined percentage of cropland, grass, moss, and shrub cover from Copernicus Global Land Cover fractions (Buchhorn et al., 2020).

2. Weather

The weather files used for the EnergyPlus software simulations come from the free and open climate.onebuilding.org website, a resource developed by Lawrie and Crawley (2022).
Specifically, two files are used:

- *MLI TT Timbuktu-Tombouctou.Intl.AP.612230 TMYx.2009-2023*: This file represents the typical meteorological year (TMYx) for Timbuktu, Mali.
- *PHL DAV Davao-Bangoy.Intl.AP.987530 TMYx*: This file represents the typical meteorological year (TMYx) for Davao, Philippines.

These TMYx datasets are artificially constructed years, where each month is selected from the 2009-2023 period to best represent the typical weather conditions. The solar data in these files is derived from the ERA5 reanalysis dataset. The other meteorological data comes from World Meteorological Organization (WMO) stations. Details regarding the WMO stations used are provided below.

Timbuktu (Mali)	Davao (Philippines)
	
N 16° 43.80' W 3° 0.48' Elevation 263 m Time Zone {GMT +0.0 hours}	N 7° 7.56' E 125° 38.76' Elevation 29 m Time Zone {GMT +8.0 hours}

The TARGET and SOLWEIG models use the same weather files for their input meteorological data. This selection is based on the maximum seven-day temperature period for each location. The resulting periods are May 20–26, 2013, for Timbuktu, and April 24–30, 2018, for Davao.

The following hourly meteorological variables are extracted as input for TARGET:

- Dry bulb temperature [°C]
- Relative humidity [%]
- Wind speed [m/s]
- Wind direction [°]
- Surface pressure [hPa]
- Incoming shortwave radiation [W/m^2]
- Incoming longwave radiation [W/m^2]

The following hourly meteorological variables are extracted as input for SOLWEIG:

- Dry bulb temperature [°C]
- Relative humidity [%]
- Incoming shortwave radiation [W/m^2]

3. Building performance models for Energy Plus

The methodological approach used to model the indoor conditions of the classrooms is based on an archetype-driven strategy. Each model was configured with a representative classroom at its core, as means to obtain in Energy Plus the operative temperature as main comfort indicator. The operative temperature is defined as the average of the air temperature and the mean radiant temperature of surrounding surfaces. The main objective of the task is to reduce the operative temperature below the upper comfort limit or as close as possible to it.

For the model representing the school in Davao, Philippines. A typical semi-outdoor classroom was simulated within a four-storey building. The test classroom is located at the centre of the building. Surfaces adjacent to other classrooms, as well as the floor and ceiling, were treated as adiabatic. Only the external facades were modelled as being exposed to outdoor conditions.

General information about the model:

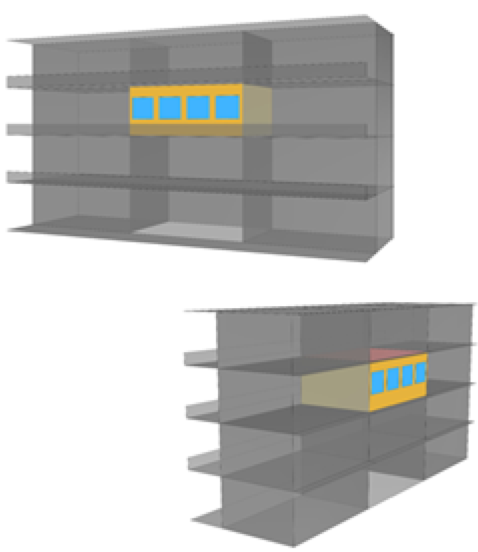
Storey:	3 of 4
Window to Wall ratio	35%
Indoor height	3.6m
Fraction of the window that is operable	50%
Fraction of the height of the window that is operable	85%

Thermal properties of materials:

Element	U-Value	Description
Exterior walls	2.00 W/m^2K	20 cm, concrete blocks
Interior walls	2.00 W/m^2K	20 cm, concrete blocks
Roof and Floor	0.54 W/m^2K	30 cm Lightweight concrete slab
Windows	5.7 W/m^2K	Single glazing windows

Building to analyse

Views of the model vs real life building



For the model representing the school in Timbuktu, Mali. A typical single floor classroom was simulated. The test classroom is located at the centre of the building. A surface adjacent to the other classroom was the only one treated as adiabatic. The external facades were modelled as being exposed to outdoor conditions being floor, roof, and 3 of the 4 sides.

General information about the model:

Storey:	ground
Window to Wall ratio	35%
Indoor height	3.6m
Fraction of the window that is operable	50%
Fraction of the height of the window that is operable	85%

Thermal properties of materials:

Element	U-Value	Description
Exterior walls	0.72 W/m^2K	30 cm, adobe blocks
Interior walls	0.72 W/m^2K	30 cm, adobe blocks
Roof and Floor	6.11 W/m^2K	Corrugated metal
Windows	No windows only a hole in the wall	There are some metal shutters that were assumed to be closed overnight.

Building to analyse

Views of the model vs real life building