CLIMED: CLIMATE DATA AND TOOLS

Subcategory. ENVI-met Software Suite

About the Resource

This resource is part of the Climate Data and Tools section of the ClimEd Scientific and Educational Platform. It is intended for students, PhD candidates, teachers, researchers, architects, urban planners, landscape architects, environmental specialists, health professionals, municipal practitioners and specialists from other climate-sensitive sectors who study the urban microclimate and develop solutions for adapting settlements to climate change.

The material provides a structured description of the ENVI-met software suite, including its purpose, principal modules, input and output data, typical workflow, application areas, advantages, limitations and recommendations for practical use. The resource can be used in ClimEd courses, practical and laboratory assignments, degree and research projects, and assessments of thermal comfort, urban overheating, air quality and the effectiveness of climate adaptation measures.

Key Feature

ENVI-met is a three-dimensional, high-resolution microclimate modelling system that represents interactions among the atmosphere, buildings, surfaces, soil, vegetation and people in the urban environment.

Subcategories for the ENVI-met Software Suite resource

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1. General Overview of ENVI-met

ENVI-met is a three-dimensional numerical software suite for modelling the urban microclimate. It is designed to analyse interactions among airflow, thermal processes, solar radiation, buildings, surface materials, soil, vegetation and water elements. Unlike tools that model only wind, solar exposure or surface temperature separately, ENVI-met treats the urban environment as an interconnected system in which a change in one element affects the other components.

The software suite is used mainly to model specific meteorological situations and compare design scenarios at the scale of a city block, street, square, residential courtyard, park or another local urban area. Typical studies cover periods ranging from one to several days and are performed at a high spatial resolution sufficient to analyse the effects of individual buildings, trees, surface materials and landscape elements.

When to Use It

ENVI-met is appropriate when it is necessary to assess how changes in urban planning, vegetation, surface materials, building geometry or water elements affect local temperature, wind, humidity, thermal comfort and air quality.

2. Main Components and Modules of the Software Suite

ENVI-met consists of interconnected tools for creating a model of the study area, configuring a meteorological scenario, performing calculations and analysing results. The exact set of applications and interface names may differ between versions; therefore, the current documentation should be checked before starting work.

Component	Main Function	Practical Application
Spatial Model Editor	Creation of a three-dimensional model of the study area	Buildings, terrain, trees, shrubs, soils, surfaces and water bodies
Meteorological Scenario Editor	Definition of initial and boundary conditions	Temperature, humidity, wind, cloud cover and radiation conditions
Simulation Engine	Numerical calculation of interactions among components	Airflow, heat exchange, moisture, radiation, vegetation and surfaces
Analysis and Visualisation Tools	Review and comparison of results	Maps, vertical profiles, time series and three-dimensional visualisations
Thermal Comfort Modules	Assessment of the effects of microclimate on people	Heat stress, pedestrian comfort and scenario comparison
Python and Integration Tools	Automation, processing and visualisation	Batch analysis, preparation of graphs and exchange with external systems

3. Input Data for Modelling

Two principal groups of data are required for modelling: a spatial description of the model area and meteorological conditions. The quality of the results depends substantially on the accuracy of the geometry, the properties of surfaces and vegetation, and the representativeness of the selected weather scenario.

Spatial Data

- boundaries of the model domain and the spatial grid resolution;
- location, height and geometry of buildings;
- materials of façades, roofs and ground surfaces;
- trees, shrubs, grass cover and their characteristics;
- soils, water surfaces and terrain;
- pollution sources or other specialised objects, where required by the study.

Meteorological Data

- air temperature and relative humidity;
- wind speed and direction;
- solar radiation, cloud cover and other atmospheric conditions;
- simulation start time, duration and initialisation parameters;
- weather-station data in CSV format, EPW files or specially prepared scenarios.

Good Practice

The meteorological scenario should correspond to the purpose of the study. A representative hot day or heatwave should be selected for overheating assessment, while characteristic wind directions and speeds should be used for ventilation analysis. The scenario and its data source should be documented.

4. Typical Workflow

1. Formulate the research question and identify the indicators to be assessed.
2. Select the spatial boundaries of the model area, grid-cell size and vertical grid structure.
3. Create a baseline three-dimensional model of buildings, surfaces, vegetation and terrain.
4. Prepare the meteorological scenario and verify the units of measurement and temporal consistency.
5. Configure calculation parameters, output variables and simulation duration.
6. Perform a test run to verify model stability and the adequacy of computational resources.
7. Run the full simulation of the baseline scenario.
8. Create one or more alternative scenarios by changing only the elements under investigation.
9. Compare results using identical time steps, heights and visualisation scales.
10. Document the input data, parameters, software version, limitations and uncertainty.

5. Main Modelling Outputs

ENVI-met produces spatial and temporal outputs that can be analysed as maps, profiles, time series and three-dimensional fields. The exact list of available variables depends on the model settings, the software version and the modules used.

- air temperature and humidity at different heights;
- airflow speed, direction and turbulence;
- temperature of surfaces, façades, roofs and soil;
- short-wave and long-wave radiation balance;
- shading and duration of solar exposure;
- evaporation, transpiration and the water balance of vegetation and soil;
- human thermal-comfort indicators;
- dispersion of pollutants and air-quality assessment;
- microclimatic parameters near façades for subsequent use in building-energy models.

6. Areas of Practical Application

Area	Typical Tasks	Example Scenarios
Urban Planning	Assessment of overheating, ventilation and spatial comfort	Changes in building density and orientation
Green Infrastructure	Analysis of the cooling effect of vegetation	Tree planting and creation of parks, green roofs and green façades
Urban Design and Materials	Comparison of surface temperatures and heat load	Light-coloured materials, permeable surfaces and shading
Public Health	Assessment of heat stress for the population	Pedestrian routes, recreational areas, school grounds and hospital sites
Air Quality	Modelling pollutant transport and dispersion	Traffic emissions and the effects of trees and street canyons
Climate Adaptation	Testing the effectiveness of adaptation measures	Baseline scenario compared with vegetation, water elements or changes in urban form

Principle of Scenario Analysis

The most informative approach is to compare baseline and alternative scenarios under identical meteorological conditions. This makes it possible to distinguish the effect of a design decision from natural weather variability.

7. Advantages and Limitations

Main Advantages

- integrated modelling of interactions among the atmosphere, buildings, surfaces, soil and vegetation;
- high spatial detail for city blocks, streets and local areas;
- the possibility of directly comparing design and adaptation scenarios;

- analysis of thermal comfort, air quality, wind, radiation and surface temperatures within a single environment;
- integration with QGIS, SketchUp, Grasshopper and other tools, depending on the version and licence;
- the possibility of automating analysis and visualisation with Python.

Main Limitations

- high processor, memory and computation-time requirements for large and detailed models;
- sensitivity of results to the quality of geometry, material properties, vegetation and meteorological conditions;
- primarily intended for microclimate studies rather than precise weather forecasting or whole-city modelling without simplification;
- the need for calibration or validation against observations when results are used for consequential management decisions;
- limited suitability for comprehensive modelling of building energy consumption; for this purpose, outputs should be transferred to specialised energy models;
- dependence of available functions, parallel calculations and the number of workstations on the licence type.

Interpretation

ENVI-met results are model-based estimates rather than direct measurements. They should be interpreted with consideration of spatial resolution, parameterisation, initial conditions, model spin-up time and uncertainty in the input data.

8. Recommendations for Use in Education and Research

Within ClimEd, ENVI-met can be used to develop practical competencies in urban climate, climate adaptation, GIS, environmental modelling, heat-risk assessment and decision support. It is advisable to begin with small educational models and gradually proceed to more complex scenarios.

- a laboratory exercise on constructing a simple model of an urban block;
- comparison of an area without vegetation and after tree planting;
- assessment of the effect of a green roof or green façade;
- analysis of shading, surface temperatures and thermal comfort;
- investigation of ventilation in a street canyon;
- assessment of surfaces with different albedo and permeability;
- development of an adaptation scenario for a schoolyard, hospital, square or residential block;
- combination of ENVI-met results with observational data, QGIS, R or Python.

9. Technical Requirements, Licensing and Integration

ENVI-met operates in the Windows environment. Computational performance is determined primarily by processor speed, the number of cores and the amount of RAM; the graphics card is not the principal computational component. Large models require substantial resources, so test calculations on a reduced domain are advisable before a full run.

Special licensing conditions are available to universities for teaching and research. The licence type determines the number of devices, the possibility of parallel calculations and access to particular functions. Current terms, prices and system requirements should be checked on the official website before purchase or installation.

ENVI-met can be integrated with geospatial and design environments. Tools or plugins for QGIS, SketchUp and Grasshopper are officially supported; newer solutions also develop links with Rhino and commonly used 2D/3D formats. Built-in Python tools can be used to process, analyse and visualise results.

10. Official ENVI-met Resources

Resource Name	Link
Official ENVI-met Website	https://envi-met.com/
Description of the Software Suite and Its Capabilities	https://envi-met.com/microclimate-simulation-software/
ENVI-met Technical Documentation	https://www.envi-met.info/
Overview of the Model Architecture	https://model.envi-met.com/hg2e/doku.php?id=intro:modelconept
Plugins and Integrations	https://envi-met.com/envi-met-plugins-for-urban-planning-and-design/
Python for ENVI-met	https://envi-met.info/doku.php?id=apps:python:start
Licensing and Pricing	https://envi-met.com/pricing/