Microscale simulation of urban heat fluxes

P. Kastendeuch

Laboratoire des Sciences de l'Image, de l'Informatique et de la Télédétection (UMR 7005 UDS/CNRS)
Contour acquisition

Real world

Detailed acquisition

Simplification
4 main types of objects

- Buildings
- Water
- Trees
- Terrain (grass, road)
Hierarchic simulation domain
Physical properties of the materials

Soil

Surface

Internal layers

Road

Wall
Boundary conditions

Atmos. IR

Solar direct + diffuse

T. + RH. + V.
Direct solar radiation

Sunbeam

Normal

β

Mask detection (shadows)

Illuminated facets and shadows

To the sun
Diffuse solar radiation

Anisotropic real sky

Visible sky

To the sun

Visible sky
Diffuse sky model

Sky dome

Sky luminance model

Clear

Overcast
Diffuse atmospheric radiation
Reflection of solar radiation

Direct

Diffuse

Reflection

Interdependence
Solar radiation received after reflections
Atmospheric IR radiation

Isotropic sky

Skyview factor
Terrestrial IR radiation

TIR radiation = emission + reflection

Atmospheric IR
The other fluxes

- Sensible heat flux
  \[ S = h(T_s - T_{air}) \]

- Latent heat flux for vegetation or water
  Penman-Monteith for vegetation or penman equation for water

- Ground heat flux
  Transient heat conduction equation in 1 dimension
For a building

Every surface

For buildings only

\[ T_{out}, T_s, T_1, T_2, T_{i-1}, T_{si}, T_{in} \]

\[ S, \Delta x, Le, Rn \]
Test with a real urban environment and validation with experimental data.
Some devices

Sonic anemometer

Pyranometer + pyrgeometer
Validation of the horizontal solar radiation

![Graph showing validation of horizontal solar radiation with simulation and measures data. The graph plots solar radiation in W m^-2 against hours TU. The simulation line is black, and the measures line is green diamonds. The graph peaks around 1000 W m^-2 with a significant drop after 12 hours TU. The diagram also illustrates the orientation with 'W' and 'E' labels.]
Simulated vertical solar radiation
Validation of the vertical solar radiation
Horizontal infrared radiation

Simulation
Measures
Differences with the measurements

![Graph showing differences with measurements over time with data points for Top and Bottom.]