Microclimate analysis of a university campus in Norway

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1. Introduction – Why urban microclimate?

1. Amplified short-wave radiation (i.e. multiple reflections)
2. Amplified long-wave radiation gain (i.e. due to pollution)
3. Decreased long-wave radiation loss (i.e. due to street canyons)
4. Anthropogenic heat sources (i.e. due to cars, industry)
5. Increased heat storage (i.e. due to construction materials)
6. Decreased evapotranspiration (i.e. less vegetation)
7. Decreased turbulent heat transport (i.e. reduced wind speeds)
1. Introduction – Aim of the study

**NTNU Gløshaugen campus** is in the early stages of a redevelopment: + 90,000 m² added until 2027 and existing buildings will be refurbished. It is part of the **Knowledge Axis** & a **Pilot project of the ZEN Centre**

| Investigate the current microclimatic conditions of a part of Gløshaugen campus |
| Use numerical tool ENVI-Met and on-site measurements for its validation |
| First step towards a more detailed study on how to improve microclimatic conditions over the course of the redevelopment |
| Evaluation of proposed solutions with models |
1. Introduction – Study area

<table>
<thead>
<tr>
<th>Category</th>
<th>Year of construction</th>
<th>Wall material</th>
<th>Roof Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>1900-1950</td>
<td>Stone: granite</td>
<td>Wood: spruce</td>
</tr>
<tr>
<td>A2</td>
<td>1900-1950</td>
<td>Solid brick</td>
<td>Wood: spruce</td>
</tr>
<tr>
<td>B1</td>
<td>1951-2000</td>
<td>Concrete: filled blocks</td>
<td>Concrete: default</td>
</tr>
<tr>
<td>B3</td>
<td>1951-2000</td>
<td>Wood: spruce</td>
<td>Wood: spruce</td>
</tr>
</tbody>
</table>
2. Methodology

Field Observations → Validation → Numerical Modeling

- Infrared Measurements
- Simulations with ENVI-Met model

94.5 m (32 grid cells)
416 m (104 grid cells)
400 m (100 grid cells)
3. Results – Microclimate analysis

Boundary conditions

i. Simulation of winter & summer Solstice and vernal & autumnal Equinox (2018)

ii. Hourly Air Temperature $T$ & Rel. Humidity $\text{RH}$ values

Daily mean Wind Speed & main wind Direction

<table>
<thead>
<tr>
<th>Date</th>
<th>$T_{\text{min}}$ (LST) $T_{\text{max}}$ (LST)</th>
<th>$\bar{w}$ [m/s]</th>
<th>$\phi$ [%]</th>
<th>$t_{sr}$ (LST)</th>
<th>$t_{ss}$ (LST)</th>
<th>$t_{\text{sim},s}$ (LST)</th>
<th>$t_{\text{sim},e}$ (LST)</th>
<th>$t_{\text{sim,tot}}$ [h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.03</td>
<td>2.6 (05:00) 4.2 (16:00)</td>
<td>1.7</td>
<td>85.1</td>
<td>06:17</td>
<td>18:35</td>
<td>06:00</td>
<td>19:00</td>
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<td>8.3 (06:00) 12.2 (18:00)</td>
<td>1.8</td>
<td>73.5</td>
<td>03:02</td>
<td>23:37</td>
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<td>24:00</td>
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<td>23.09</td>
<td>5.5 (19:00) 8.0 (15:00)</td>
<td>2.5</td>
<td>77.7</td>
<td>07:03</td>
<td>19:16</td>
<td>07:00</td>
<td>20:00</td>
<td>13.0</td>
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<tr>
<td>21.12</td>
<td>0.2 (06:00) 0.9 (12:00)</td>
<td>2.6</td>
<td>55.0</td>
<td>10:01</td>
<td>14:31</td>
<td>06:00</td>
<td>15:00</td>
<td>9.0</td>
</tr>
</tbody>
</table>
3. Results – Microclimate analysis- Simulated values of Tair

21 March 12:00

21 June 12:00
3. Results – Microclimate analysis - Simulated values of Tair

23 September 12:00

21 December 12:00
3. Results – Microclimate analysis-Wind Field

Wind speed change:
% referring to the undisturbed inflow profile at the same height level

21 June 12:00
4. Concluding remarks

• The simulated air temperatures largely correlate to the different surface types
  ➢ Materials with high heat storage capacity present higher air temperatures than the vegetated areas
  ➢ Areas in front of south-facing and sunlit surfaces present elevated local air temperatures
• On 21 December (almost no solar radiation and low sun angles) larger influence of materials
• Highest local difference in air temperature occurred on 21 June with 3.4 K, lowest on 21 December with 1.0 K
• East-west passages were identified to have highest local wind speeds (up to 57.1 % more than reference)
5. Limitations & Future work

Envi-met model limitations

➢ The program does not allow for a detailed representation of the environment (limitations in grid resolution & structure)
➢ Only basic CFD capabilities in ENVI-Met
➢ ENVI-met software is designed to model urban heat stress usually dealing with above freezing temperatures. ENVI-met is also as of now an exclusively dry model. This means precipitation is not modelled in any form within the software.

Future steps: More detailed study with several weather stations around the campus & „real“ CFD with finer discretisation