Part 5.1
Urban climate Fundamentals

Most common modeling approaches

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CL-UHI maximum intensity in dependence on city population. Figure idea based on Oke (1973; Atm. Env. 7, 769-779); values from multiple publications, Figure by Schlünzen (2021).
Statistical modeling of UHII

- Number of inhabitants explains too little of UHII.
- Essential elements need to be considered.
- Statistical model based on measurements.
Statistical modeling of UHII

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- Typical results
  - Larger wind speed $\rightarrow$ smaller CL-UHII.
  - Low day time / high night cloud cover $\rightarrow$ larger CL-UHII.

(e.g. Hoffmann et al., 2010; doi:10.1002/joc.2348)

Own figure based on data by Schlünzen et al., 2010; doi: 10.1002/joc.1968
Numerical modeling approaches – differences in how to consider effects of the urban canopy layer (UCL)

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<th>Type</th>
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<tr>
<td>Roughness length/ single layer UCL</td>
<td>• Traditional model approach (weather forecast &amp; climate models).</td>
<td>• Results not at e.g. 2 m.</td>
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<td>parameterization</td>
<td>• Fast to integrate.</td>
<td>• Vertical interpolation (empirical functions, displacement height, sub-surface).</td>
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<td>Multi-layer UCL parameterization</td>
<td>• Vertical heat, moisture, momentum radiation fluxes calculated within UCL.</td>
<td>• Intermediate computing resources (time step).</td>
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<td>• Vertical changes in heat storage and anthropogenic heat emission considered.</td>
<td>• In further development.</td>
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<td>• High vertical resolution (&lt; 5 m).</td>
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<td>UCL resolving</td>
<td>• Each building / tree realistically included.</td>
<td>• Large computing resources (time and space wise).</td>
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<td>• Fluxes in 3D.</td>
<td>• In development (e.g. nesting not always available, no humidity fluxes, not precipitation).</td>
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<td>• Lowest level &lt; 3 m, direct result use.</td>
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What model type to use

- Depends on the purpose of the assessment.
- Statistical models are fast and can be applied to future climate (if urban fabric is the same).
- Numerical models are more resources consuming, and allow
  - assessment of urban development scenarios in current and future climate,
  - temperature and UHII calculations at different heights.
- Using observations / models, you have to know about the data quality and representativeness (space and time).