Climate change in cities

Can remote sensing help to optimise mitigation strategies?

Dr. Wieke Heldens, Dr. Thomas Esch & Dr. Hannes Taubenböck
DLR-DFD, Department Land Surfaces
Team Urban Areas and Land Management
Climate Change: General trend

Air temperature in Germany for the years 1881 – 2011 and predictions by climate simulations

- yearly mean temperature
- smoothed mean
Climate Change: Implications for cities

- The **awareness about climate change** and its possible consequences for urban areas is growing.

- Planning authorities want to **evaluate the climatic effects** of their planning activities:
  - **maintain the livability** of cities in the future, e.g.
    - create places with reduced temperatures
    - Facilitate corridors of fresh air
    - Adapted water management to cope with increasing rainfall
Urban Climate Analysis: Information needs

Information is required:

- on the possible changes of the climate

- on the effect of changes in land use (city structure, new buildings, parks, streets) on the local climate

- on possible mitigation strategies against negative climate impacts

Can remote sensing help to gather this information?
Urban Climate Analysis: **Potential of remote sensing**

- Area-wide
- Automated and objective mapping
- Regular updates

<table>
<thead>
<tr>
<th>Remote Sensing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Satellite data</strong></td>
</tr>
<tr>
<td>thermal Data</td>
</tr>
<tr>
<td>(Landsat, ASTER, …)</td>
</tr>
<tr>
<td>optical Data</td>
</tr>
<tr>
<td>(Landsat, Ikonos, …)</td>
</tr>
<tr>
<td>Radar Data</td>
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<tr>
<td>(e.g. TerraSAR-X)</td>
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<tr>
<td><strong>Airborne data</strong></td>
</tr>
<tr>
<td>thermal Data</td>
</tr>
<tr>
<td>(single band, multispectra)</td>
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<tr>
<td>optical Data</td>
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<tr>
<td>(hyperspectral data, aerial images, stereo data)</td>
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<tr>
<td>Lidar Data</td>
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<tr>
<td>(accurate height models)</td>
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*Isar and Deutsches Museum, Munich, Germany (airborne hyperspectral data, false color composite)*
Urban Climate Analysis: Relevant urban properties

<table>
<thead>
<tr>
<th>Urban spatial characteristics</th>
<th>Climate surface parameters</th>
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<tbody>
<tr>
<td></td>
<td>Temperature</td>
</tr>
<tr>
<td>Building structure</td>
<td>●</td>
</tr>
<tr>
<td>H/W ratio of street canyons</td>
<td>●</td>
</tr>
<tr>
<td>Sky view factor</td>
<td>●</td>
</tr>
<tr>
<td>Land cover</td>
<td>●</td>
</tr>
<tr>
<td>Albedo</td>
<td>●</td>
</tr>
<tr>
<td>Emissivity</td>
<td>●</td>
</tr>
<tr>
<td>Thermal inertia</td>
<td>●</td>
</tr>
<tr>
<td>Impervious area</td>
<td>●</td>
</tr>
<tr>
<td>Vegetation fraction</td>
<td>●</td>
</tr>
<tr>
<td>Surface water</td>
<td>●</td>
</tr>
<tr>
<td>Land use</td>
<td>●</td>
</tr>
<tr>
<td>Traffic density</td>
<td>●</td>
</tr>
<tr>
<td>Industrial areas</td>
<td>●</td>
</tr>
</tbody>
</table>

Overview of urban spatial characteristics that influence the main for climate surface parameters.

H/W ratio = height to width ratio
Urban Climate Analysis: Potential of remote sensing

- Measuring climate parameters
- Mapping surface characteristics related to urban climate
- Supporting climate modelling
Remote Sensing: **Measuring climate parameters**

- Surface temperature
- Albedo
- Radiation
Remote Sensing: Measuring climate parameters

NOAA July 29th 2009
Remote Sensing: Measuring climate parameters

Landsat (satellite-borne) and Daedalus (airborne) thermal image of Munich (June 2007)

Surface temperature (°C)

20 25 30 35

5 km
Remote Sensing: **Measuring climate parameters**

*Landsat (satellite-borne) and Daedalus (airborne) thermal image of Munich (June 2007)*

*Surface temperature (°C)*

- 20
- 25
- 30
- 35

5 km
Remote Sensing: Measuring climate parameters
Remote Sensing: Mapping surface characteristics

- Building structure
- Land use / Land cover
- Impervious surface
- Vegetation density
- ..
Remote Sensing: Mapping surface characteristics
Remote Sensing: Mapping surface characteristics

Vegetation density per building block in Munich

Data source: Airborne hyperspectral data (HyMap)
Remote Sensing: **Supporting climate modelling**

- Basic spatial information:
  - Buildings
  - Object heights
  - Surface materials
  - Vegetation properties
  - ...
Remote Sensing: Supporting climate modelling

Atmosphere
- Wind
- Temperature
- Vapor
- Turbulence
- Pollutants

Solar radiation (date, time, location)

Temperature, Humidity

Wind speed & direction

Surfaces
- Ground surface fluxes
- Fluxes at walls/roofs
- Heat transfer through walls

Vegetation
- Foliage temperature
- Heat exchange
- Vapor exchange
- Water interception
- Water transport

Soil system
- Temperature
- Water flux
- Water bodies

Biometeorology
- PMV

Applied urban micro climate model:
ENVI-met, University of Mainz (www.envi-met.com)
Remote Sensing: Supporting climate modelling

Airborne hyperspectral data (4 m)

Height model (airborne stereo data)

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Remote Sensing: Supporting climate modelling

Leaf Area Index (LAI)  Albedo  Surface materials

Applied urban micro climate model:
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Remote Sensing: Supporting climate modelling

Roof and facade properties

Plant properties

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Remote Sensing: Supporting climate modelling

Air temperature [° Kelvin]
- <291.25
- 291.25 – 291.75
- 291.75 – 292
- 292 – 292.25
- 292.25 – 292.75
- 292.75 – 293
- 293 – 293.75
- > 293.75

Wind speed [m/s]
- < 0.5
- 0.5 – 1
- 1 – 1.5
- 1.5 – 2
- 2 – 2.5
- > 2.5

Predicted Mean Vote
- <1.5
- 1.5 – 2
- 2
- > 2

Buildings

Applied urban micro climate model: ENVI-met, University of Mainz (www.envi-met.com)
Remote Sensing: Supporting climate modelling

Applied urban micro climate model: ENVI-met, University of Mainz (www.envi-met.com)
Conclusions - Can remote sensing help to optimise mitigation strategies?

What remote sensing cannot provide:

- direct measurements of air temperature, precipitation, wind etc.

- measurement/simulation of the effect of the spatial changes on the local climate

What remote sensing can provide:

- Support of in situ measurements and simulations:
  - Time series of RS date since 1970 to learn from the past
  - Up-to-date basic spatial information for climate models
Conclusions - Can remote sensing help to optimise mitigation strategies?

Required information to which remote sensing can contribute:

a) possible changes of the climate
   + surface temperature
   + albedo

b) on the effect of changes in land use (city structure, new buildings, parks, streets) on the local climate
   + mapping city structure (change)
   + mapping land use/land cover change

c) possible mitigation strategies for negative climate impacts
   + identifying location where such strategies might be implemented
Thank you for your attention!