Climate change in cities

Can remote sensing help to optimise mitigation strategies?

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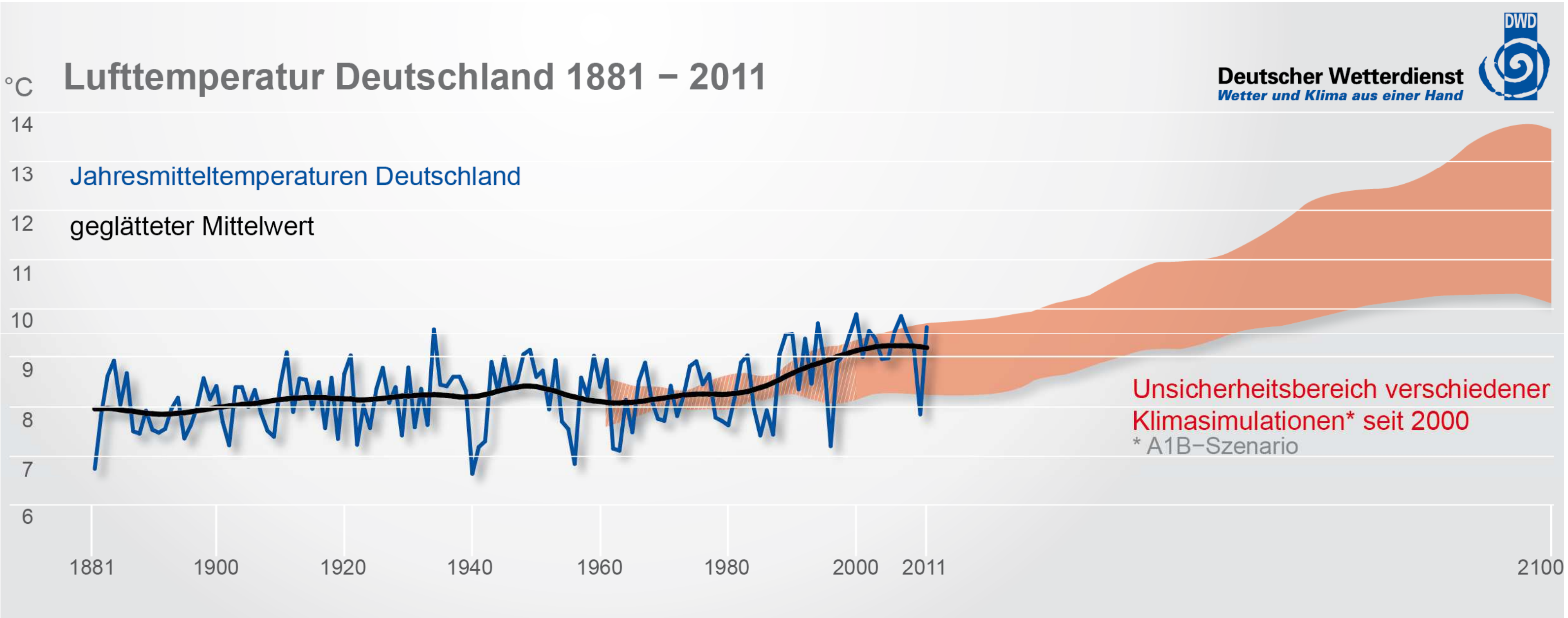
Team Urban Areas and Land Management

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

Isar and Deutsches Museum, Munich, Germany (airborne hyperspectral data, false color composite)

Remote Sensing	
Satellite data	thermal Data (Landsat, ASTER, …)
	optical Data (Landsat, Ikonos, …)
	Radar Data (e.g. TerraSAR-X)
Airborne data	thermal Data (single band, multispectra)
	optical Data (hyperspectral data, aerial images, stereo data)
	Lidar Data (accurate height models)

Urban Climate Analysis: Relevant urban properties

Urban spatial characteristics	Climate surface parameters			
	Temperature	Wind speed	Humidity and precipitation	Air quality
Building structure	●	●	●	●
H/W ratio of street canyons	●	●		●
Sky view factor	●			
Land cover	●	●	●	●
Albedo	●			
Emissivity	●			
Thermal inertia	●			
Impervious area	●	●	●	
Vegetation fraction	●	●	●	
Surface water	●			●
Land use	●		●	●
Traffic density	●		●	●
Industrial areas	●		●	●

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

H/W ratio = height to with ratio

Urban Climate Analysis: Potential of remote sensing

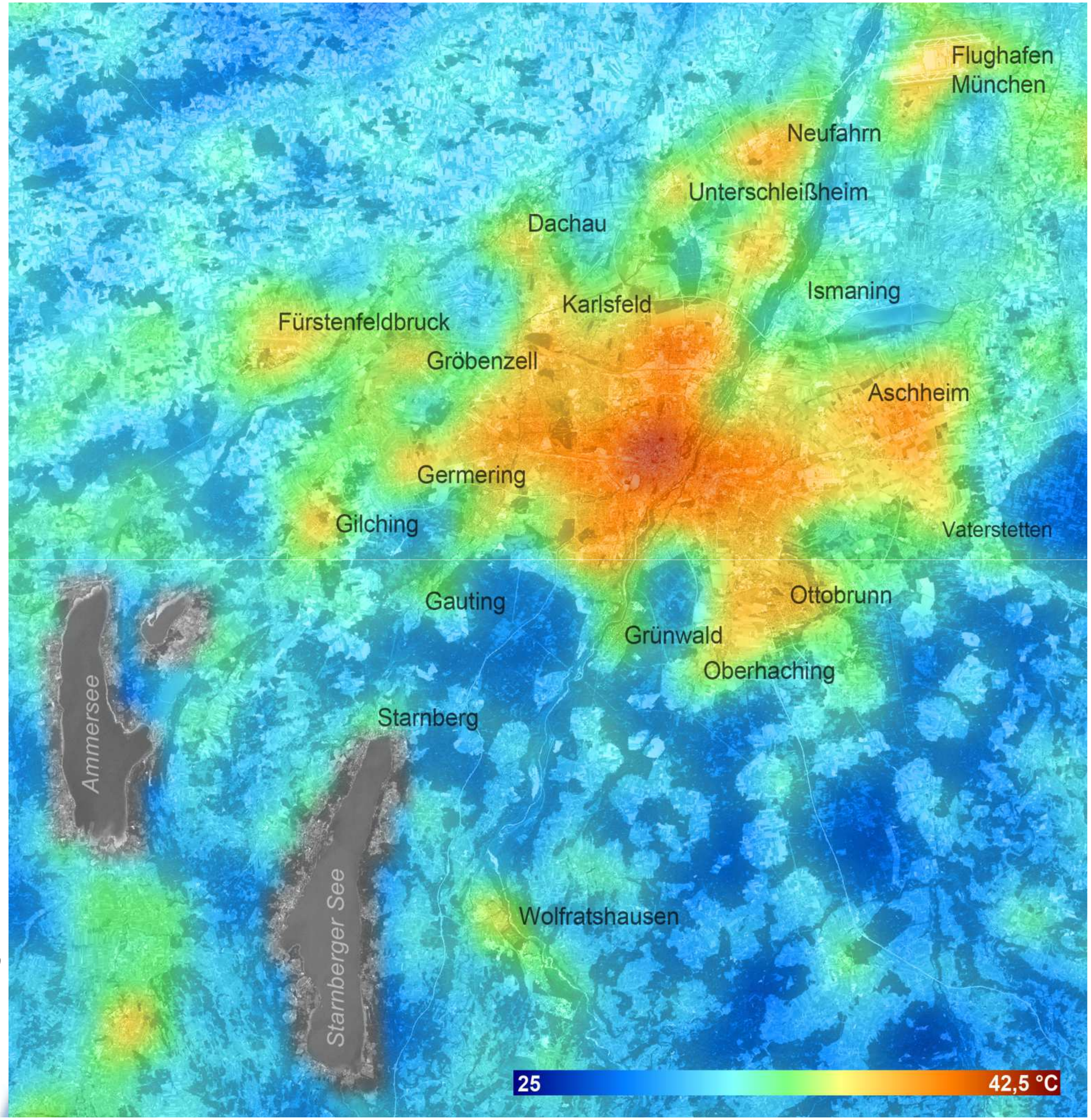
- Measuring climate parameters
- Mapping surface characteristics related to urban climate
- Supporting climate modelling

Isar and Deutsches Museum, Munich, Germany (airborne hyperspectral data, false color composite)

Remote Sensing: Measuring climate parameters

- Surface temperature
- Albedo
- Radiation

Remote Sensing: Measuring climate parameters



NOAA July 29th 2009

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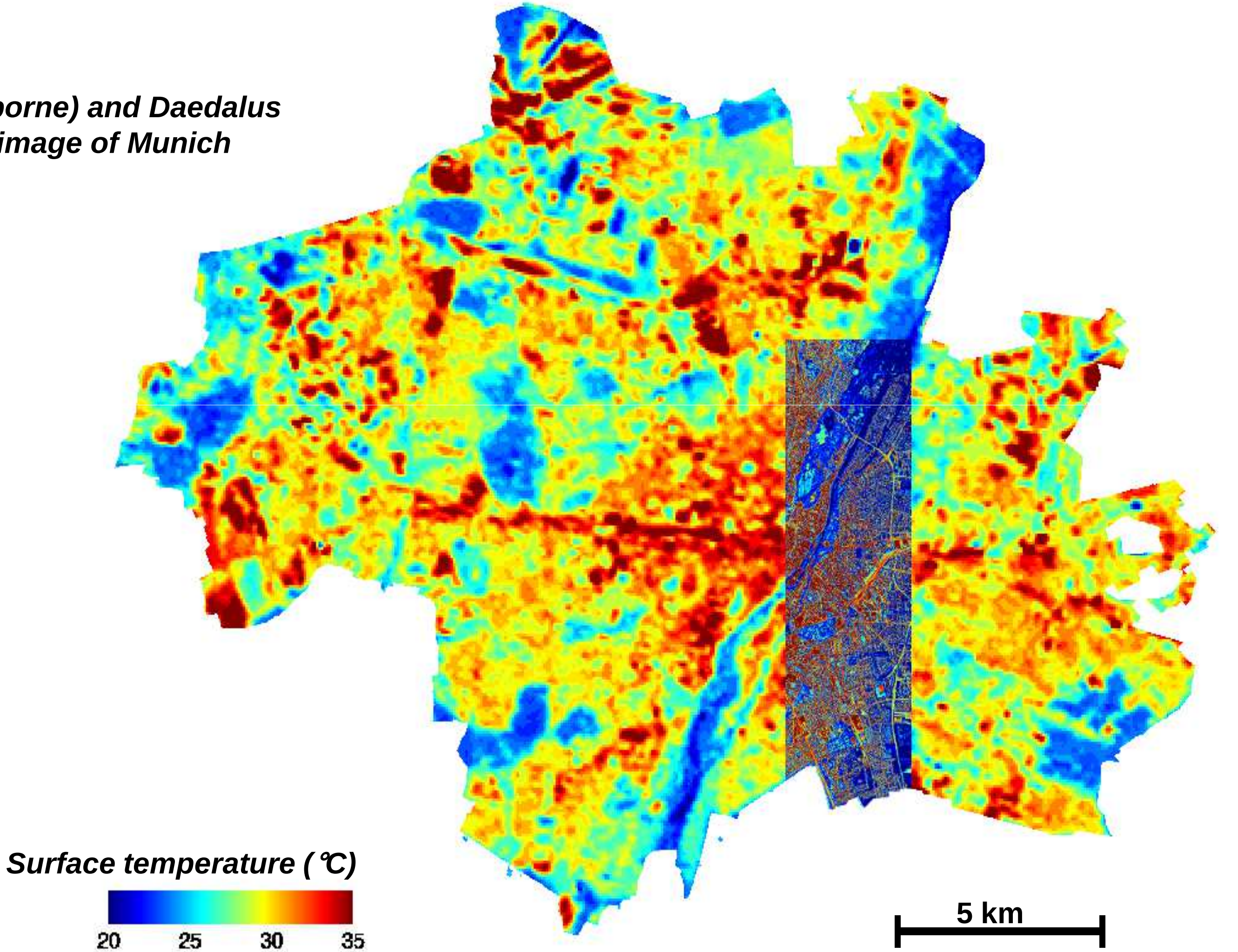
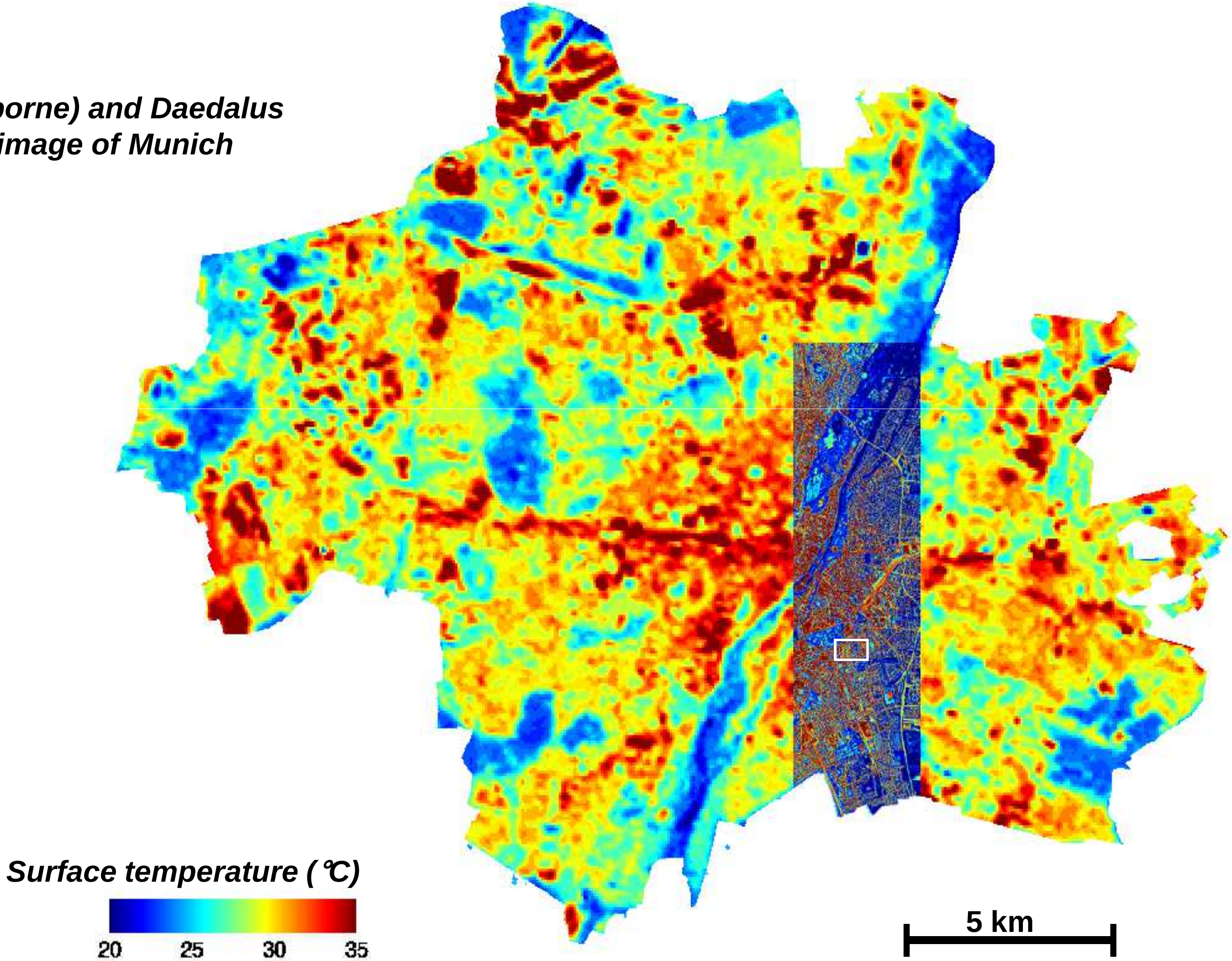
Remote Sensing: Measuring climate parameters

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



Remote Sensing: Measuring climate parameters

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



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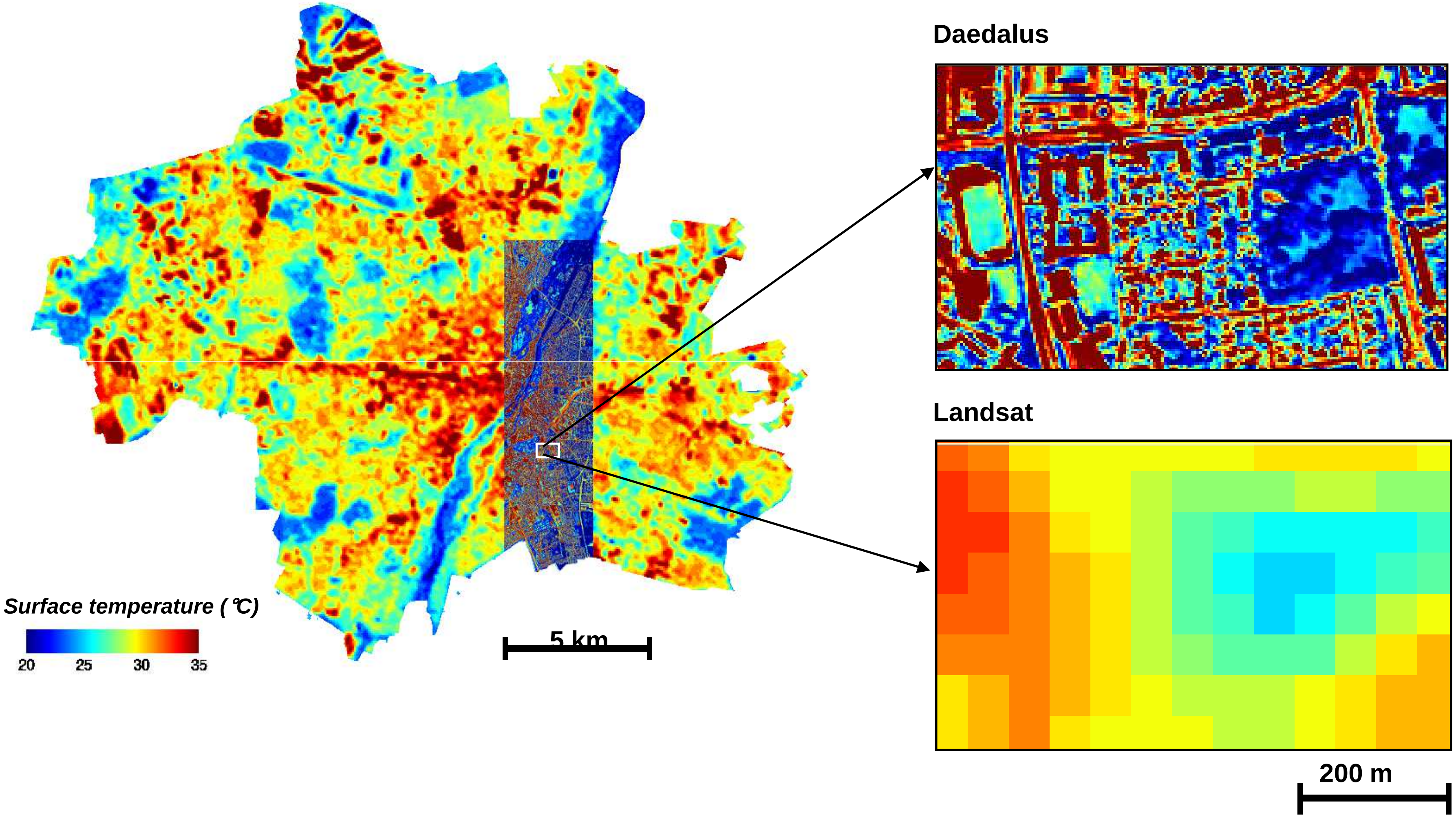
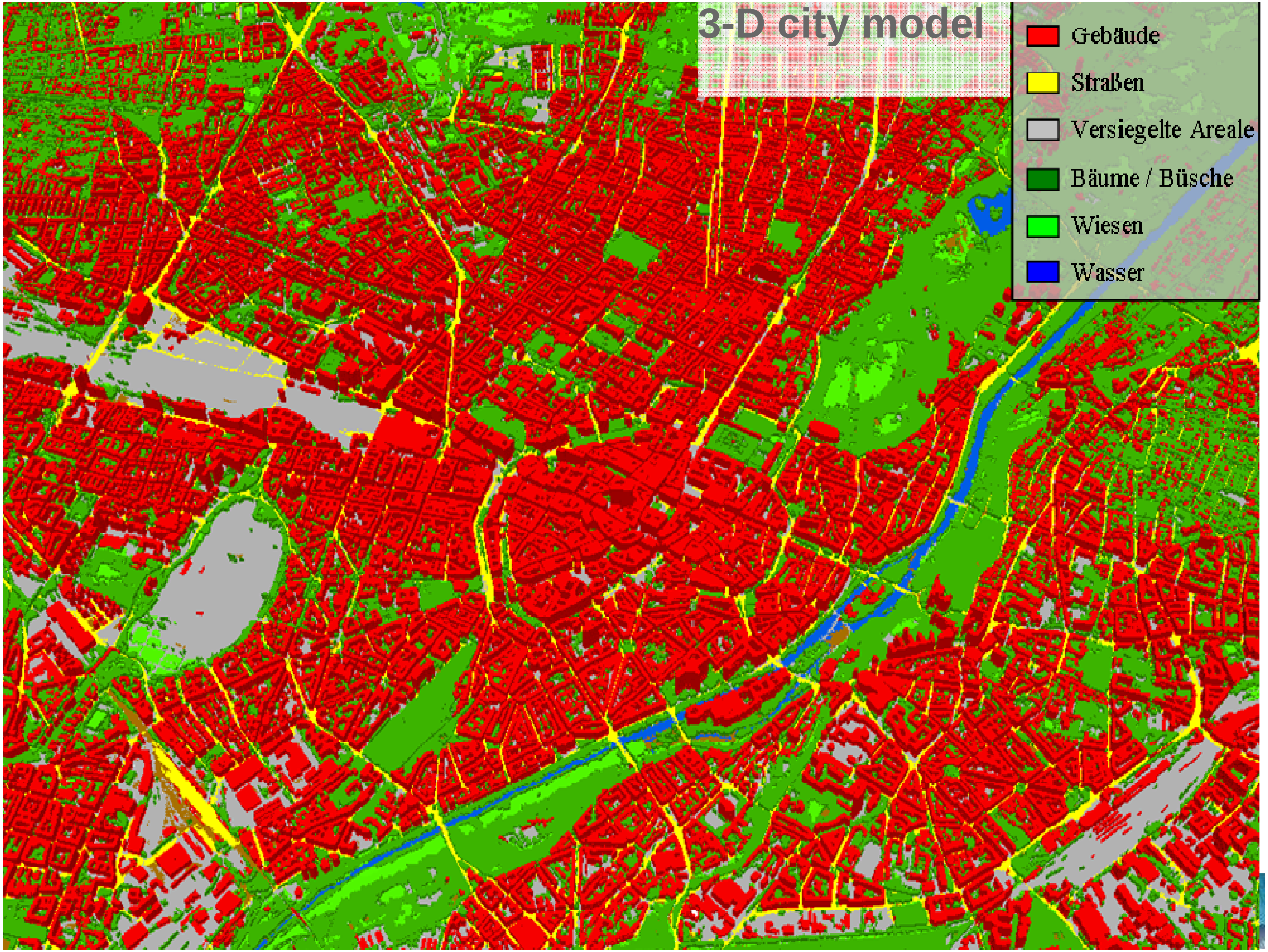
Remote Sensing: Measuring climate parameters

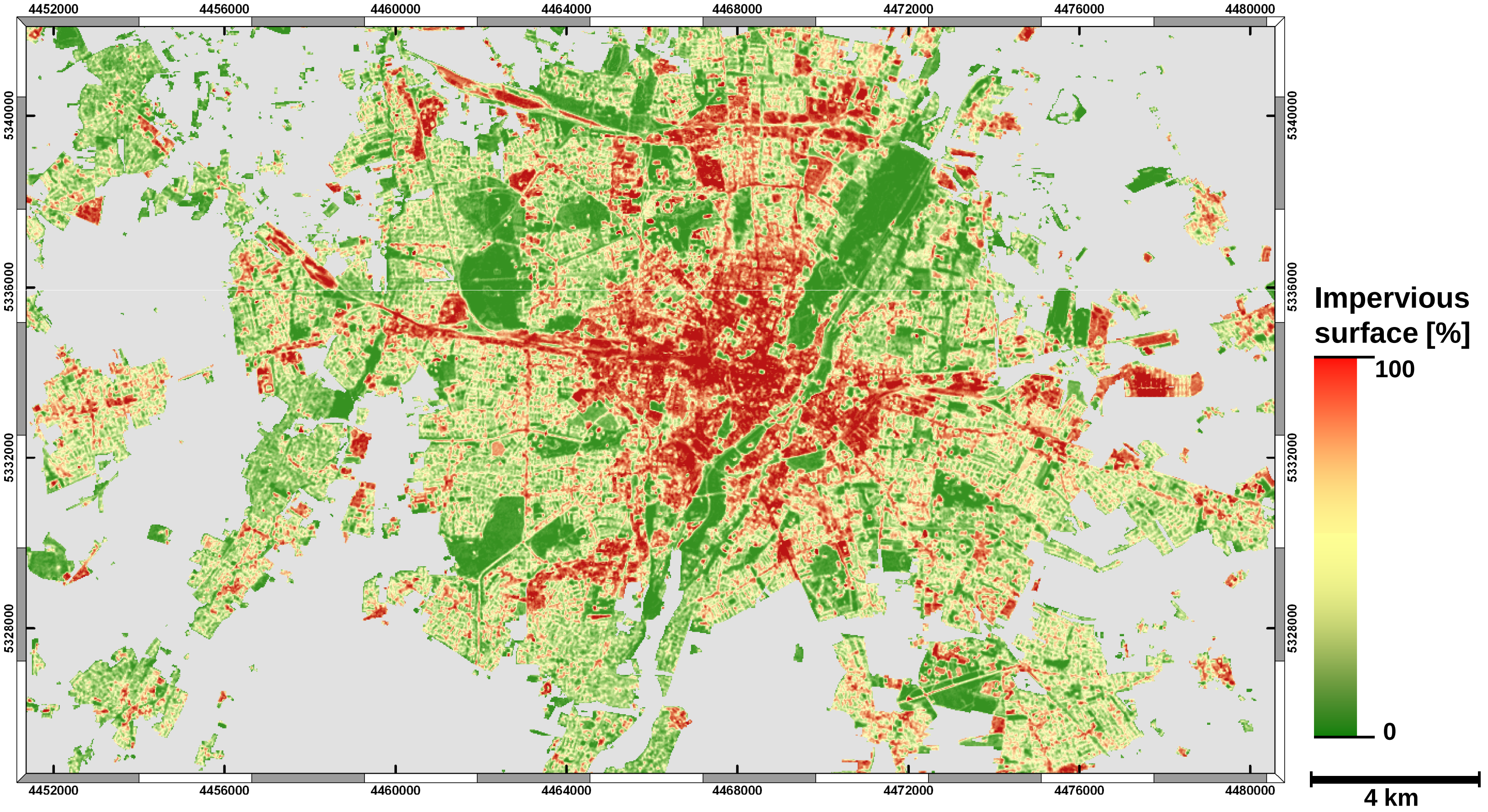


Remote Sensing: Mapping surface characteristics

- Building structure
- Land use / Land cover
- Impervious surface
- Vegetation density
- ..


3-D city model
Gebäude
Straßen
Versiegelte Areale
Bäume / Büsche
Wiesen
Wasser

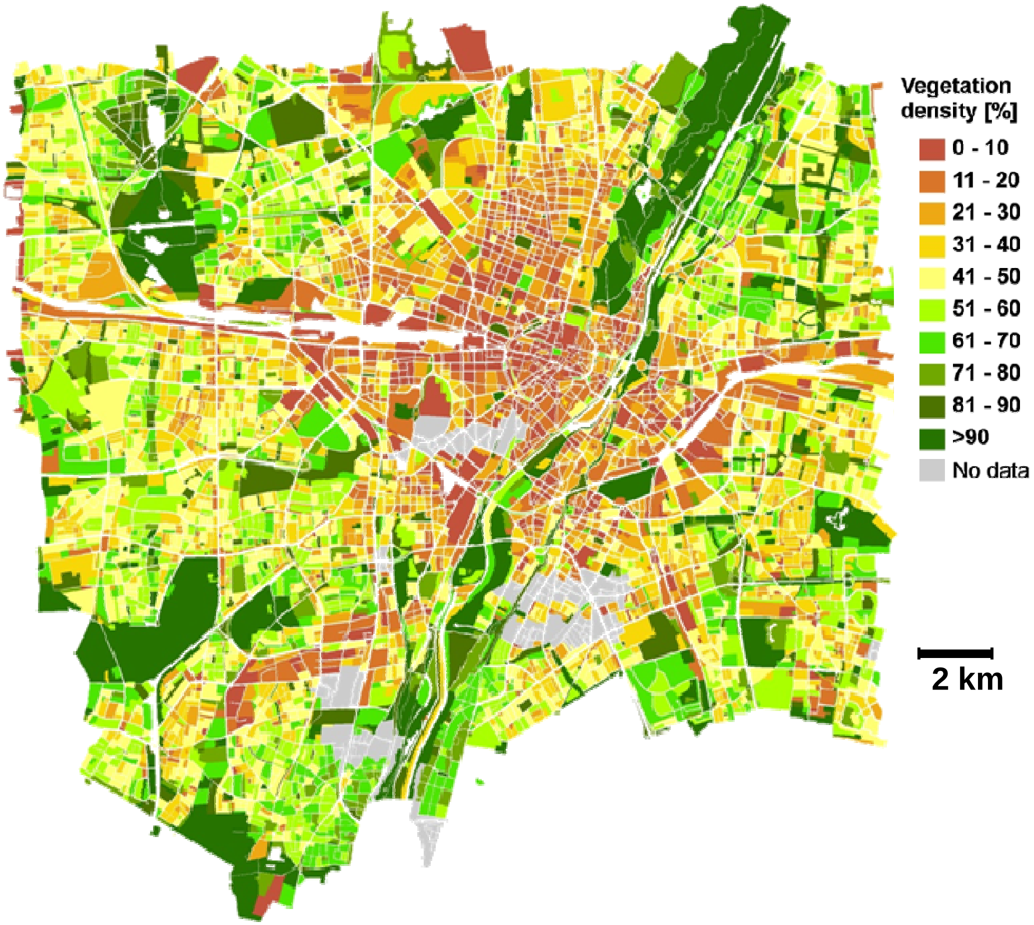
Remote Sensing: Mapping surface characteristics



Remote Sensing: Mapping surface characteristics

Vegetation density per building block in Munich

Data source: Airborne hyperspectral data (HyMap)



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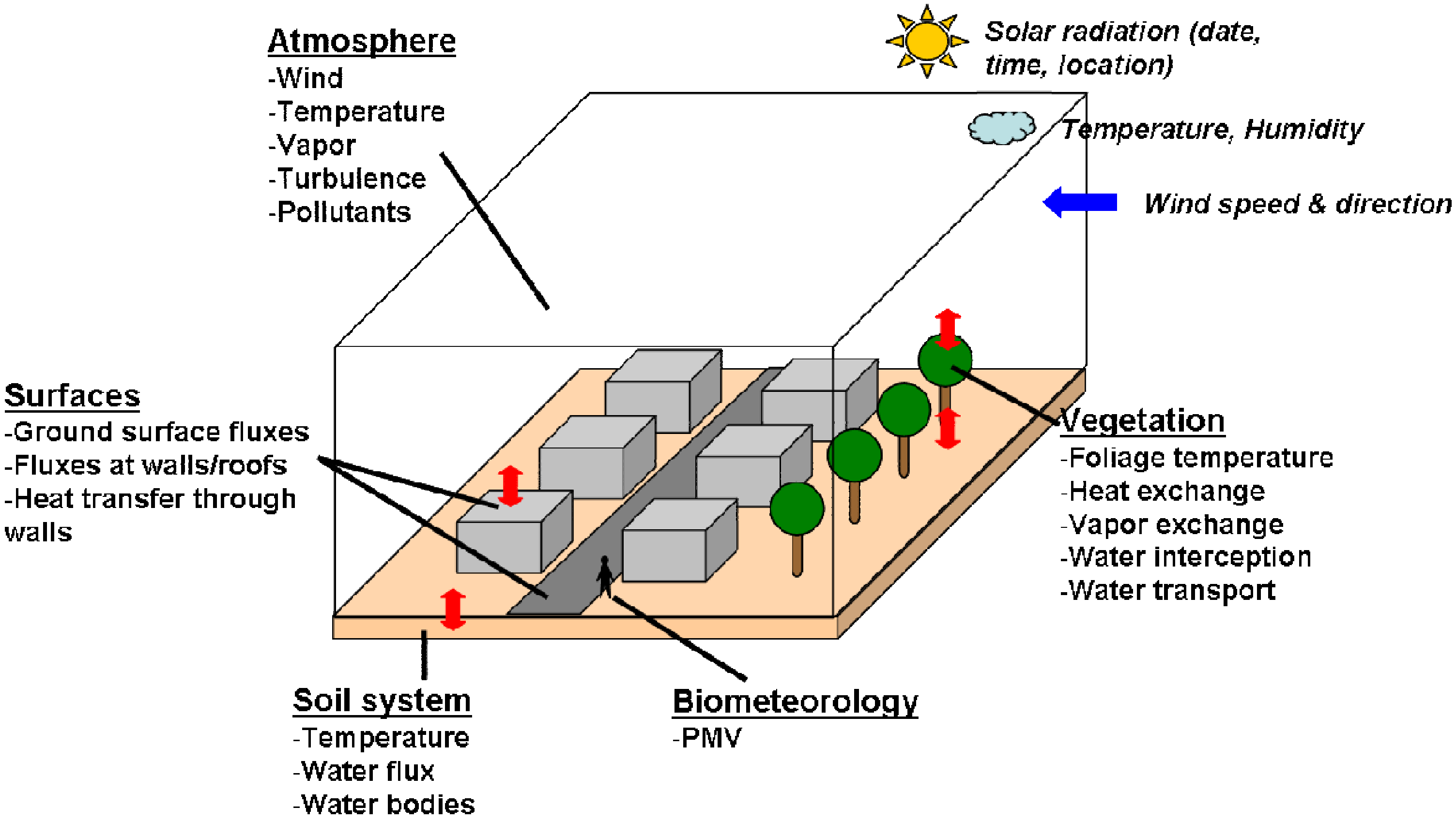
Remote Sensing: Supporting climate modelling

- Basic spatial information:
  - Buildings
  - Object heights
  - Surface materials
  - Vegetation properties
  - …

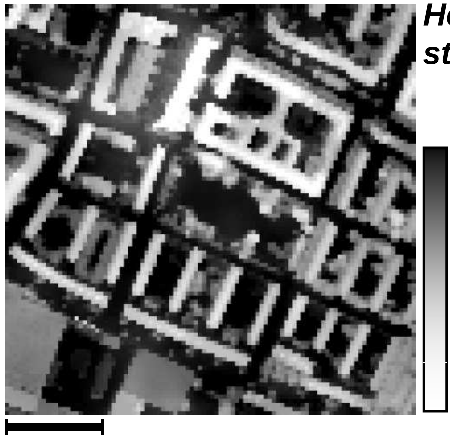
Remote Sensing: Supporting climate modelling



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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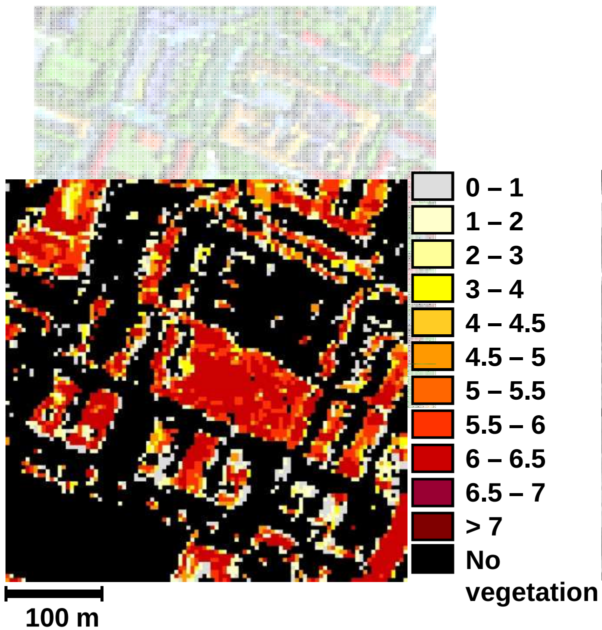
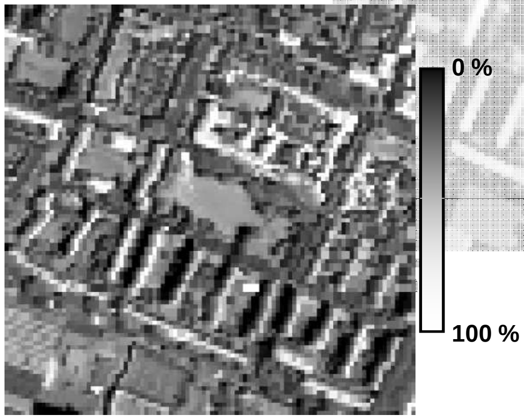
ENVI-met, University of Mainz (www.envi-met.com)

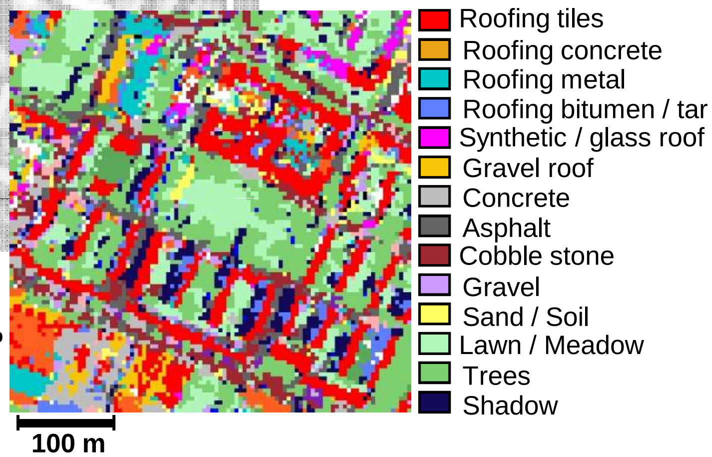
Remote Sensing: Supporting climate modelling



Leaf Area Index (LAI)



Albedo



Surface materials

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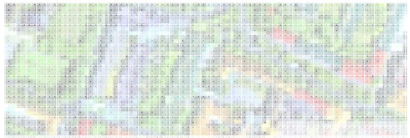
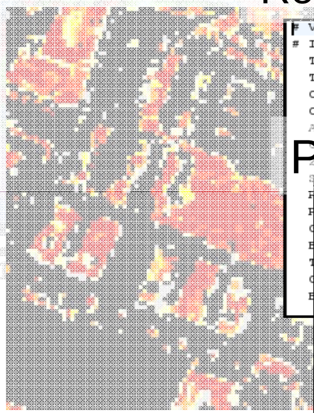
Remote Sensing: Supporting climate modelling



Roof and facade properties

V4 ENVI-MET Walls database

# ID	Density[kg/m³]	Reflection[%]	Absorption[%]	Transmission[%]	Emissivity[%]	K-Value[W/(m*K)]	Specific heat capacity[J/(kg*K)]	Thickness[m]	Color in Editor	Usage ID	Extra ID
Tr	1700	39	61	0	90	0.81	840	0.05	255	1	0
Td	1700	31	69	0	90	0.81	840	0.05	255	1	0
CT	2100	24	76	0	90	1.1	840	0.05	2187519	1	0
Co	2100	25	75	0	90	1.28	840	0.05	2187519	0	0
Al	2700	51	49	0	18	203	880	0.03	13158400	0	0
[illegible]	8600	18	82	0	20	384	390	0.03	13158400	0	0
Zi	[illegible]	[illegible]	[illegible]	0	5	113	390	0.03	13158400	0	0



Plant properties

V3 -------- ENVI-met Database Version 3 ---------------- this file is only usable with ENVI-met V3.0 or higher --

ID	C?	TY	rs-m	a_f	HH.HH	TT.TT	LAD1	LAD2	LAD3	LAD4	LAD5	LAD6	LAD7	LAD8	LAD9	LAD10	RAD1	RAD2	RAD3	RAD4	RAD5	RAD6	RAD7	RAD8	RAD9	RAD10	NAME
xx	C3	03	200	0.20	00.63	00.50	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Grass 50 cm aver. dense...
so	C3	03	70	0.20	00.63	1.200	1.580	0.820	0.380	0.290	0.270	0.290	0.330	0.400	0.520	0.740	0.000	0.900	0.200	0.200	0.200	0.200	0.200	0.200	0.760	0.000	soja 90. soja 63cm........
lg	C3	03	200	0.20	00.18	03.00	0.300	0.600	0.900	1.200	1.500	1.800	2.000	1.500	1.000	0.700	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	luzerne 18cm..............
MO	C3	01	400	0.20	20.00	02.00	0.040	0.060	0.070	0.110	0.130	0.150	0.140	0.130	0.100	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20m aver. dense., no
DO	C3	01	400	0.20	20.00	02.00	0.110	0.140	0.180	0.270	0.330	0.370	0.360	0.330	0.250	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20 m dense., no disti
DM	C3	01	400	0.20	20.00	02.00	0.075	0.075	0.075	0.075	0.250	1.150	1.060	1.050	0.920	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20 m dense., distinct
dm	C3	01	400	0.20	20.00	02.00	0.075	0.075	0.075	0.075	0.250	1.150	1.060	1.050	0.920	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20 m dense., distinct
ds	C3	01	400	0.20	10.00	02.00	0.075	0.075	0.075	0.075	0.250	1.150	1.060	1.050	0.920	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 10 m dense.,distinct
sm	C3	01	400	0.20	20.00	02.00	0.150	0.150	0.150	0.150	0.650	2.150	2.180	2.050	1.720	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20 m very dense, dist
sk	C3	01	400	0.20	15.00	02.00	0.150	0.150	0.150	0.150	0.650	2.150	2.180	2.050	1.720	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 15 m very dense, dist
H2	C3	01	400	0.20	06.00	01.00	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.300	2.200	1.500	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Hedge dense, 2m..........
T1	C3	01	400	0.20	10.00	02.00	0.000	0.000	2.180	2.180	2.180	2.180	2.180	2.180	1.720	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 10 m very dense, leaf
gr	C3	03	200	0.20	00.50	00.50	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Grass 50 cm aver. dense...
bs	C3	01	400	0.20	20.00	02.00	0.000	0.000	0.005	0.075	0.250	1.150	1.060	1.050	0.920	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20 m dense.,distinct
sc	C3	01	400	0.20	20.00	02.00	0.000	0.000	0.150	0.150	0.650	2.150	2.180	2.050	1.720	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20 m very dense, free
fo	C3	01	400	0.20	20.00	02.00	0.110	0.140	0.180	0.270	0.330	0.370	0.360	0.330	0.250	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Forst 20 m dense., no dist
l1	C3	01	400	0.20	15.00	02.00	0.040	0.060	0.070	0.110	0.130	0.150	0.140	0.130	0.100	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree, light 15 m.........
l2	C3	01	400	0.20	20.00	02.00	0.040	0.060	0.070	0.110	0.130	0.150	0.140	0.130	0.100	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree, light 20 m.........
he	C3	01	400	0.20	02.00	01.00	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Hedge dense, 2m..........
ma	C4	03	200	0.20	01.50	00.50	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Maize, 1.5 m..............
gb	C3	03	200	0.20	00.50	00.50	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Grass 50 cm aver. dense...
gz	C3	03	200	0.20	00.50	00.50	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Grass 50 cm aver. dense...
T2	C3	01	400	0.20	16.00	02.00	0.000	0.000	2.180	2.180	2.180	2.180	2.180	2.180	1.720	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 15 m very dense, leaf
Tb	C3	01	400	0.20	16.00	02.00	2.000	2.000	2.180	2.180	2.180	2.180	2.180	2.180	1.720	0.000	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 15 m very dense.....
ee	C3	01	400	0.20	20.00	02.00	0.500	0.500	1.000	1.110	1.130	1.500	1.800	2.000	1.500	0.800	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 20m aver. dense., no
TH	C3	01	400	0.20	15.00	02.00	0.000	0.000	0.000	0.000	0.400	0.450	0.450	0.490	0.490	0.400	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	Tree 15m dense, distinct c

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

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Remote Sensing: Supporting climate modelling

3D input data set

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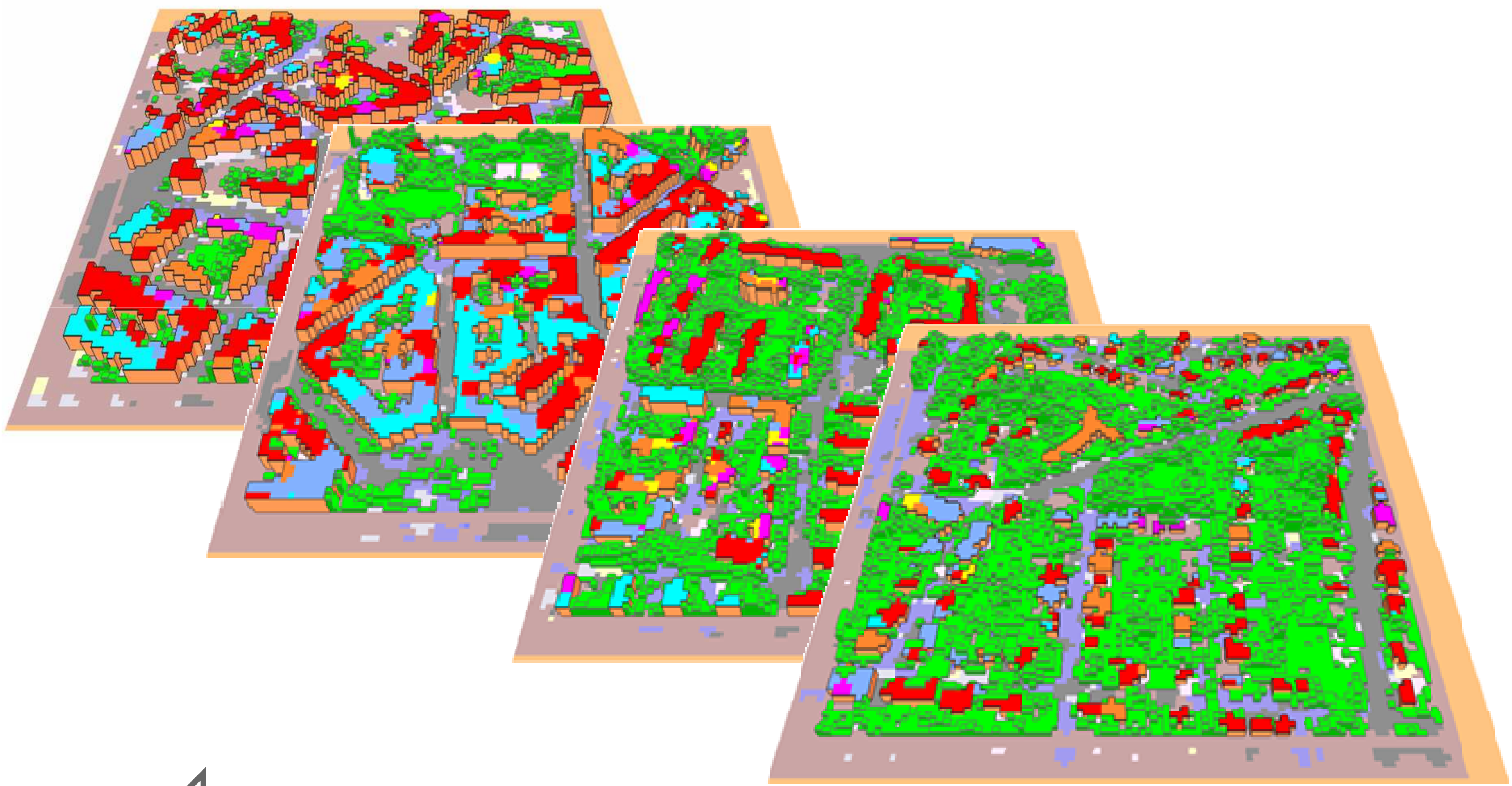
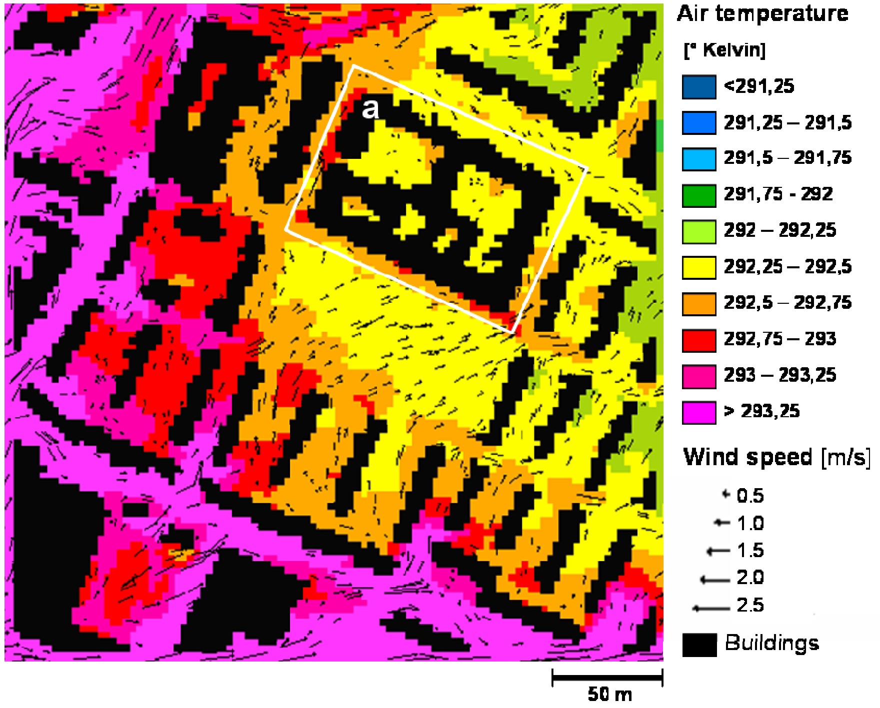
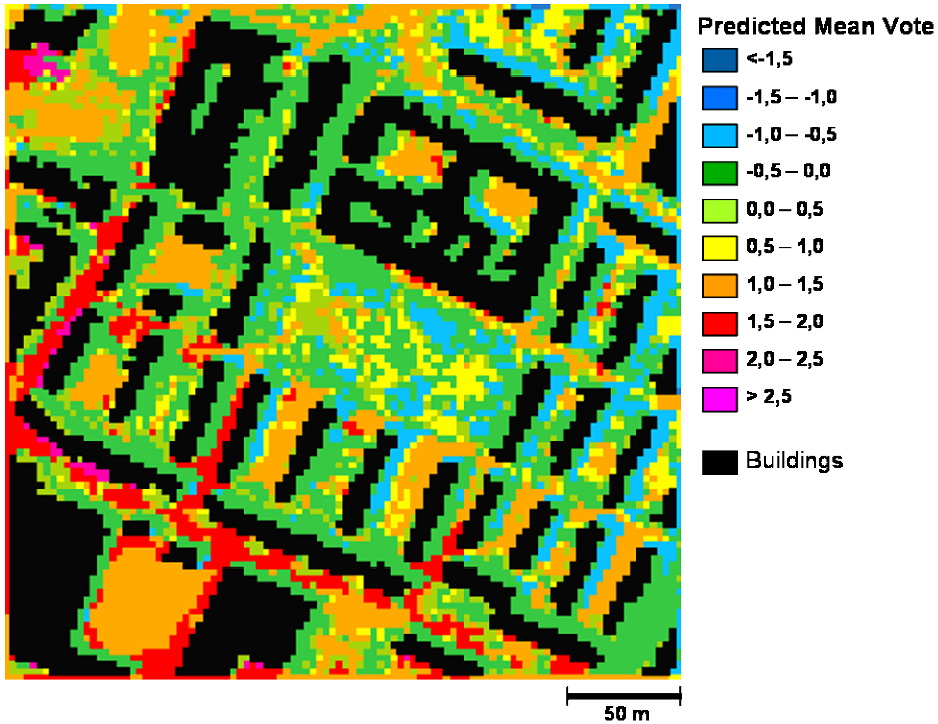
Remote Sensing: Supporting climate modelling



Remote Sensing: Supporting climate modelling





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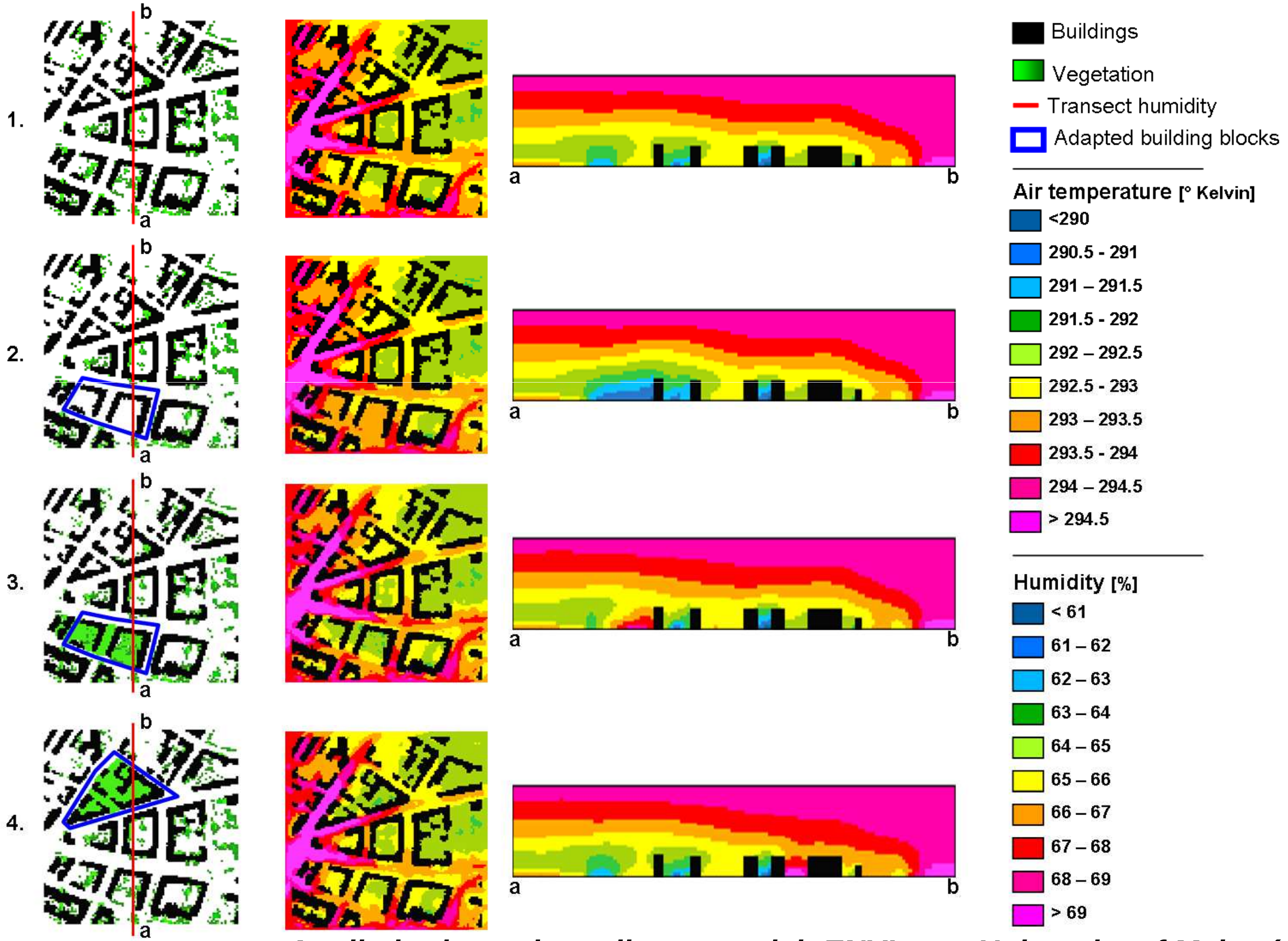
Remote Sensing: Supporting climate modelling

Simulation area *Air temperature* *Humidity*



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

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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

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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!