Evaluating urban climate model simulations with low-cost air temperature measurements

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Why low-cost temperature measurements?

Advantages:

- Exploiting technological potential
- Increasing density of monitoring networks
- Filling gaps in in-situ observational data
- Limited resources
- Crowd-sourcing
- Business opportunity....

Mobile measurements with low-cost devices

Stationary low-cost measurements at the weather station in Vienna, Austria

Problems:

- Accuracy and reliability of measurement devices
- Design for industrial applications
- Non-standard collecting procedure

Questions:

- **What quality can be expected from the low-cost measurements?**
- **Can they be used for urban climate applications?**

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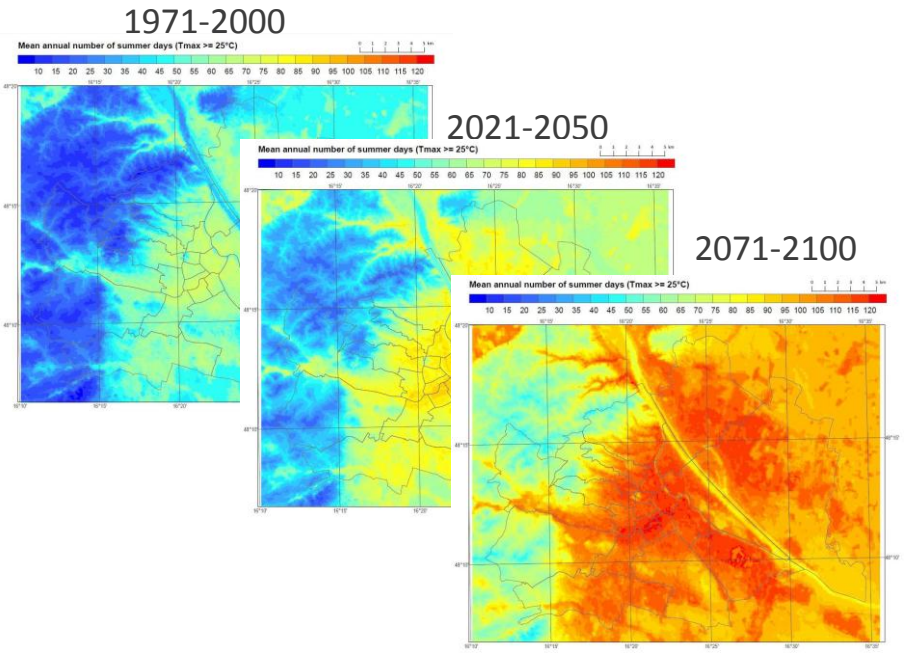
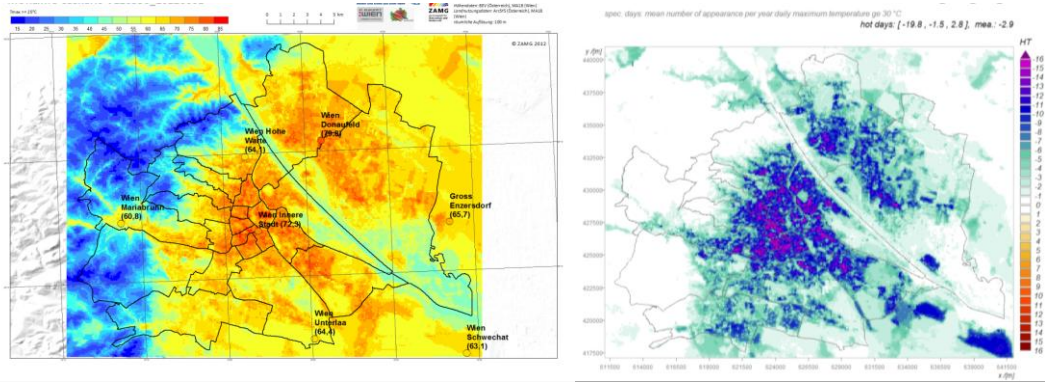
Urban climate model applications with MUKLIMO_3

- Heat load assessment
- Downscaling of future climate scenarios on urban scale
- Sensitivity simulations for climate change adaptation strategies
- Support for urban planning
- Reconstruction of urban climate
- Improvement of heat warning systems



Bokwa et al.: "Modelling the impact of climate change on heat load increase in Central European cities", ICUC9 CCMA2: Climate modeling: methodologies for impacts studies



Andre et al. "Modeling reduction of Urban Heat Island effect by improving radiative properties of buildings and districts", ICUC9 POSTER 23: UDC - Building climate and energy consumption

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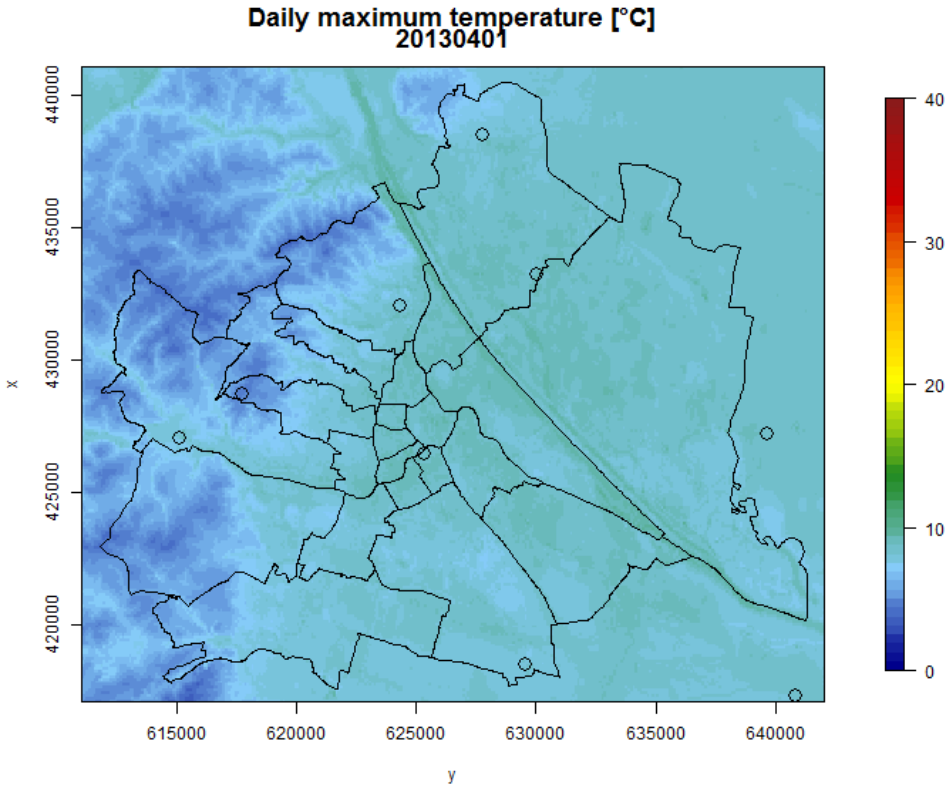
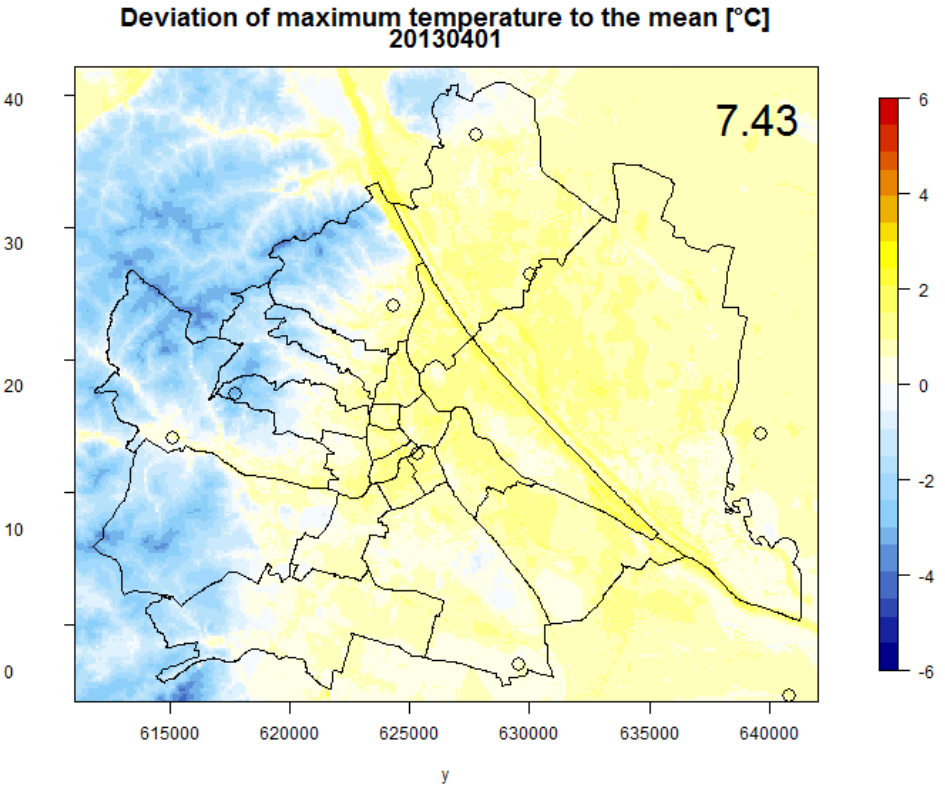
Urban climate simulations in NWP mode

Experiments: ALARO-MUKLIMO_3 daily simulations, April-October 2013





Needed high spatial resolution observational data for model validation!

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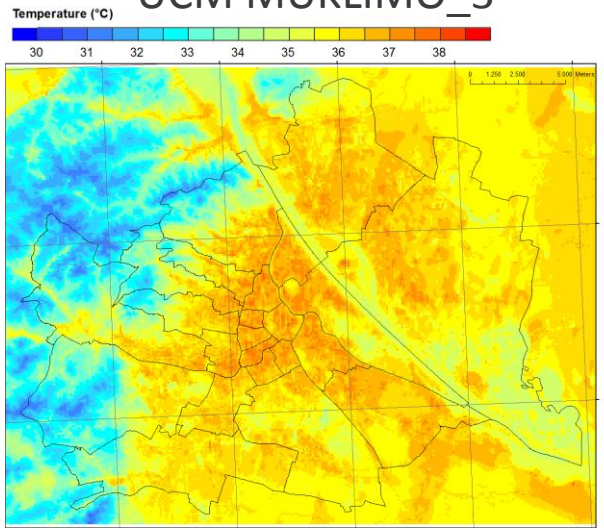
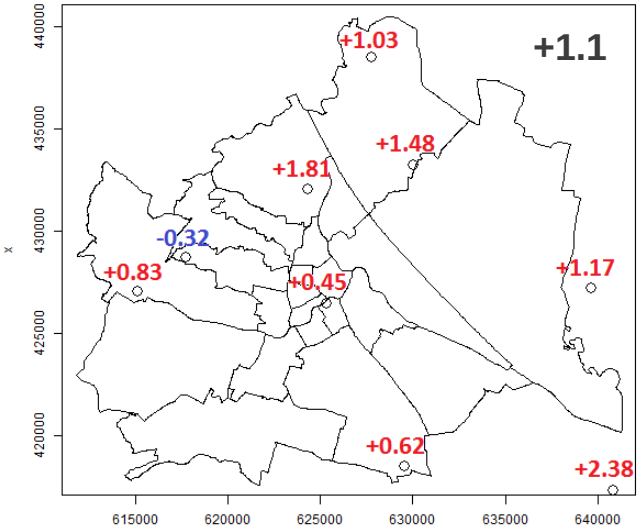
How good are the model simulations?

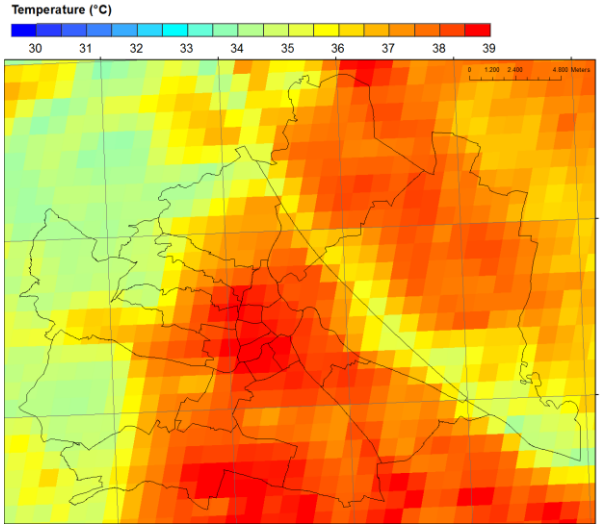
UCM MUKLIMO_3



Operational weather stations



MODIS LST



Thermal images

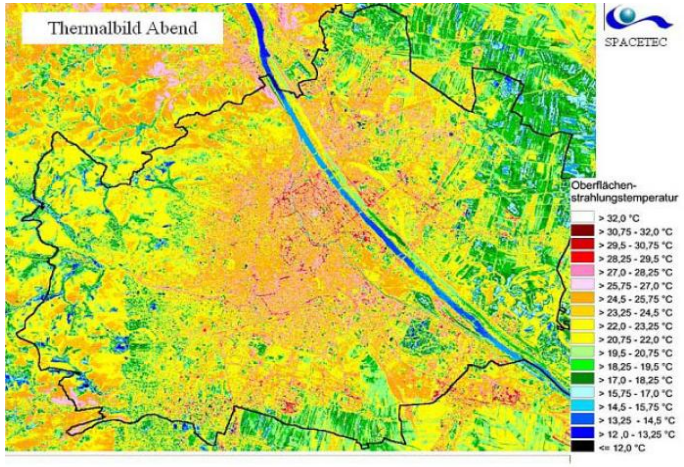


Abbildung 19: Thermalbefliegung 15.08.2001 abends 21 Uhr MEZ

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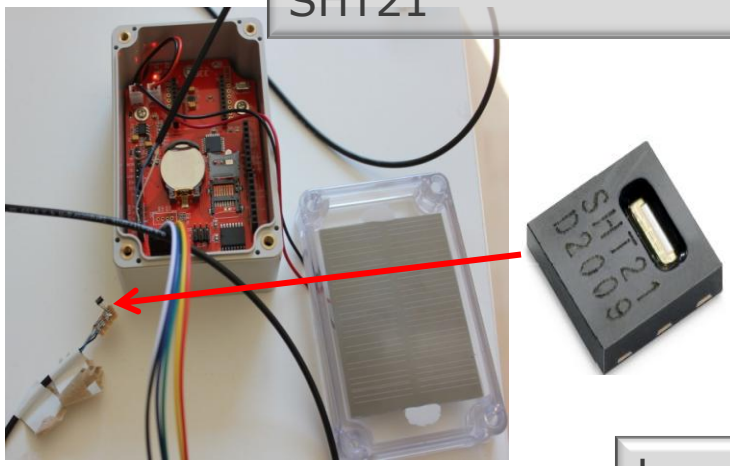
Temperature sensors and data loggers

Arduino-based data logger + Sensirion SHT21



Onset HOBO UX100-003

Maxim iButton

Lascar EL-USB-2-LCD+

Arduino-based data logger + AOSONG AM2315

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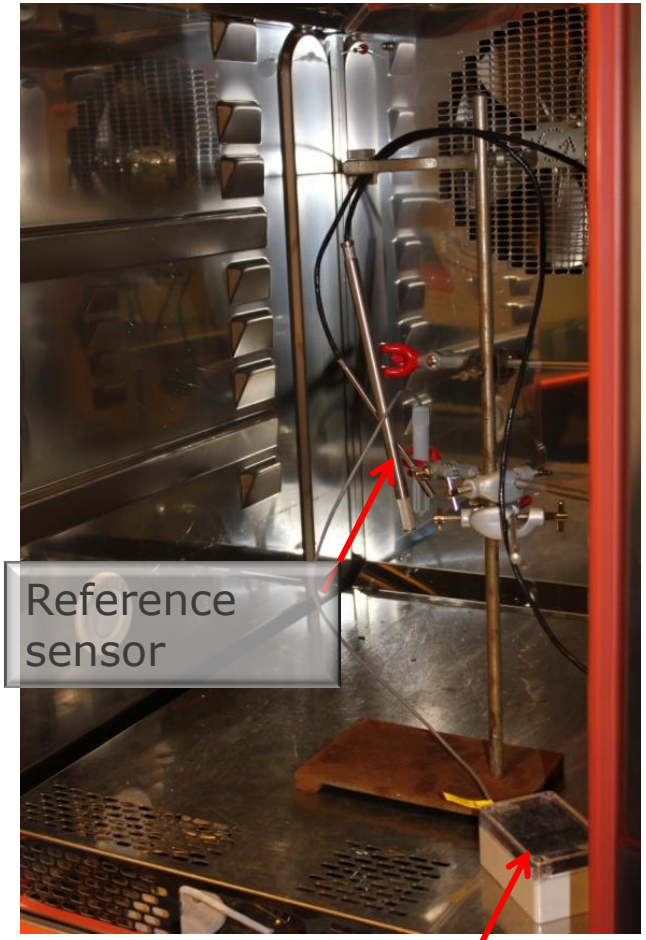
Response time and time constant of devices

Maxim iButton

Calibration and testing of measurement devices



ZEITKONSTANTENPRÜFUNG / TEST REPORT TIME CONSTANT

Hersteller / Manufacture: **Eigenbau**

Modell / Model: **SENSIRION SHT21 an Eigenbau-Elektronik**

Referenz Reference	Messbrücke mit Temperaturfühler Testing bridge	Burster Kelvimat 4323 SN Y26-0653

Zwangsbelüftung / forced ventilation: 2 m/s

	Anzeigewerte / Reading		
	Startwert start value	63,2% Wert 63,2% value	Endwert final value
RF [%]	20,4	35,0	43,5
t [mm:ss]	00:00	**00:04**	00:21

Zwangsbelüftung / forced ventilation: 5 m/s

	Anzeigewerte / Reading		
	Startwert start value	63,2% Wert 63,2% value	Endwert final value
RF [%]	20,5	35,5	44,3
t [mm:ss]	00:00	**00:04**	00:20

Korrekturwerte / Correction values

Istwert Actual value	Sollwert Reference value	Korrekturwert Offset
T [°C]	T [°C]	T [°C]
16,00	15,39	-0,61
20,00	19,40	-0,60
25,00	24,39	-0,61
30,00	29,36	-0,64
35,00	34,33	-0,67
40,00	39,29	-0,71
45,00	44,27	-0,73

Korrekturwert = Sollwert - Istwert

Offset= Reference value - Actual value

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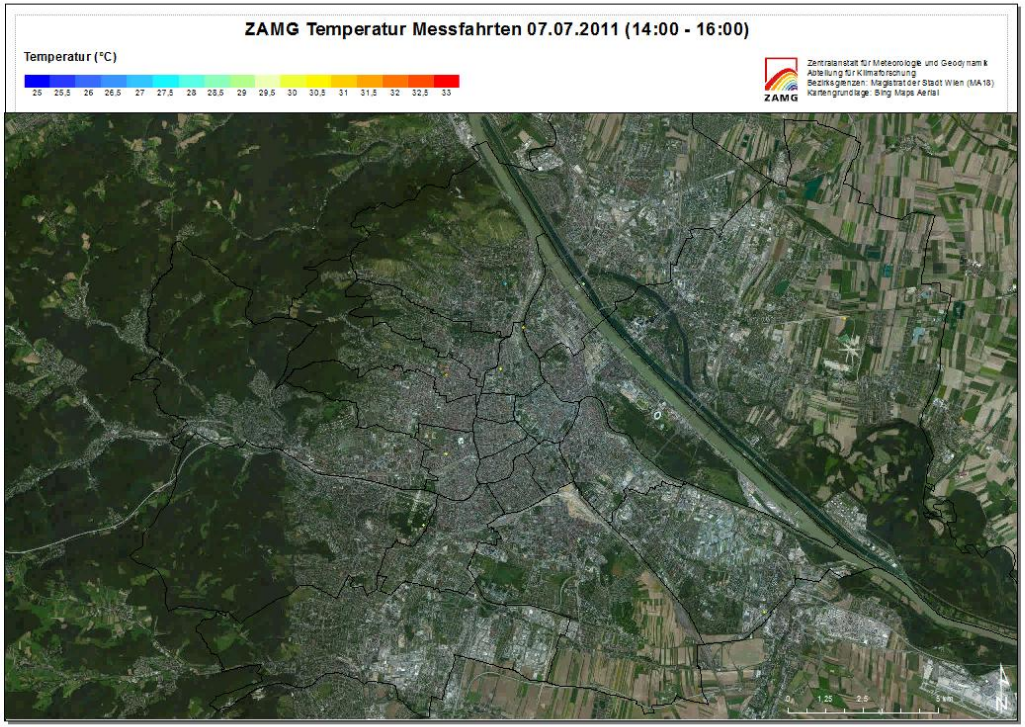
Mobile measurements by bicycles

- July 7, 2011, 14:00 – 16:00 (CEST)
- 11 routes through Vienna
- 15-30 km per route, more than 300 km in total
- ~16 000 air temperature measurements on a hot day
- iButton, GPS
- Correction for velocity and daily cycle (15:00 CEST)



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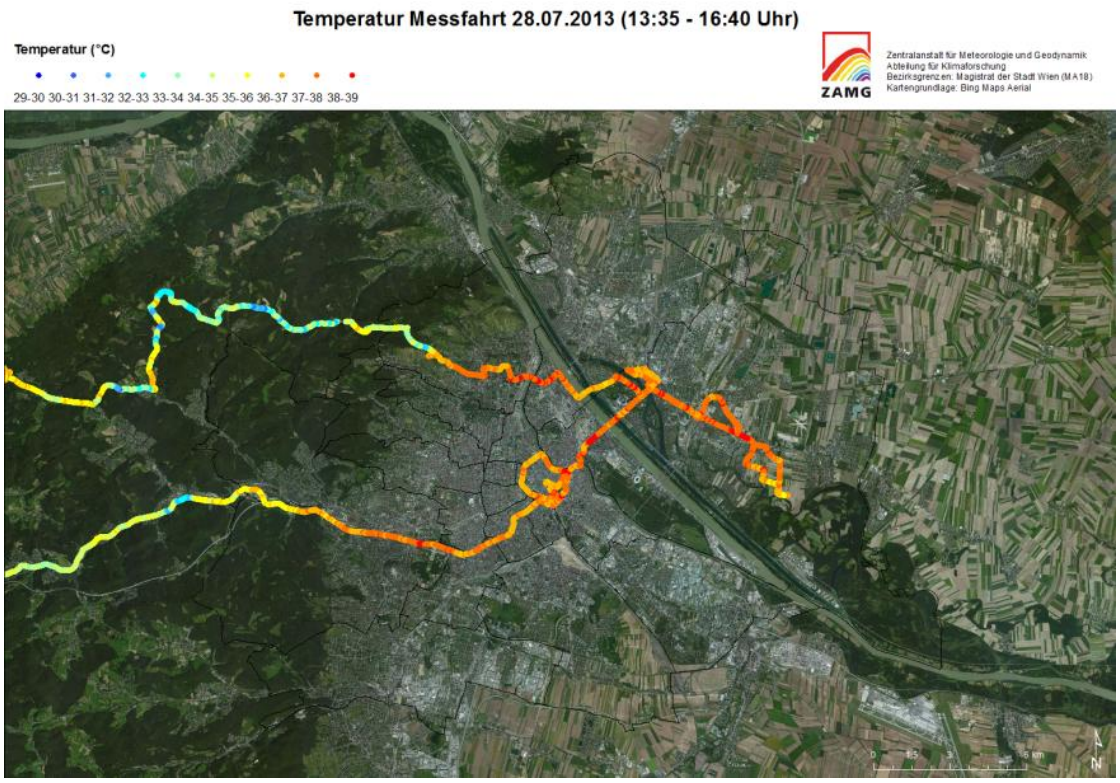
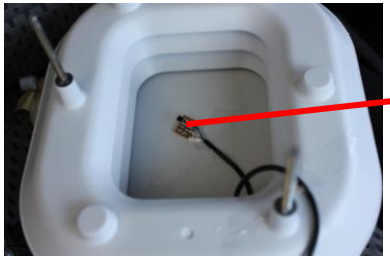
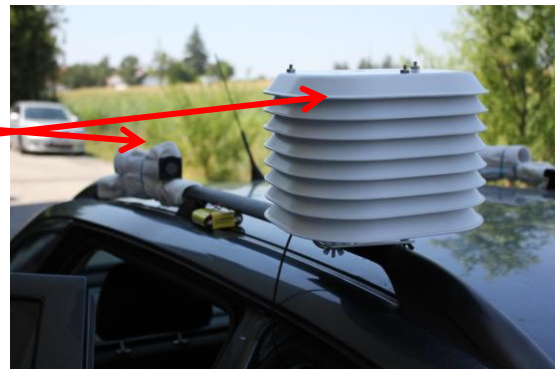
Mobile measurements by car

- July 28, 2013, 14:00 – 17:00
- Cross-section through city
- Air temperature and relative humidity measurements
- Arduino-based data logger + Sensirion SHT21, Onset HOBO UX100-003, GPS
- Correction for systematic error, velocity and daily cycle (15:00 CEST)

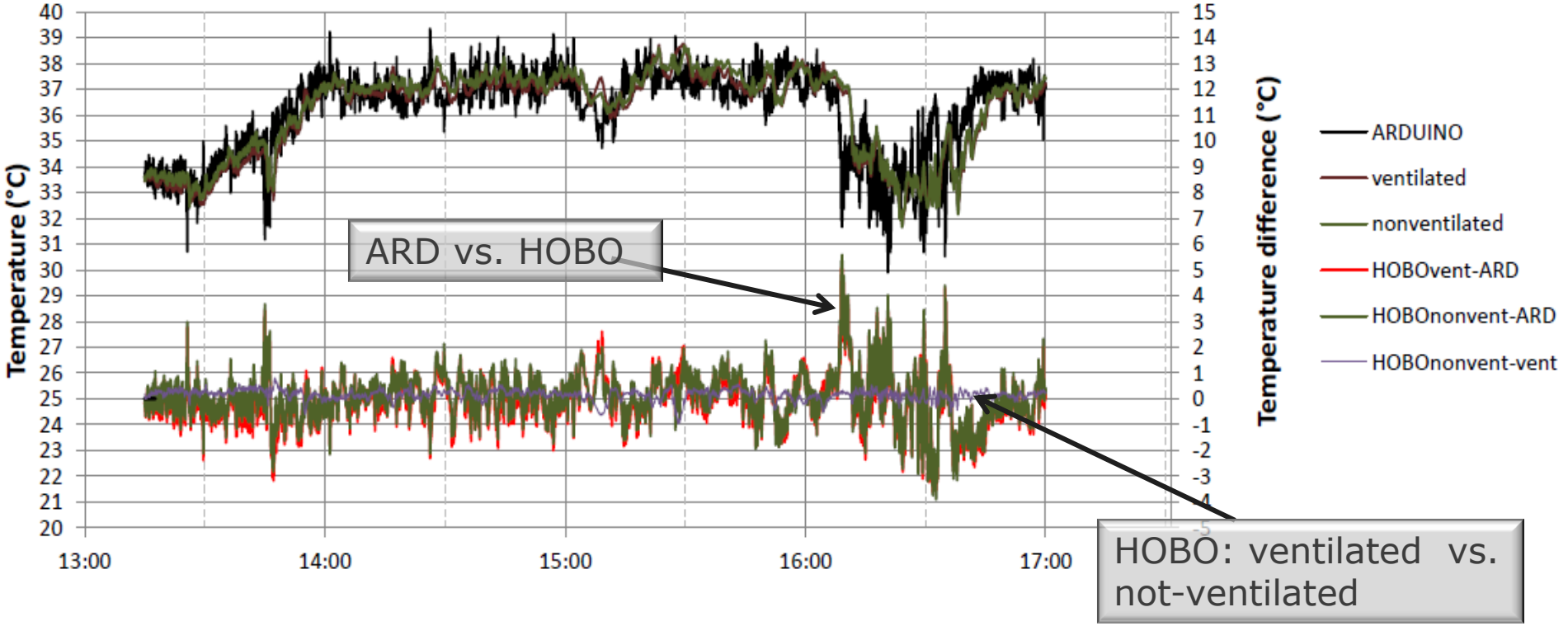






Comparison of measurement devices

Arduino-based data logger + Sensirion SHT21 sensor (ARD) vs. Onset HOBO UX100-003 (HOBO)



- Small difference (ΔT=0.15°C) between ventilated and non-ventilated mobile observations
- Significant difference between devices with different time constant and radiation protection

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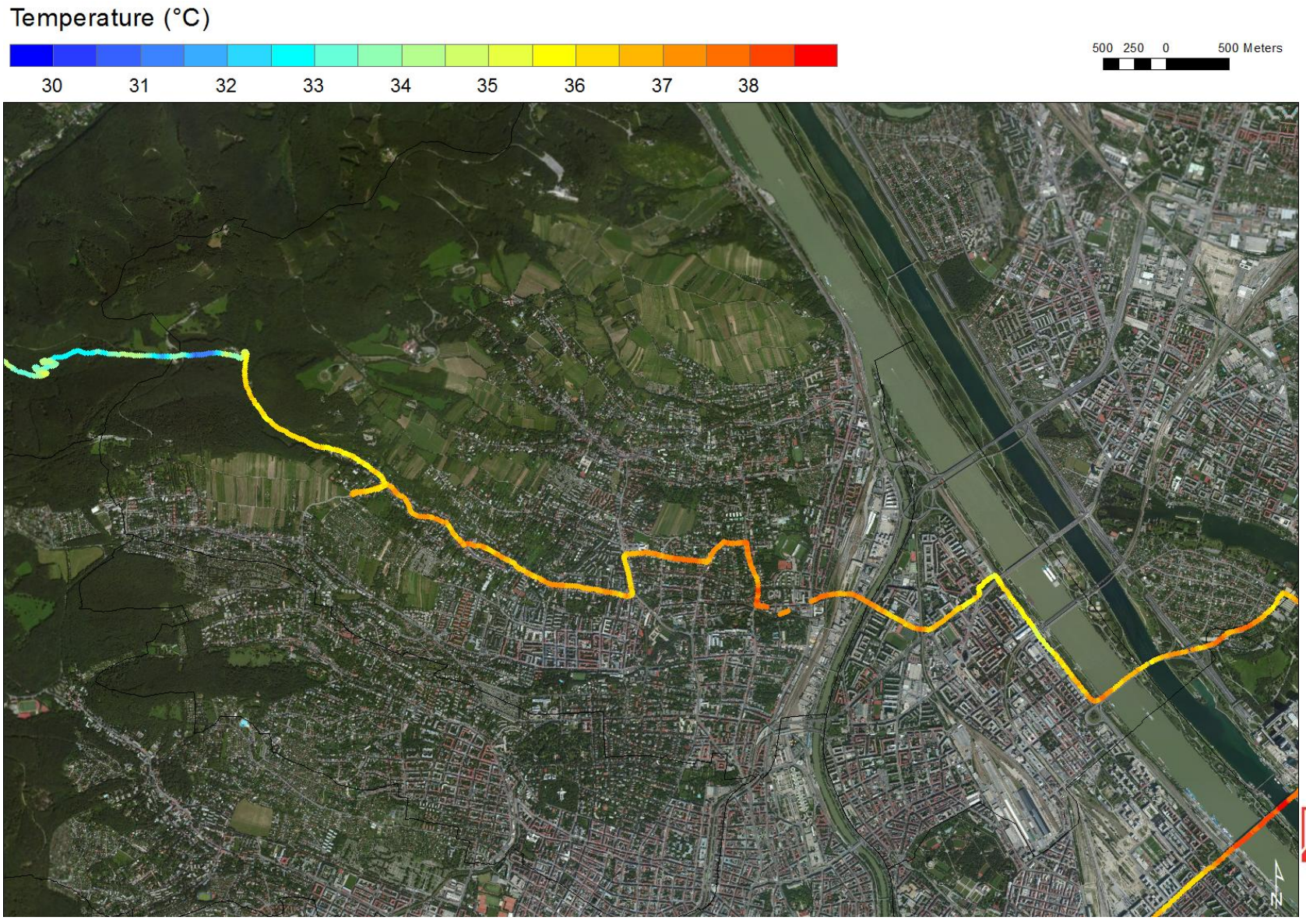
Measurements: Arduino-based data logger + Sensirion SHT21 sensor



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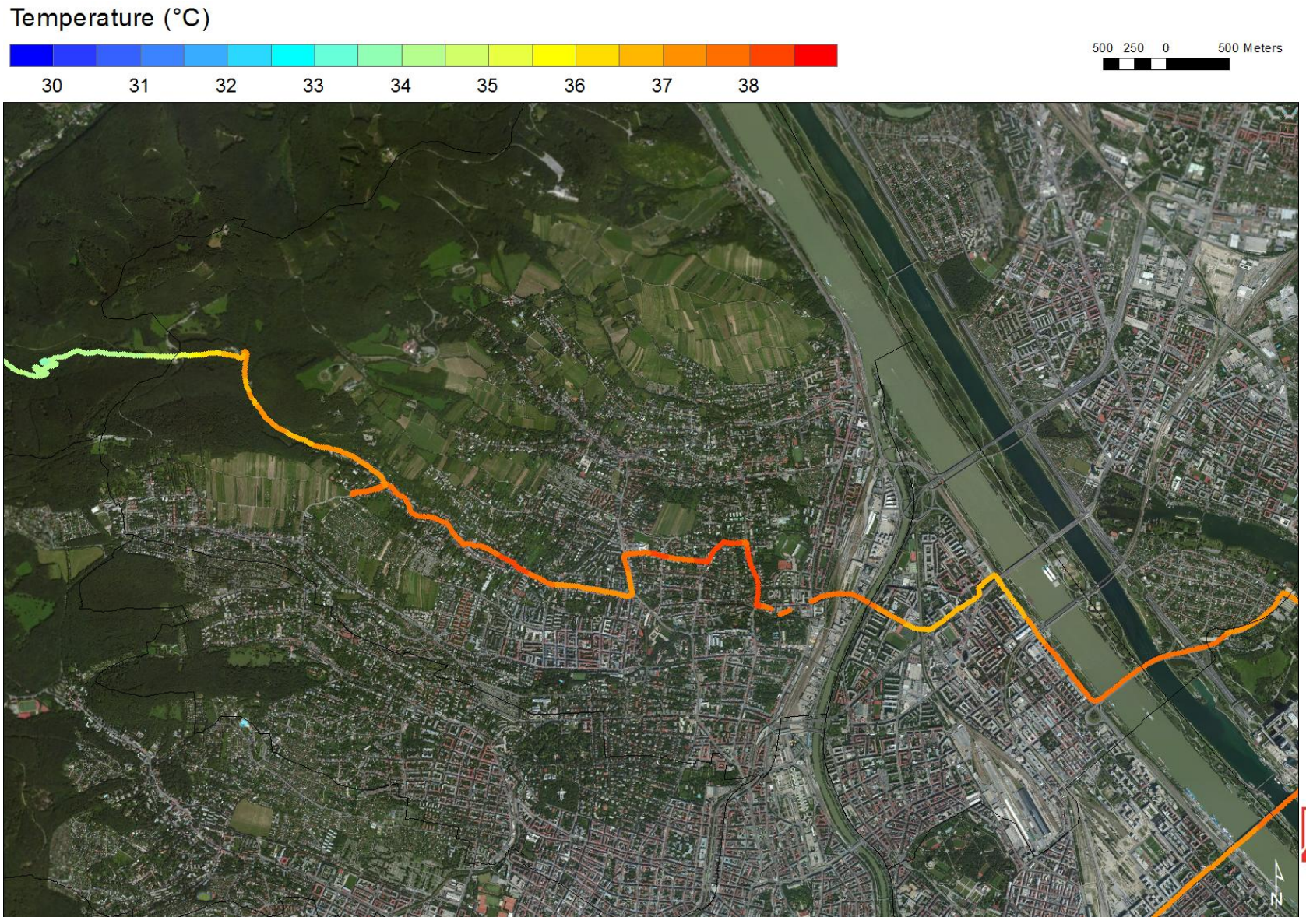
Measurements: Onset HOBO UX100-003



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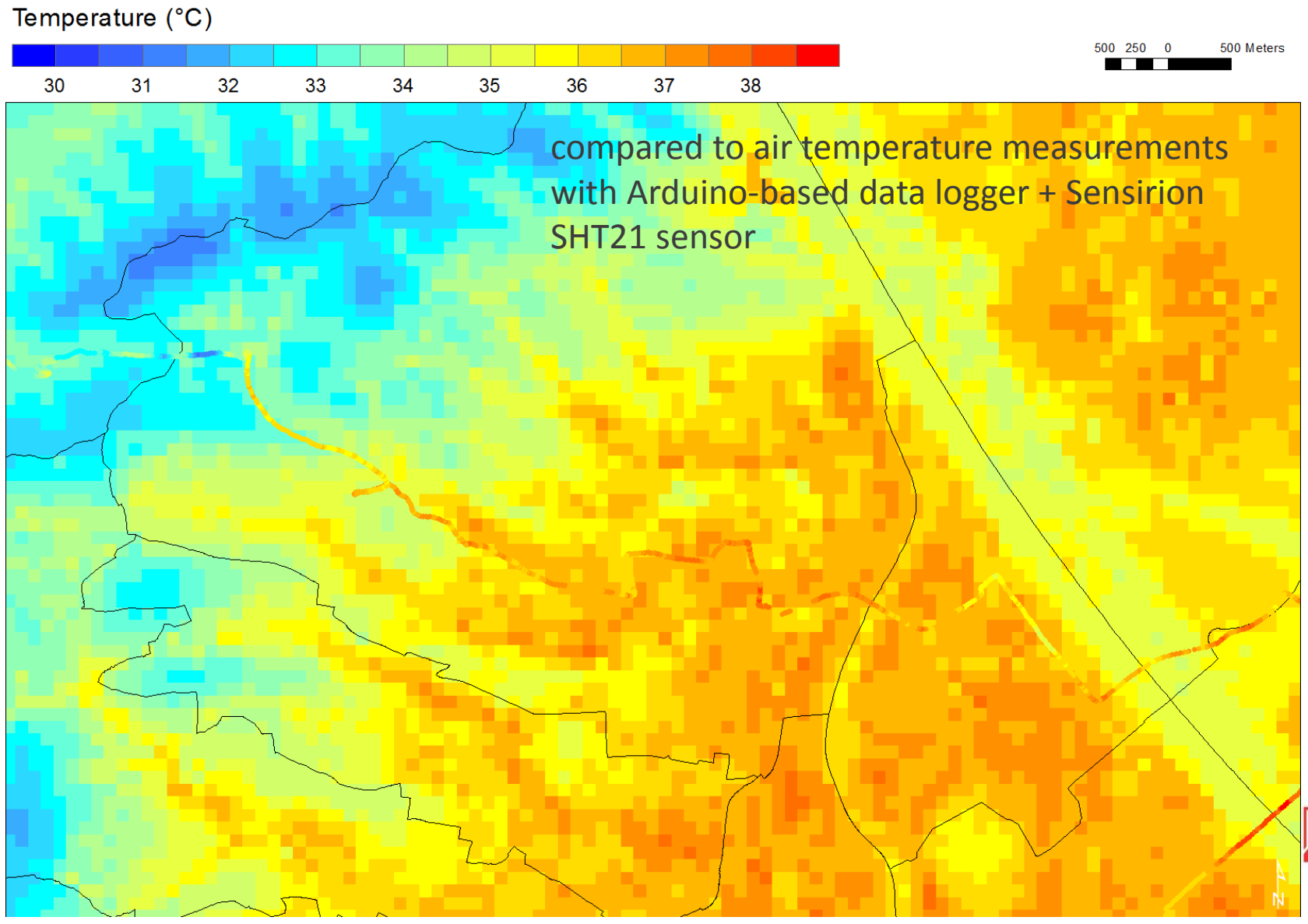
MUKLIMO_3 Simulation



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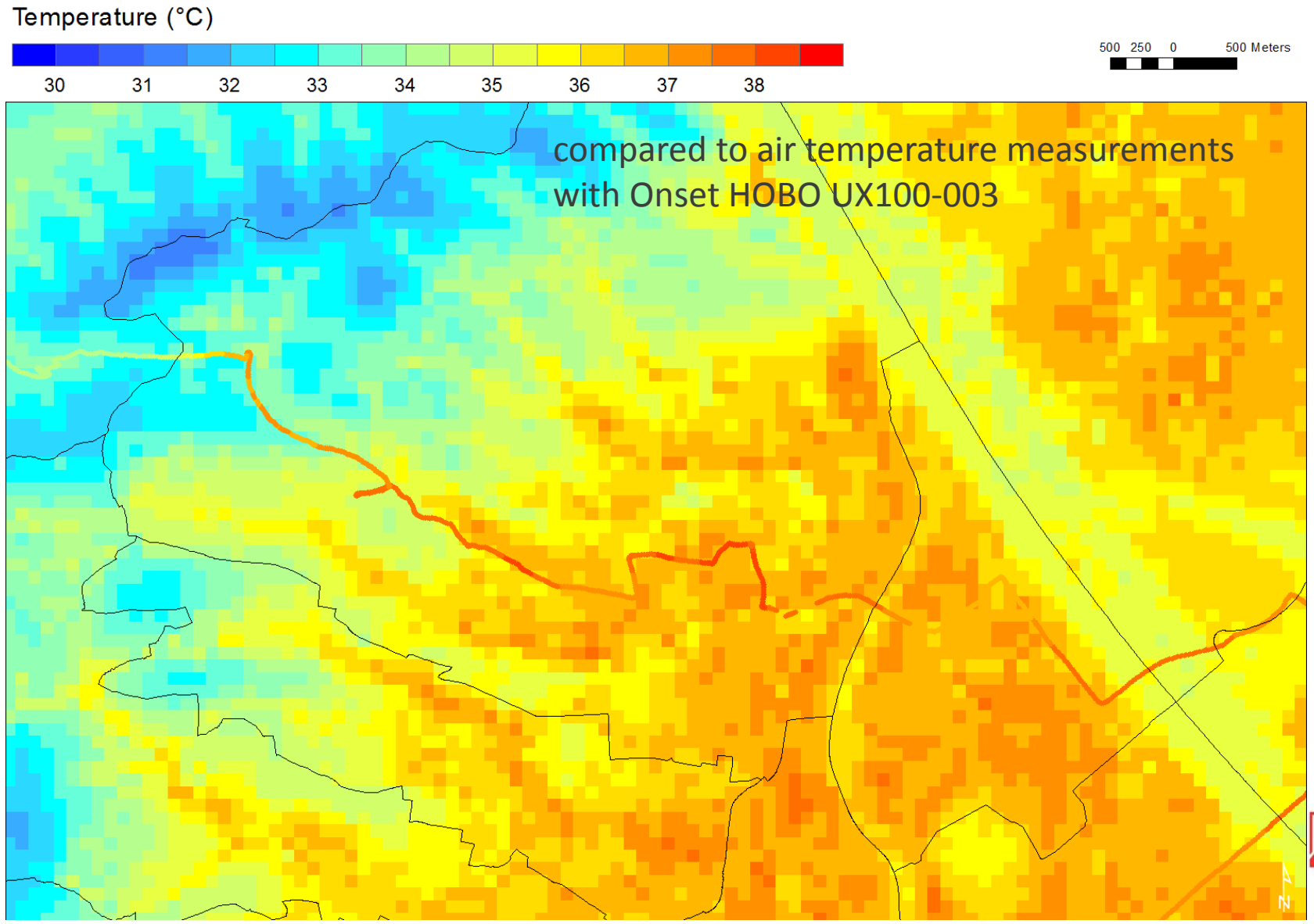
MUKLIMO_3 Simulation



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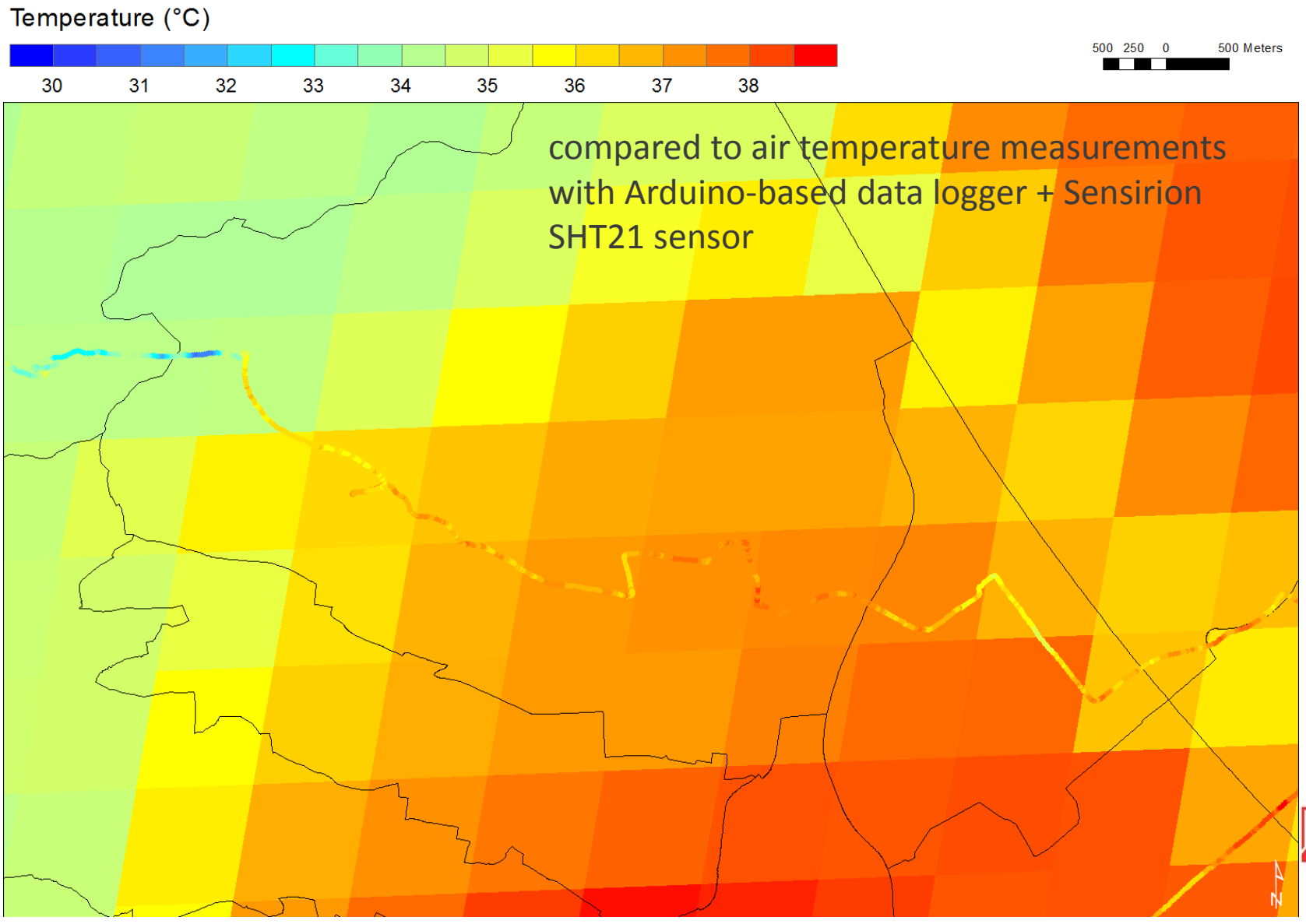
MODIS satellite: land surface temperature



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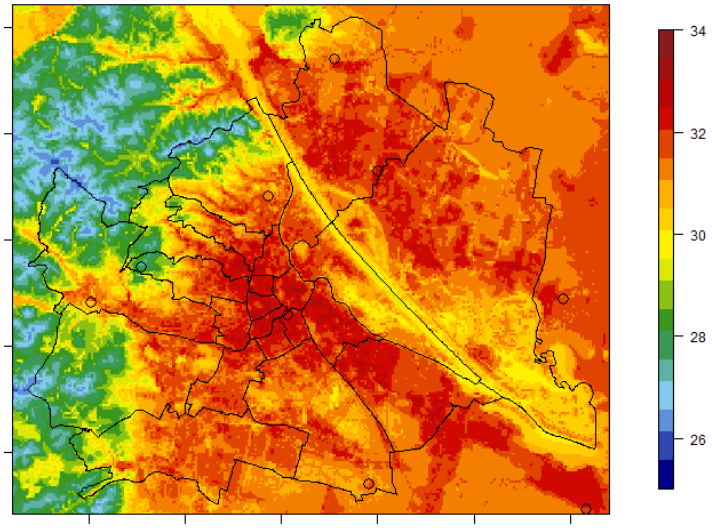
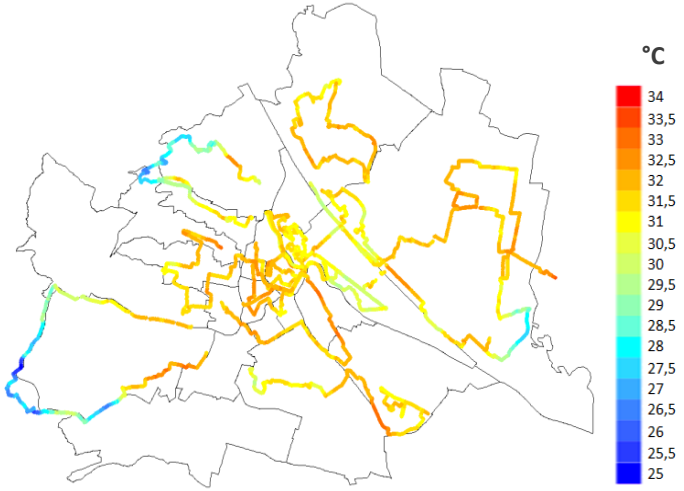
Model validation for July 7, 2011 at 15:00 CEST

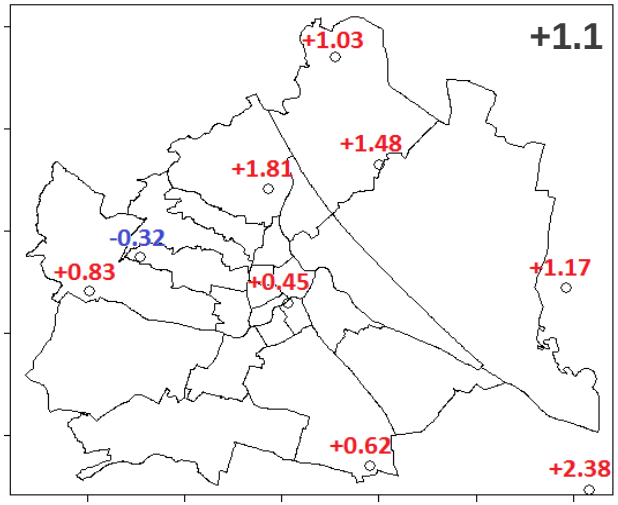
Modelled air temperature



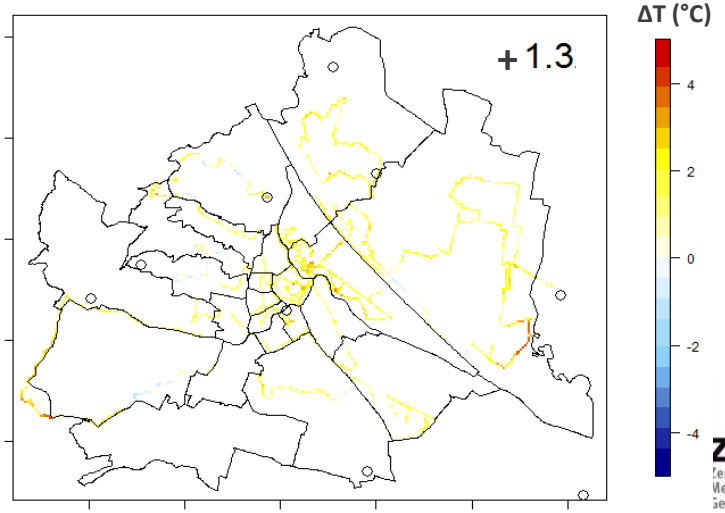
Mobile measurements



Difference at the monitoring stations



Difference for mobile measurements



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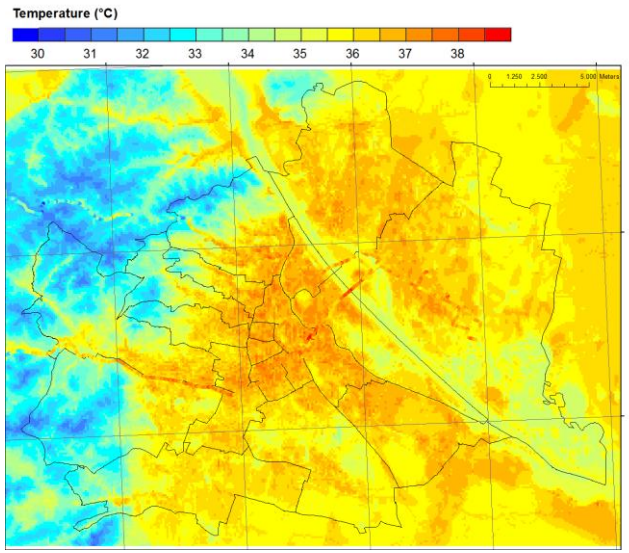
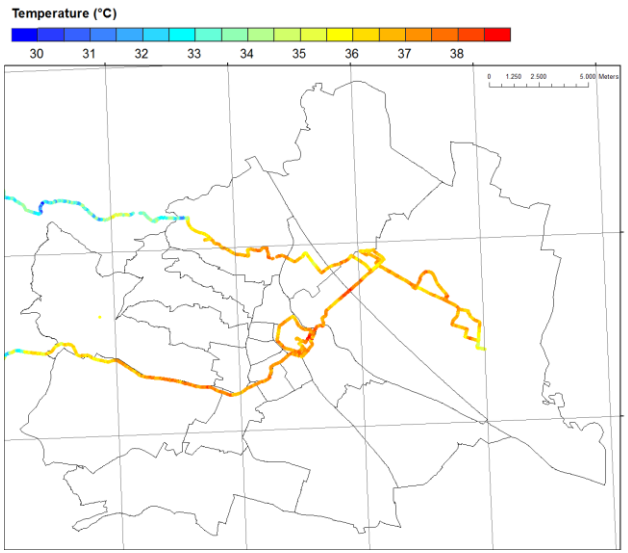
Model validation for July 28, 2013 at 15:00 CEST

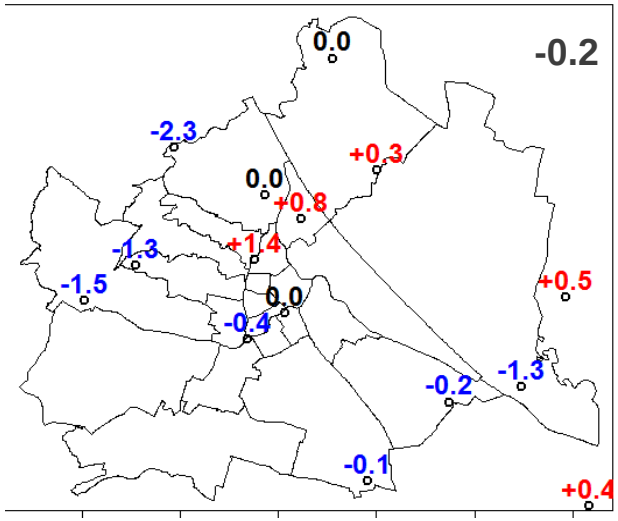
Modelled air temperature



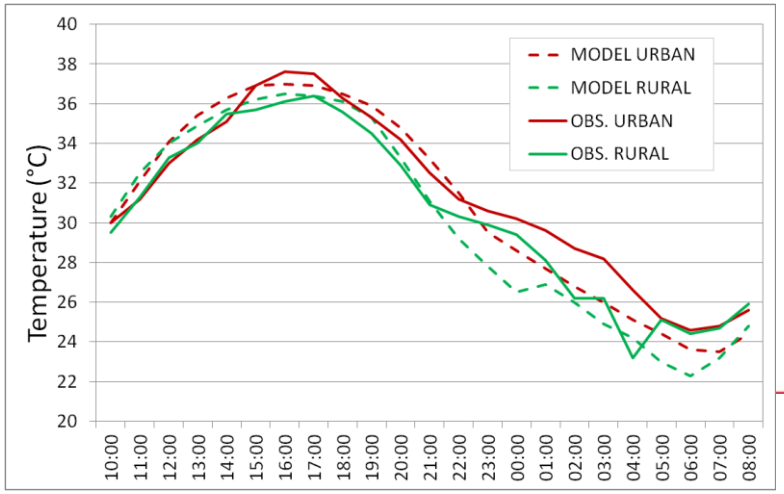
Mobile measurements



Difference at the monitoring stations

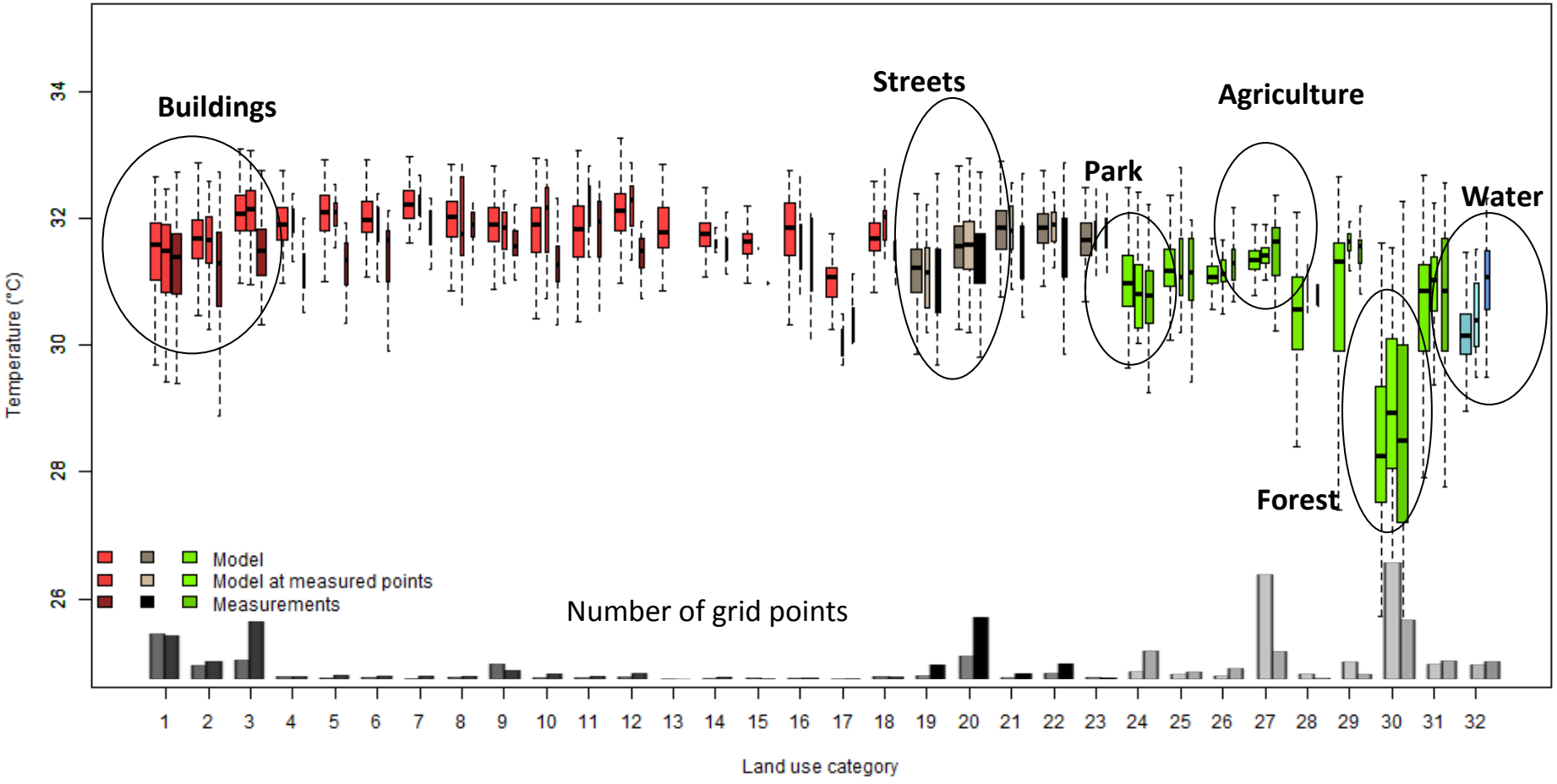


Daily cycle



Comparison per land use class

Measurements with iButtons



Summary

- Urban climate model applications need high spatial resolution meteorological observations for validation.
- Low-cost measurement devices have sufficient precision to be used for data acquisition.
- However, reliability and design of low-cost devices needs to be adapted and improved.
- Validation with mobile measurements increases reliability of urban climate models.
- Need for standardization of observational procedure and data post-processing for mobile measurements

Thank you for your attention!

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