

# The influence of green areas and roof albedos on air temperatures during extreme heat events in Berlin, Germany

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POTSDAM INSTITUTE FOR  
CLIMATE IMPACT RESEARCH

## Aims of this talk

analyse the influence of green areas and roof albedo during extreme heat events (EHE) in Berlin:

- reference simulations with the current state of Berlin for EHEs 2000–2009
- urban effects are represented by urban canopy scheme DCEP
- evaluation with 2 m temperature from surface weather station
- sensitivity simulations: modified vegetation fraction in Berlin, increased roof albedo

analyse the structure of the simulated urban heat island in terms of urban canopy parameters

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## Set-up of the simulations and the evaluation

- Identification of extreme heat events

- Model set-up

- Derivation of urban canopy parameters

- Weather stations in Berlin and surroundings

## Analysis of the reference simulations

- Evaluation

- Structure of the simulated heat island

## Average temperature changes in the sensitivity runs

## Summary

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# Identification of extreme heat events

- use definition of EHE by Huth et al. (2000) as well as Meehl and Tebaldi (2004): air temperature above certain thresholds
- thresholds for Berlin based on statistics of 2 m temperature at Berlin-Tegel and Berlin-Tempelhof for 1970–1999
- resulting in the EHE with at least 5 days: 2002/07/28–2002/08/01, 2003/08/01–2003/08/13, 2006/07/01–2006/07/07, 2006/07/17–2006/07/28, 2008/07/24–2008/08/01

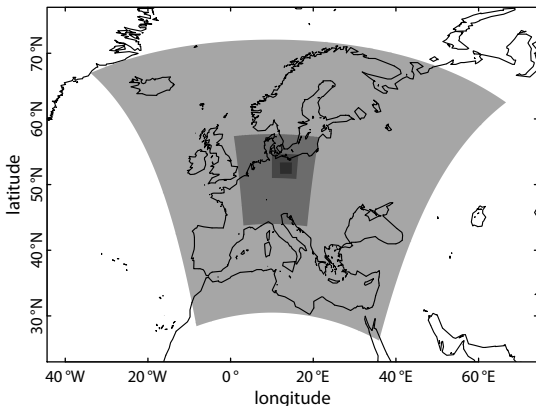
# Identification of extreme heat events

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# Simulation with CCLM

simulations starting 2 days before EHE

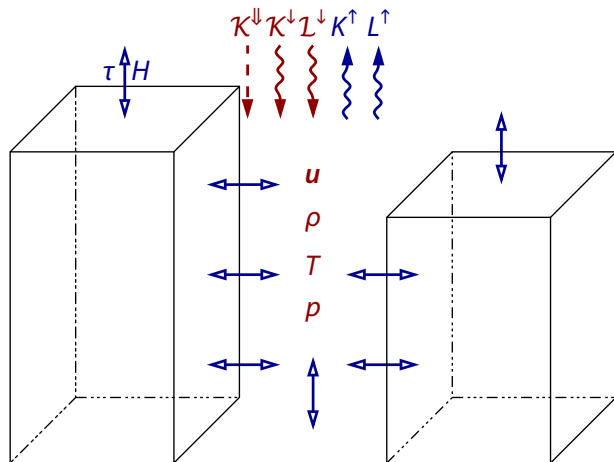
- 24 km resolution nested into ERA-Interim
- 7.8 km resolution
- 2.8 km resolution
- 1.0 km resolution with and without DCEP for the area of Berlin



initial water content of 24 km simulation from climate simulation starting in 1995

# Double Canyon Effect Parametr. (Schubert et al. 2012)

## Multilayer Street Canyon model



Input of DCEP:

- $L^\downarrow$ : longwave rad. (down)
- $K^{\downarrow,\downarrow}$ : shortwave rad. (down)
- $u$ : wind velocity
- $\rho$ : air density
- $T$ : air temperature
- $p$ : air pressure

Output of DCEP:

- $L^\uparrow$ : longwave rad. (up)
- $K^\uparrow$ : shortwave rad. (up)
- $H$ : sensible heat flux
- $\tau$ : momentum flux

→ poster: evaluation of CCLM/DCEP with flux measurements



# Setup of DCEP

**reference** current state of Berlin (as described in the following)

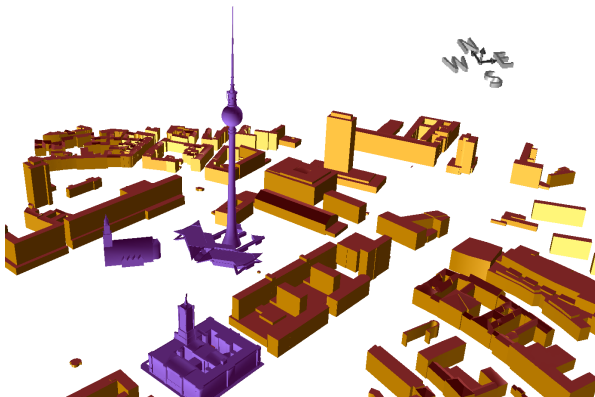
**V-25, V+05, V+15** natural surface fraction  $f_{\text{nat}} \equiv 1 - f_{\text{urb}}$  of each urban grid cell modified: -25 %, 5 % and 15 %

**AR40, AR65** roof albedo increased to 0.40 and 0.65 (initial value: 0.16)

**VAR** combined V+15 and AR65

# Usage of morphological data and impervious surface map

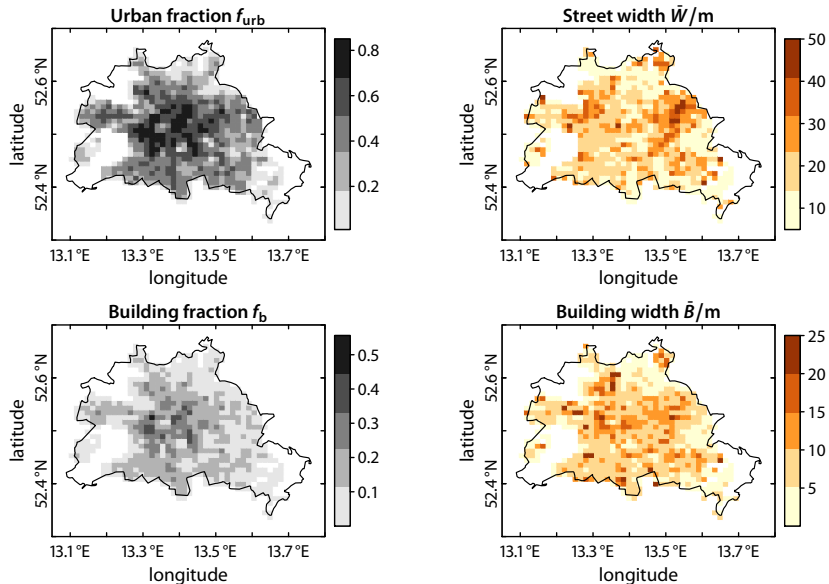
- for Berlin: highly detailed 3d data in CityGML format available
- used to calculate morphological DCEP parameters



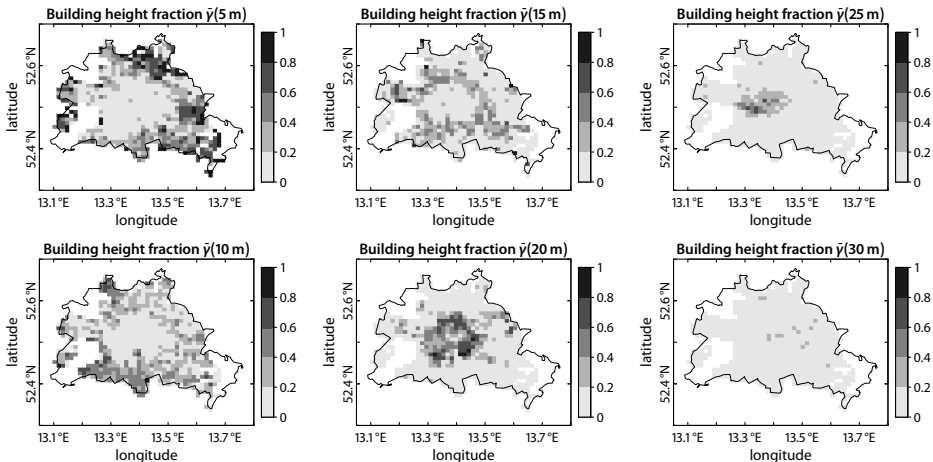
- buildings described by planar polygons
- polygons are differentiated into roof, wall and ground surfaces

- urban fraction based on impervious surface map

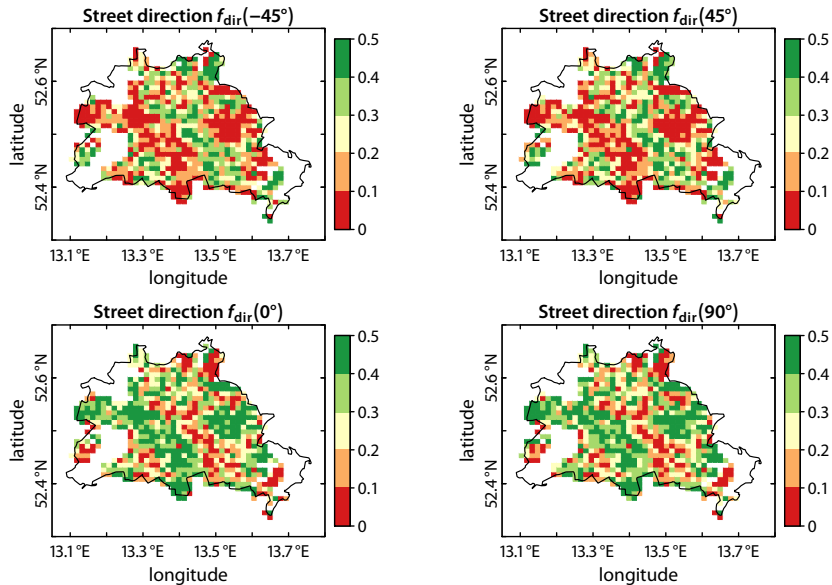
# Results of conversion for Berlin (1 km resolution)



# Building height distribution



## Further results: weight of street directions



# Weather stations in Berlin



**Alexanderplatz**



**Tegel**

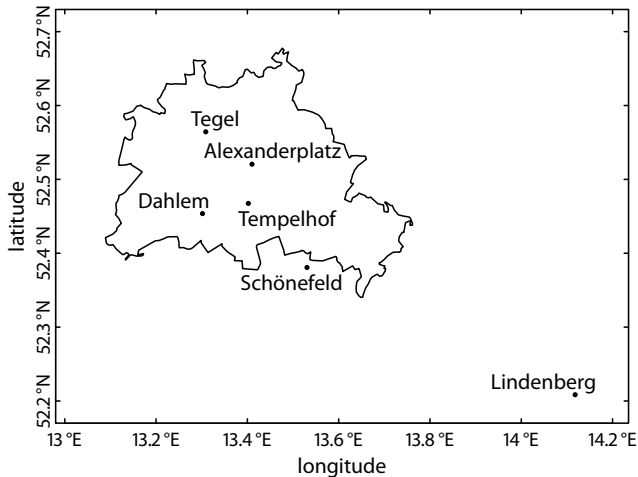


**Dahlem**



**Tempelhof**

## Other stations



**Lindenberg**  
rural station approx.  
60 km away from  
Berlin-Alexanderplatz

**Schönefeld**  
at the southern  
border of Berlin

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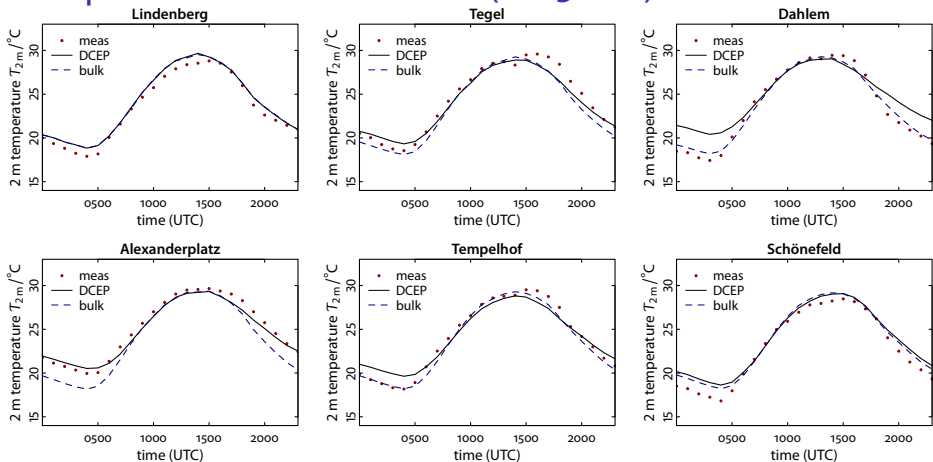
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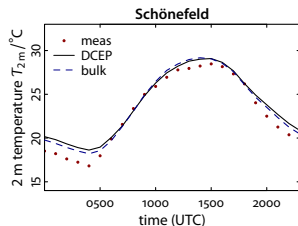
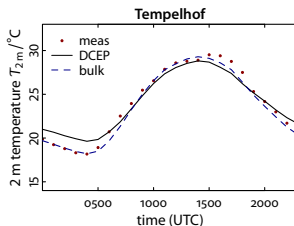
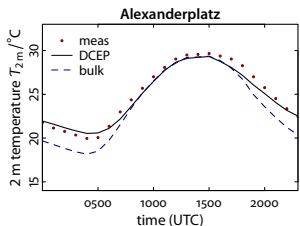
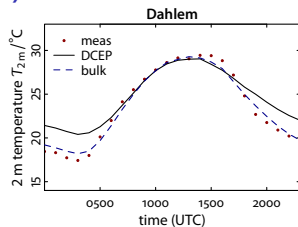
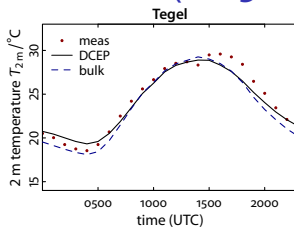
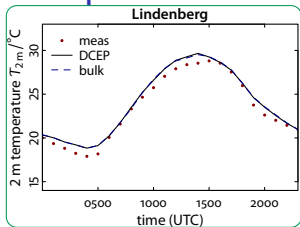
## Summary



# Comparison with station data (2003 EHE)

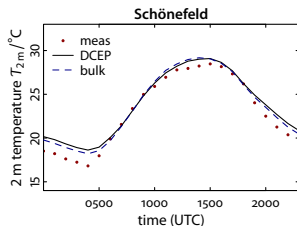
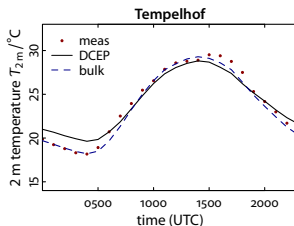
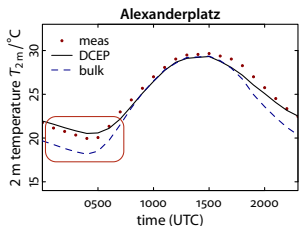
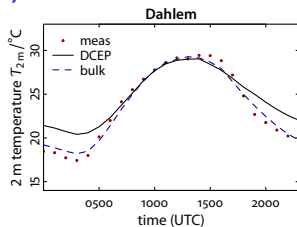
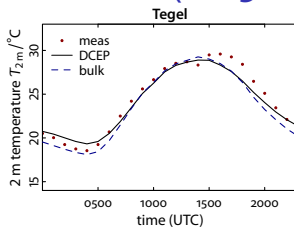
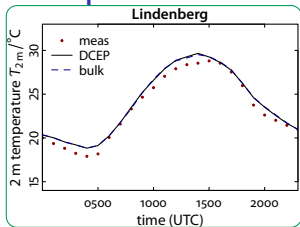


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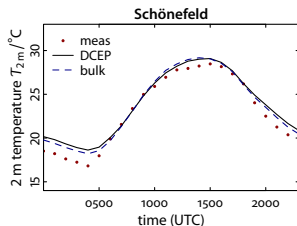
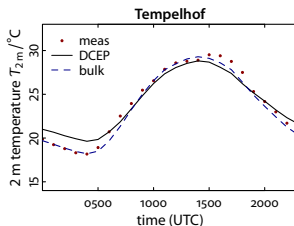
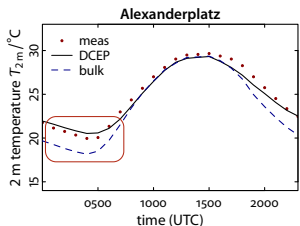
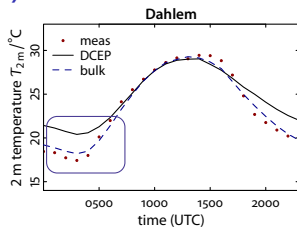
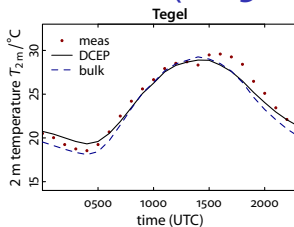
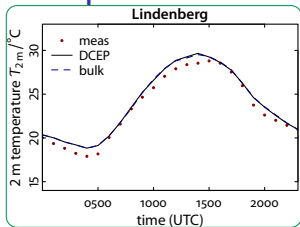
- Lindenberg: good performance;

# Comparison with station data (2003 EHE)



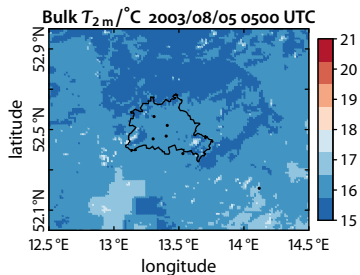
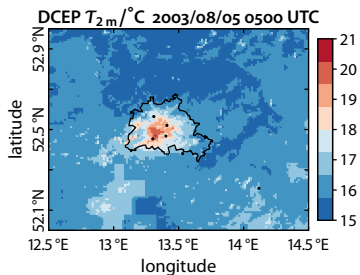
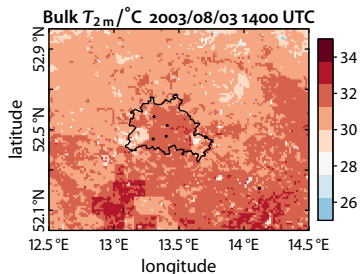
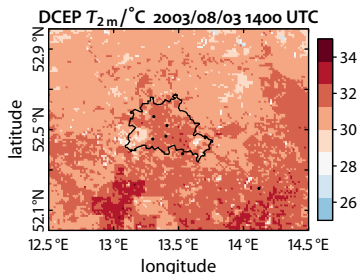
- **Lindenberg:** good performance; **Alexanderplatz:** CCLM/DCEP good, bulk scheme too cold during nighttime

# Comparison with station data (2003 EHE)



- Lindenberg: good performance; Alexanderplatz: CCLM/DCEP good, bulk scheme too cold during nighttime
- overestimation of nighttime temperatures at other stations by CCLM/DCEP (not representative for urban environment: cooler than Lindenberg)

# Urban heat island with DCEP and bulk (2003 EHE)



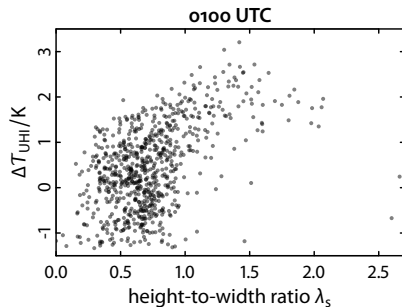
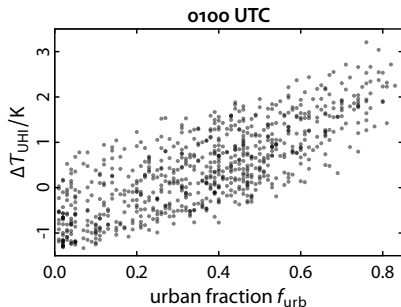
DCEP captures UHI during the night, the default bulk scheme not

# Simulated urban heat island (2003 EHE)

Definition of urban heat island (UHI) intensity:

$$\Delta T_{\text{UHI}} = T_{2\text{m}} - T_{2\text{m}}^{\text{Lindenberg}}$$

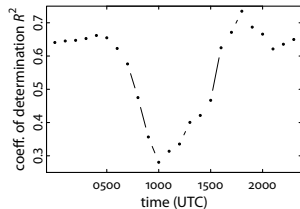
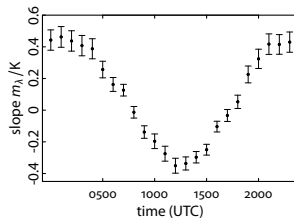
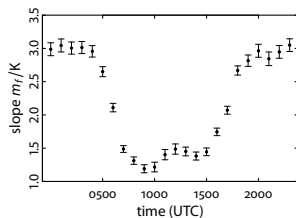
averaged over the EHE for every hour of the day, resulting in



# Model of the simulated heat island intensity (2003 EHE)

fit the UHI intensity to the following model:

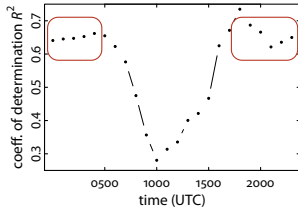
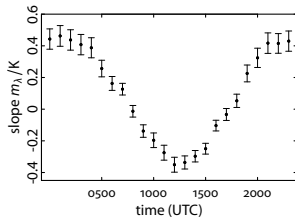
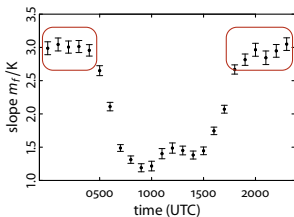
$$\Delta T_{\text{UHI}} = \Delta T_{\text{UHI}}(f_{\text{urb}}, \lambda_s) = m_f f_{\text{urb}} + m_\lambda \lambda_s + n$$



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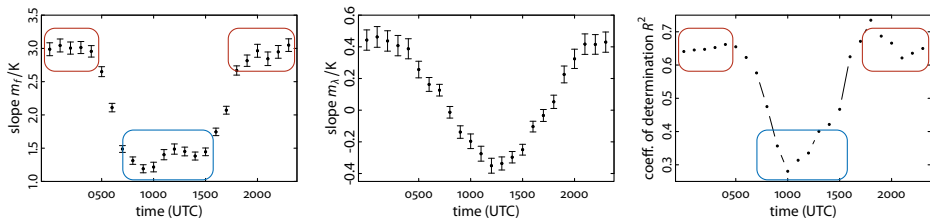
- strongly pronounced urban heat island during the night (fit works relatively well)



# Model of the simulated heat island intensity (2003 EHE)

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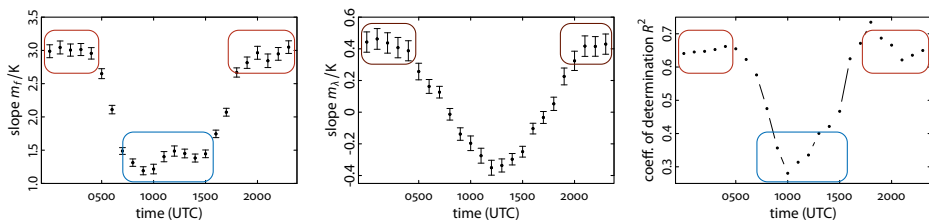


- **strongly pronounced urban heat island during the night (fit works relatively well), weak heat island during the day (fit less good)**

# Model of the simulated heat island intensity (2003 EHE)

fit the UHI intensity to the following model:

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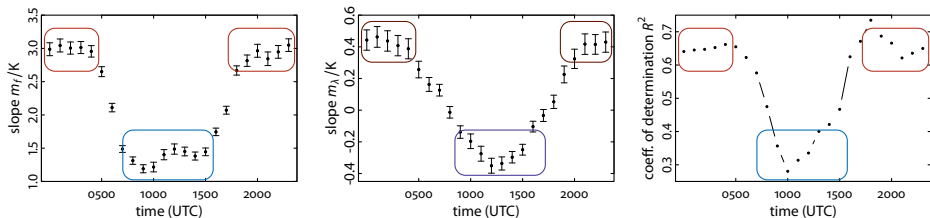


- strongly pronounced urban heat island during the night (fit works relatively well), weak heat island during the day (fit less good)
- urban heat island more intense with larger height-to-width ratio during nighttime

# Model of the simulated heat island intensity (2003 EHE)

fit the UHI intensity to the following model:

$$\Delta T_{\text{UHI}} = \Delta T_{\text{UHI}}(f_{\text{urb}}, \lambda_s) = m_f f_{\text{urb}} + m_\lambda \lambda_s + n$$



- strongly pronounced urban heat island during the night (fit works relatively well), weak heat island during the day (fit less good)
- urban heat island more intense with larger height-to-width ratio during nighttime, smaller during daytime

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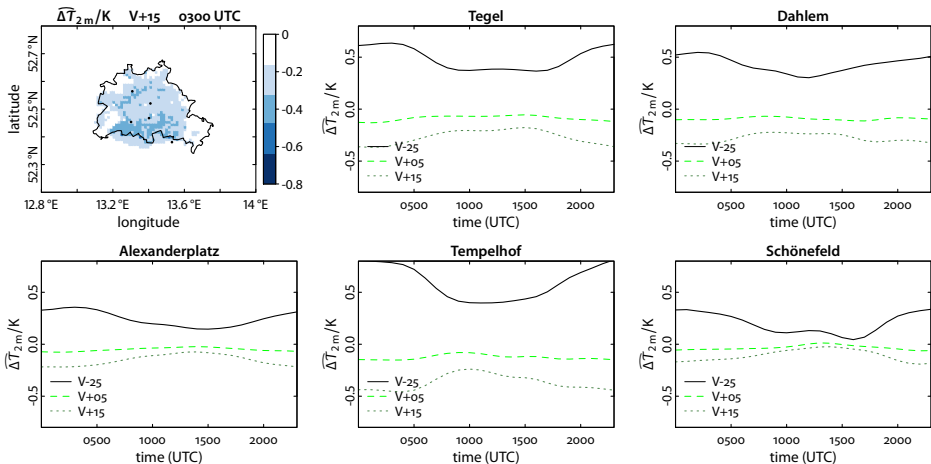
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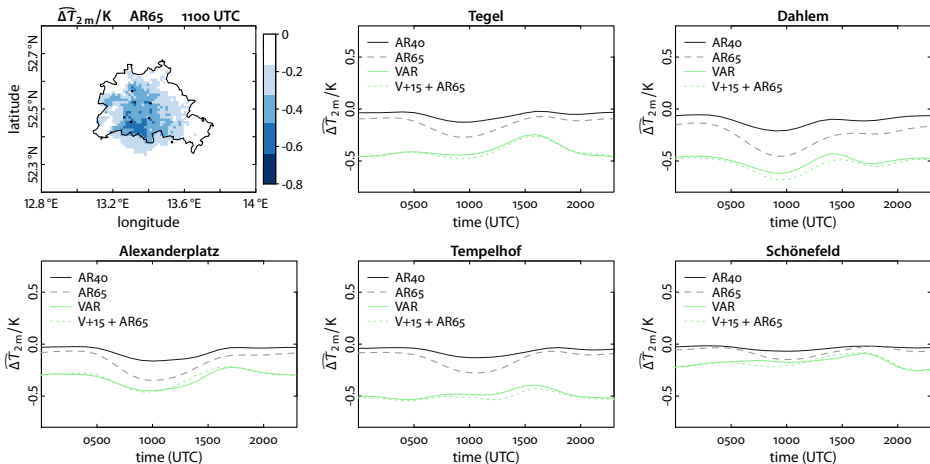
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# Modified fraction of natural surfaces (2003 EHE)



up to 0.5 K cooler 2 m temperatures, effect more pronounced at nighttime due to difference in total heat storage capacity and radiation trapping

# Modified roof albedo (2003 EHE)



up to 0.5 K cooler 2 m temperatures, more pronounced during daytime,  
 advection of cooler air in less dense areas

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## Properties of DCEP

- CCLM/DCEP simulations with urban canopy parameters based on highly detailed building data: allow direct analysis of UHI mitigation measures
- CCLM/DCEP captures urban heat island during nighttime, default bulk scheme not
- increased vegetation fraction by 15 % reduces 2 m by up to 0.5 K, effect most pronounced during nighttime
- cooling of up to 0.5 K for increase of roof albedo from 0.16 to 0.65, most pronounced during daytime
- cooling effects of increased vegetation fraction and roof albedo approximately add up

→ more details in an upcoming paper in the Meteorologische Zeitschrift



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*Thank you for your attention!*