Sensitivity of Perceived Temperature on meteorological variables and urban morphology parameters

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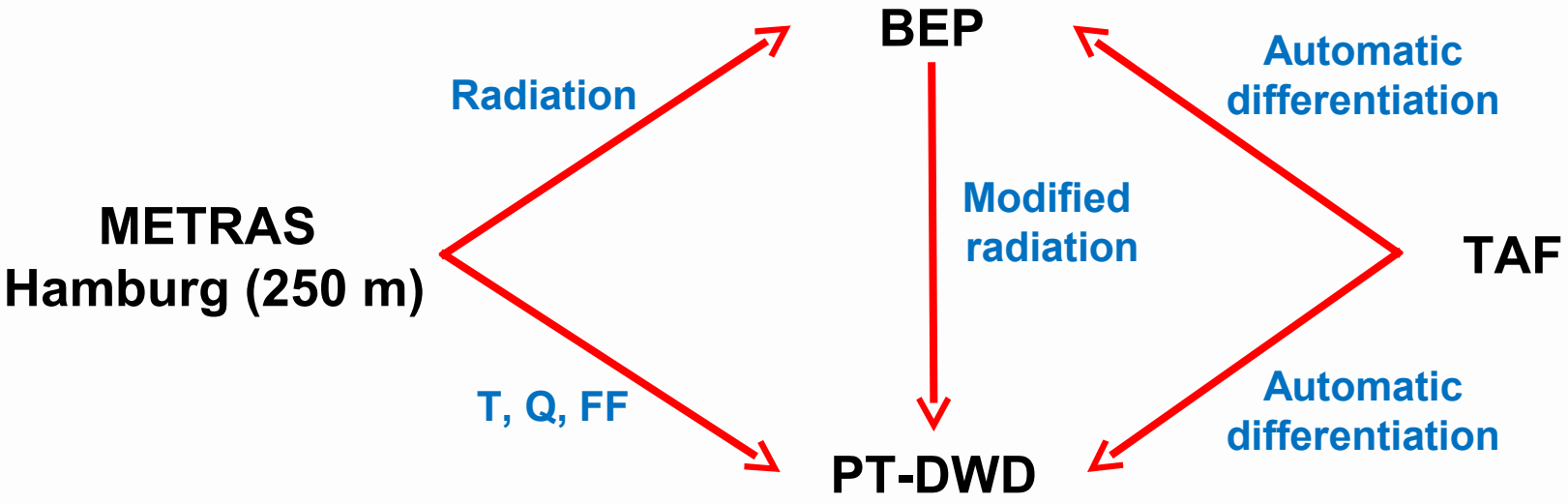
Motivation

- **Human thermal comfort depends not only on air temperature**

- **Perceived Temperature (PT, Staiger et al., 2011)**
  - Energy budget of a reference human body
  - Reference indoor environment
  - Depends on temperature, humidity, wind speed, radiant temperature

- **Goal of this study**
  - Sensitivity of PT on meteorology and urban morphology
  - Which precision of the input data is required?
  - How can PT be influenced most efficiently?

Methodology



Sensitivities for 13 typical meteorological situations during the summer (Hoffmann and Schlünzen, 2012)

METRAS: Mesoscale atmospheric and transport model (Schlünzen et al., 2012)

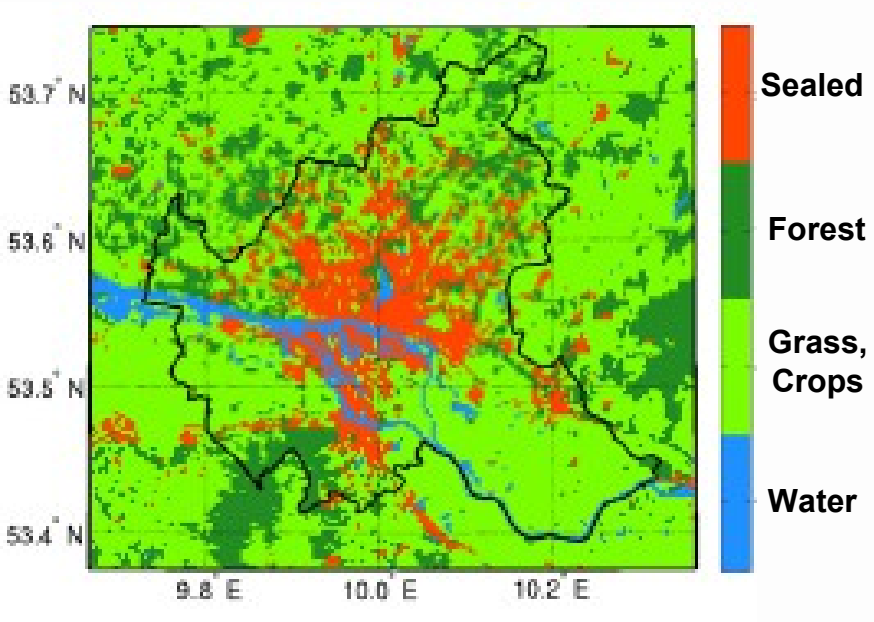
BEP: Building Effect Parametrisation (Martilli et al., 2002)

TAF: Transformation of Algorithms in Fortran (Giering and Kaminski, 1998)

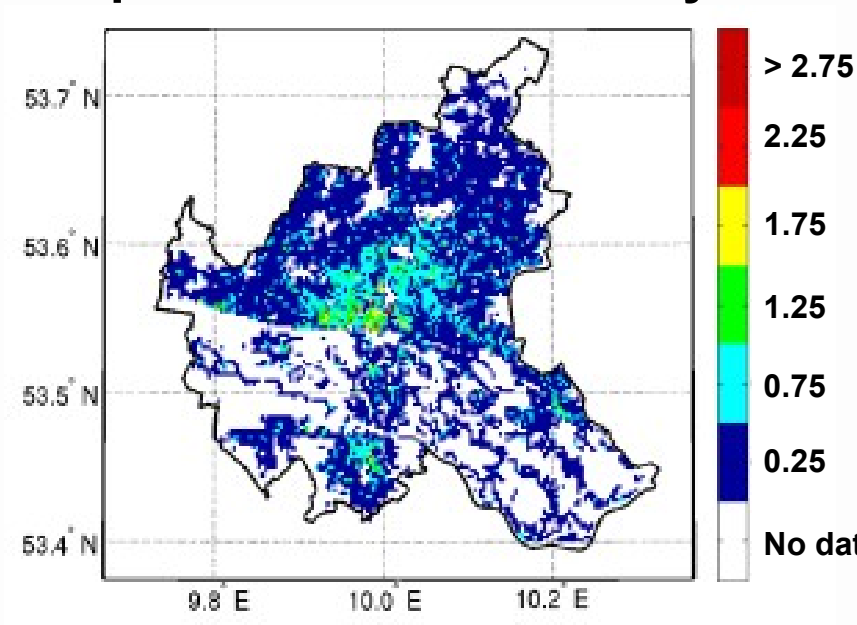
Domain of investigation

Greater city of Hamburg in northern Germany

Surface cover



Aspect ratio of street canyons



Green city, mainly low aspect ratio

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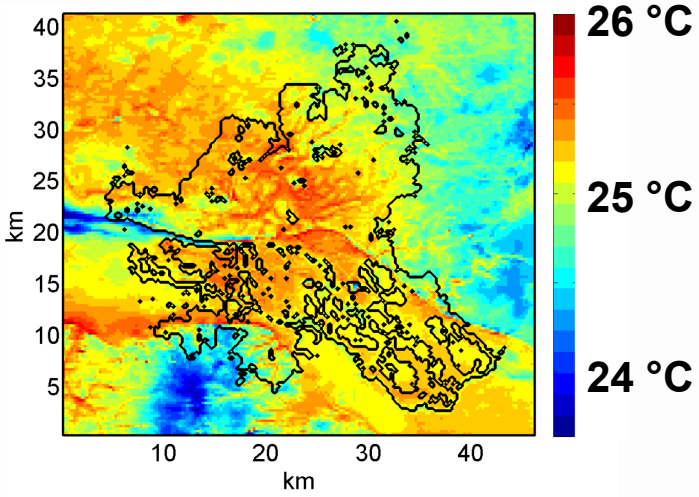
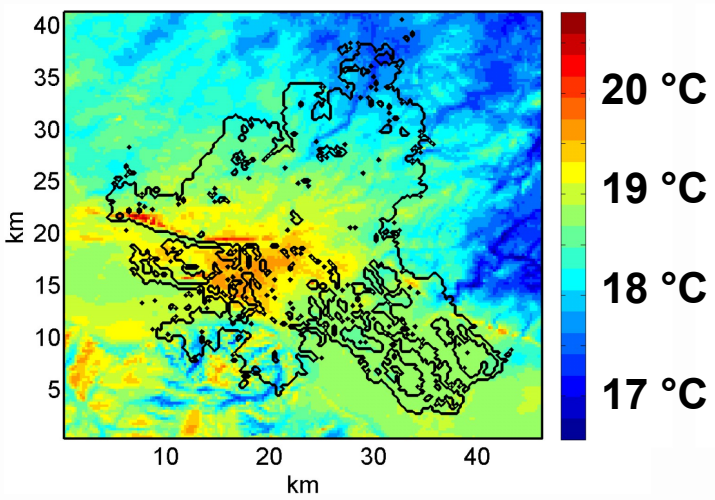
Results
- Exemplary for 10 June 2006

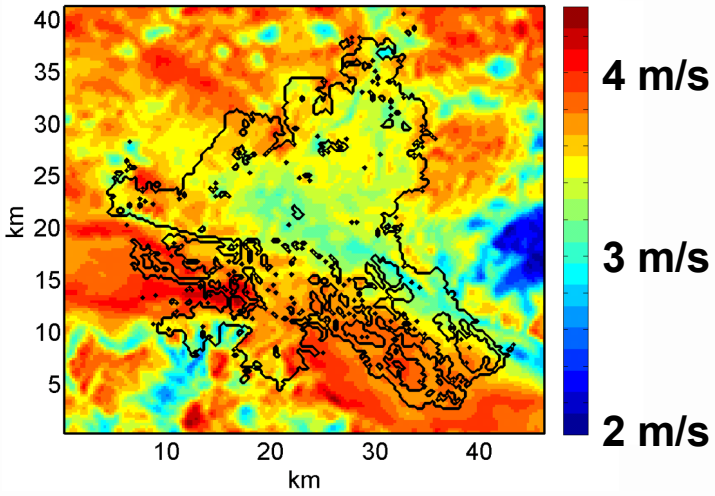
Air temperature, 10:00-16:00



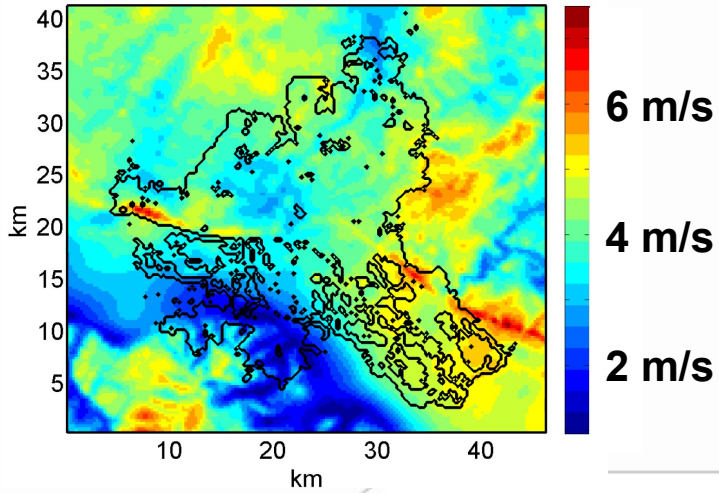
Air temperature, 21:00-24:00



Wind speed, 10:00-16:00



Wind speed, 21:00-24:00



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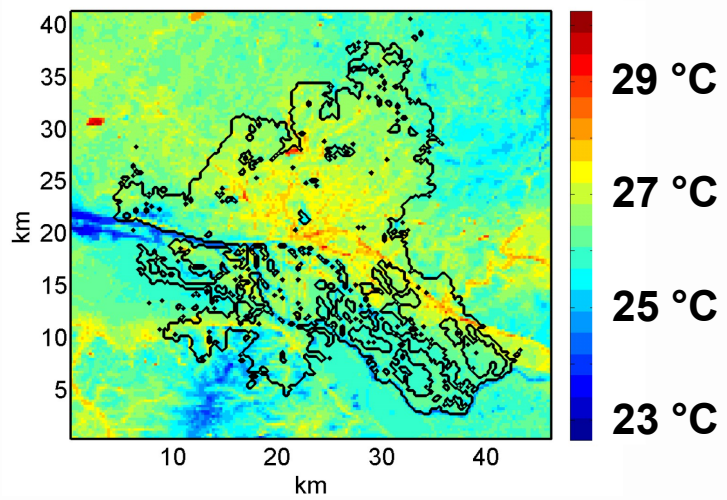
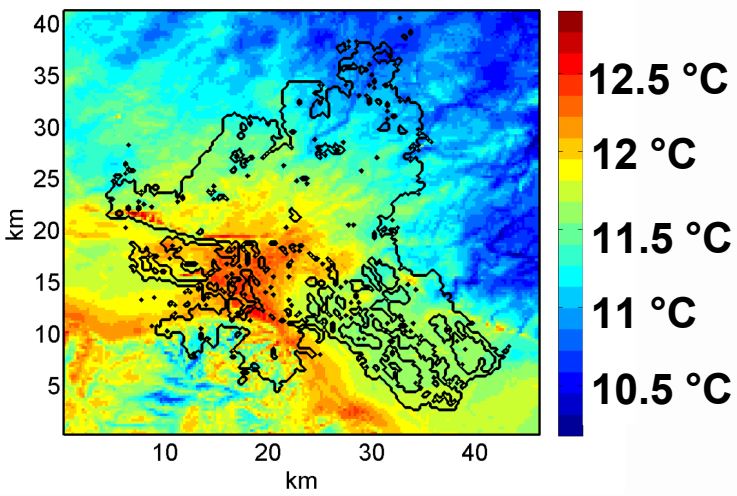
Results
- Exemplary for 10 June 2006

PT, 10:00-16:00



Low to medium heat stress

PT, 21:00-24:00



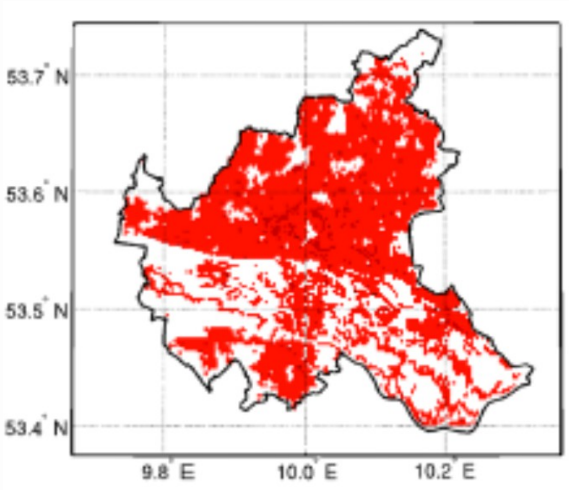
Comfort achievable

No meteorological situation with cold stress

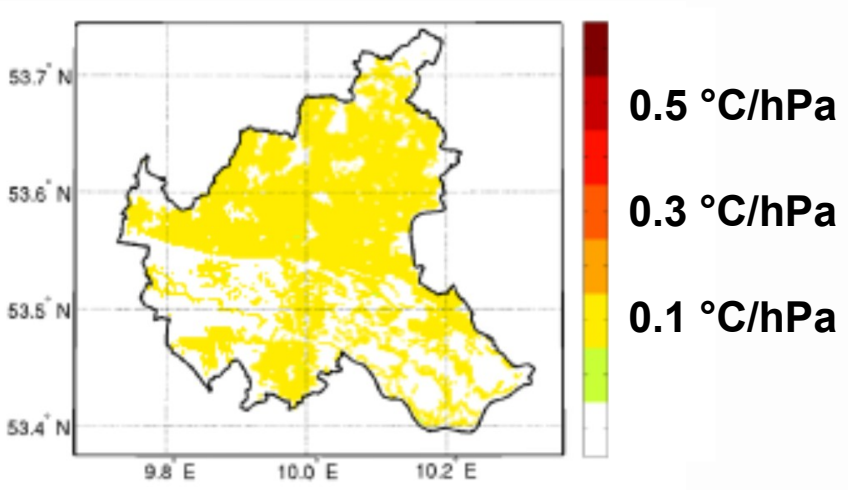
Results
- Exemplary for 10 June 2006

Sensitivity (partial derivative) of PT on water vapour pressure

10:00-16:00



21:00-24:00



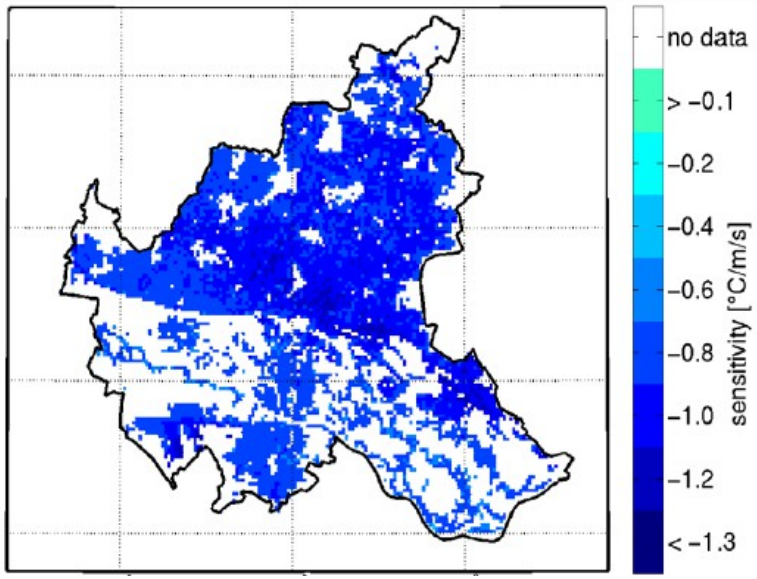
High (low) sensitivity when in heat stress (comfort) range

Physical reason is transpiration

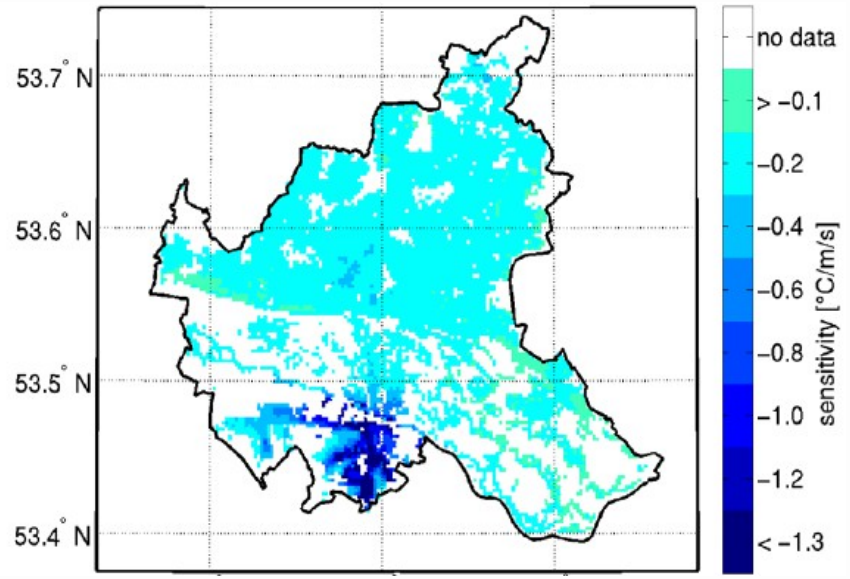
Results
- Exemplary for 10 June 2006

Sensitivity (partial derivative) of PT on wind speed

10:00-16:00



21:00-24:00



Higher sensitivity when in heat stress range

Higher sensitivity for low wind speeds

Results
- Generalised results for 13 meteorological situations

Which precision is required for 1 K precise PT?

Variable	Required precision
Air temperature	1 K
Water vapour pressure	2.5 hPa if heat stress
	5-10 hPa if comfort
Wind speed	< 1.0 m/s if ff < 3m/s
	> 1.0 m/s if ff > 3m/s
Mean radiant temperature	3 K if heat stress
	10 K if comfort
Street canyon width	1 m around noon
	10 m after sunset
Building heights	1-5 m around noon
	>> 5 m after sunset

Results published in Schoetter et al., 2013, Meteorologische Zeitschrift

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Conclusion and potential further studies

- **Required precision of PT**
  - Temperature and water vapour pressure achievable
  - Low wind speeds in street canyons very challenging
  - Urban morphology data challenging

- **Modification of PT (e.g. adaptation measures)**
  - Investigate effect of humidity increase due to urban vegetation
  - Avoid areas with very low wind speed
  - Higher buildings only when wind speed is not reduced too much

- **Potential further studies**
  - Separate insolated and shaded part of the street canyon
  - Situations with cold stress
  - Sensitivities of PT on material characteristics (e.g. albedo)

References

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