The urban heat island London

Find the differences

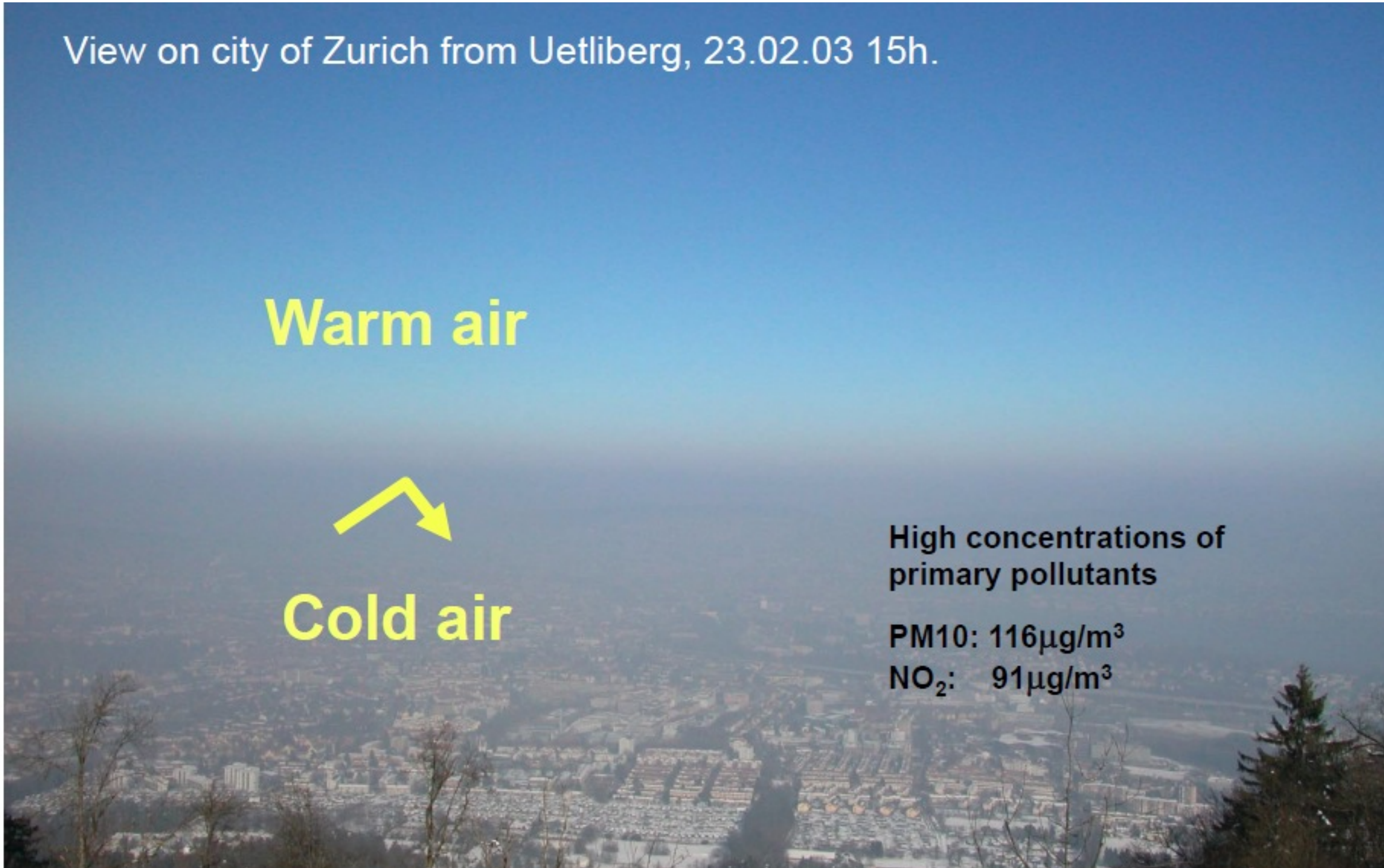
Shanghai, Pudong District, 1987

The Atlantic, August 2013

Shanghai, Pudong District, 2013

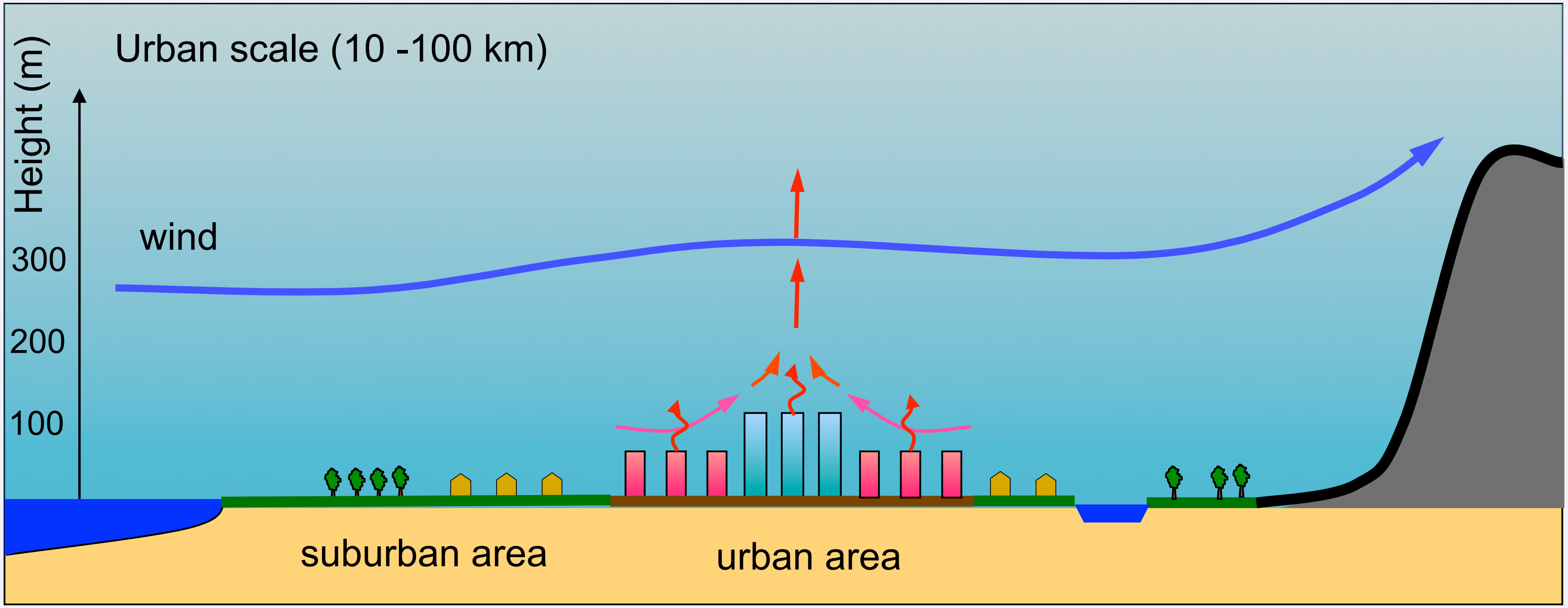
The Atlantic, August 2013

Winter Smog (due to inversion)

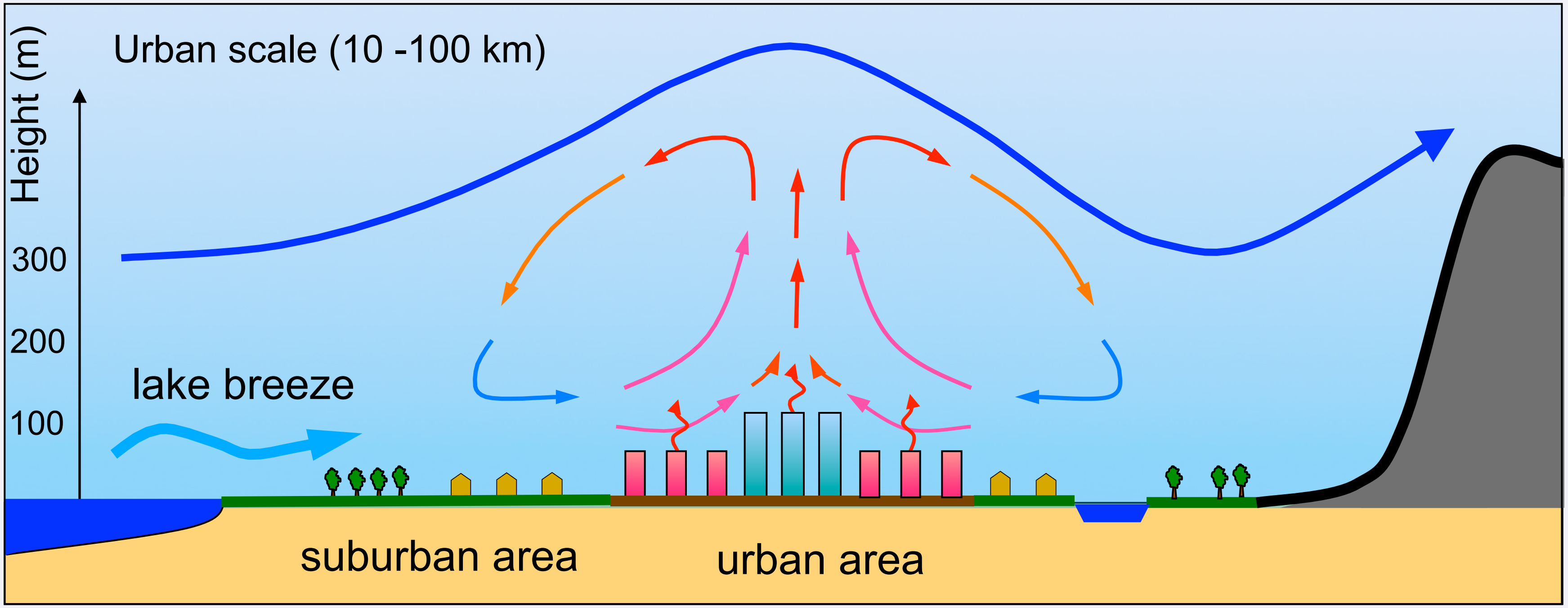


D. Brunner, Empa

Physics of the Built Environment

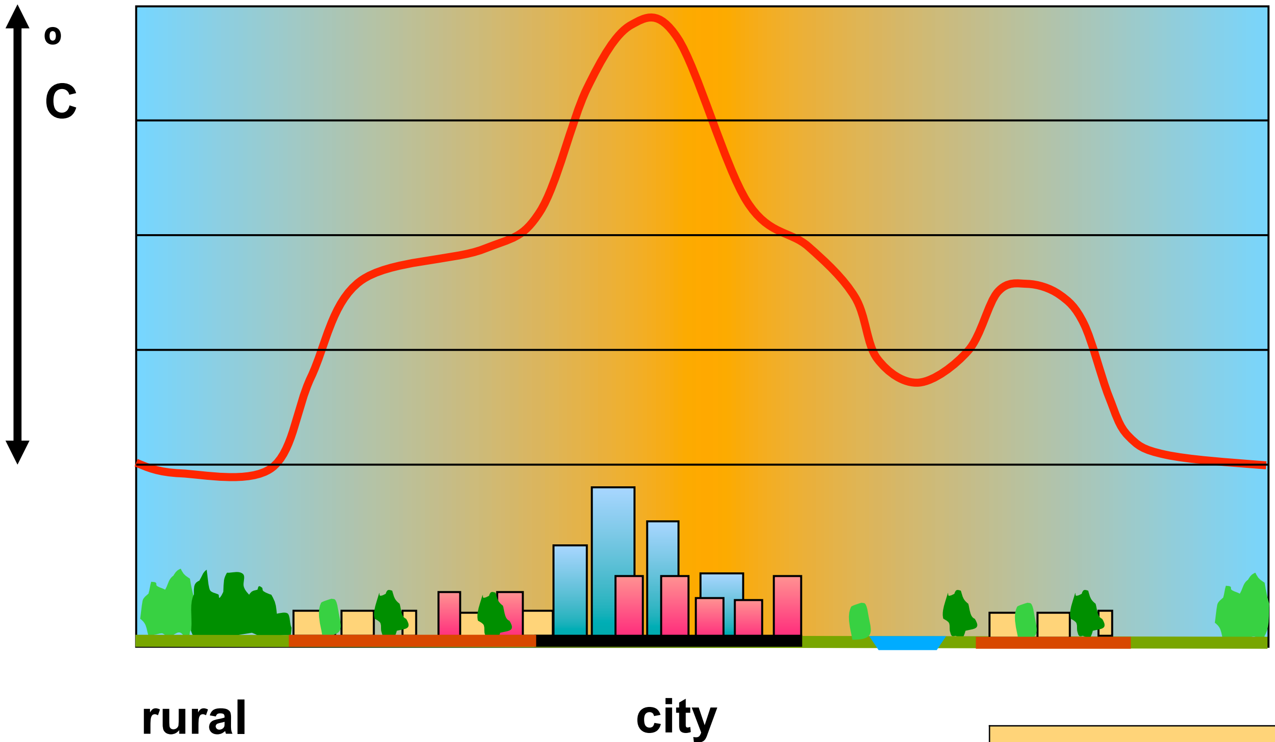


Physics of the Built Environment

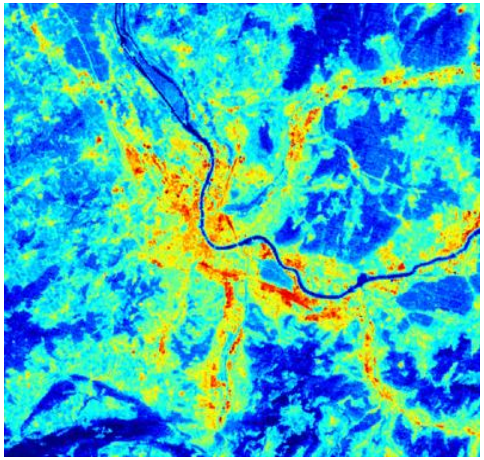


Urban heat island in Switzerland

Temperature difference between city and rural temperature = urban heat island intensity



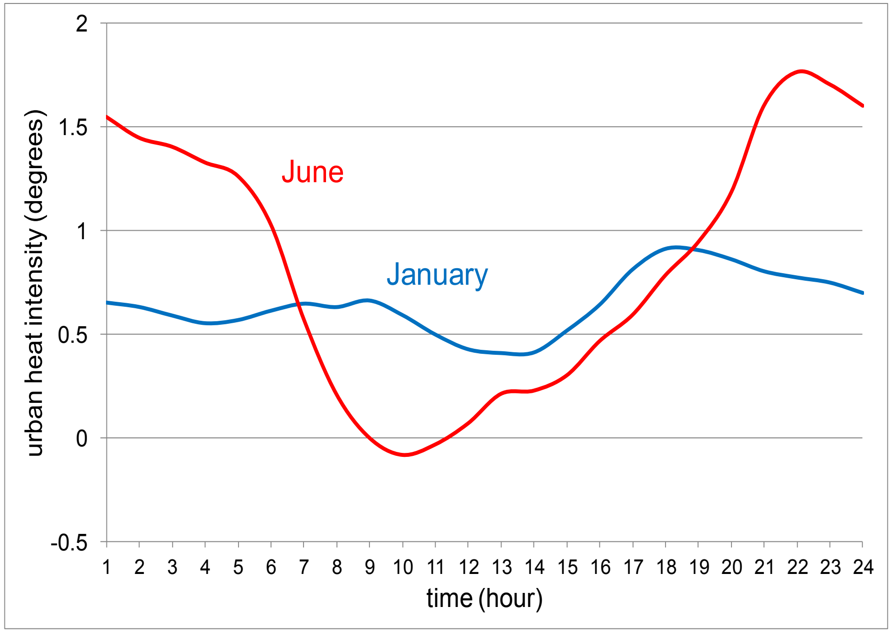
Heat island Basel

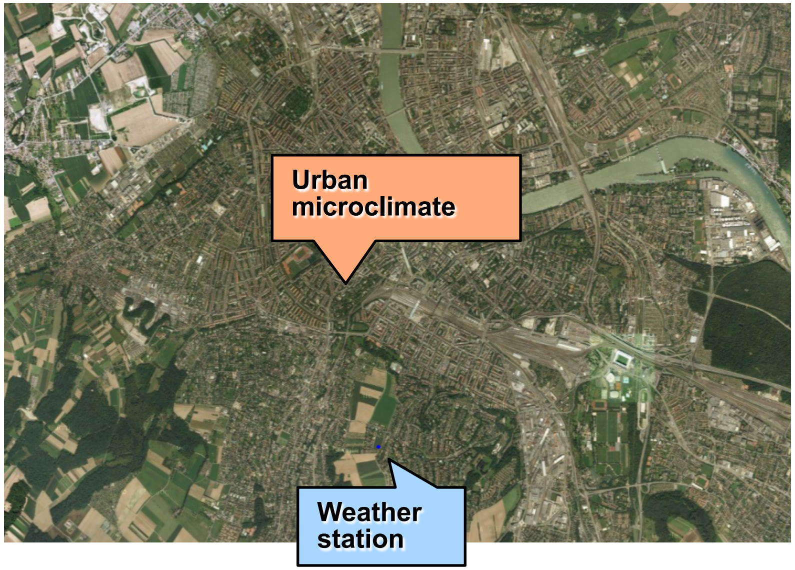


Town, City	*Heat island intensity*
Biel, Fribourg	5 K
Basel, Bern	6 K
Zürich	7 K

Wanner & Hertig, 1983

Urban heat island – air temperature

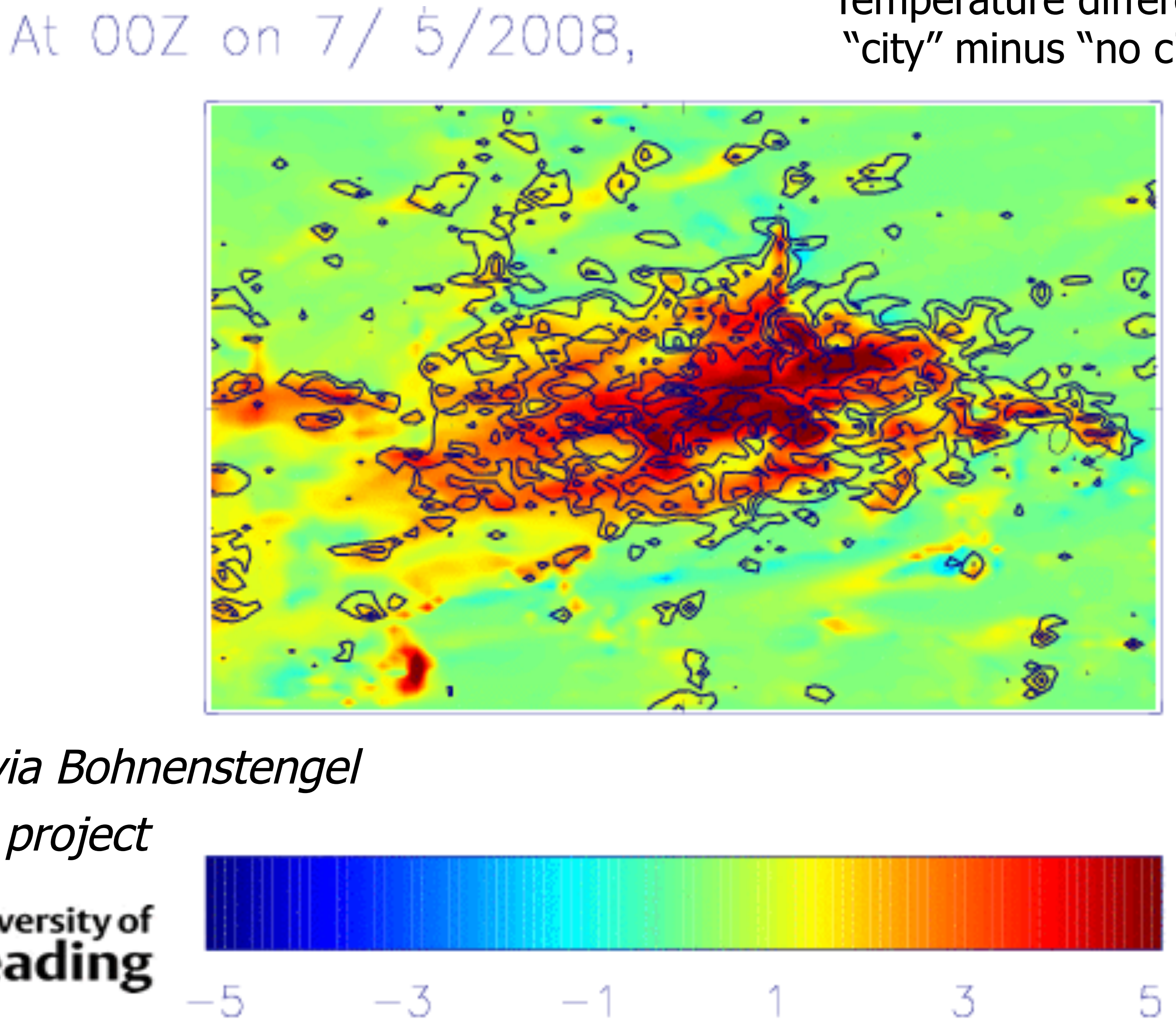




City of Basel

Simulating Urban Heat Island - London

Temperature difference at 1.5m
"city" minus "no city"

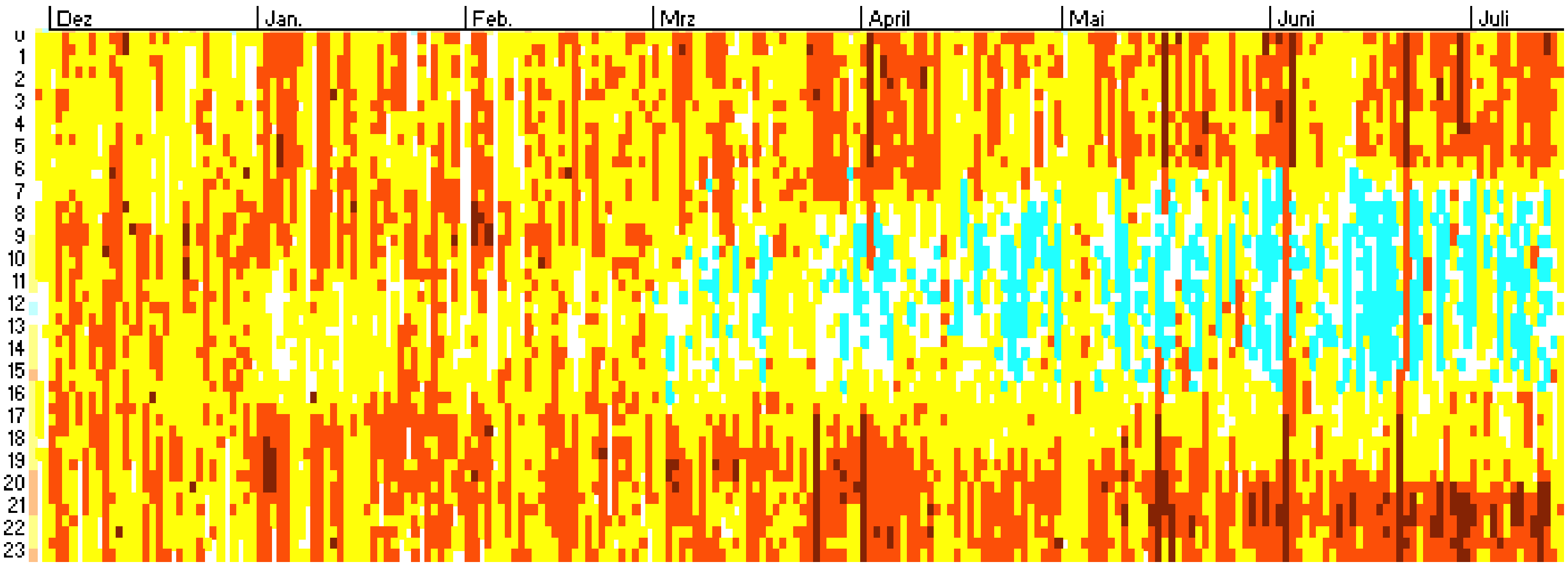


Dr Sylvia Bohnenstengel

LUCID project

University of Reading

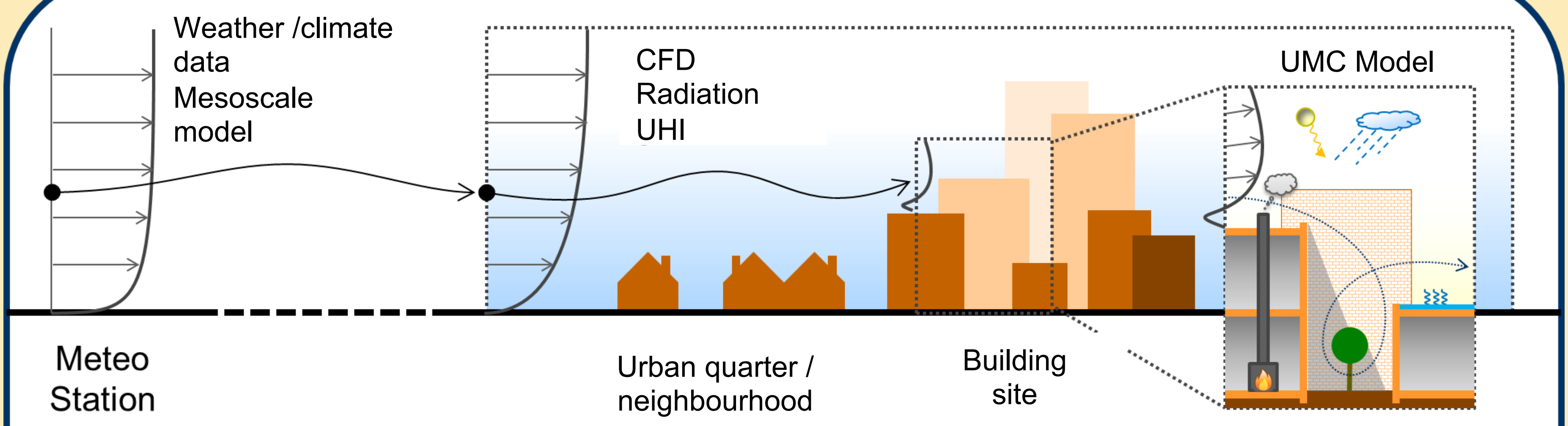
UHI Basel



	Temperature is more than 0.5°C lower than at the rural measurement station "Schönebuch"
	Temperature is +- 0.5°C identical with the rural measurement station "Schönebuch"
	Temperature is between 0.5°C and 2°C higher than at the rural measurement station "Schönebuch"
	Temperature is between 2°C and 4°C higher than at the rural measurement station "Schönebuch"
	Temperature is more than 4°C higher than at the rural measurement station "Schönebuch"

- UHI effect at the quarter type street canyon (measurement station Sperrstrasse)

From meteostation to urban micro climate



CFD: Computational Fluid Dynamics
UHI Urban Heat Island
UMC Urban Micro Climate

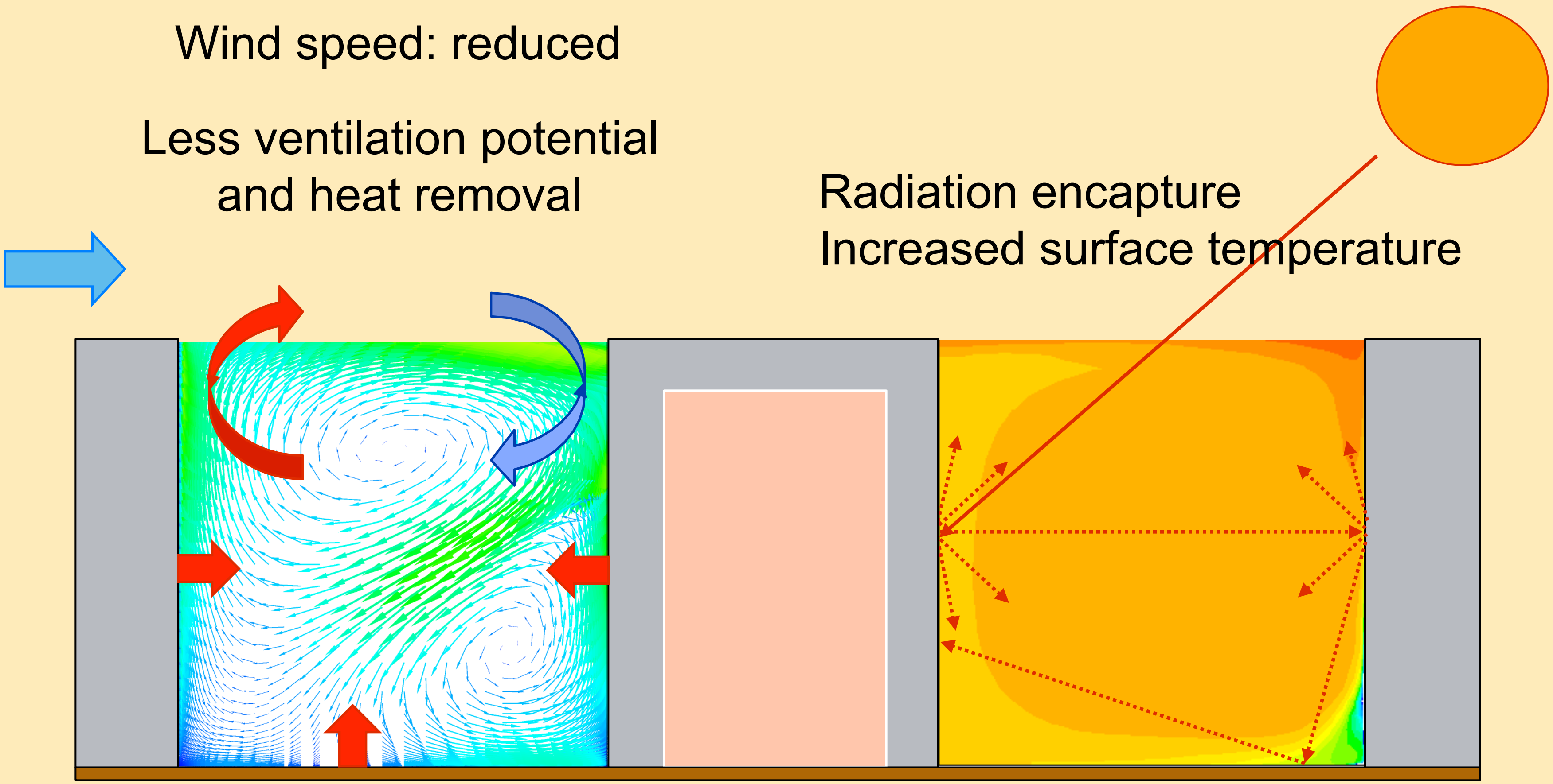
Impact of UHI on local climate ?

Urban Microclimate Modelling

Wind speed: reduced

Less ventilation potential
and heat removal

Radiation encapture
Increased surface temperature

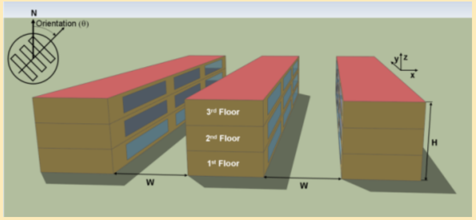


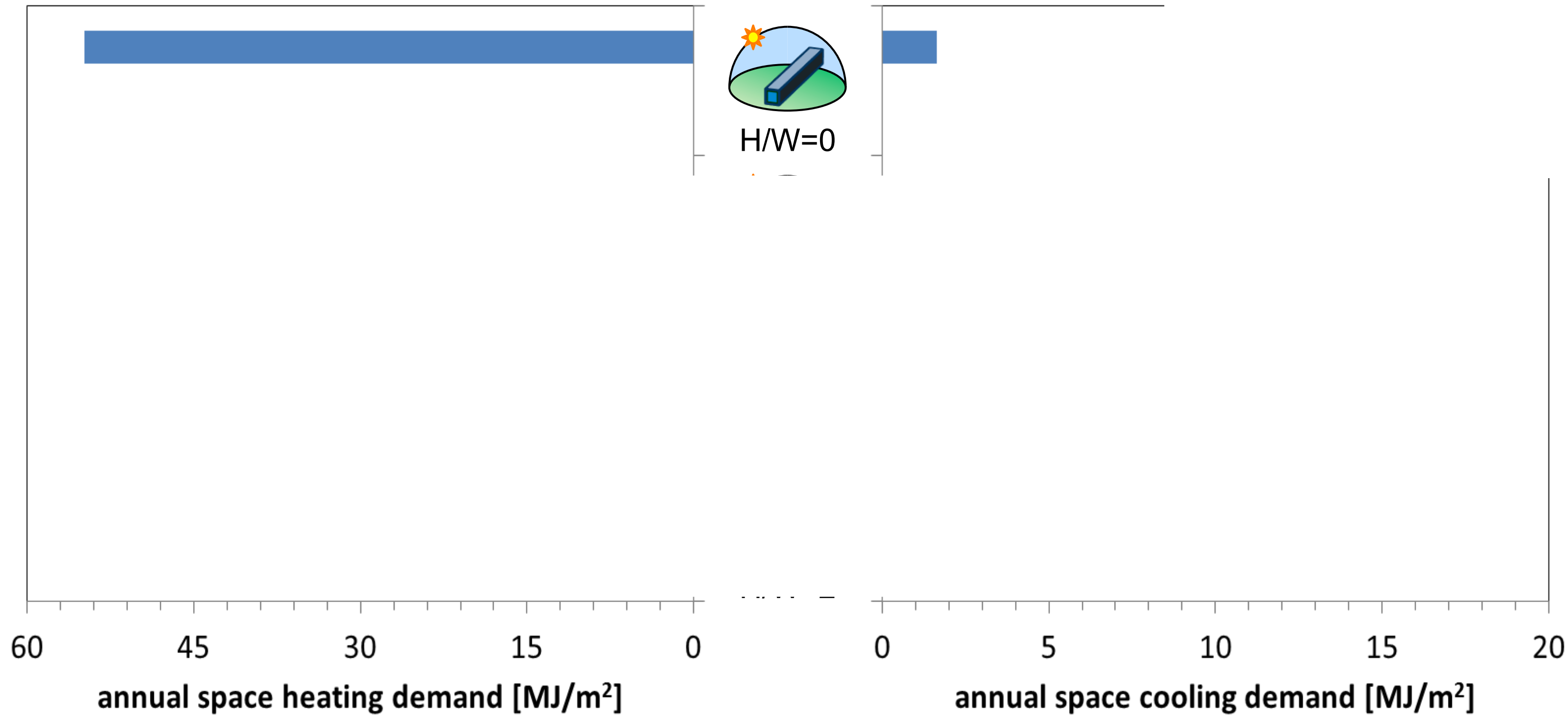
Lower convective heat
transfer coefficients

Increased air temperatures
Buoyancy driven ventilation

Space heating and cooling energy demand

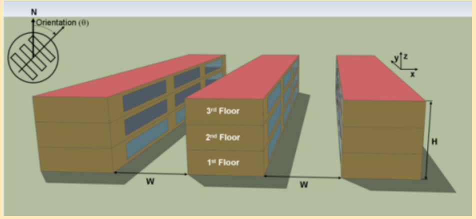
New building type, Θ = 0°

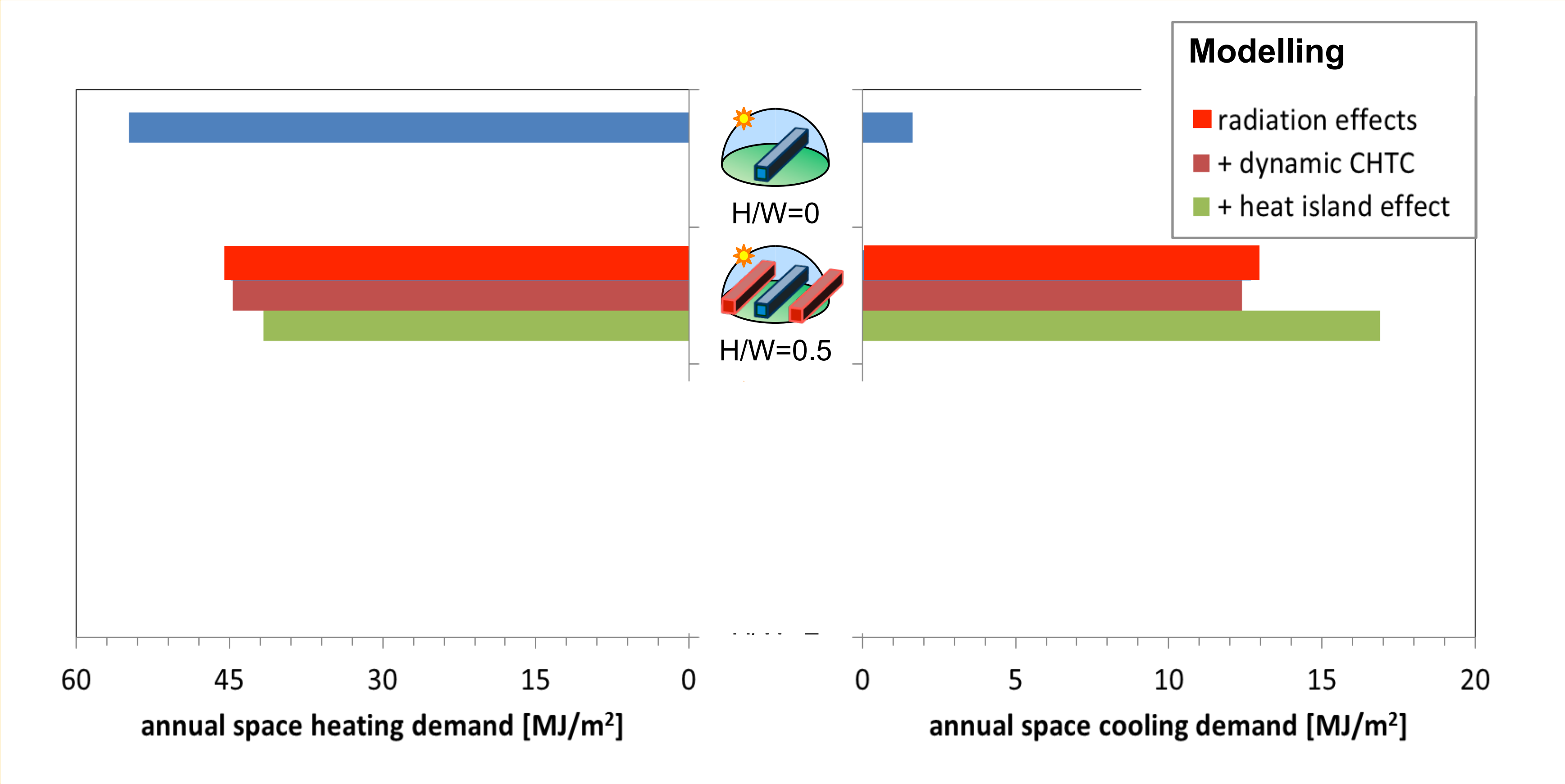




Space heating and cooling energy demand

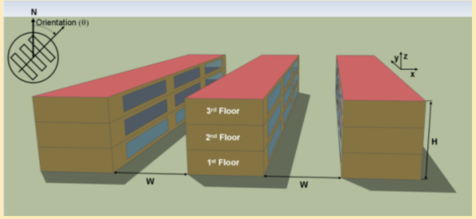
New building type, Θ = 0°

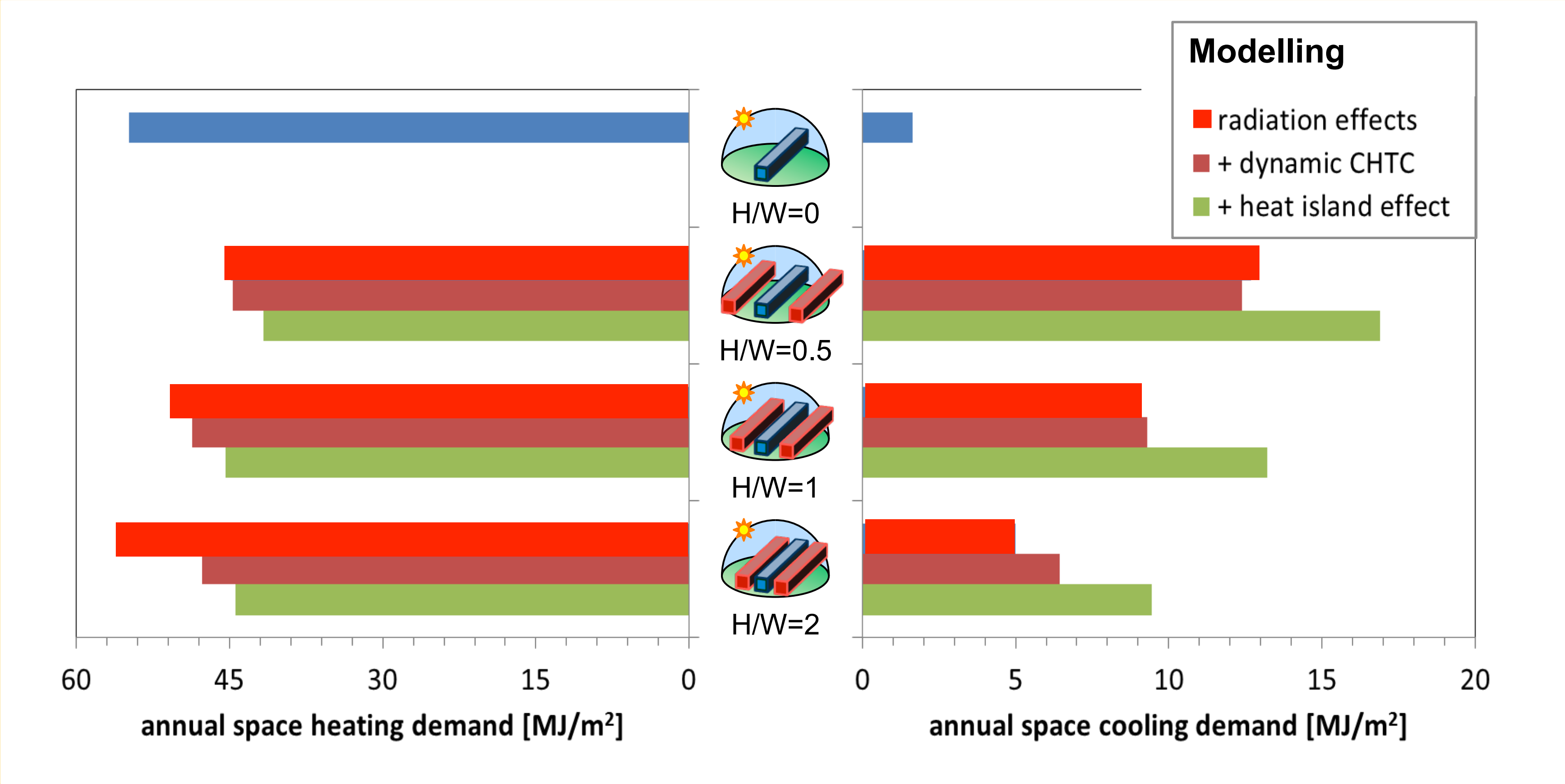




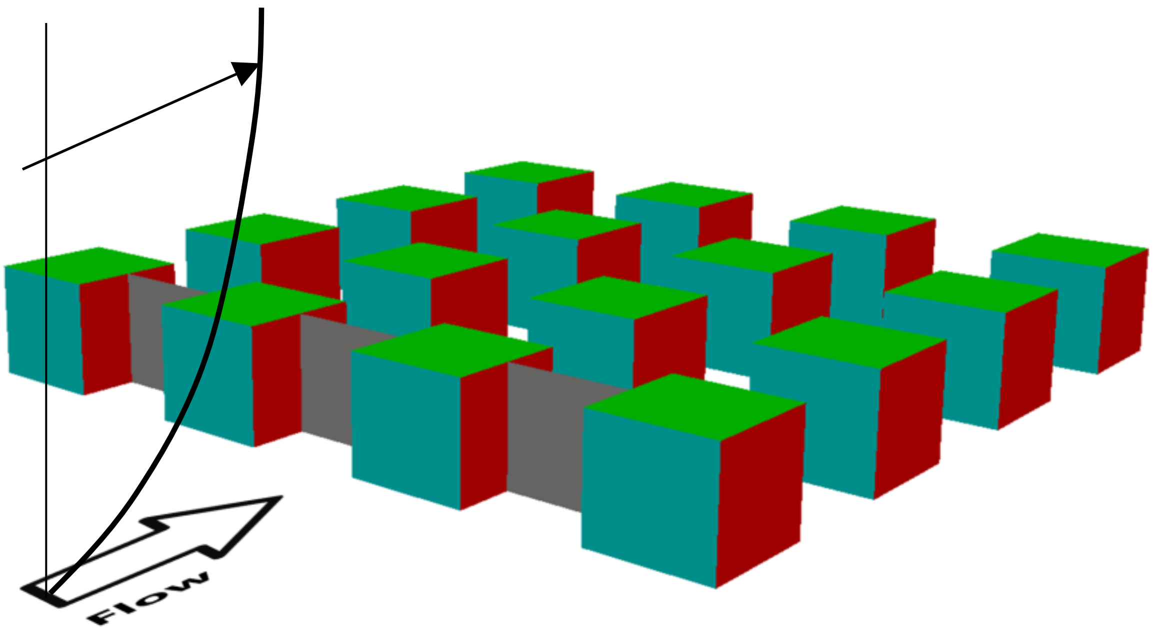
Space heating and cooling energy demand

New building type, Θ = 0°





Wind – buoyancy driven ventilation
BES - CFD Study – heat removal from urban areas



atmospheric boundary layer
1 m/s and 5.5 m/s at 10 m height

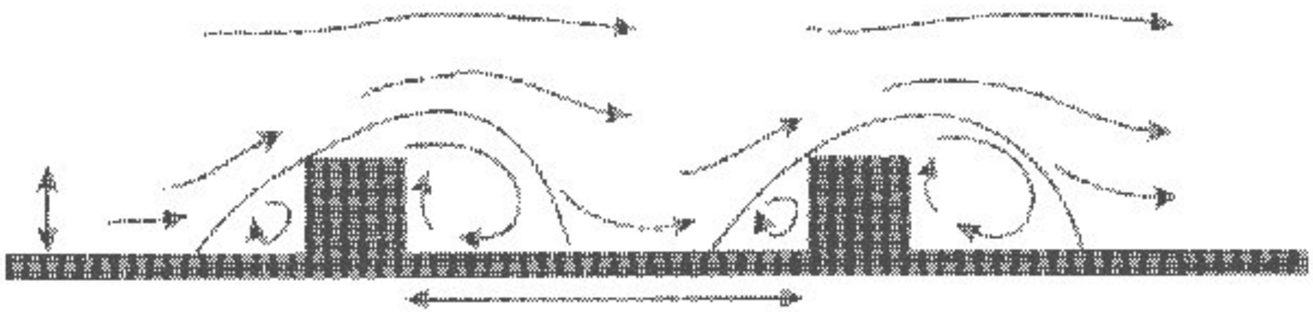
Ambient temperature of 25.5 °C

Building energy balance to determine surface temperature
1 summer hour of climate of Zürich (Switzerland)

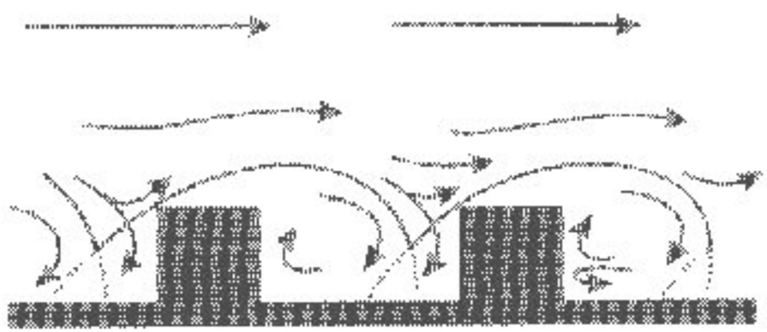
Removal of heat from urban areas

Street canyon flow

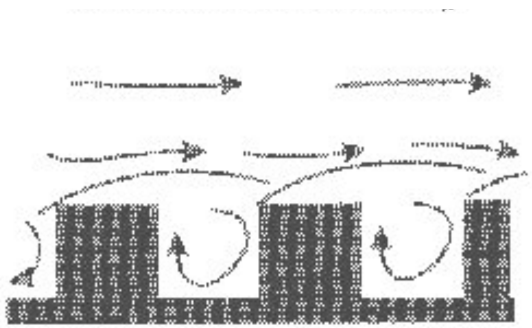
Isolated roughness flow



Wake interference flow



Skimming flow

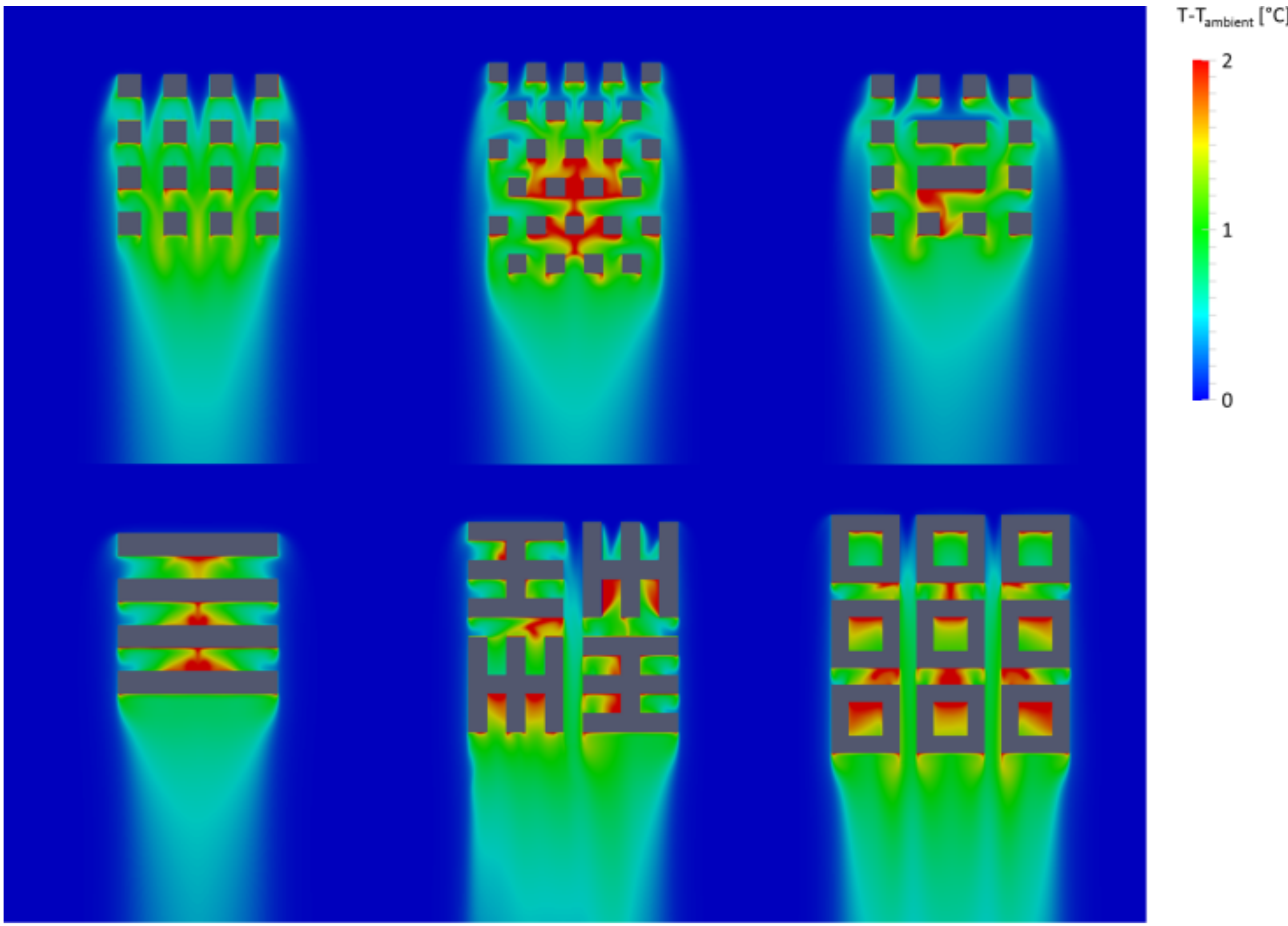


Oke 1971

Local heat island intensities

temperature difference between the local air temperature and the ambient air temperature at 1.75m height

U10=5.5 m/s



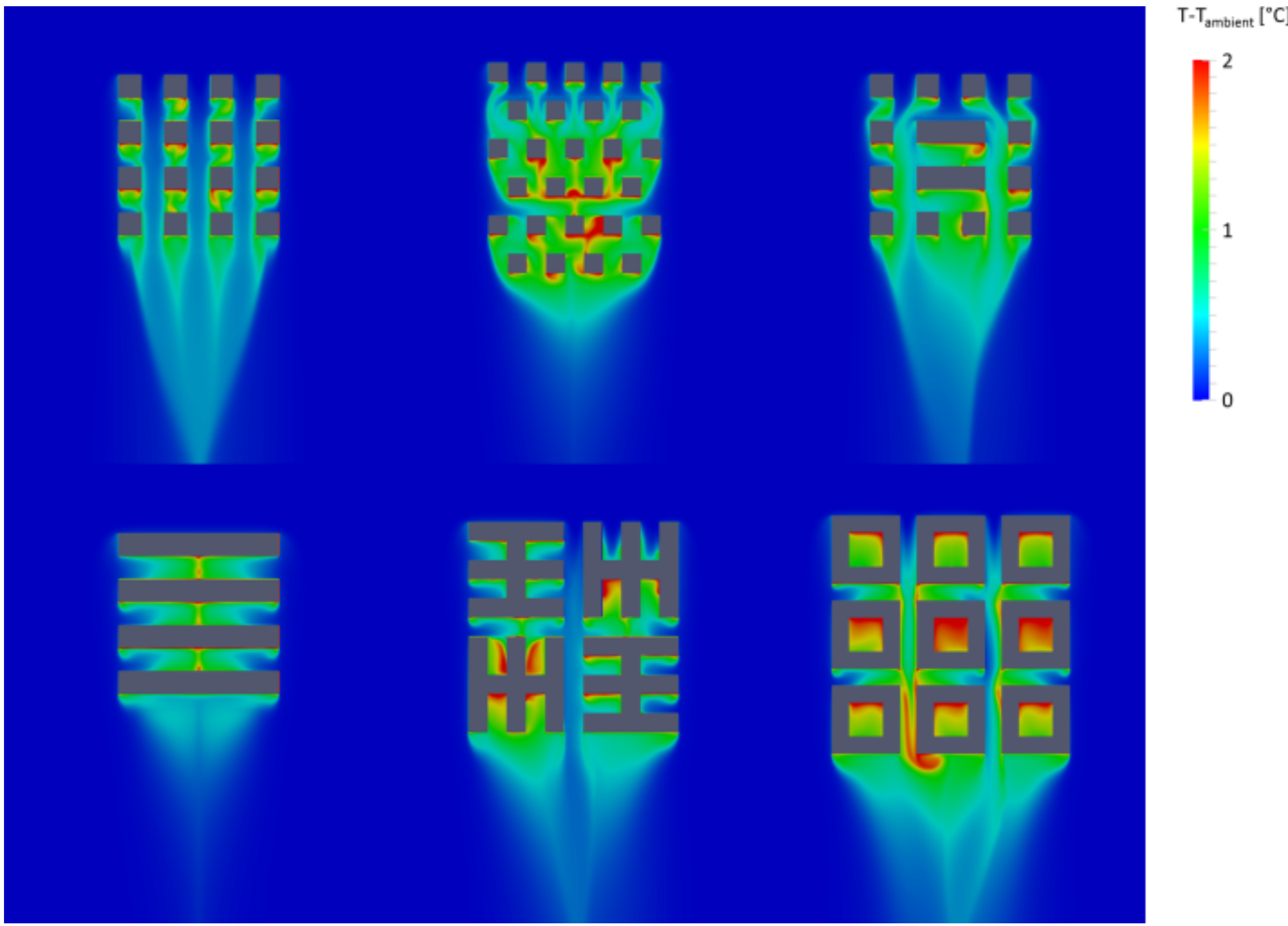
High wind speeds: lower buoyancy effect

Allegrini 2013

Local heat island intensities

temperature difference between the local air temperature and the ambient air temperature at 1.75m height

U10=1 m/s



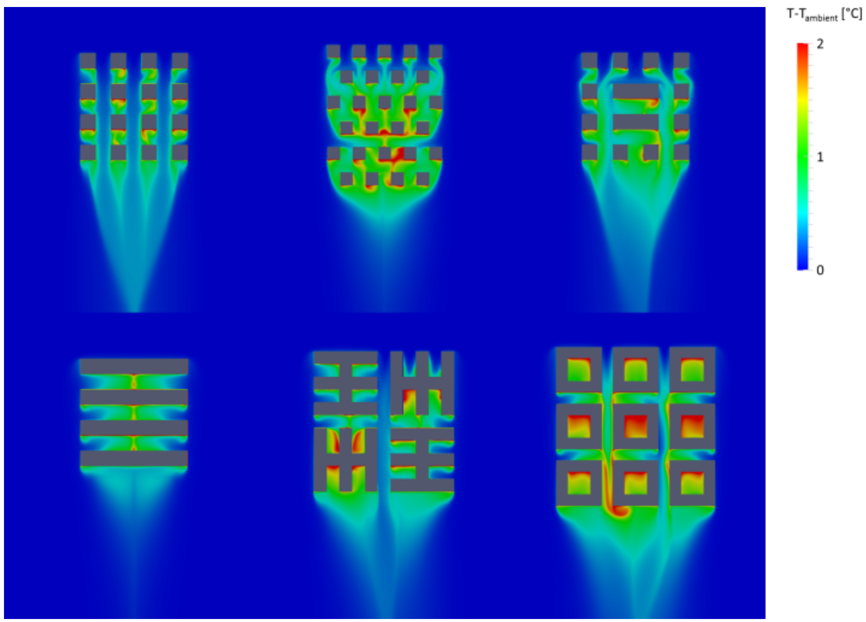
Low wind speed: stronger buoyancy effects

Allegrini 2013

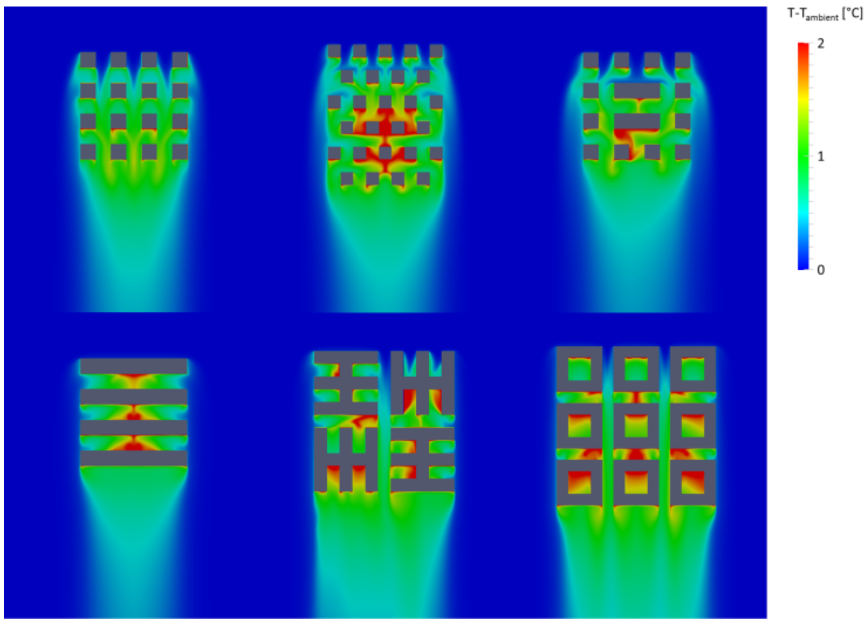
Local heat island intensities

temperature difference between the local air temperature and the ambient air temperature at 1.75m height

U10=1 m/s



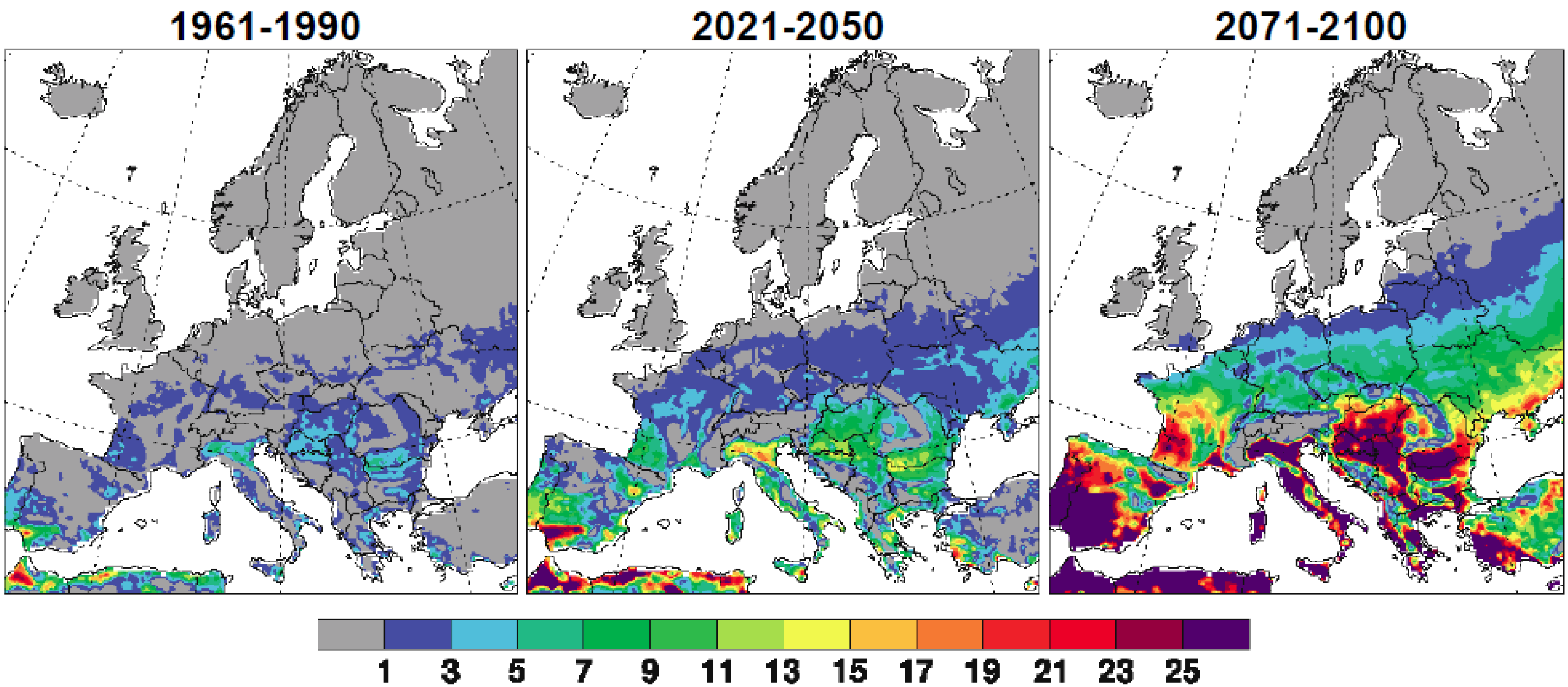
U10=5.5 m/s



For low wind speeds more hot air can leave the street canyons through the shear layer, due to stronger buoyancy effects.

Allegrini 2013

High-impact heatwave scenarios



Number of days with apparent temperature ≥ 40.6°C
(large heat stroke risk with extended exposure)

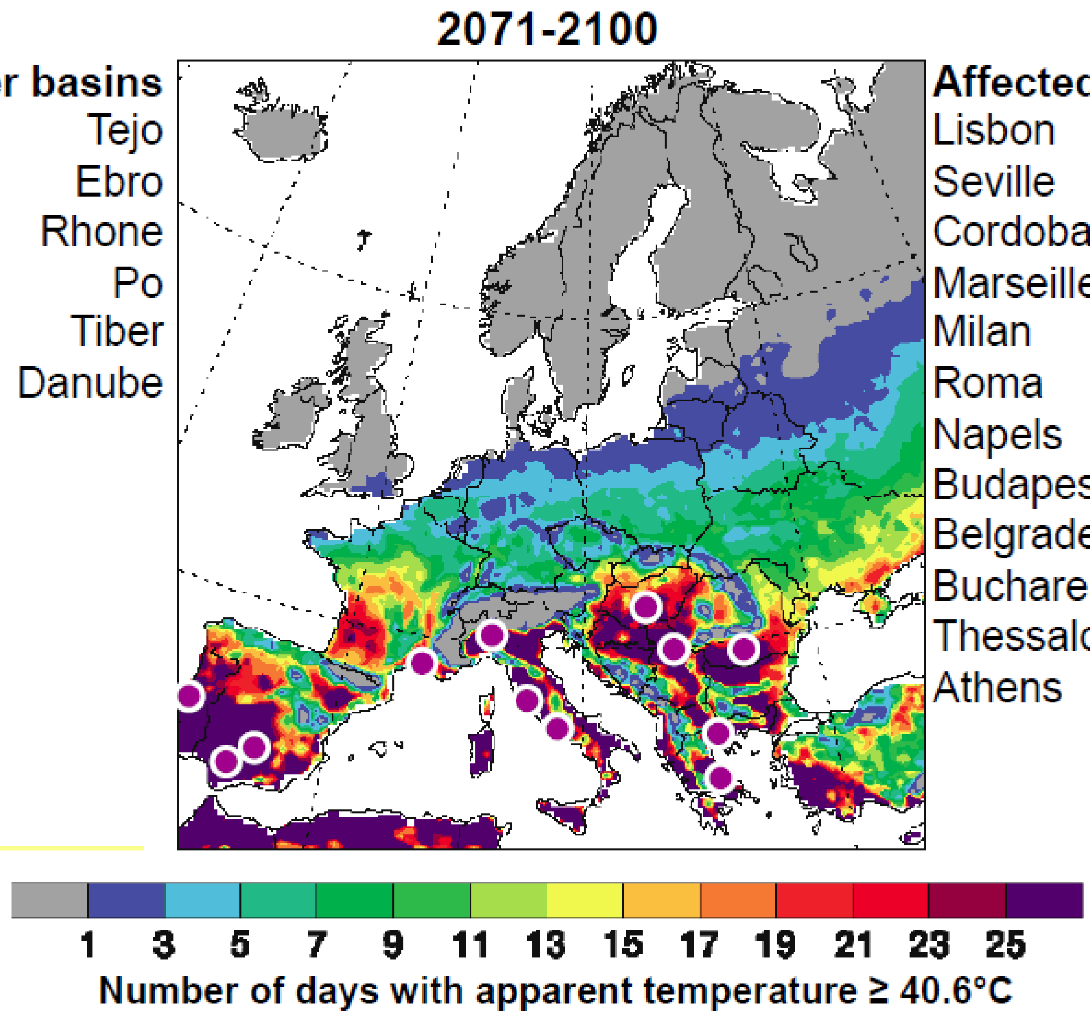
Dramatic increases in low-altitude Mediterranean (river basins and coasts)

Fischer and Schär 2010, *Nature Geoscience*, ENSEMBLES, mean of 6 models, scenario A1B

Affected regions

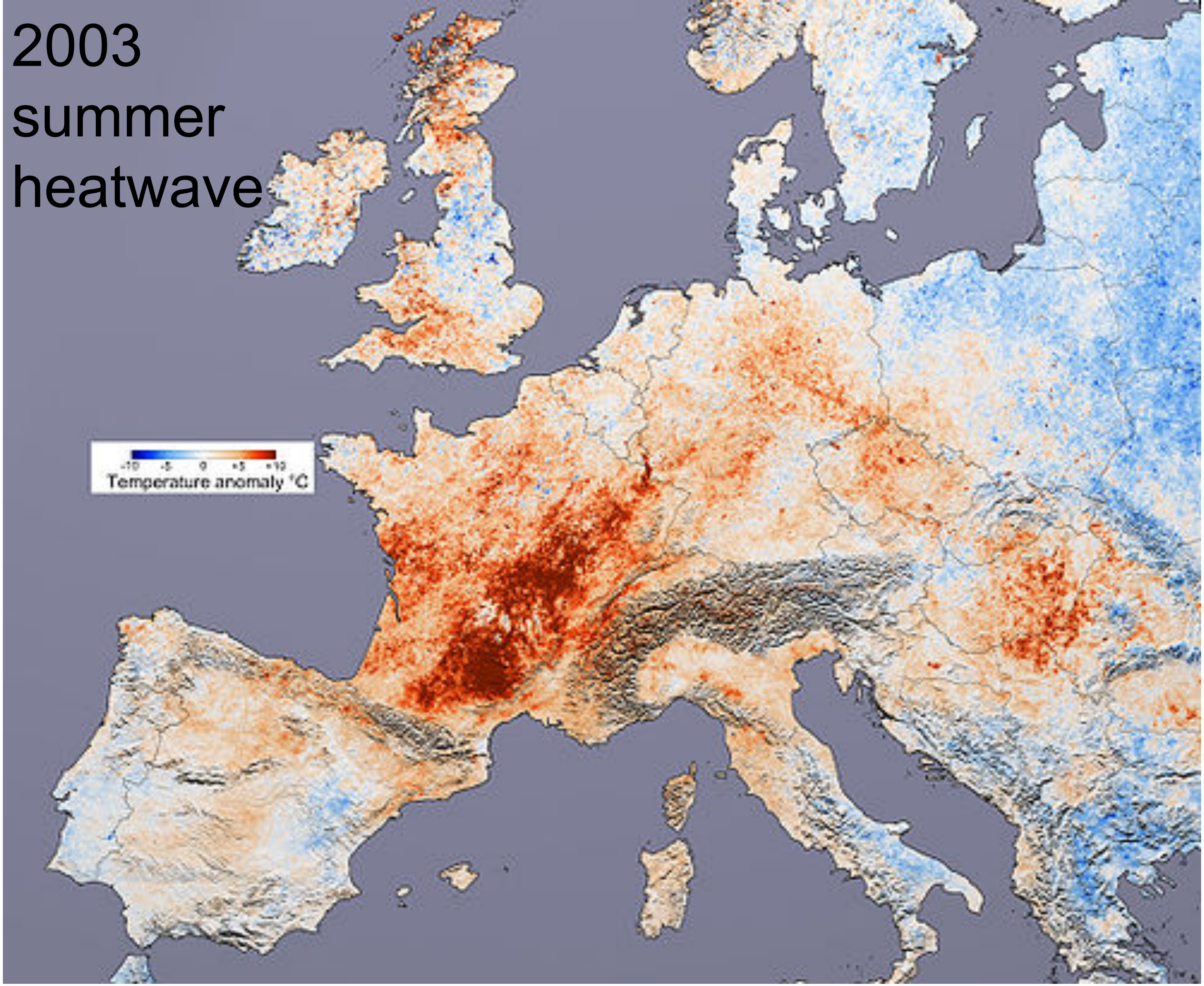
Affected river basins
Tejo
Ebro
Rhone
Po
Tiber
Danube

Affected towns
Lisbon
Seville
Cordoba
Marseille
Milan
Roma
Napels
Budapest
Belgrade
Bucharest
Thessalonica
Athens



(Fischer & Schär, 2010, *Nature Geoscience*)

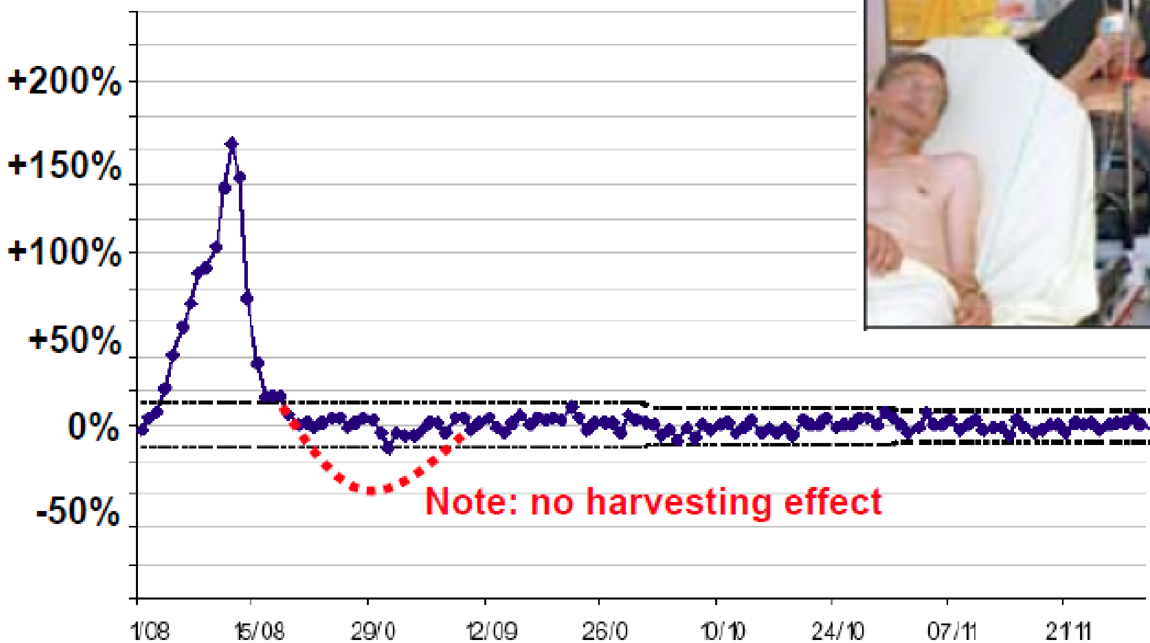
2003 summer heatwave



J.F. Barlow, U. Reading

Excess mortality in France

Excess mortality = mortality beyond longterm mean



Date: August 1 - November 30, 2003

Schär, ETH Zürich

(INSERM 2004)

Evaluation of urban thermal comfort

Universal Thermal Climate Index (UTCI)

Equivalent ambient temperature of a reference environment providing the same physiological responses of a reference environment

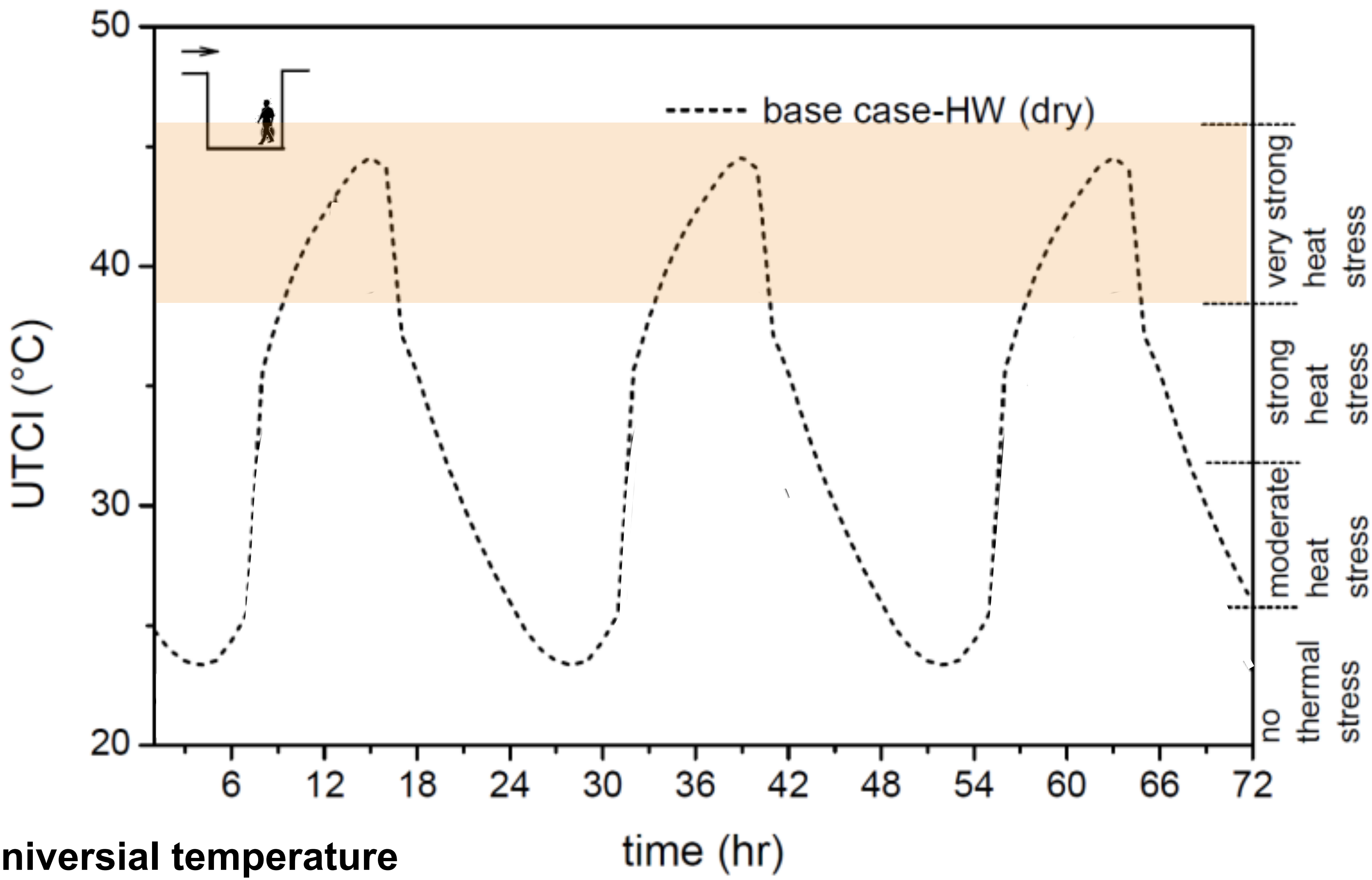
- ❑ air temperature
- ❑ mean radiant temperature
- ❑ relative humidity
- ❑ wind speed
- ❑ clothing
- ❑ activity

$$T_{mrt} = \left[T_{umrt}{}^{4} + \frac{f_p \propto_p I_{dir}}{\varepsilon_p \sigma} \right]^{0.25}$$

Surface temperatures of environment radiating to the person

Direct solar radiation on person

Heat wave (Zurich 2003)

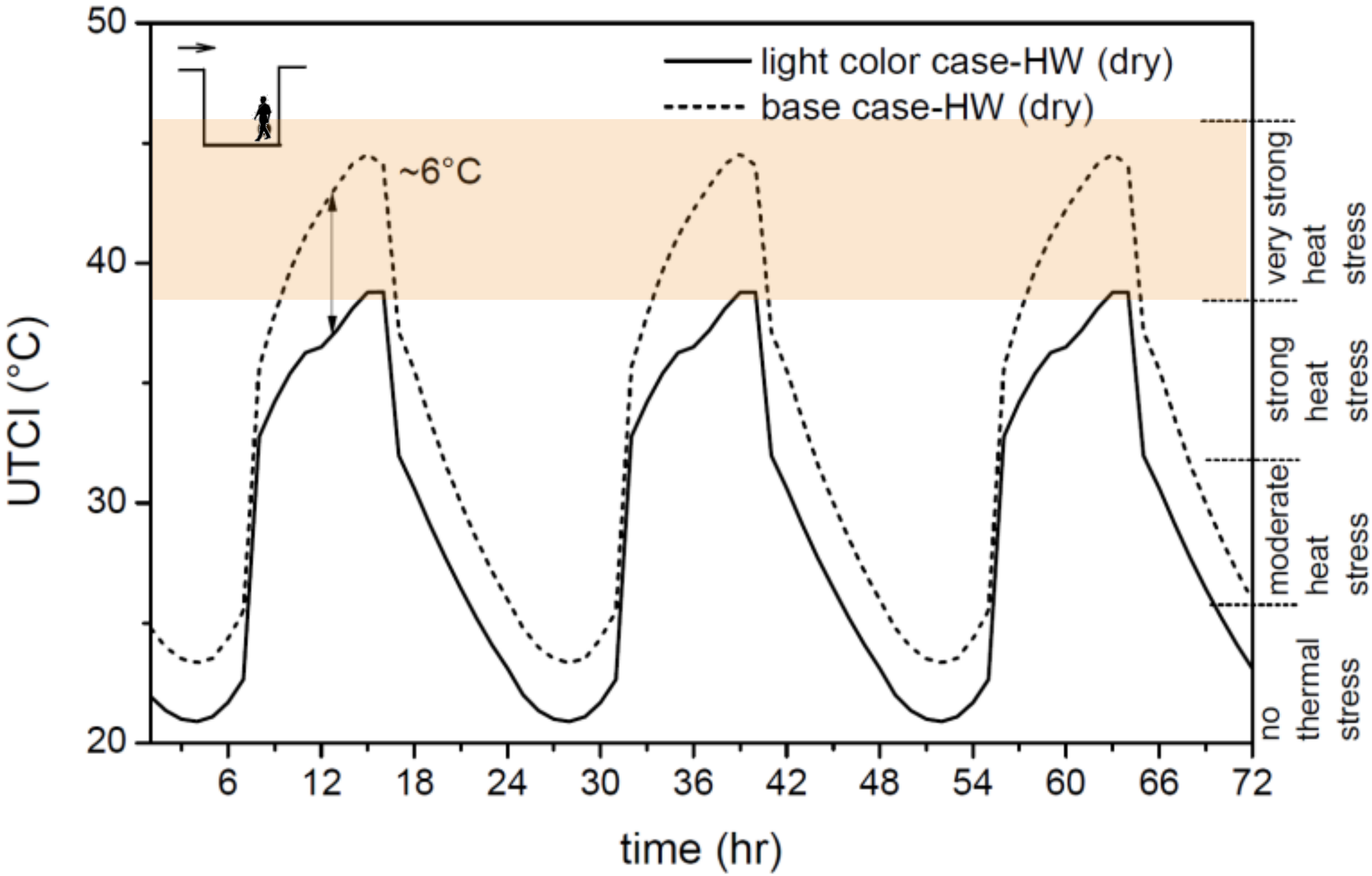


Universial temperature Comfort index

Saneinejad et al. 2013

Materials with high albedo value

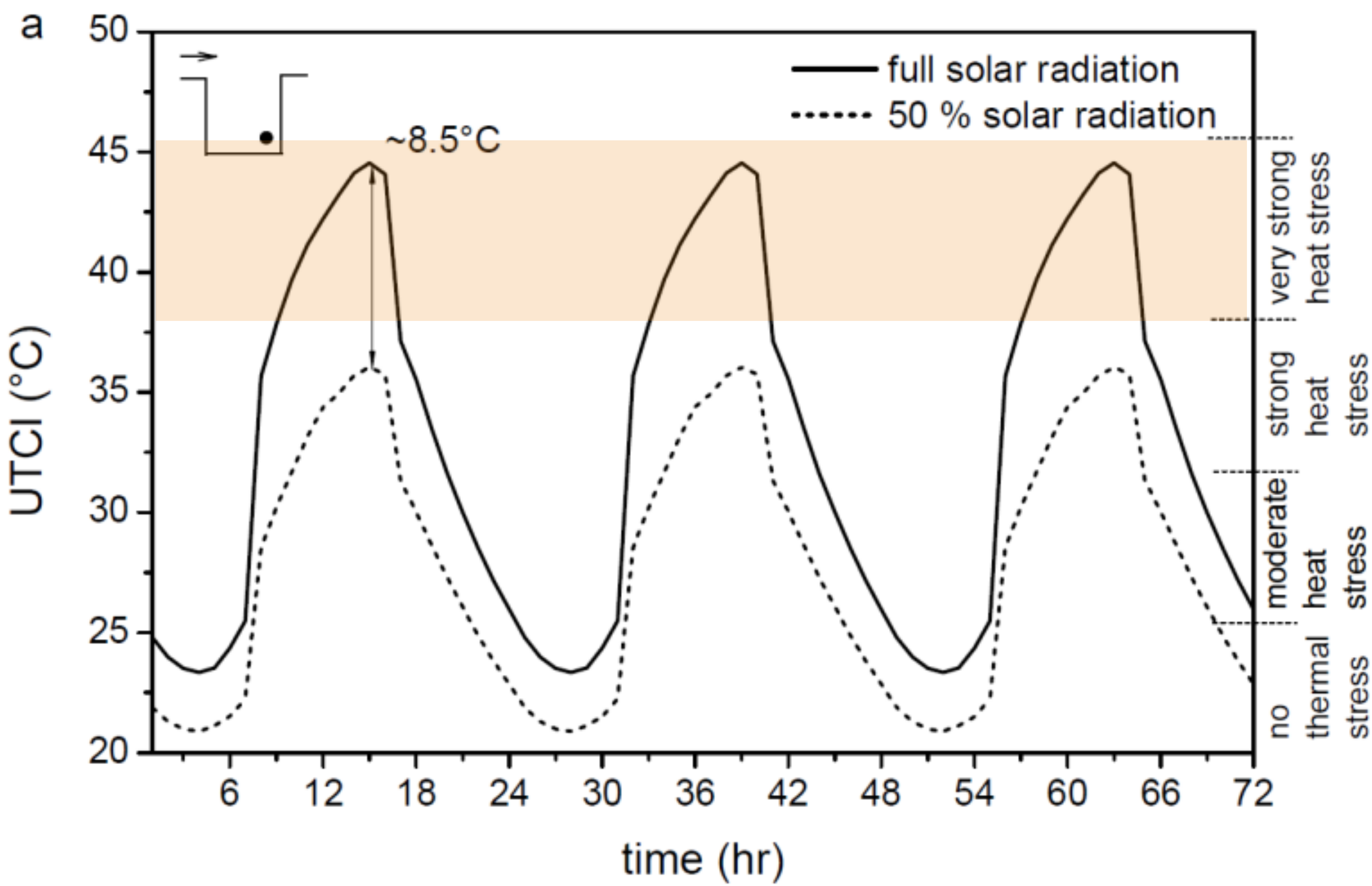
Heat wave : white colors



Saneinejad et al. 2013

Shadowing

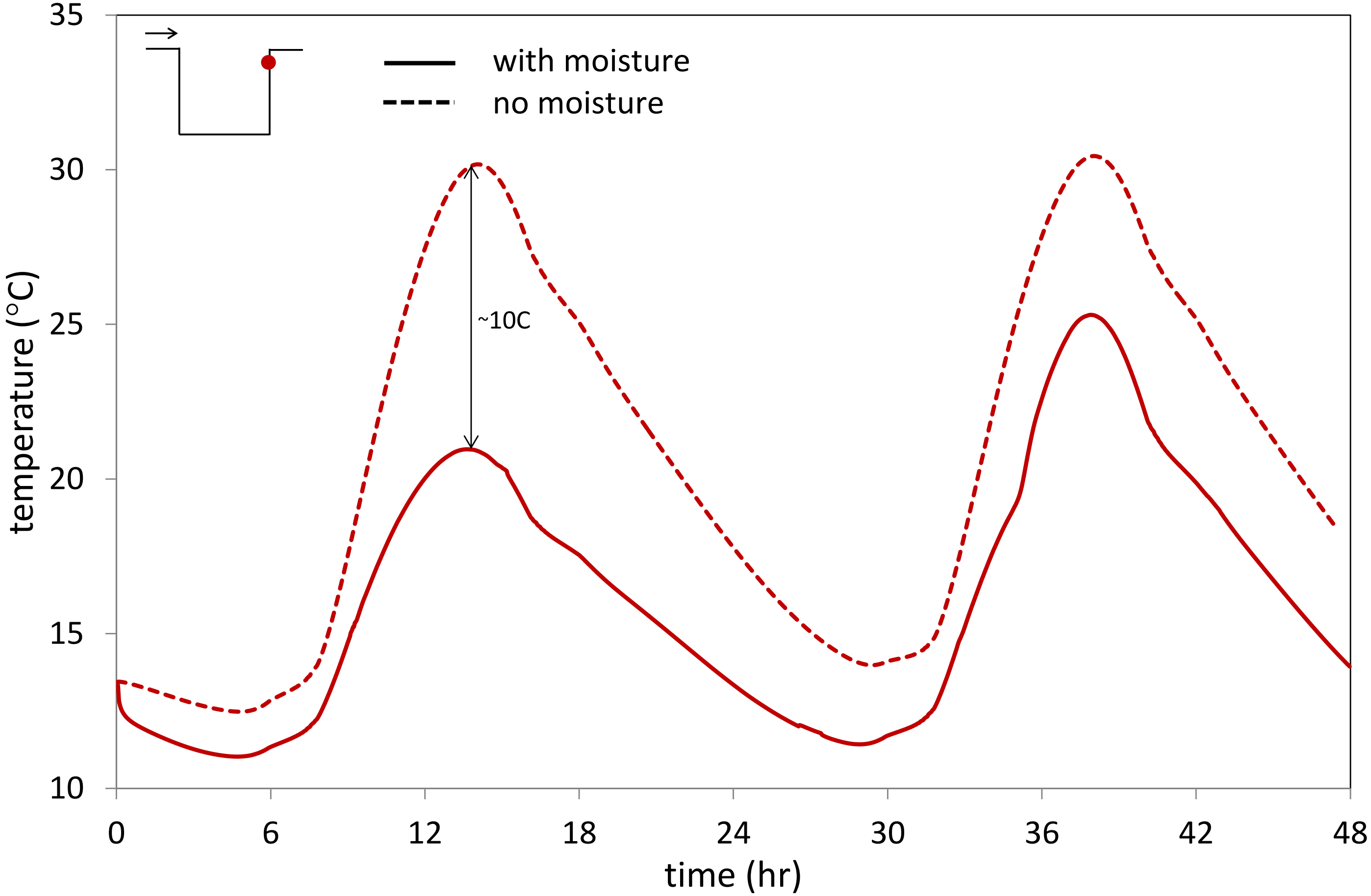
Heat wave : 50 % shadowing



Saneinejad et al. 2013

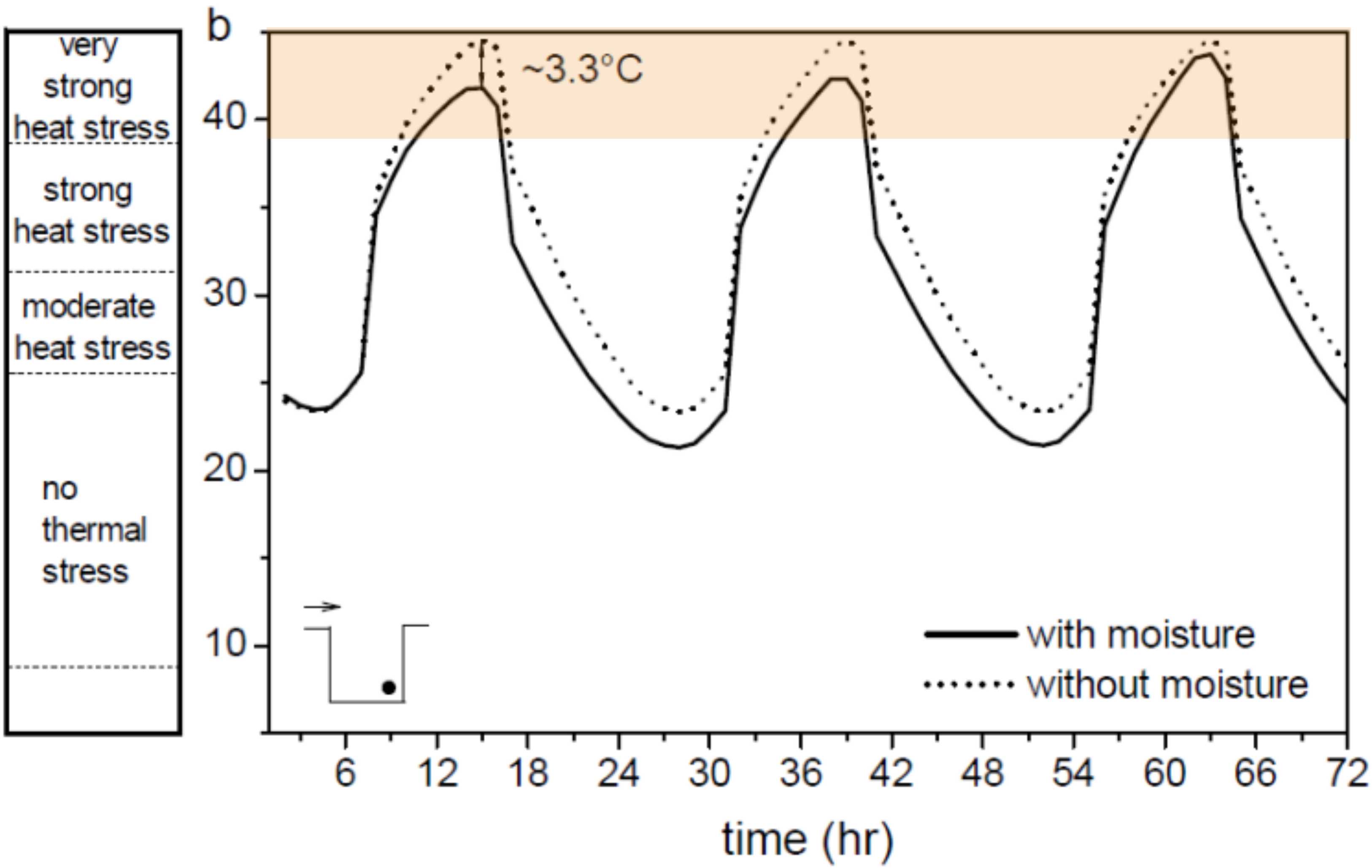
Heat wave : evaporative cooling

Surface temperature: cooling of evaporating wall



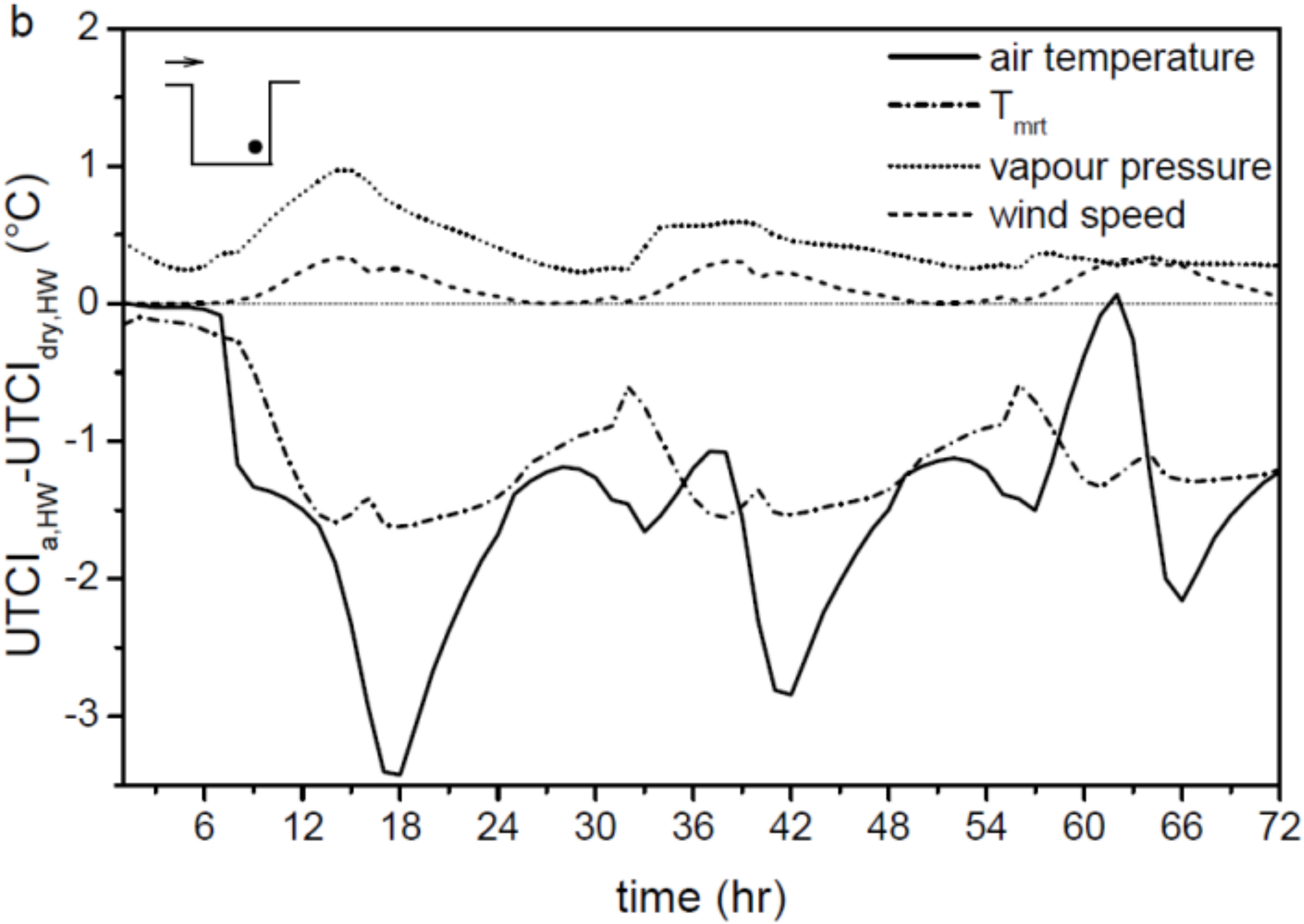
Saneinejad et al., 2013

Heat wave : evaporative cooling



Saneinejad et al., 2013

Heat wave : evaporative cooling



Saneinejad et al., 2013

Questions