Green or grey? Integration of nature-based solutions in densifying cities

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EGU General Assembly 2020

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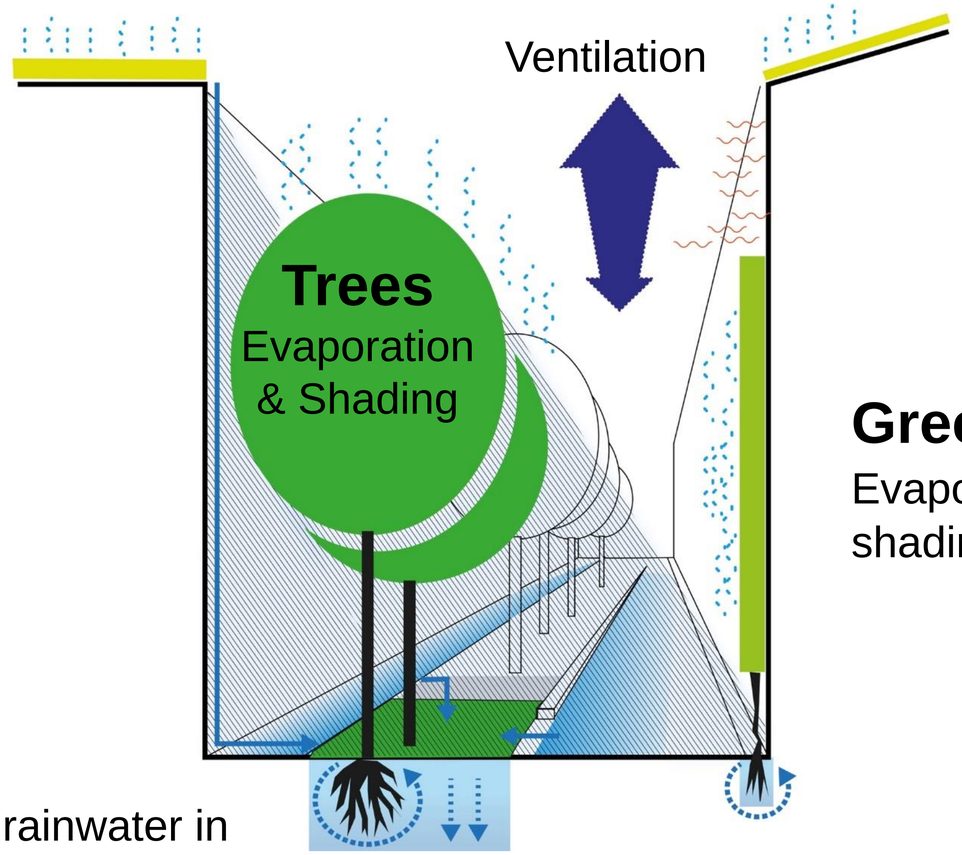
Urban microclimate & urban green

In the light of climate change, urban green spaces provide multiple regulatory services (e.g. Erell 2017)



Retention of rainwater in tree pit

Green roofs

Evaporation & Retention

Green façades

Evaporation and shading of façade

Source: Adapted from ZSK, 2018

Densification vs urban green?

High rise buildings without green (S.Erlwein)

Growing world population leads to rising housing demand and densification of cities.

Densification is however often associated with loss of urban green space (Haaland & van den Bosch, 2015).

Regulatory services of urban green are thus threatened (Emmanuel & Steemers, 2018).

Research questions

„The question is not whether or not to densify, but rather how.“
Bay and Lehmann, 2017

I) How is urban green affected by densification?

II) How can the tradeoffs between densification and greening for thermal comfort be (effectively) minimized/ reduced?

Messestadt Riem, Munich (S.Erlwein)

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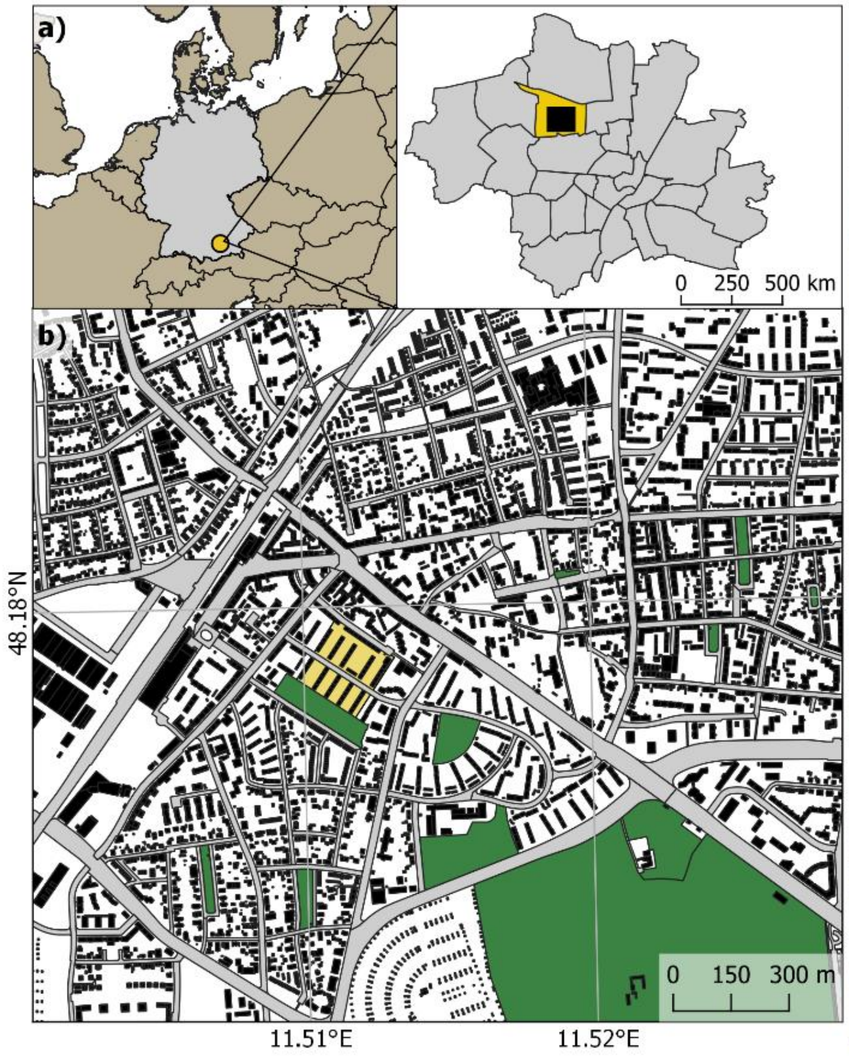
Study site – redevelopment area Moosach



Location: Munich, Bavaria, Germany

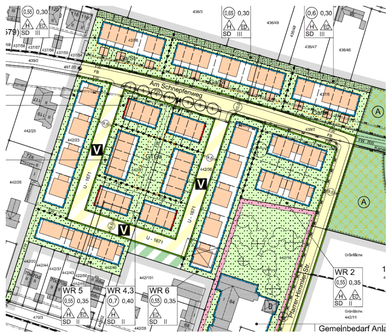
Residential redevelopment area
Total size: 3,42 ha
Trees: 158
Veg Cover: 50,1%

11 row buildings of 14m height

Study area Moosach (base map data and aerial image provided by Agency for Digitisation, High-Speed Internet and Surveying; pictures and map by S. Erlwein)

Methodological approach

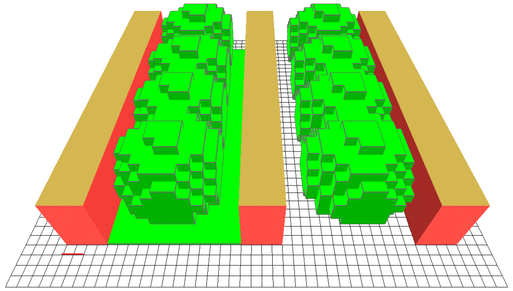
1 Identification of densification processes & parameters



Analysis of building plans
&
planning documents of
the City of Munich

2 Assessment in field laboratory

Microclimate modelling of human thermal comfort (ENVI-met)

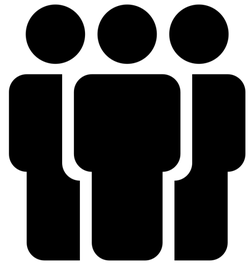


Status quo

Densification scenarios

Climate change adaptation scenarios

Negotiations with & feedback from city planners



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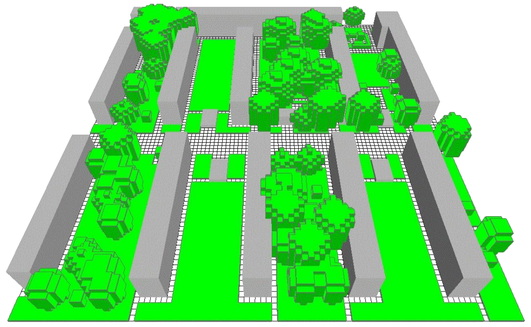
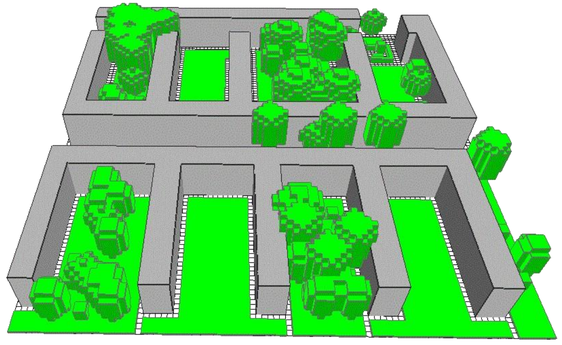
Densification scenarios

I) Densification type

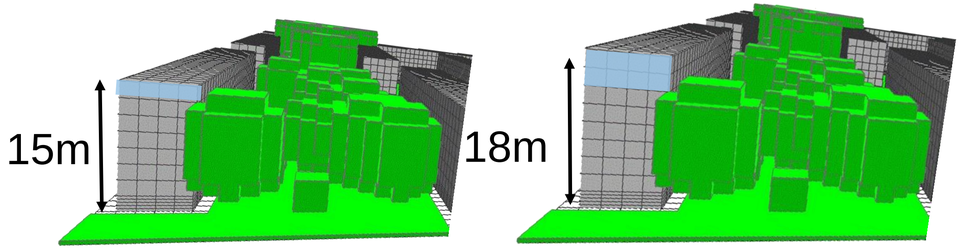


additional floors only



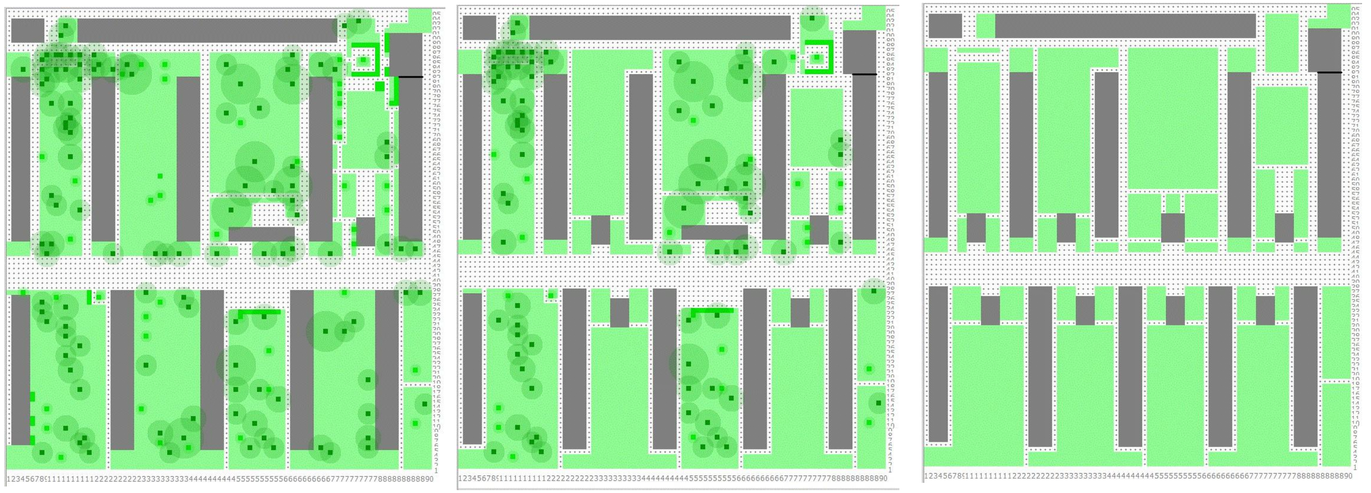
Additional floors & buildings

II) Building heights



Per planning regulation, one parking space per flat must be provided. However, this ratio can be reduced to 0.6/0.4.

III) Underground car parks/loss of vegetation



1 car park (100% trees)

4 car parks (60-50% trees)

8 car parks (0% trees)

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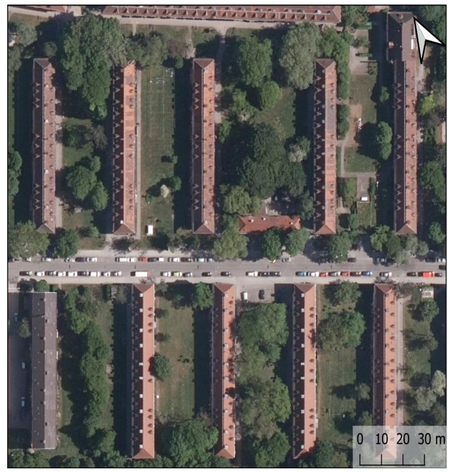
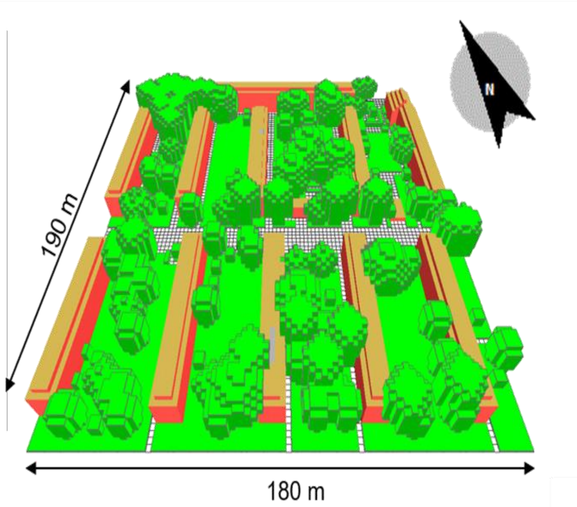
Methodological approach: Microclimate simulation

Spatial data





2 m x 2 m resolution, 8 scenarios

Data base

Buildings and facades, soil material, tree characteristics (height, LAI, crown shape)

Meteorological input data

Summer heat day, 48h

ENVI_MET Microclimate simulation tool

(Bruse & Fleer 1998)

Results

u.a. PET = Physiological Equivalent Temperature

PET (°C)

- Index for human thermal outdoor comfort
- Influencing parameters: air temperature, wind speed, rel. humidity, mean radiant temperature
- Clothing, activity

(Höppe 1999, Staiger et al. 2019)

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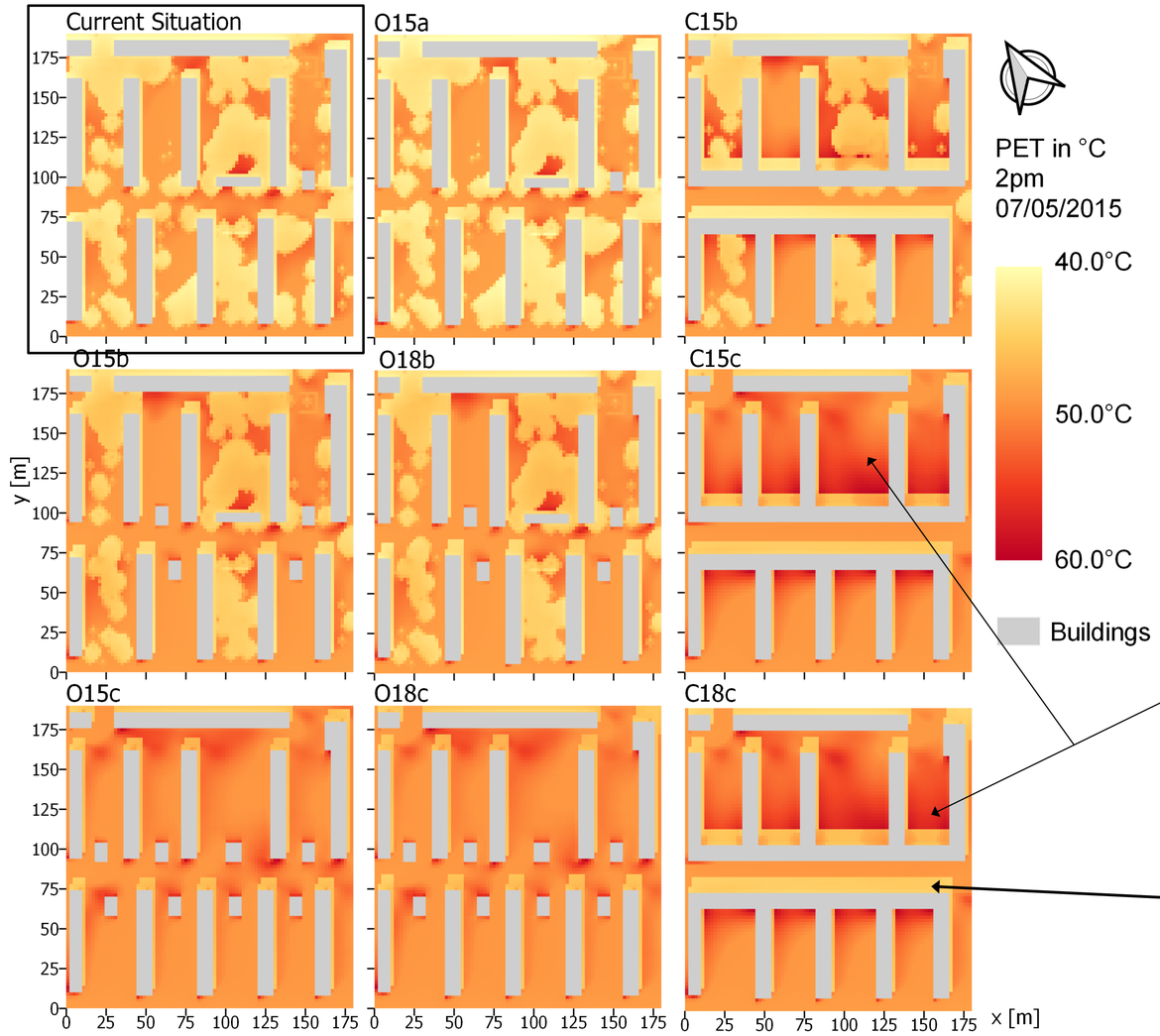
Results – Daytime thermal comfort

PET 07/05/2015, 2pm



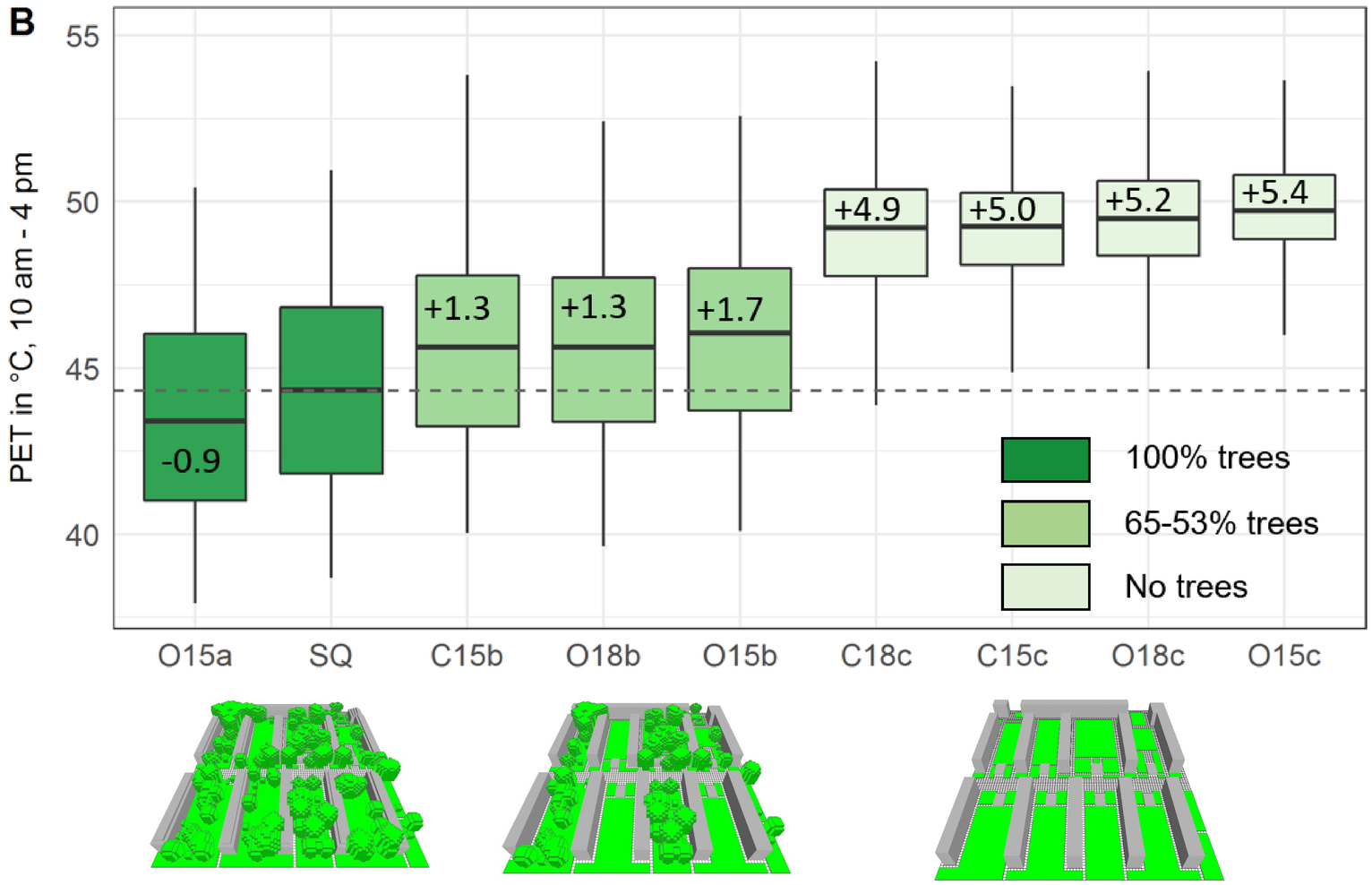
- **Very high overall PET values**
- **Coolest locations in shadows of buildings and trees**

Elevated temperatures in courtyards due to blocked wind flows

Shading of street southern street side

Results – daytime thermal comfort

Boxplot comparison (average 10am-4pm)



Scenarios without trees on average 5 °C PET hotter than the status quo(SQ)

No linear correlation between amount of trees and daytime thermal comfort

Scenario with increased building height, but same vegetation (O15a) cooler than status quo

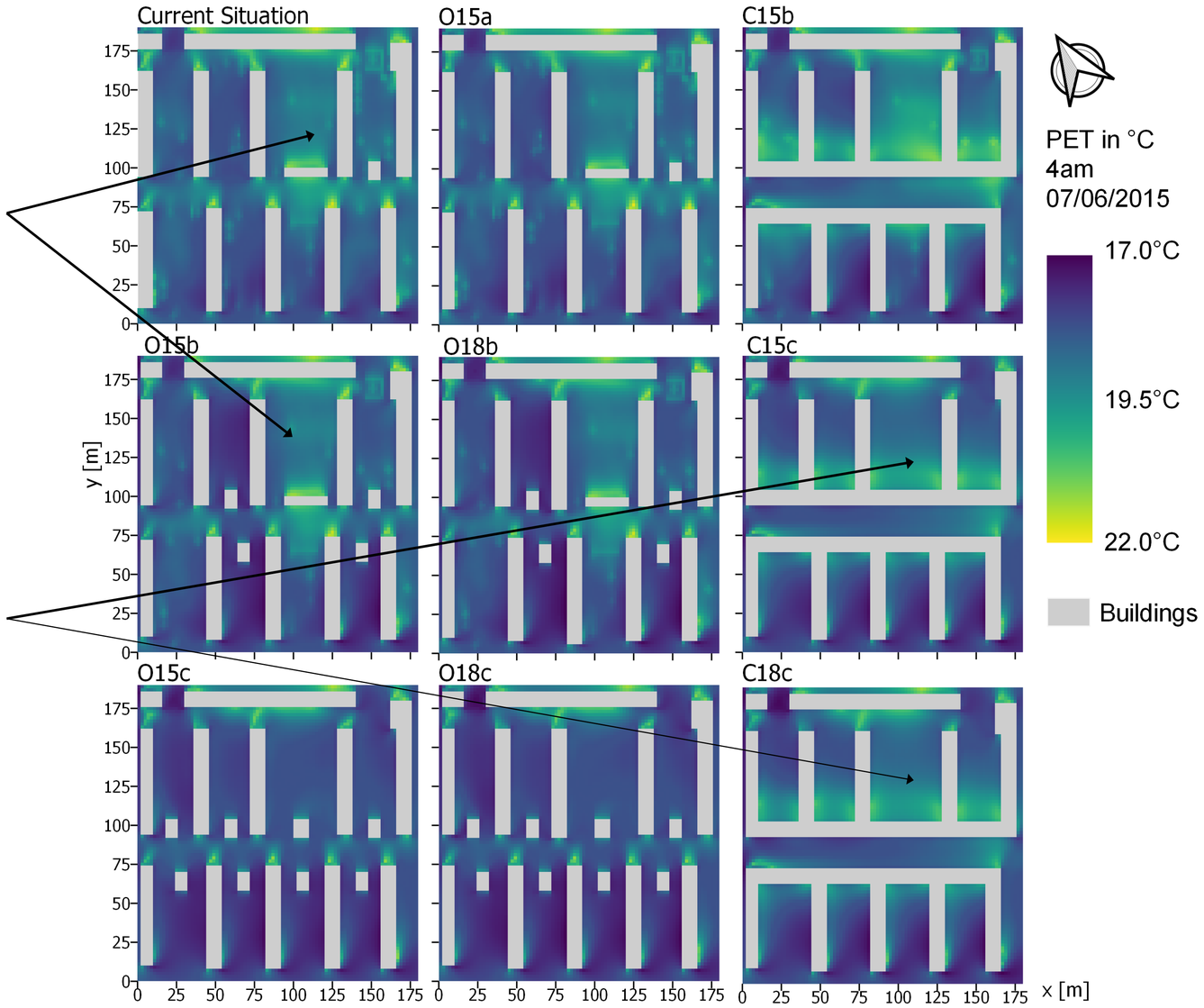
Results – nighttime thermal comfort

PET 07/06/2015, 4am

Heat trapping by tree canopies

Closed arrangements lead to elevated night time temperatures in courtyards

Coolest scenarios with open rows and no trees



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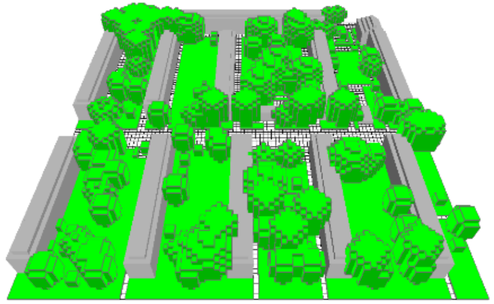
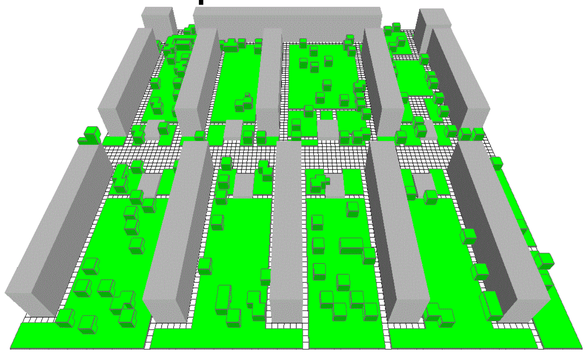
Results – Scenario replanted trees

What if the original trees (up to 22 m height) are replaced by newly planted trees (6 m)?

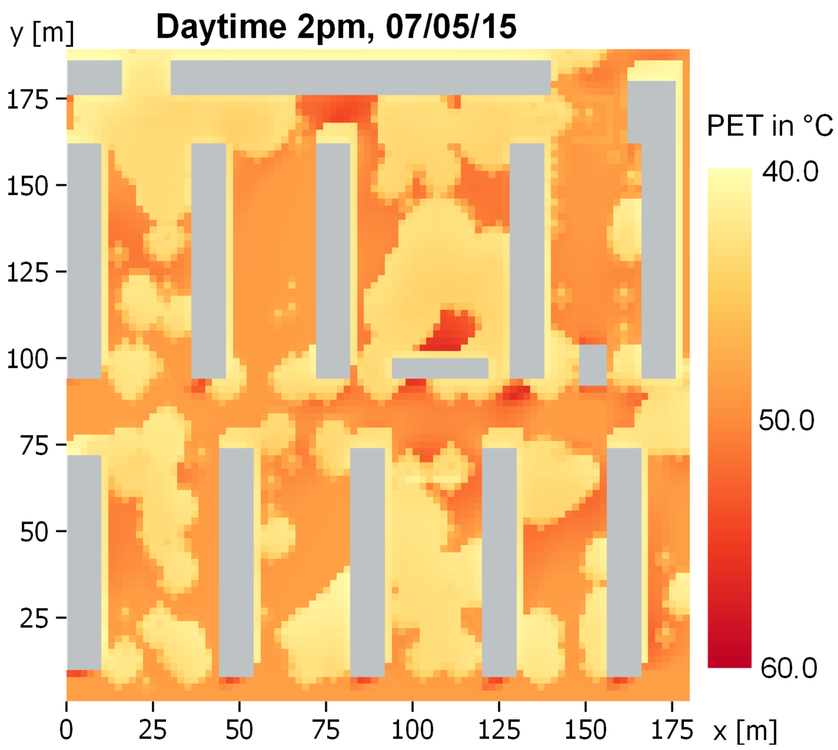
Status quo



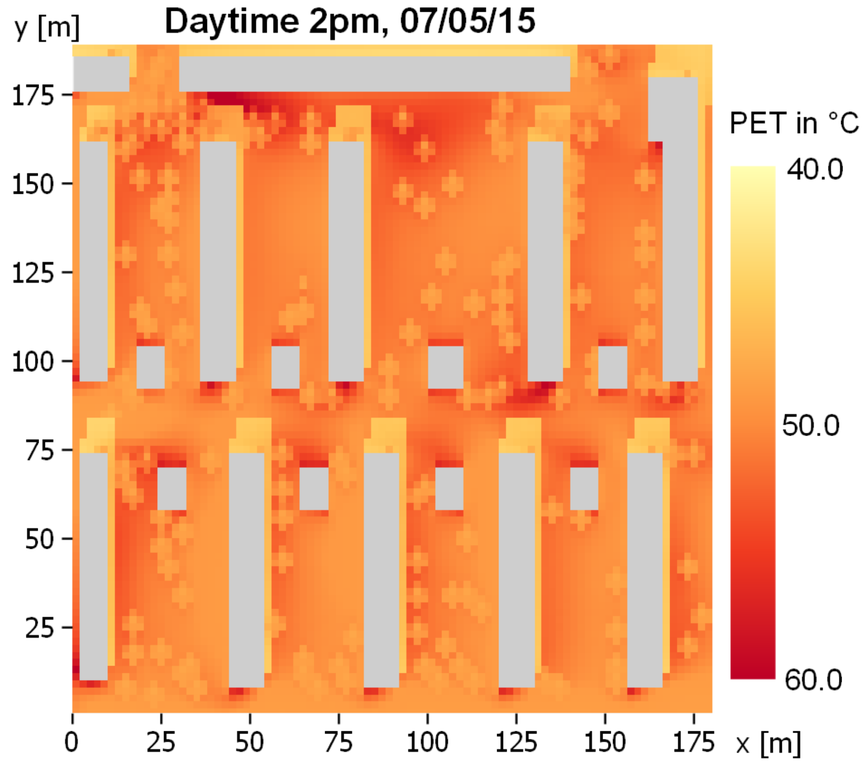
Replanted trees



Status quo



Replanted trees



=> On average 3.3°C PET hotter than status quo!

Discussion

- **Preservation of existing vegetation as most important factor reducing diurnal outdoor heat stress**
- **Tradeoffs between daytime and nighttime**
- **Closed blocks: Higher number of flats, but increase of built surface, impact on nocturnal cooling**
- **Increased shade with higher buildings, but more flats = more parking space and less amount of green**

Scena-rio	Trees	Flats*	PET 10am-4pm	PET 4am
Status Quo	158	366	44.3	18.8
O15a		+61	-0.9°C	-0.1°C
O15b	-56	+61	+1.7°C	-0.2°C
O15c	-158	+61	+5.4°C	-0.4°C
C15b	-76	+186	+1.3°C	+0.1°C
C15c	-158	+186	+5°C	-0.1°C
O18b	-56	+146	+1.3°C	-0.3°C
O18c	-158	+146	+5.2°C	-0.4°C
C18c	-158	**+297**	+4.9°C	-0.1°C

*1 flat = 90m² (average flat size according to building plans)

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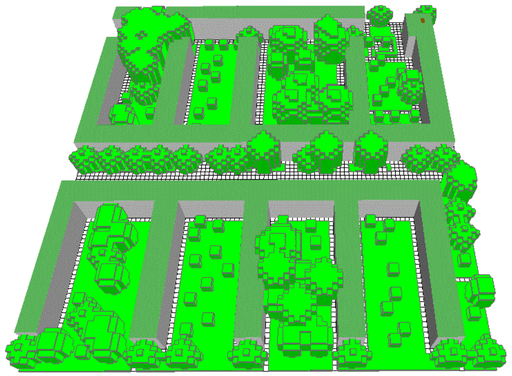
Conclusions & Outlook

Conclusions:

- Not only increasing building mass, but also side effects (eg parking space demand) threaten urban green space
- Mobility is a key factor to achieve green & dense neighbourhoods
- Densification concepts should avoid blocking cooling breezes and seek to preserve mature trees

Outlook:

- Development of scenarios with nature based solutions (eg. green roofs, green facades) to explore climate change adaptation potential of densification processes
- Coupling with indoor thermal comfort and resource efficiency assessment



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Thank you for your attention!

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