Microclimate analysis of a university campus in Norway

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Content

1. Introduction

- Why urban microclimate?
- Aim of study
- Study area

2. Methodology

- Field observations
- Numerical modeling

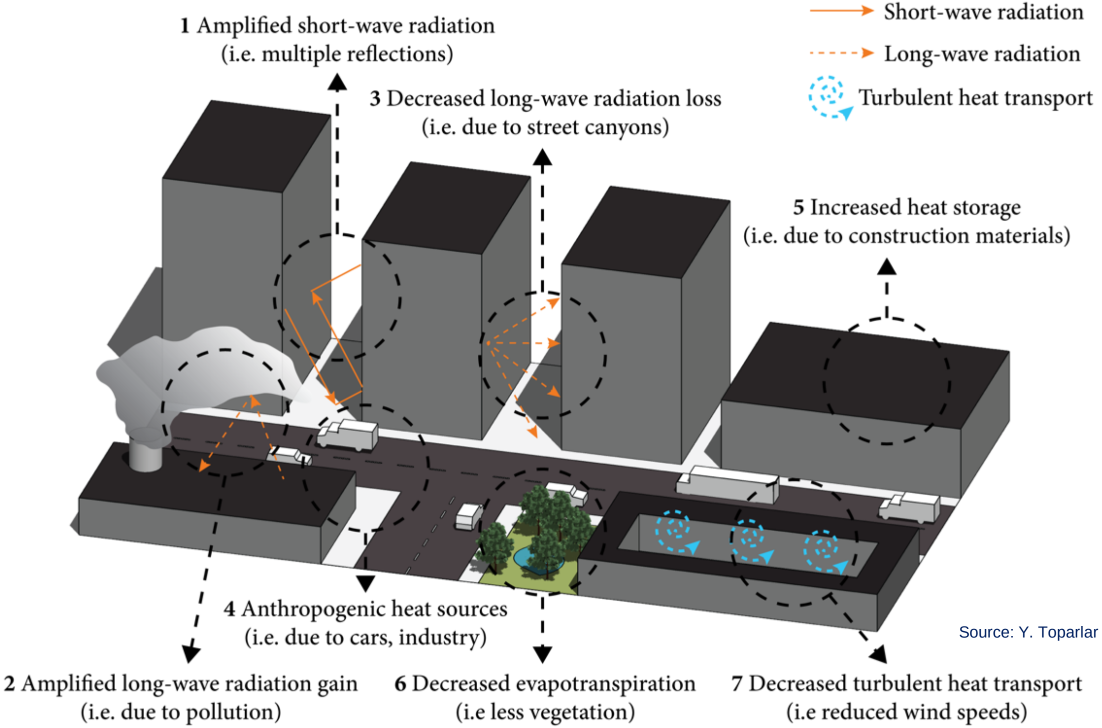
3. Results

- Microclimate analysis

4. Concluding remarks

5. Limitations & Future work

1. Introduction – Why urban microclimate?



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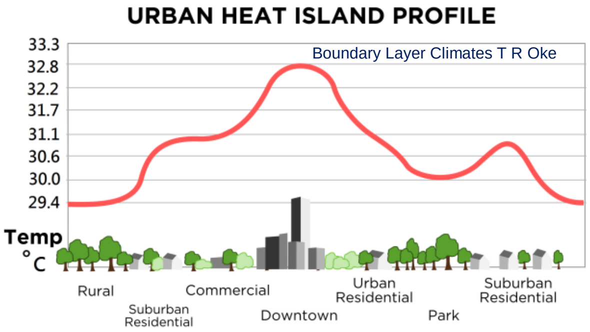

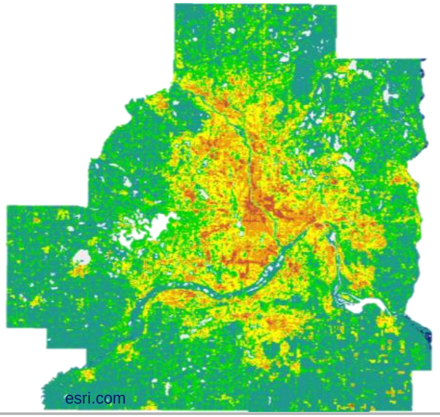

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1. Introduction – Aim of the study

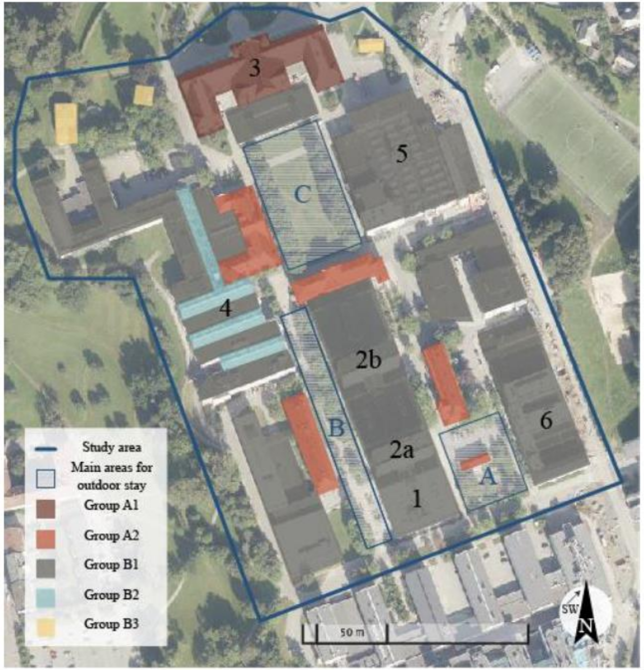
NTNU Gløshaugen campus is in the early stages of a redevelopment:

+ 90 000 m² added until 2027 and existing buildings will be refurbished.

It is part of the **Knowledge Axis** & a **Pilot project of the ZEN Centre**

- Investigate the current microclimatic conditions of a part of Gløshaugen campus
- Use numerical tool ENVI-Met and on-site measurements for its validation
- First step towards a more detailed study on how to improve microclimatic conditions over the course of the redevelopment
- Evaluation of proposed solutions with models

1. Introduction – Study area



Category	Year of construction	Wall material	Roof Material
A1	1900-1950	Stone: granite	Wood: spruce
A2	1900-1950	Solid brick	Wood: spruce
B1	1951-2000	Concrete: filled blocks	Concrete: default
B2	1951-2000	Glass: clear float	Glass: clear float
B3	1951-2000	Wood: spruce	Wood: spruce

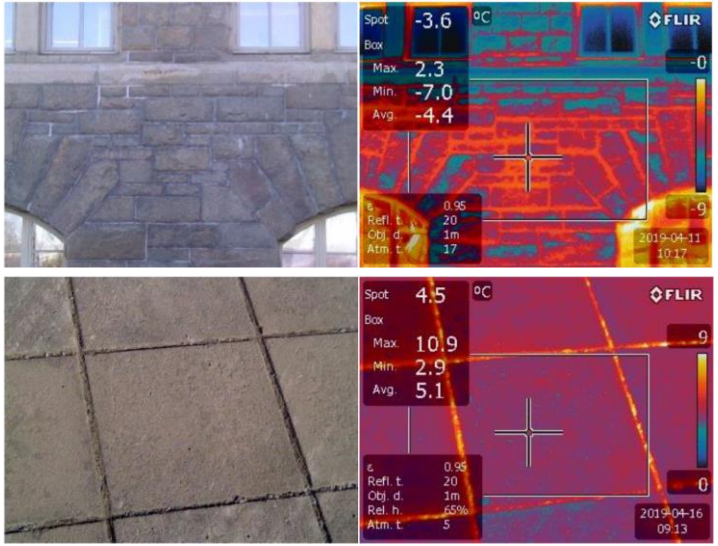
2. Methodology

Field Observations

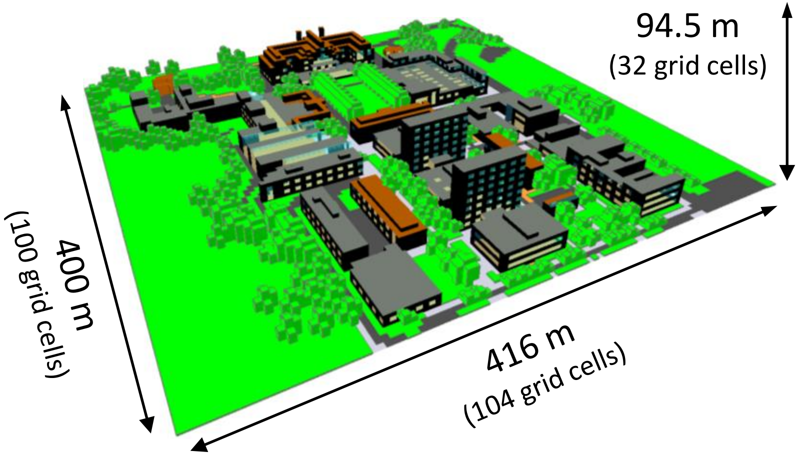
Validation

Numerical Modeling

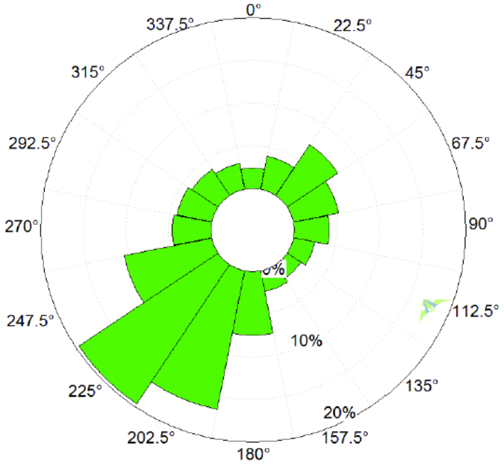
Infrared Measurements



Simulations with ENVI-Met model



3. Results – Microclimate analysis



Boundary conditions

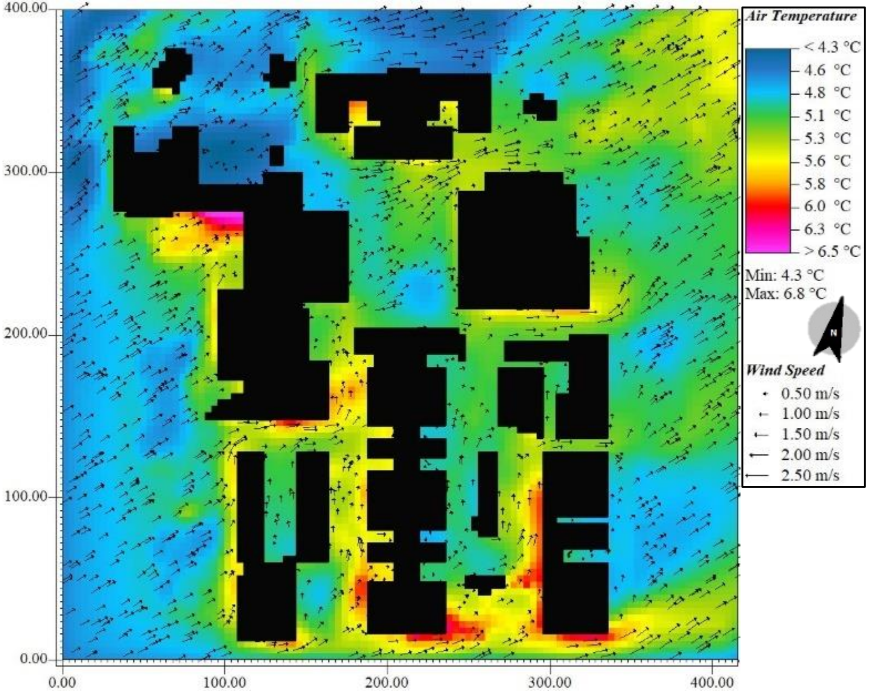
i. Simulation of winter & summer Solstice and vernal & autumnal Equinox (2018)

ii. Hourly Air Temperature T & Rel. Humidity RH values
Daily mean Wind Speed & main wind Direction

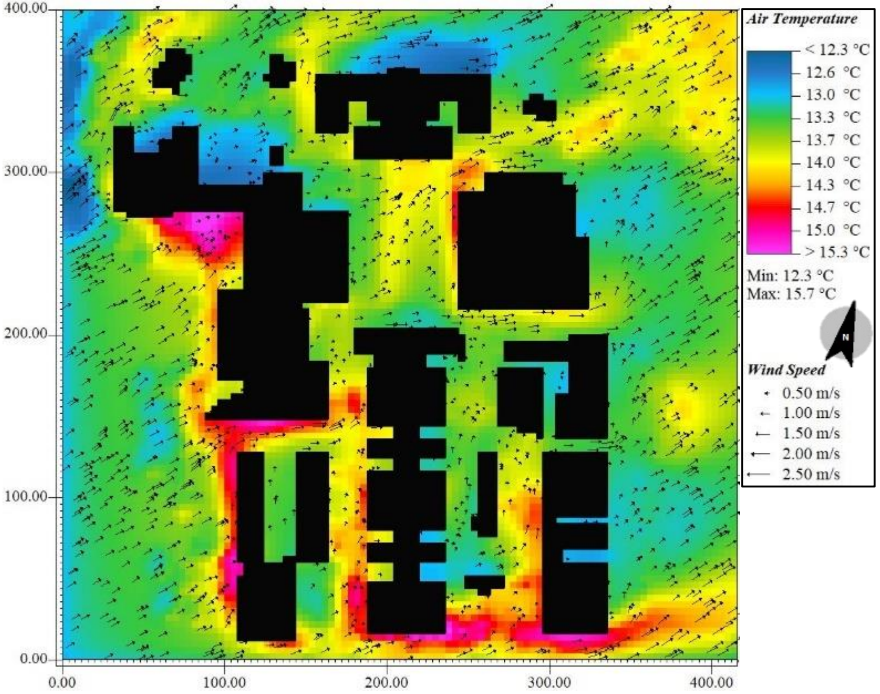
	T_{min} (LST) [°C]	T_{max} (LST) [°C]	$\bar{w}$ [m/s]	$\bar{\phi}$ [%]	t_{sr} (LST)	t_{ss} (LST)	$t_{sim,s}$ (LST)	$t_{sim,e}$ (LST)	$t_{sim,tot}$ [h]
21.03.	2.6 (05:00)	4.2 (16:00)	1.7	85.1	06:17	18:35	06:00	19:00	13.0
21.06.	8.3 (06:00)	12.2 (18:00)	1.8	73.5	03:02	23:37	03:00	24:00	21.0
23.09.	5.5 (19:00)	8.0 (15:00)	2.5	77.7	07:03	19:16	07:00	20:00	13.0
21.12.	0.2 (06:00)	0.9 (12:00)	2.6	55.0	10:01	14:31	06:00	15:00	9.0

3. Results – Microclimate analysis- Simulated values of Tair

21 March 12:00

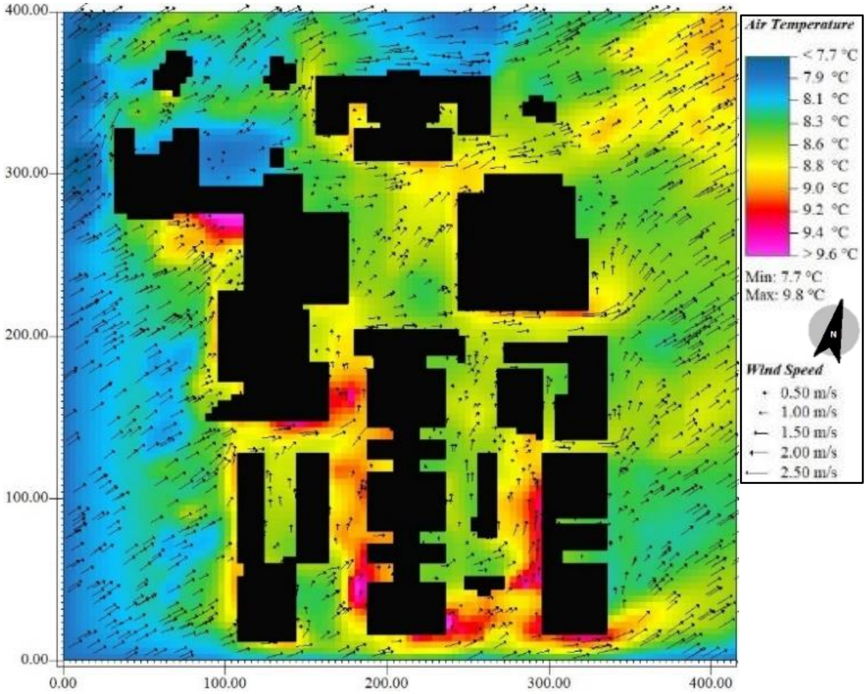


21 June 12:00

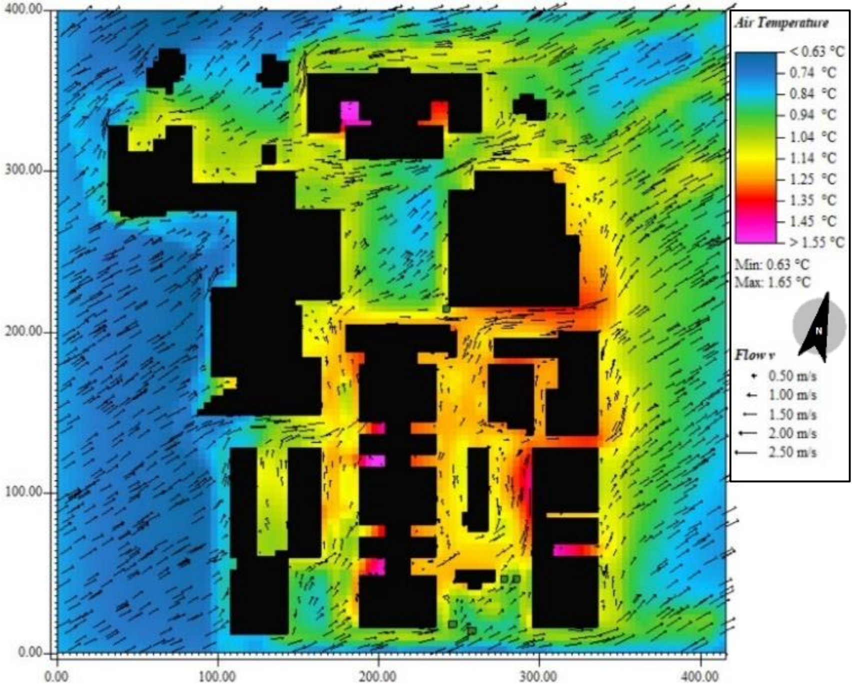


3. Results – Microclimate analysis- Simulated values of Tair

23 September 12:00



21 December 12:00



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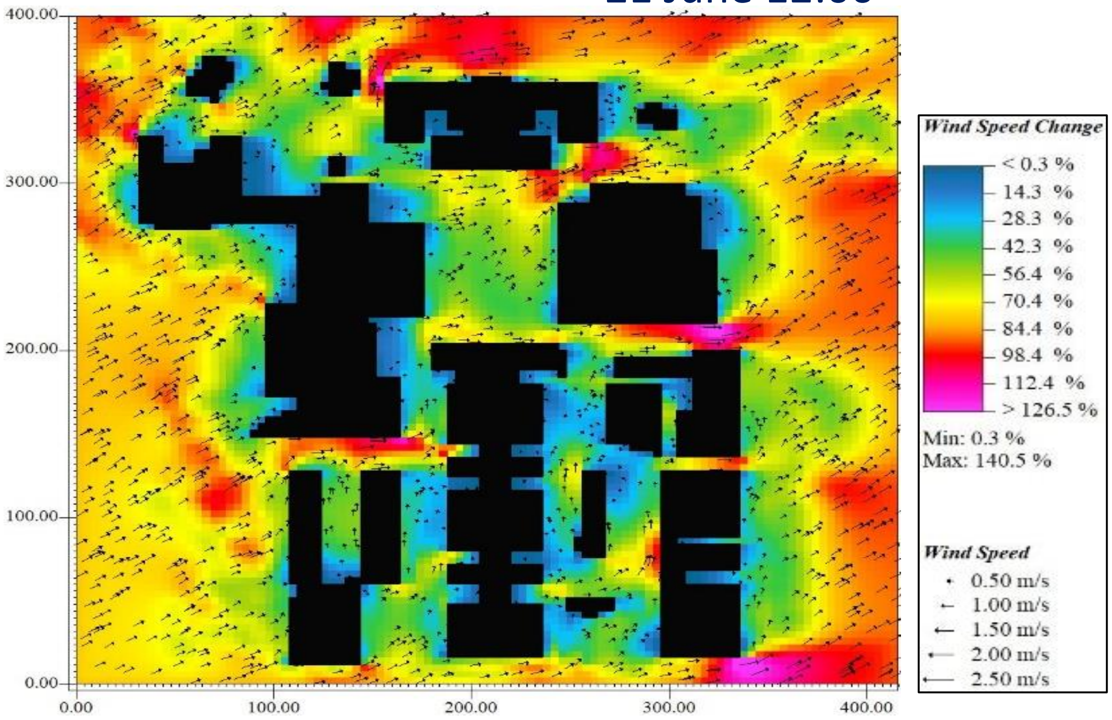
3. Results – Microclimate analysis-Wind Field

21 June 12:00

Wind speed change:
% referring to the undisturbed inflow profile at the same height level



4. Concluding remarks

- The simulated air temperatures largely correlate to the different surface types
  - ➢ Materials with high heat storage capacity present higher air temperatures than the vegetated areas
  - ➢ Areas in front of south-facing and sunlit surfaces present elevated local air temperatures
- On 21 December (almost no solar radiation and low sun angles) larger influence of materials
- Highest local difference in air temperature occurred on 21 June with 3.4 K, lowest on 21 December with 1.0 K
- East-west passages were identified to have highest local wind speeds (up to 57.1 % more than reference)

5. Limitations & Future work

Envi-met model limitations

- The program does not allow for a detailed representation of the environment (limitations in grid resolution & structure)
- Only basic CFD capabilities in ENVI-Met
- ENVI-met software is designed to model urban heat stress usually dealing with above freezing temperatures. ENVI-met is also as of now an exclusively dry model. This means precipitation is not modelled in any form within the software.

Future steps: More detailed study with several weather stations around the campus & „real“ CFD with finer discretisation