URBAN METEOROLOGY AND THE IMPACT OF URBAN PLANNING

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HELSUS
HELSINKI INSTITUTE OF SUSTAINABILITY SCIENCE

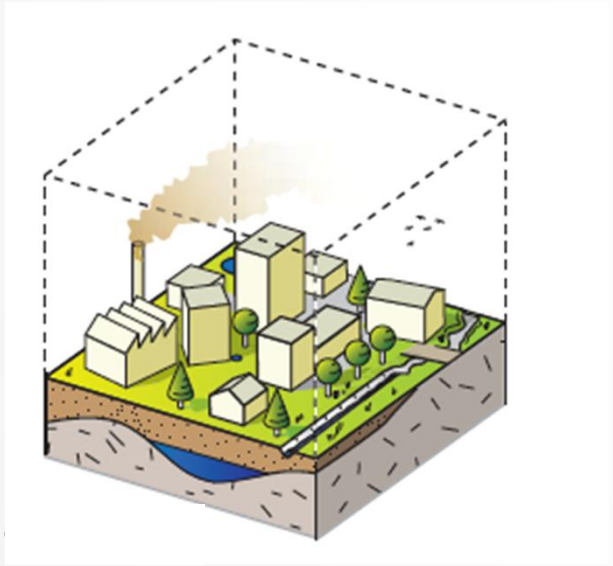
CONTENT

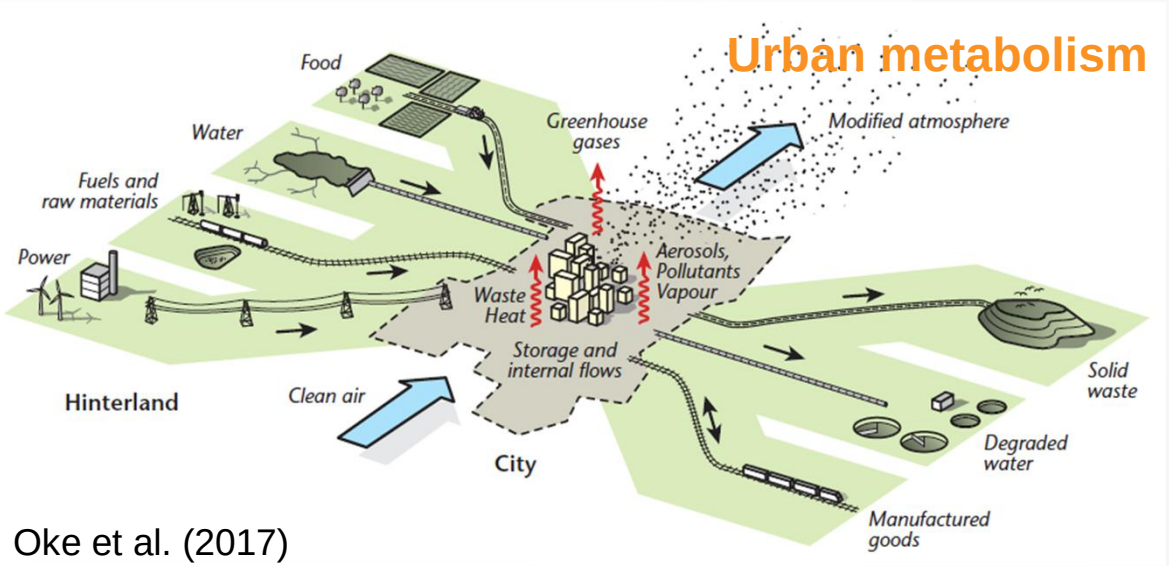
- What is urban meteorology?
- How the interaction between urban surface and atmosphere can be measured?
- Computational fluid dynamics to be used in urban meteorology research
- Examples on how urban meteorology research can support urban planning

Oke et al. (2017)

WHAT IS URBAN METEOROLOGY?

- Urban area is in constant interaction with the atmosphere
- This interaction depends on **urban form** and **function** which is directly connected to urban metabolism (i.e. flows and transformation of materials and energy in a city)

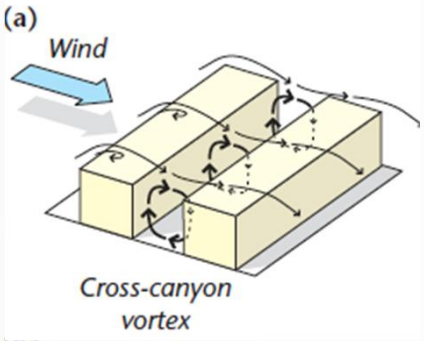




Oke et al. (2017)

EXAMPLES ON THE EFFECT OF URBAN SURFACE ON ATMOSPHERE

Urban form	Urban function
Friction to the air flow	Emissions of greenhouse gas emissions (CO_2 the most important)
Decreased evaporation	Air pollutant emissions (gases, aerosol particles)
Increased heat emissions	Increased heat emissions

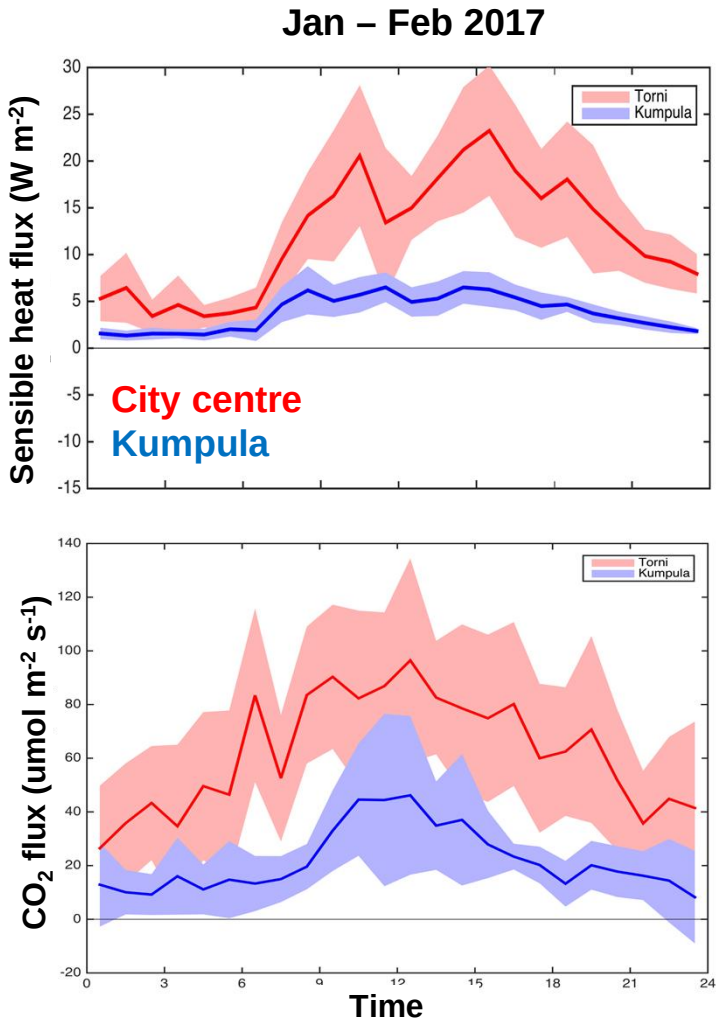


DIRECT MEASUREMENTS OF INTERACTIONS IN HELSINKI

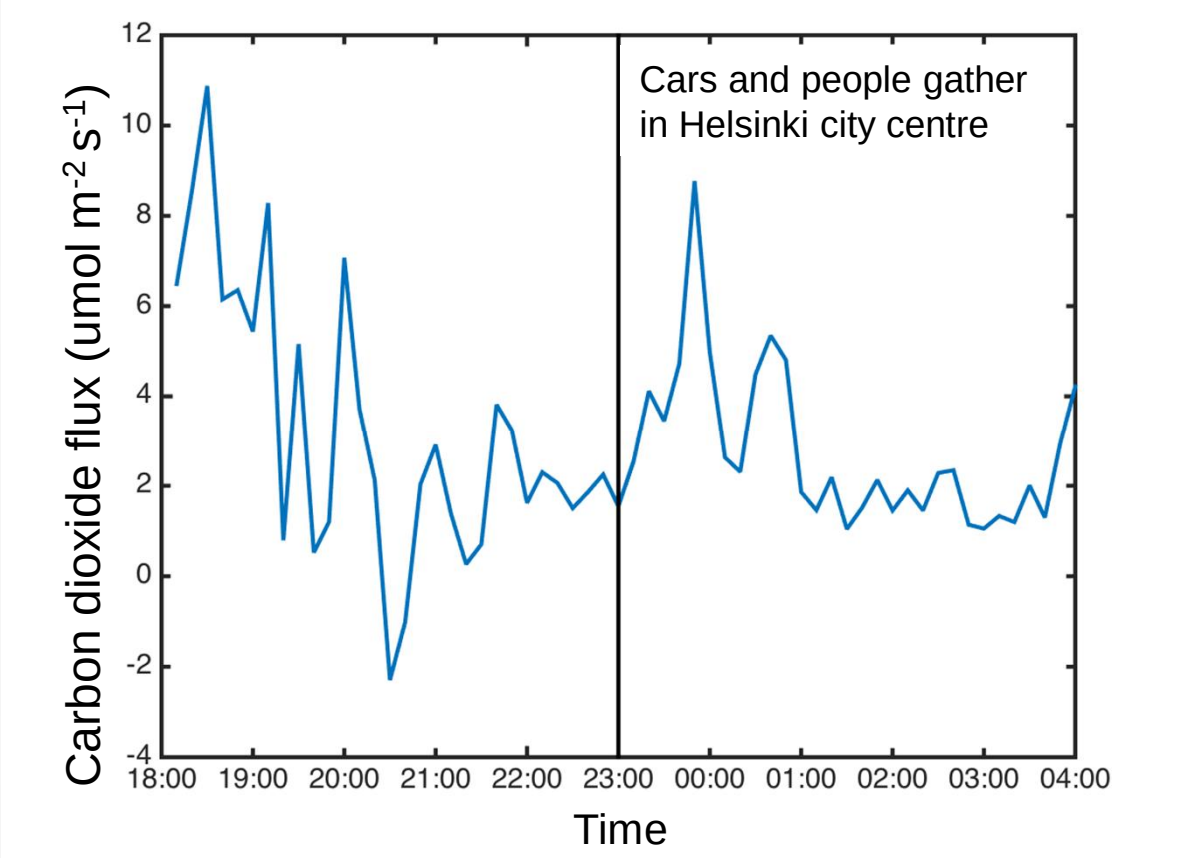
- Micrometeorological measurement of energy, mass and momentum carried out by turbulence (i.e. flux per area per time unit)

Kumpula since 2005

City centre since 2010

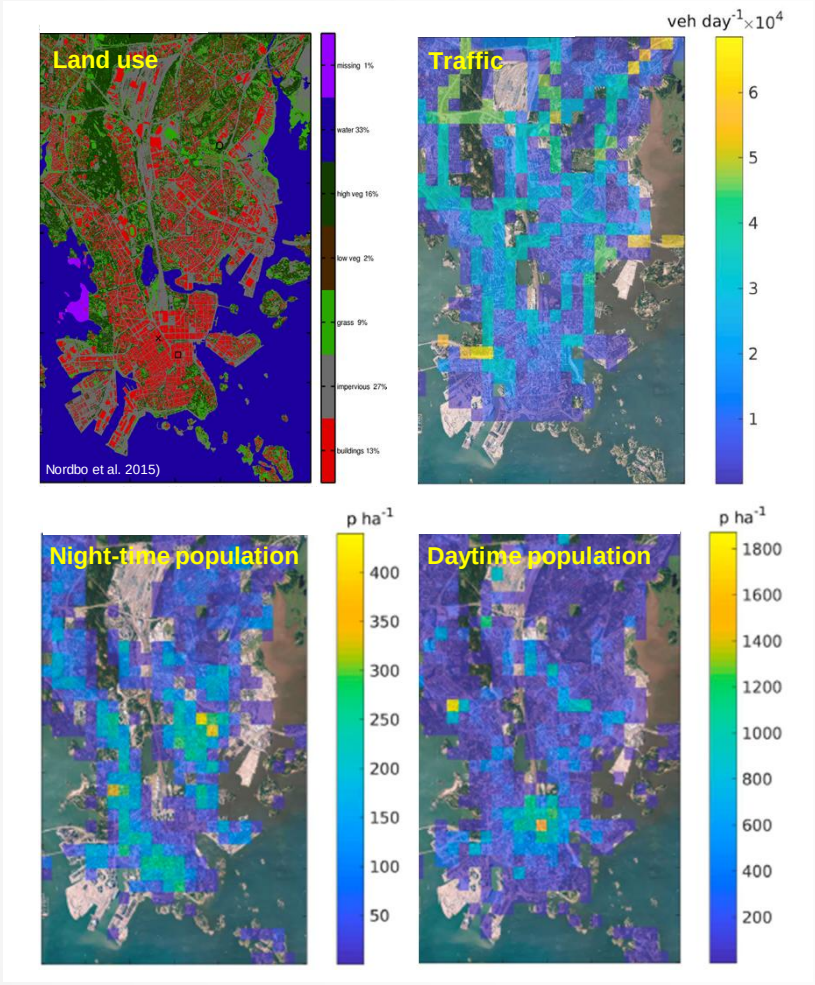


DIRECT INFORMATION ON PEOPLE'S ACTIVITY

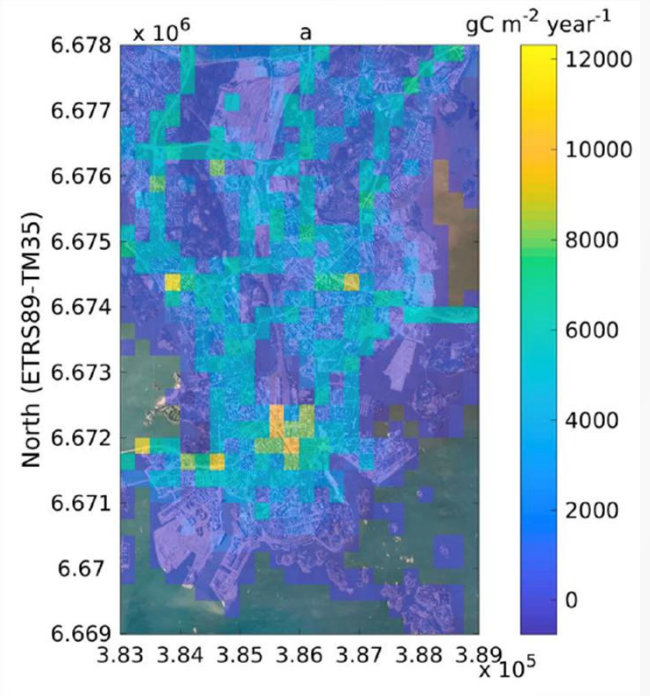


Celebrations of Finland winning the ice hockey world championship in city centre in 15.-16.5.2011

SPATIAL LOCAL-SCALE CO_2 EMISSIONS IN HELSINKI IN 2012



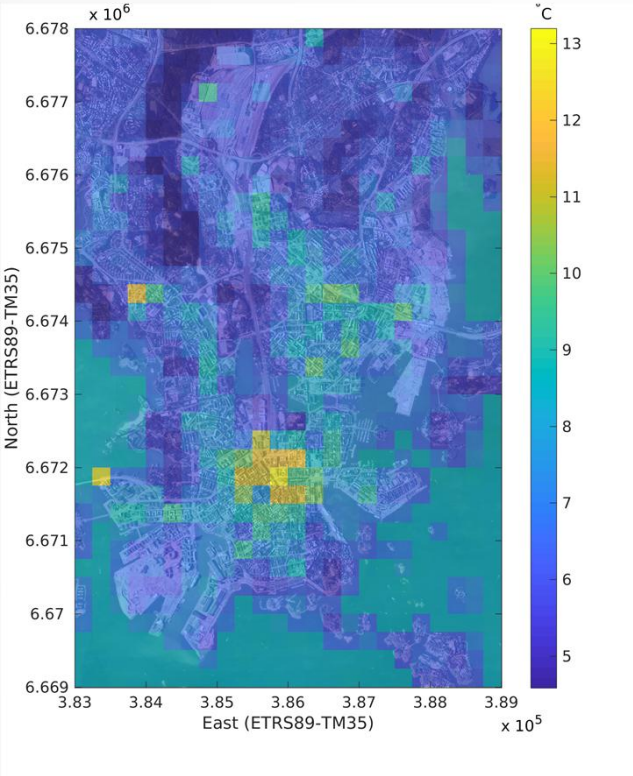
- Emissions: Traffic, human metabolism, domestic energy use, soil & vegetation respiration
- Sinks: vegetation uptake
- Data from open databases
- For population, mobility from/to each 250 m x 250 m grid (Digital Geography Lab, UHEL)



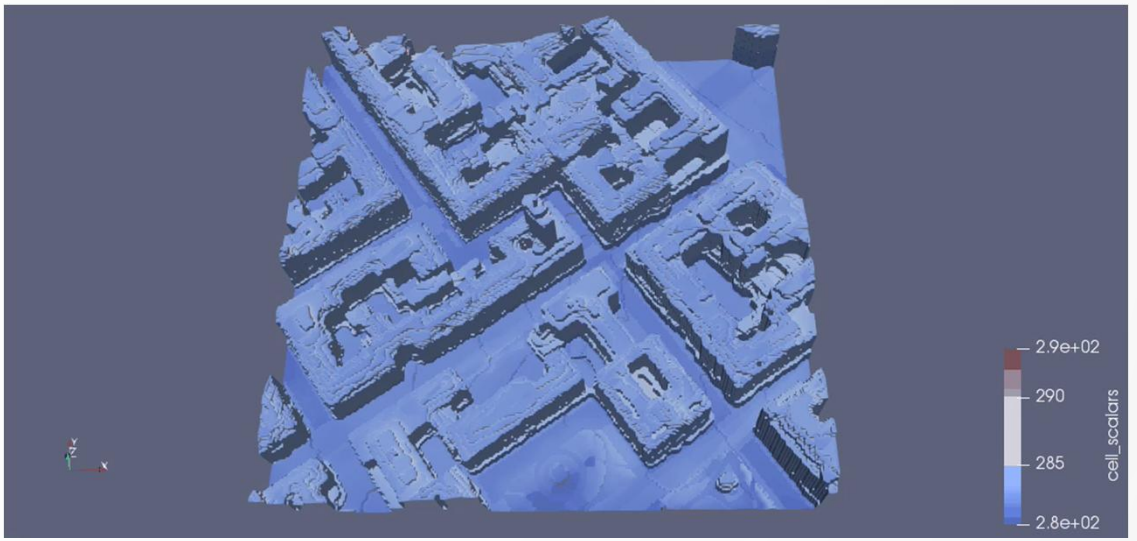
Järvi et al. 2019

RADIATION, HEAT EMISSIONS AND URBAN FORM DETERMINE FORMATION OF URBAN HEAT ISLAND

2 m air temperature in 2012



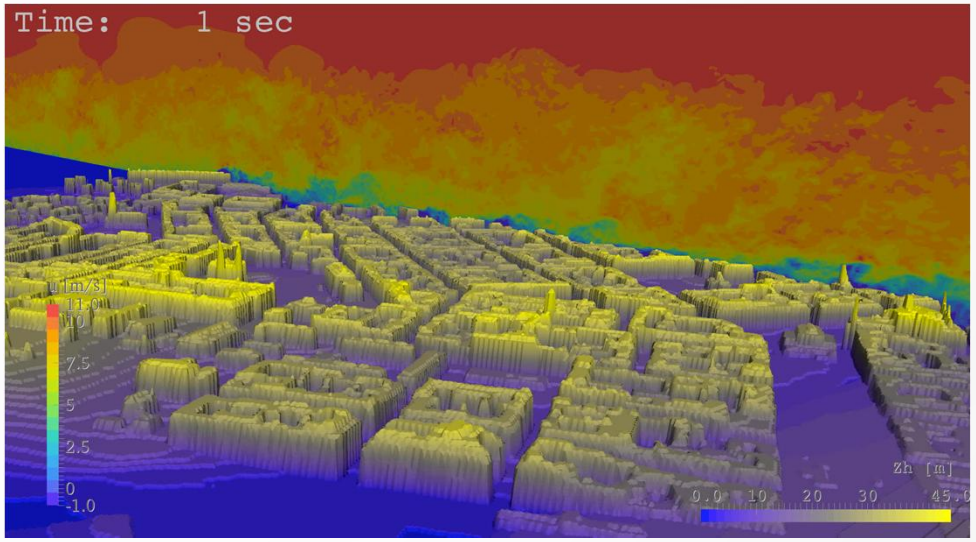
Surface temperature on June 2017 (2 h)



By Jani Strömberg

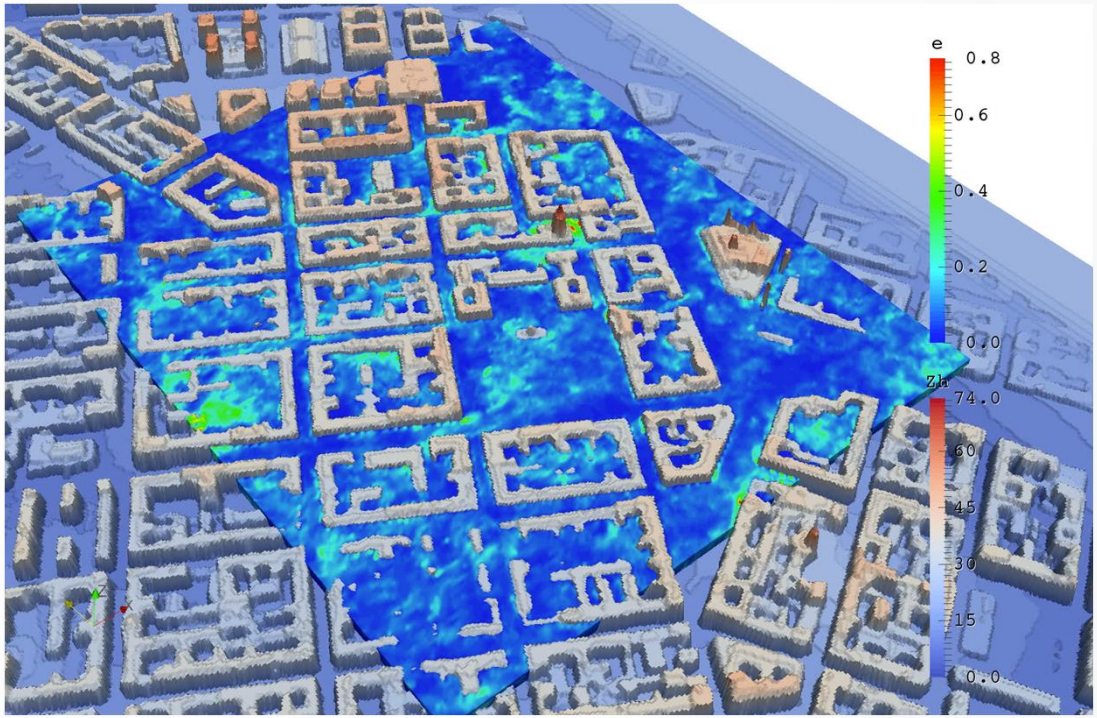
COMPUTATIONAL FLUID DYNAMICS USED IN URBAN MET RESEARCH

- Large eddy simulation (LES) can solve 3D flow above urban landscapes
- LES model PALM model (Maronga et al. 2019) particularly designed for urban areas
  - < 1 m spatial resolution
  - Parallelized
  - Nesting capability
  - Permeable vegetation
  - Aerosol dynamics



By Mikko Auvinen

TURBULENT KINETIC ENERGY IN CENTRAL HELSINKI



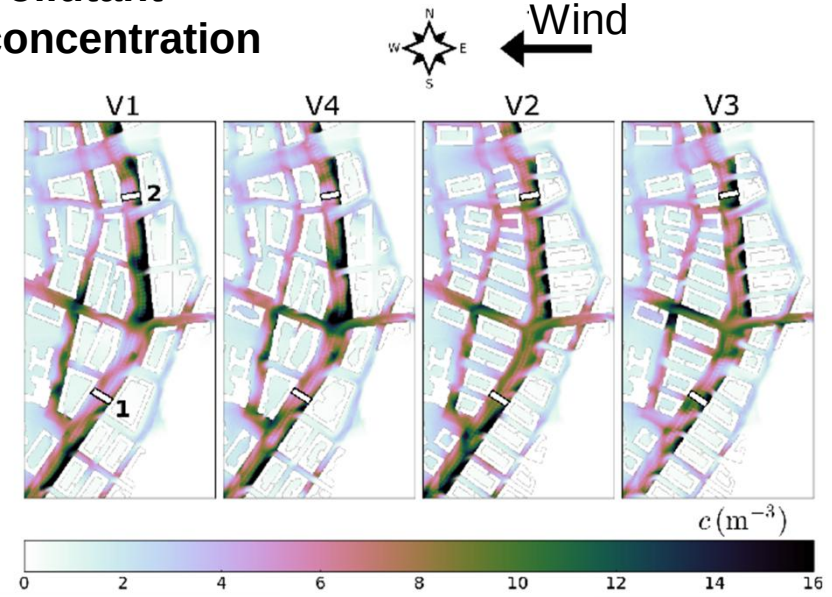
By Mikko Auvinen

Meteorology (i.e flow) + emissions + aerosol processes determine the local air pollutant concentrations!

HOW DIFFERENT BUILDING BLOCK LAYOUTS MODIFY LOCAL POLLUTANT CONCENTRATIONS?

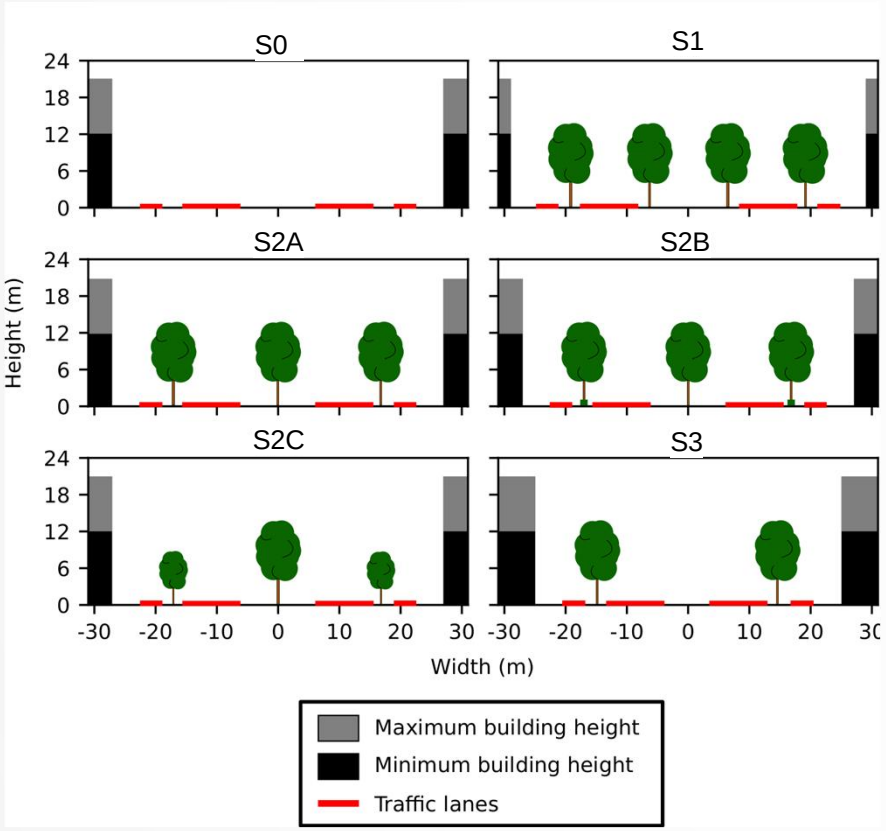
Improvement up to 10%

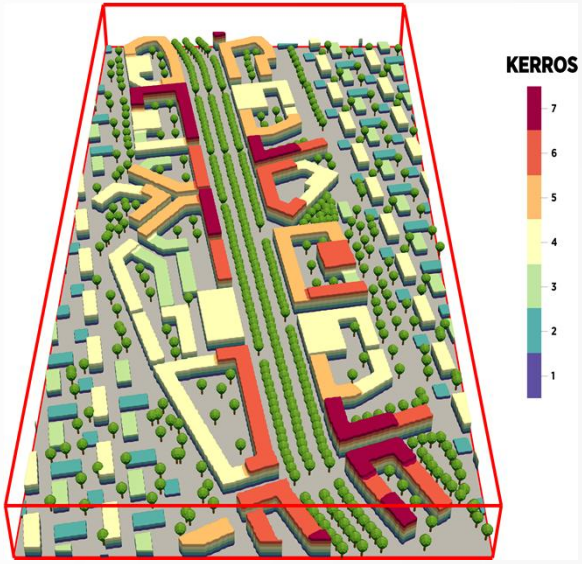
Pollutant concentration

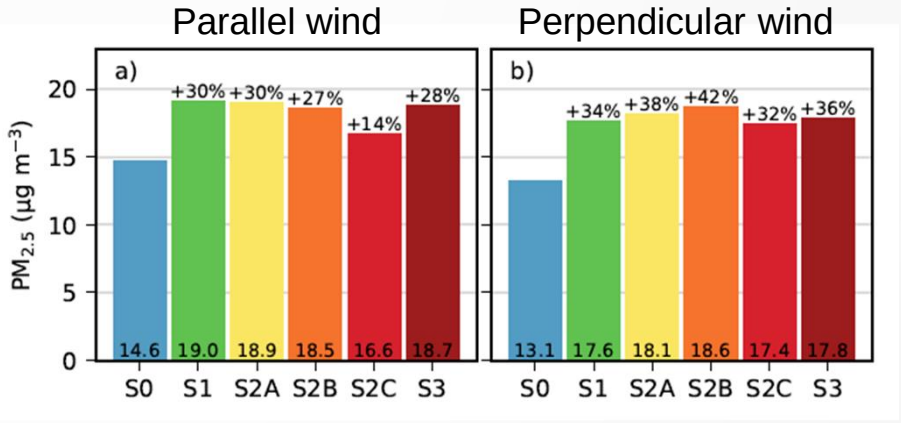


Kurppa et al. 2018

GOOD – BAD URBAN VEGETATION

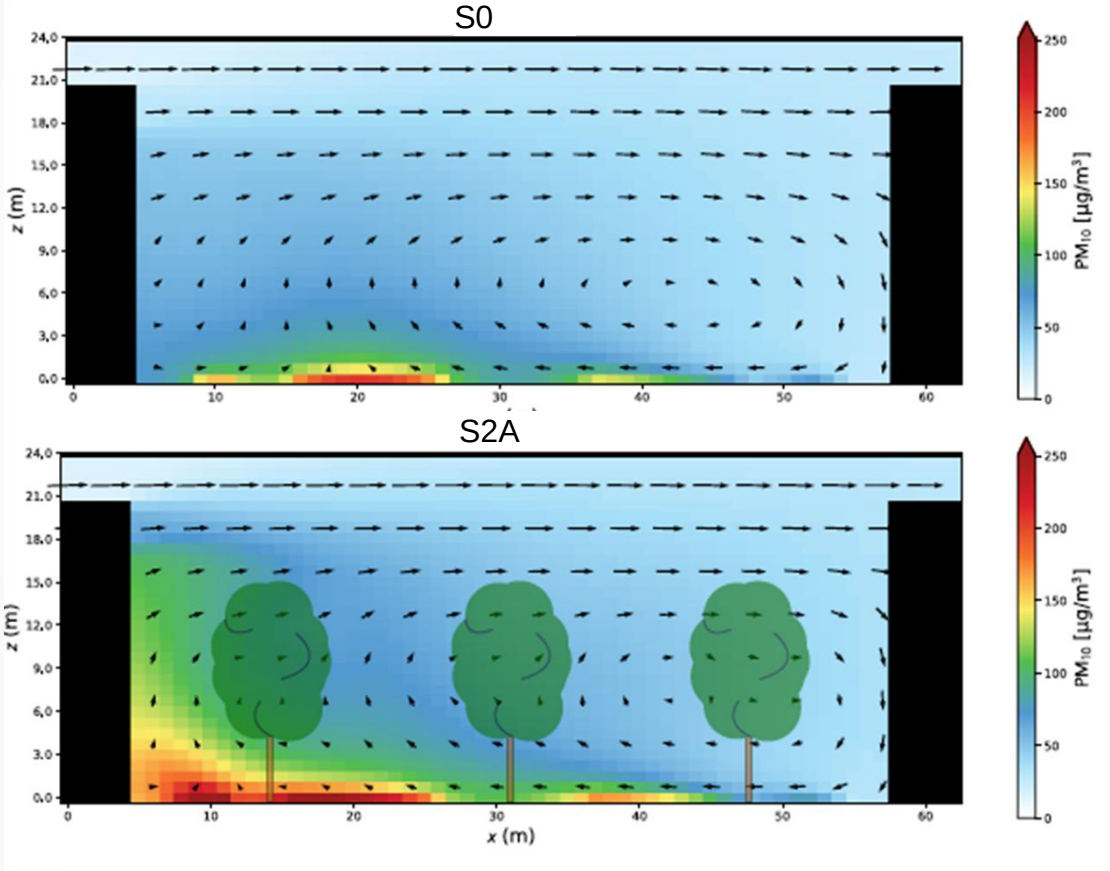






By Sasu Karttunen

AERODYNAMIC EFFECT GREATER THAN DRY DEPOSITION



By Sasu Karttunen

CONCLUSIONS

- Urban meteorology results from the interaction between urban surface and the atmosphere
- Increased pollutant and GHG emissions
- Interaction can be measured using micrometeorological techniques
- We get information on people's movements
- CFD modelling can resolve many of the urban specific atmospheric features
- Can be used in urban planning

THANK YOU!

HTTPS://WWW.HELSINKI.FI/EN/RESEARCHGROUPS/URBAN-METEOROLOGY

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