Aarhus University
Department of Environmental Science

Extending the application range of the parameterised street canyon model OSPM

- general air pollution trends in Denmark

Matthias Ketzel, Christopher Andersen, Jibran Khan, Steen Solvang Jensen

Department of Environmental Science, Aarhus University, Denmark

Outine

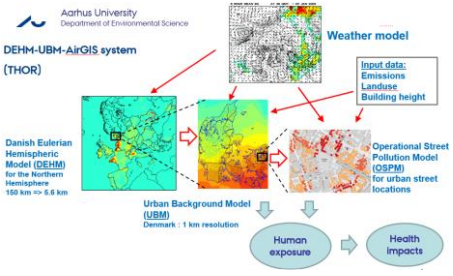
Intro, the Danish Air Pollution Modelling System

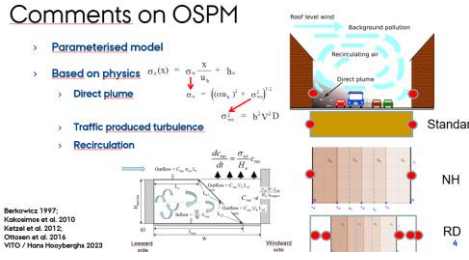
Comments on improving OSPM's dispersion "core"

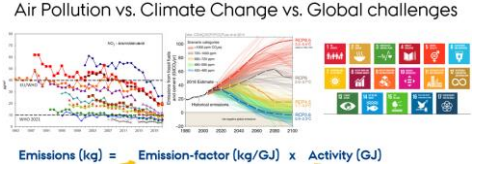
Improving OSPM results

- New detailed traffic counts
- Observed trends in Danish air pollution levels
- Validation

Conclusions / Outlook

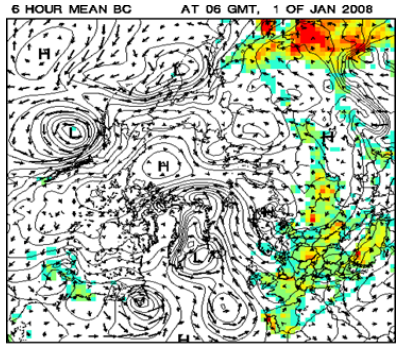






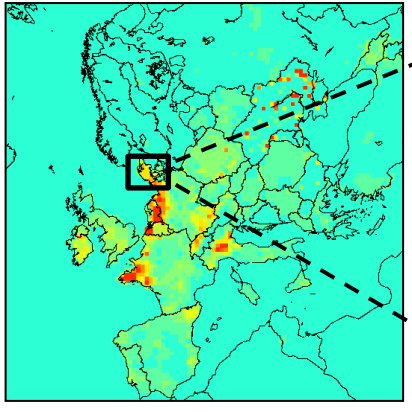
Aarhus University
Department of Environmental Science

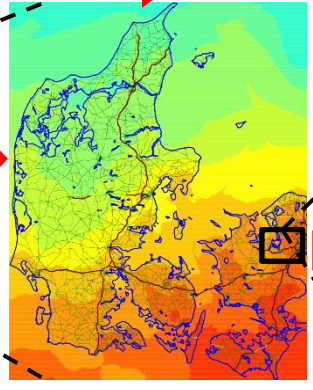
DEHM-UBM-AirGIS system (THOR)



Weather model

Input data:
Emissions
Landuse
Building height





Danish Eulerian Hemispheric Model (DEHM)
for the Northern Hemisphere
150 km => 5.6 km

Operational Street Pollution Model (OSPM)
for urban street locations

Urban Background Model (UBM)
Denmark : 1 km resolution

Human exposure → Health impacts

Comments on OSPM

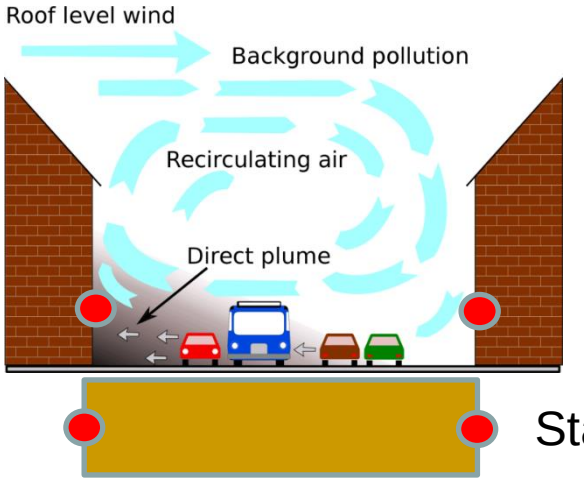
- **Parameterised model**
- **Based on physics**
  - **Direct plume**

$$\sigma_z(x) = \sigma_w \frac{x}{u_b} + h_o$$

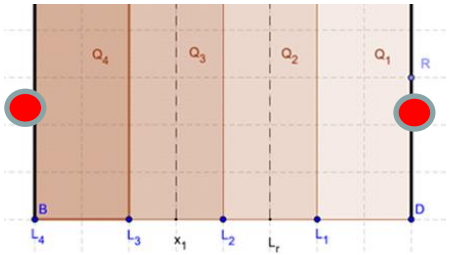
$$\sigma_w = \left((\alpha u_b)^2 + \sigma_{wo}^2\right)^{1/2}$$

$$\sigma_{wo}^2 = b^2 V^2 D$$

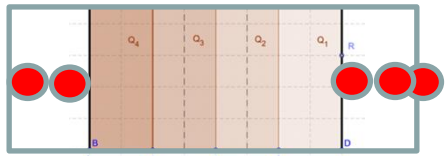
  - **Traffic produced turbulence**
  - **Recirculation**



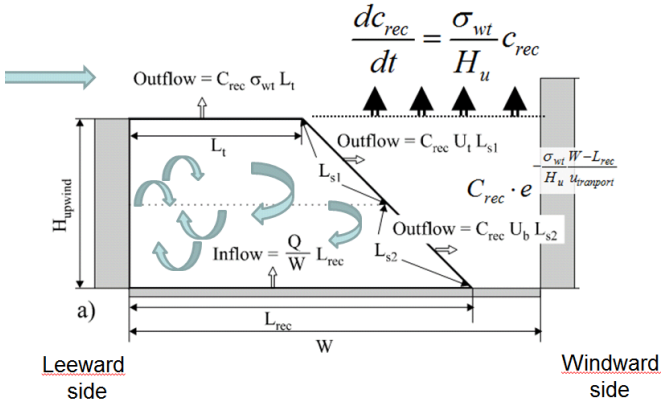
Standard



NH



RD



Berkowicz 1997;
Kakosimos et al. 2010
Ketzel et al. 2012;
Ottosen et al. 2016
VITO / Hans Hooyberghs 2023

Comments on extending OSPM

Project with VITO (earlier talk by Hans) + own work on HCAB

Non-homogeneous emissions (NH)

Variable receptor distance (RD)

=> some improvement in model performance vs. lots of manual work

=> keep the balance 

Other probably more relevant factors - improve input data:

=> urban background conc. as input for OSPM

(later talk by Christopher)

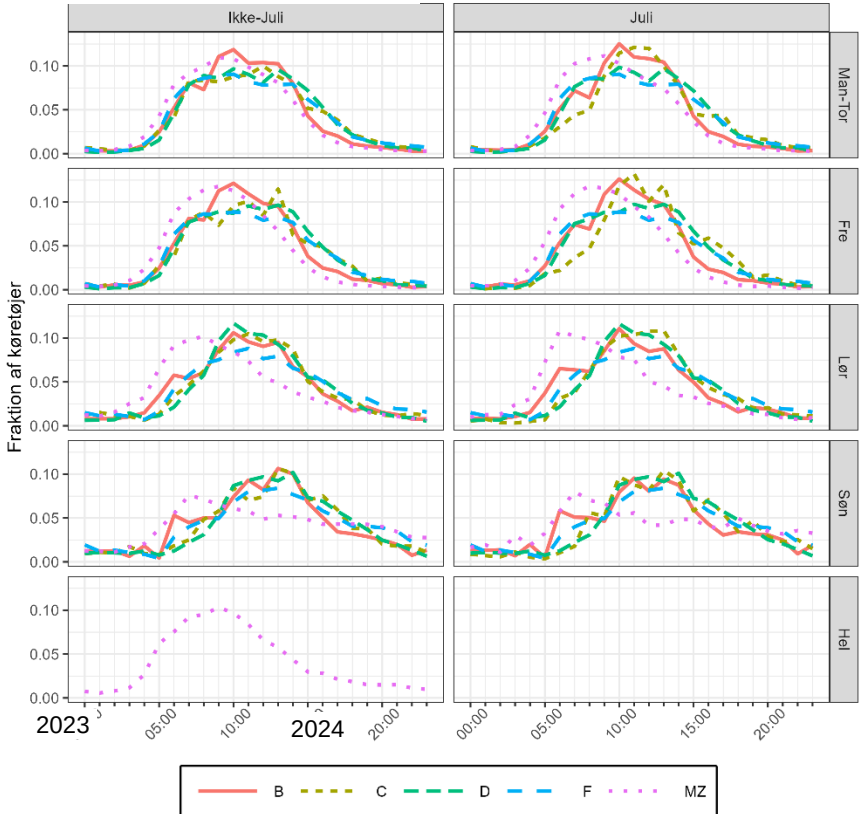
=> detailed local emission based on 1 year of traffic counts

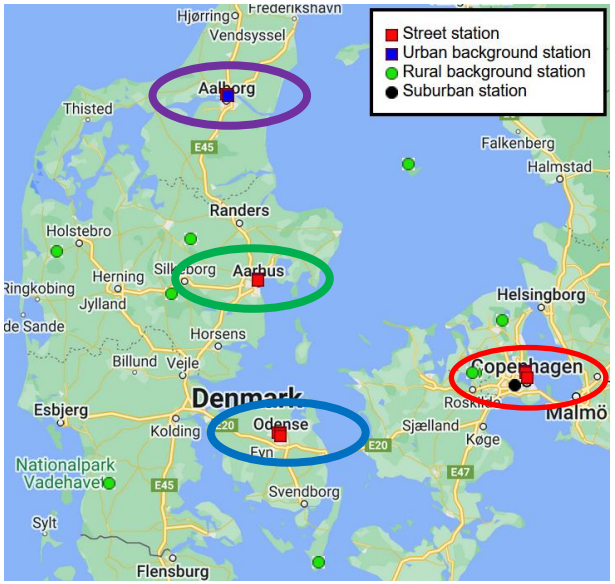
(new traffic variation / new local share of electric vehicles)

Detailed traffic counts

One year 5-2023 / 5-2024

Trucks > 32 t





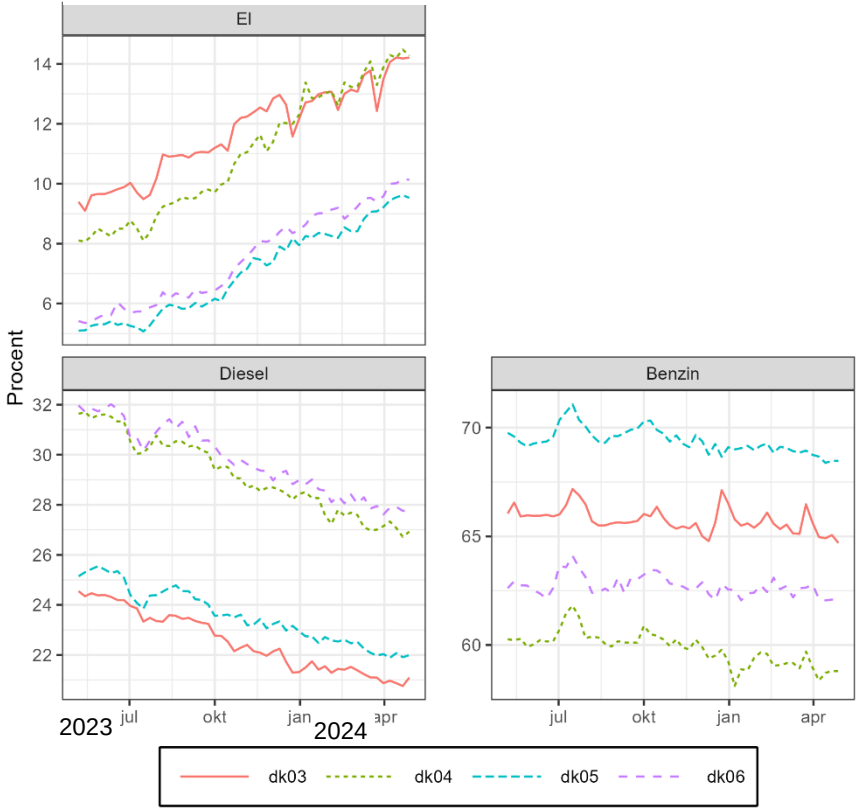
Number plate reading
Low emission zone in four cities
About 300.000 records per day
All relevant data from national vehicle registry
=> Vehicle type, age, fuel, EURO class, ….

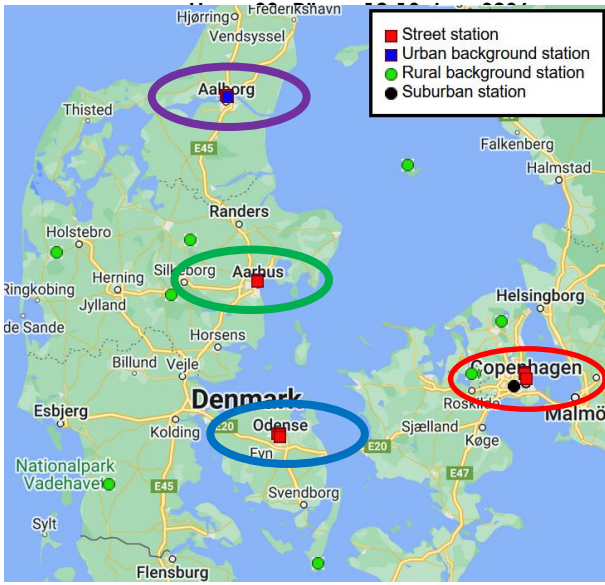
Aarhus University
Department of Environmental Science

Detailed traffic counts

One year 5-2023 / 5-2024

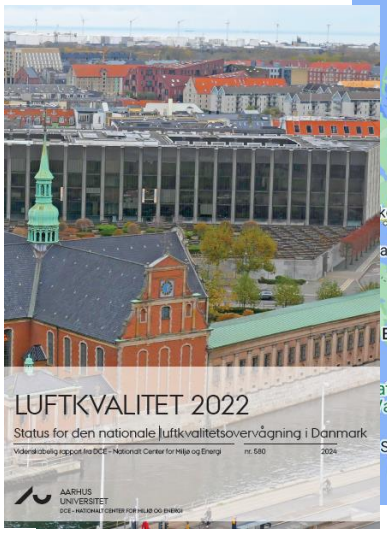
Cars

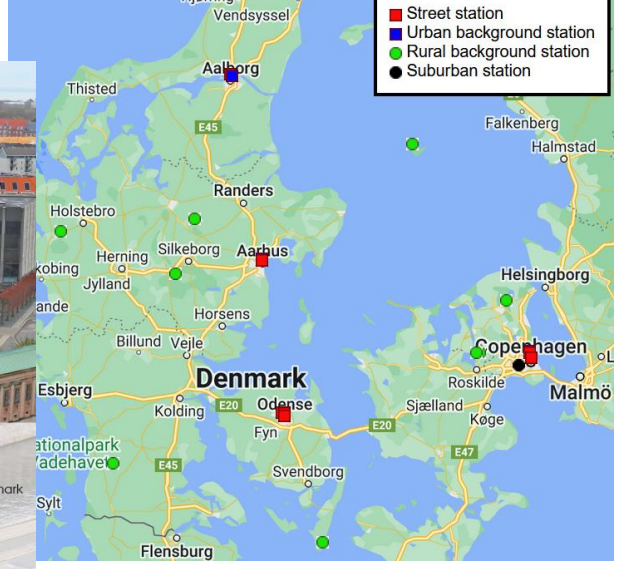


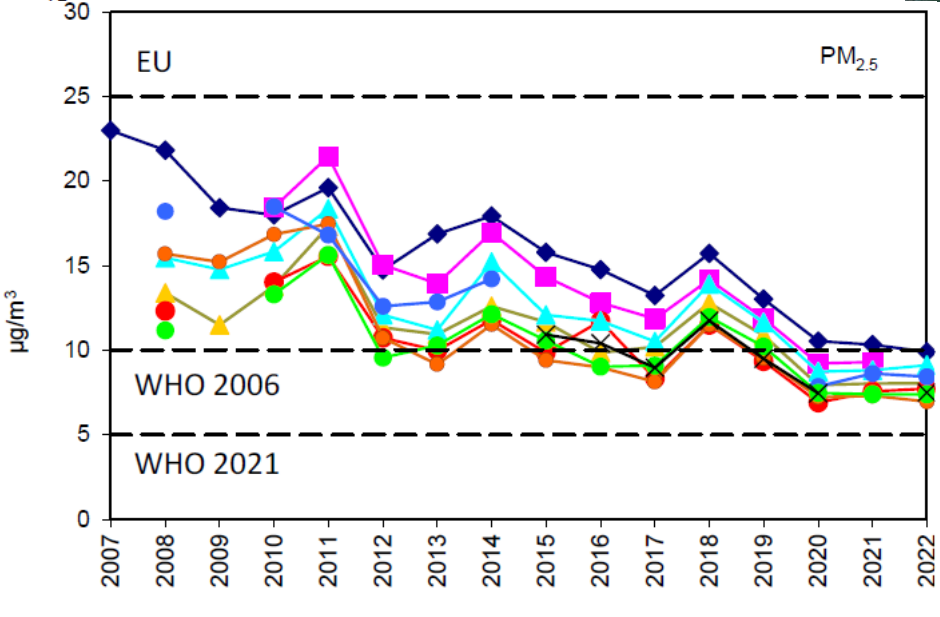


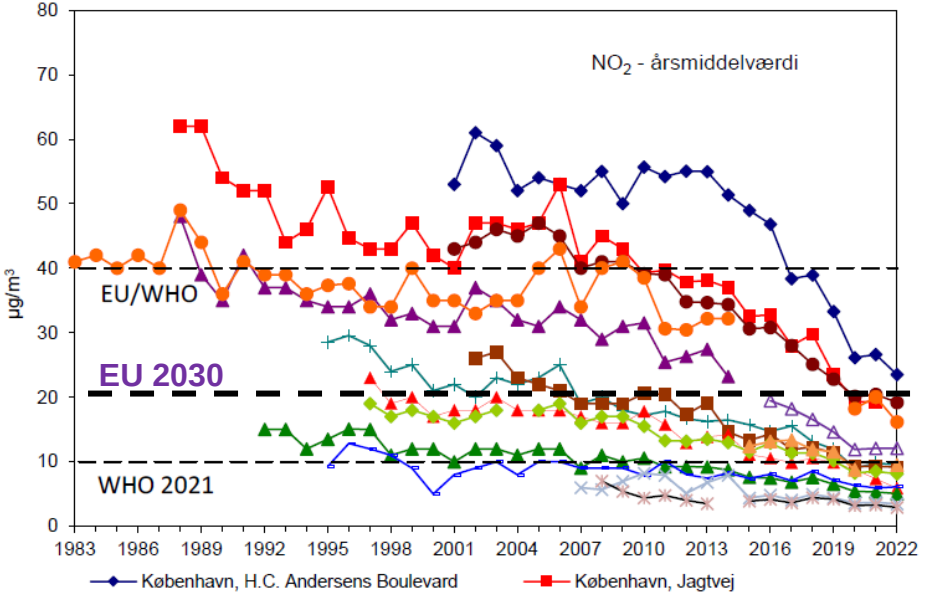
Aarhus University
Department of Environmental Science

Measurements in DK used for validation



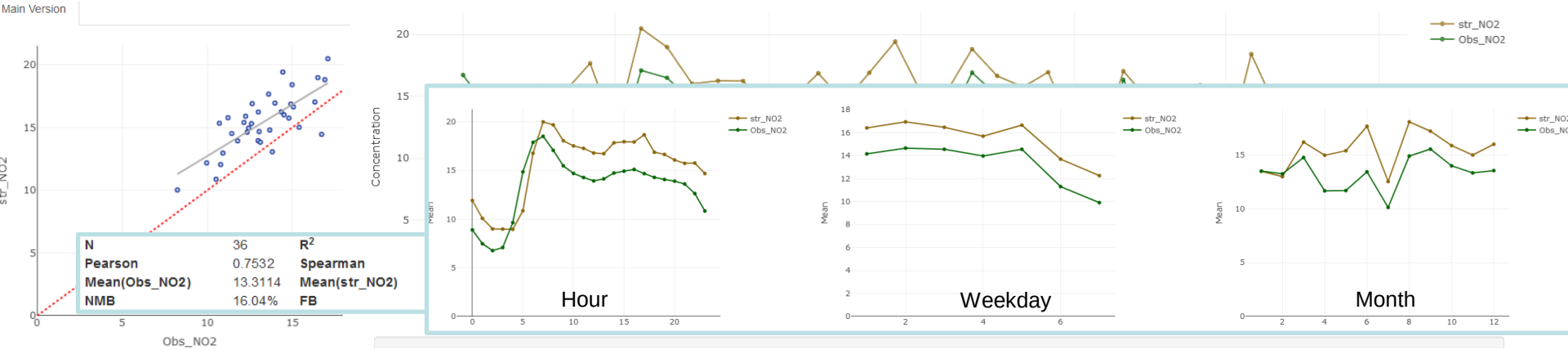




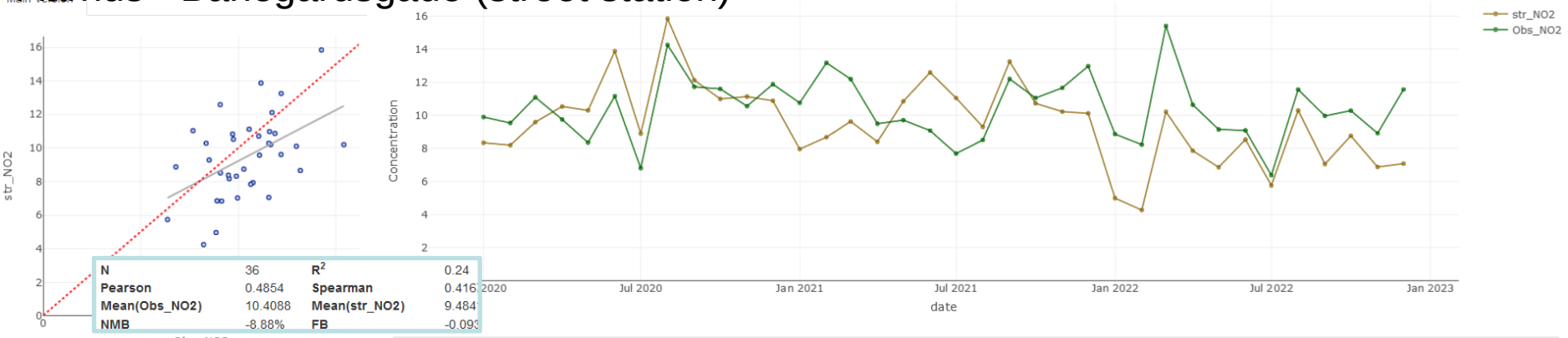


Evaluation examples: NO_2 data (monthly)

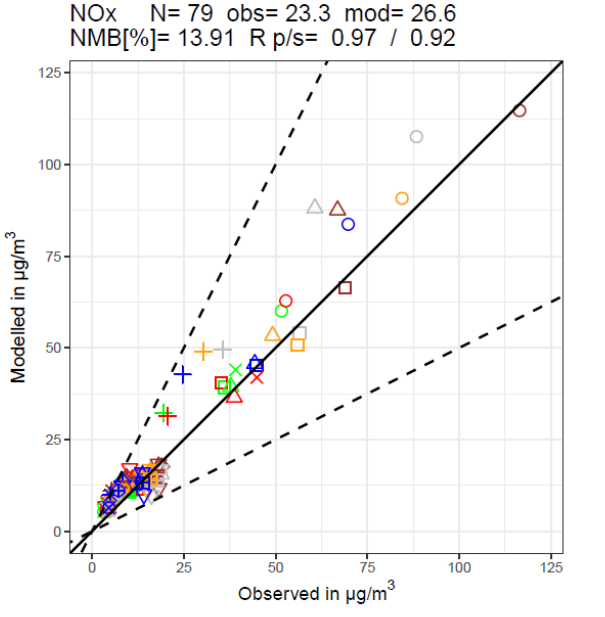
Copenhagen – H.C. Andersens Boulevard (street station)

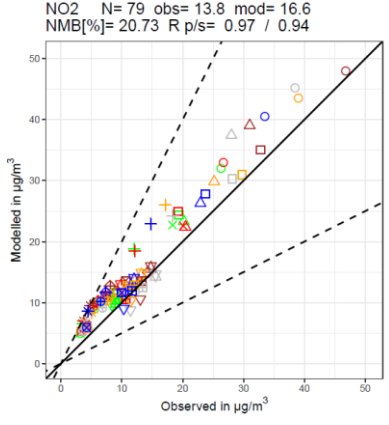


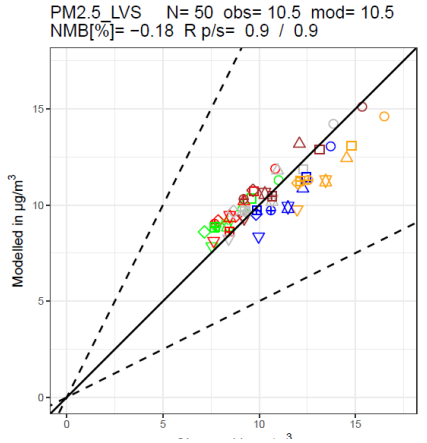
Aarhus - Banegårdsgade (street station)

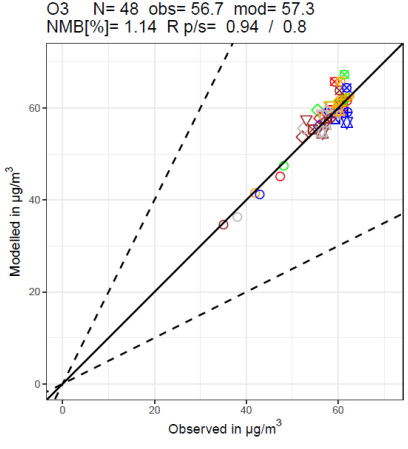


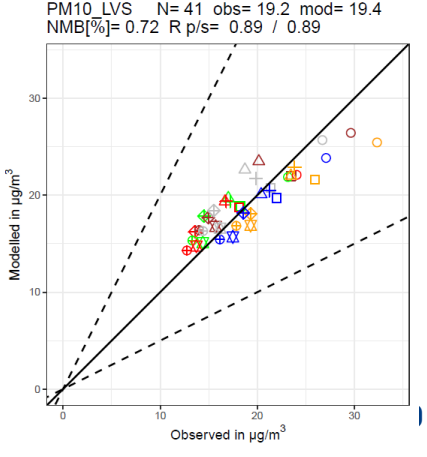
"Global statistics" space & time







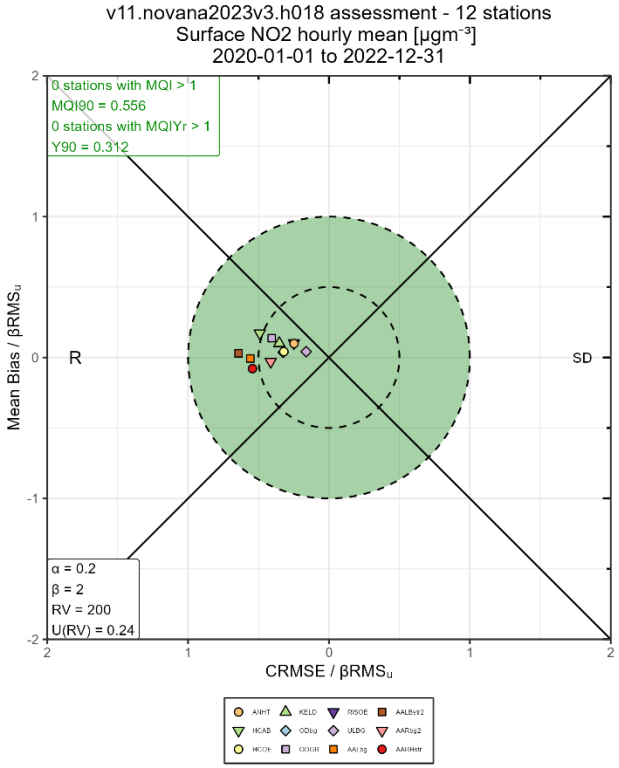


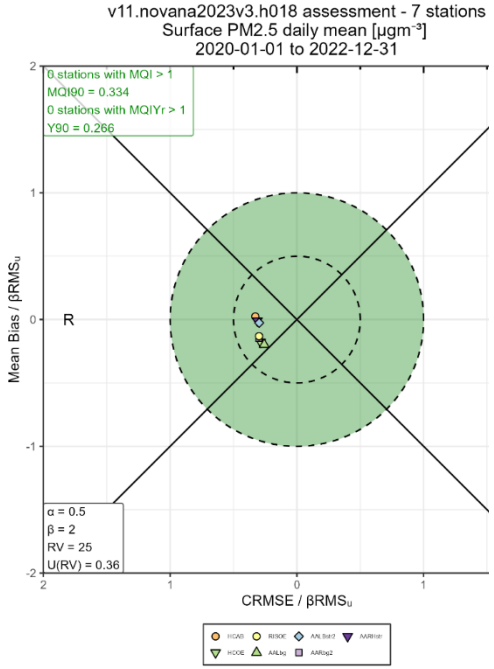


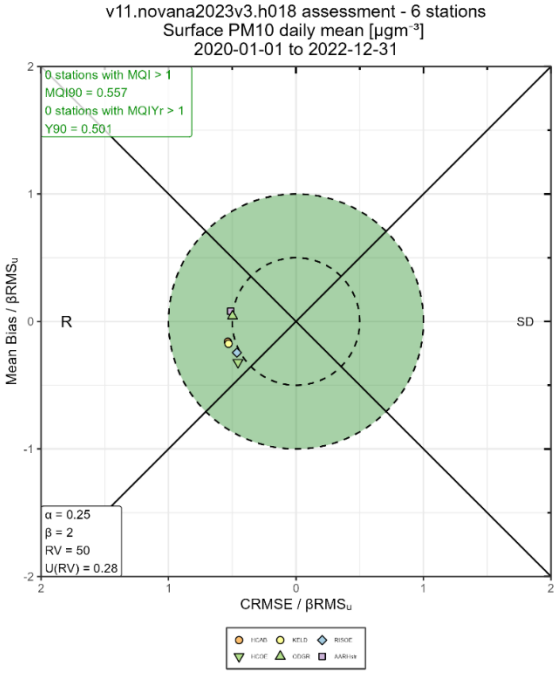
”Harmonisation” in model validation presentation

FAIRMODE/DeltaTool methodology – Target diagrams – All stations (rural/urban/street)

R – functions implemented by Chr. Andersen





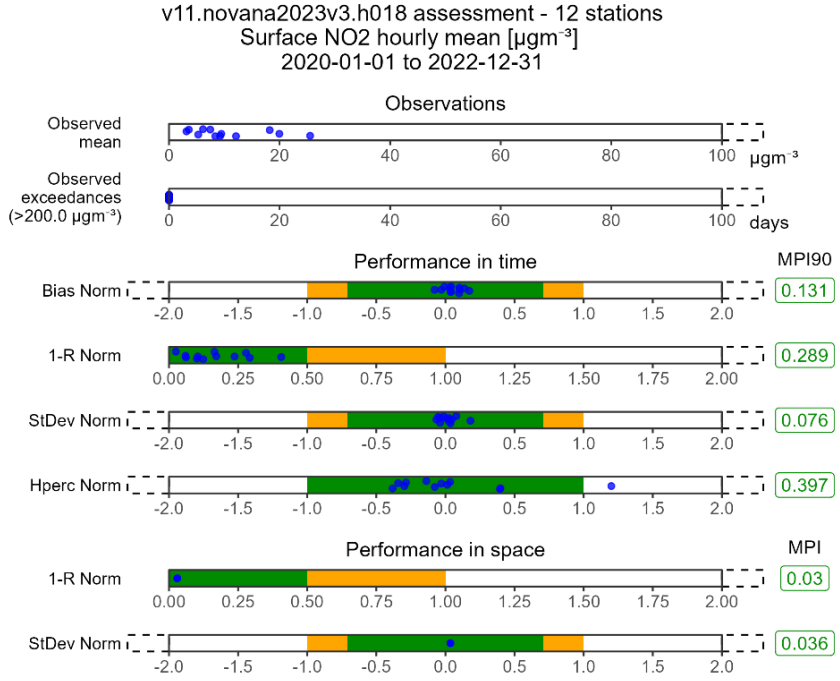


https://github.com/Stoffer4/FAIRMODE-Plots

”Harmonisation” in model validation presentation

FAIRMODE/DeltaTool methodology – Summary tables – here NO_2

R – functions implemented by Chr. Andersen



https://github.com/Stoffer4/FAIRMODE-Plots

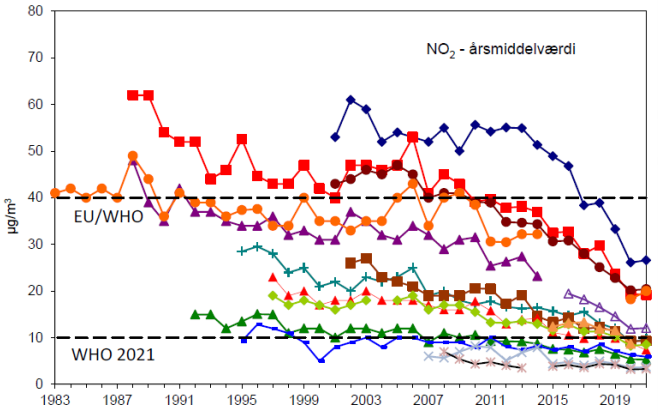
Conclusions (1/2)

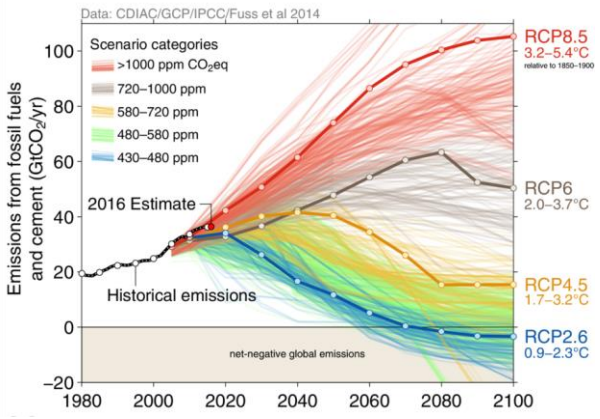
OSPM – street canyon modelling:

- Project with VITO on using the extended versions (NH + RD) shows some potential for improving the dispersion algorithm
- Input data sensitivity is dominating compared to the dispersion effects
- Keeping the balance with simple/robust model and input data demand
- Share of electric cars has increased a lot – there are differences from city to city, detailed traffic counts very useful

FAIRMODE plots have been introduced in DK => models are fit for purpose!

Air Pollution vs. Climate Change vs. Global challenges





Emissions (kg) = Emission-factor (kg/GJ) x Activity (GJ)

Technical solutions (filters, SECA, NECA)
Changing fuels (EV, ammonia,…)
Replacing compounds (PFAS …)

Changing habits
Living standard
consumption

It is possible:
Covid-19
Energy crisis with
Ukraine war

Most in focus in the moment, but not sufficient !

More attention / research needed here !!

Conclusions / Outlook (2/2

Denmark is approaching the WHO 2021 guideline levels for NO_2 and $PM_{2.5}$

- Therefore air pollution reduction is no longer the main argument to reduce individual traffic
- Other arguments are noise, uptake of space, congestions, climate effects

Picture: Morten Skou Nicolaisen, Aarhus Kommune.