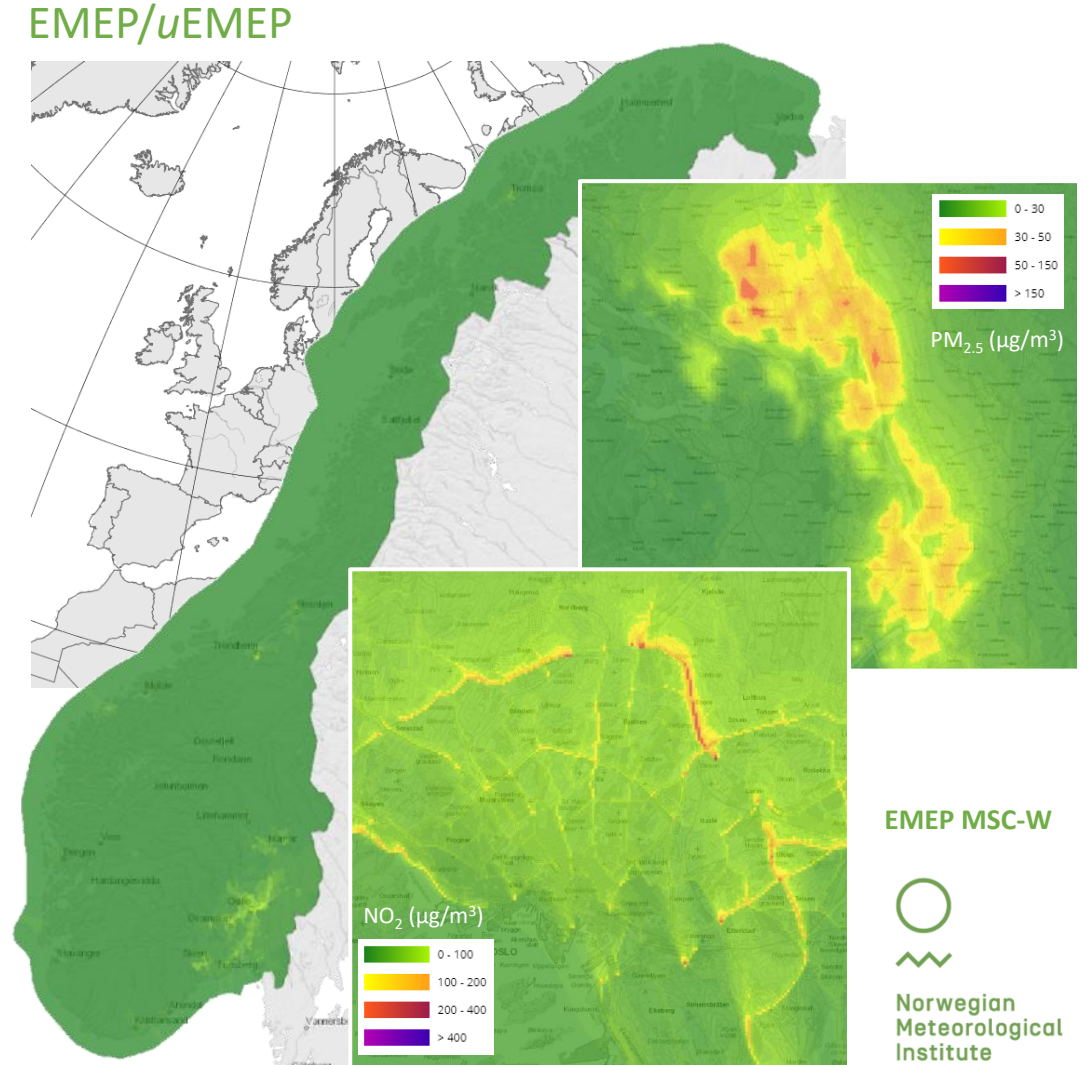


# Recent applications of uEMEP for fine scale modelling in Europe

**Bruce Rolstad Denby, Qing Mu, Eivind Grøtting Wærsted, Hilde Fagerli**  
*(EMEP/MSC-W, MET Norway)*

# Contents

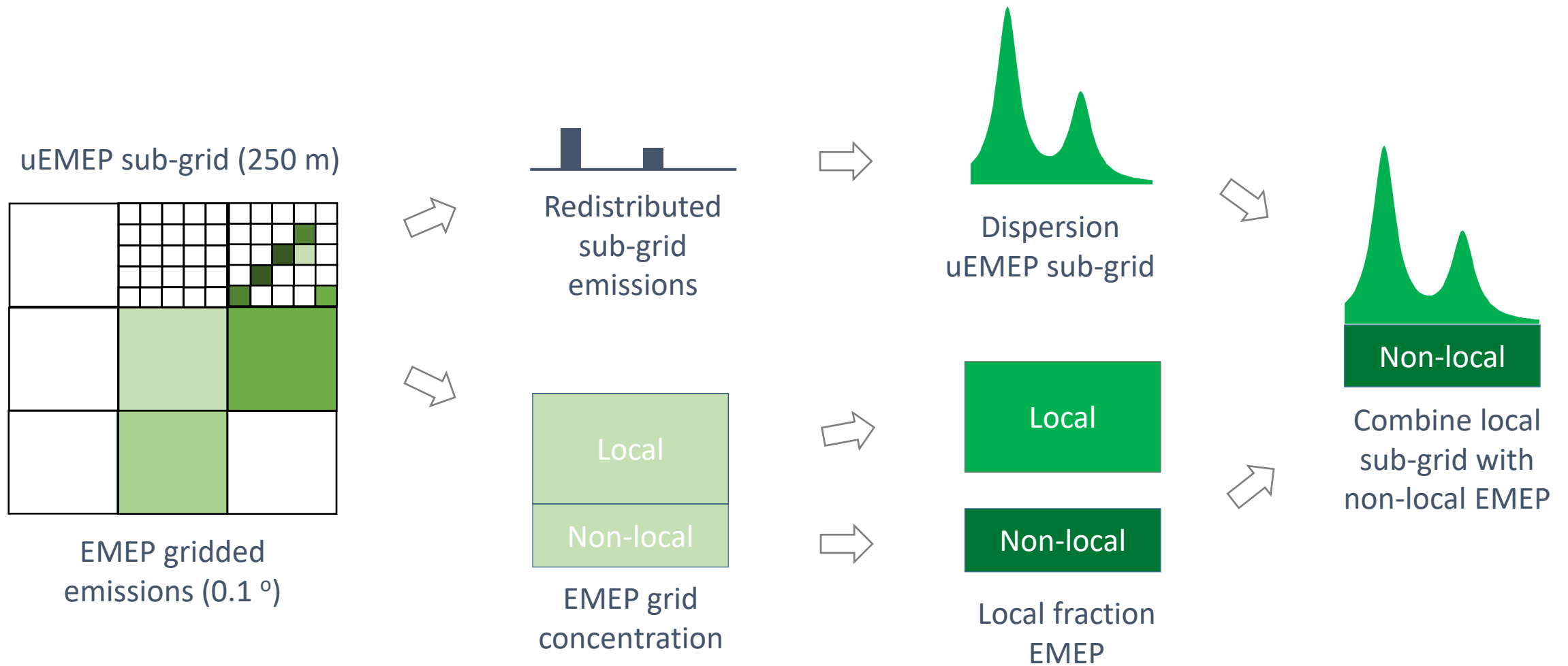
- What is uEMEP?
- Recap of last presentation
- Applications in Norway
- Applications for FAIRMODE
- Applications for the DGENV
- Relevance for EPCAC



# What is uEMEP?

- uEMEP (urban EMEP) is an extension of the EMEP MSC-W model used to downscale EMEP to around 100 m
- It can be inserted anywhere in the EMEP domain and deals with double counting of emissions by utilizing the 'local fraction' output from EMEP
- uEMEP dispersion is calculated using a Gaussian dispersion model
- It can be run on hourly data (Norwegian forecast) or can calculate annual means using a rotationally symmetric dispersion kernel (European application)
- Emissions can be provided in two ways. Using independent sub-grid emissions (Norwegian forecast) or by redistributing EMEP gridded emissions using proxy emission data (Europe)
- Source contributions are calculated for each downscaled sector and pollutant
- Maps are made between 50 m and 250 m resolution and calculations at individual receptor points are at 25 m

# How does uEMEP downscaling work ?

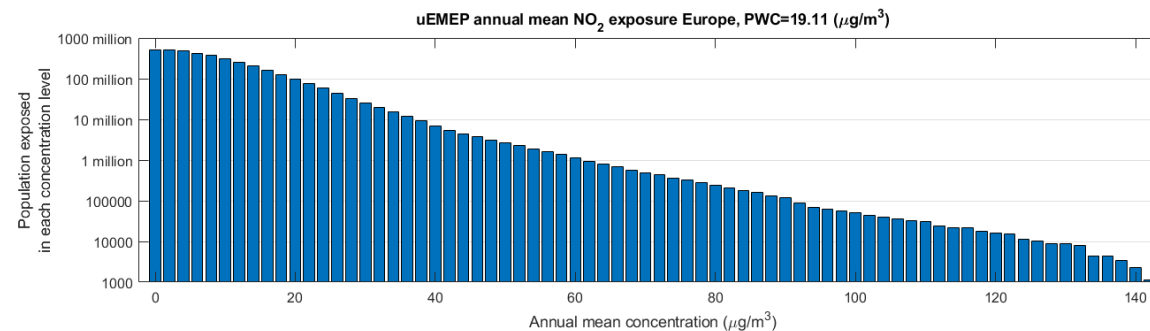
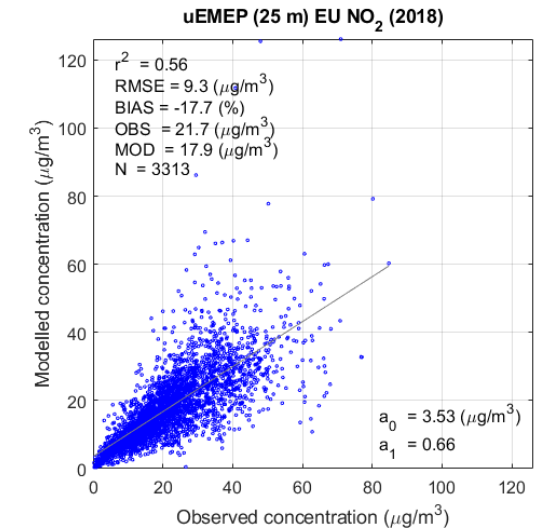
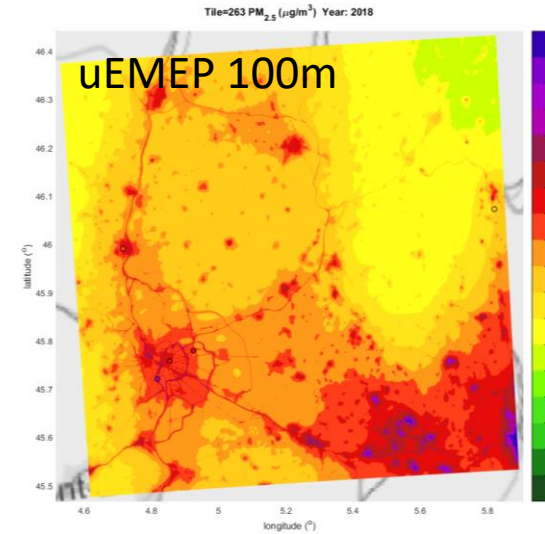


# Some points

- Currently downscaled sources include traffic, residential heating, shipping, off road, aviation
- The uEMEP 'local' downscaling calculation extends over a limited region. In the European application this is  $\pm 0.1^\circ$ . The uEMEP calculations represent all sub-grid emissions within these regions
- Outside of this region, or for sectors that are not downscaled, EMEP provides the 'non-local' contribution
- Downscaling is limited to primary emissions ( $\text{NO}_x$  is downscaled and converted to  $\text{NO}_2$ )
- The sub-grid traffic data are line sources so higher resolutions will better reflect the traffic contribution and local concentration gradients
- The sub-grid resolution of residential combustion (and other) proxy emissions is 250 m so any higher resolution calculations will not improve these contributions
- 250 m population data is used for exposure

# Recap of previous presentation

- Example maps for Europe
- Validation for  $\text{NO}_2$  and  $\text{PM}_{2.5}$
- Exposure in Europe



# Activities in Norway

# Air quality forecasting service

<https://luftkvalitet.miljodirektoratet.no/>

**LUFTKVALITET I NORGE**  
Offentlig informasjon om lokal luftkvalitet

Varsel Målestasjoner Kart Lær mer Om tjenesten

Se varslet luftkvalitet der du er

Søk etter tettsted, by, område etc

**Varslet luftforurensning**  
Luftkvaliteten varierer lokalt, også innenfor kommuner.

Steder	Nå	Kl. 14 - 24	I morgen
<a href="#">Oslo</a>	Lite	Lite	Lite
<a href="#">Bergen</a>	Lite	Moderat	Moderat
<a href="#">Trondheim</a>	Lite	Moderat	Høy
<a href="#">Stavanger</a>	Lite	Lite	Lite
<a href="#">Bærum</a>	Moderat	Høy	Moderat
<a href="#">Kristiansand</a>	Lite	Lite	Lite

Mine mest besøkte steder  
[Trondheim\(Trondheim\)](#)

Kartvisning >

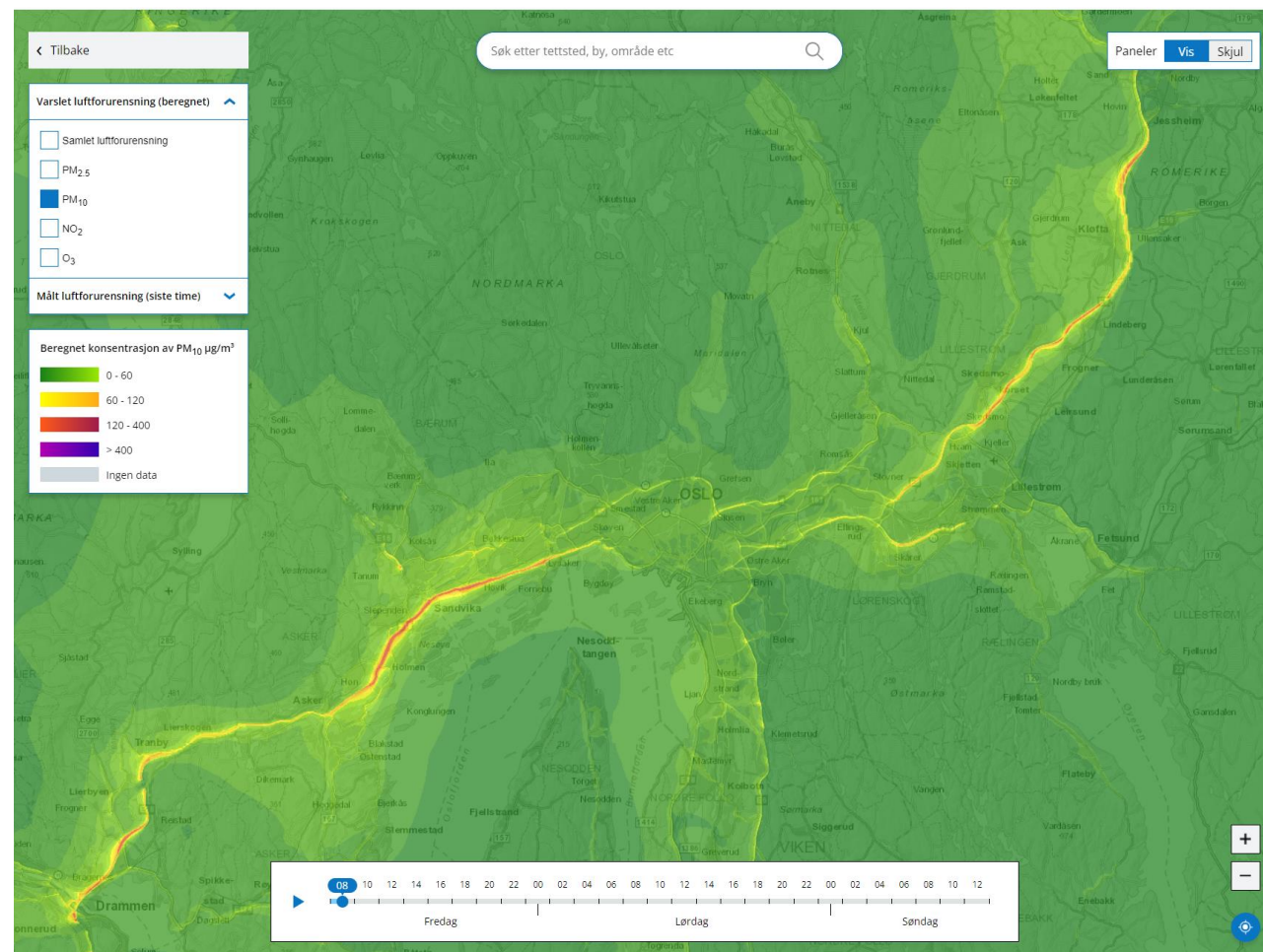
Varslet er basert på beregninger utført av Meteorologisk institutt. Data for "I morgen" vises først etter at varslet er oppdatert (oppdateres hver morgen).

**Forurensningsnivå**  
Forurensningsnivåene er vist ved hjelp av fargekoder (forurensningsklasser).

Lær mer om hva de ulike forurensningsklassene betyr og hvilke betydning forurensningsnivået har for din helse.  
[Les om helseråd og forurensningsklasser her.](#)

Luftforurensning

- Svært høy
- Høy
- Moderat
- Lite
- Ingen data





# Expert user service: maps/exposure/sources/emissions for all municipalities

<https://www.miljodirektoratet.no/tjenester/fagbrukertjeneste-for-luftkvalitet/>

## Fagbrukertjeneste for luftkvalitet

Oversikt over lokal luftkvalitet i Norge for kommuner og andre fagbrukere.

### Maps

Søk etter en kommune

Årsmiddel Korttidsmiddel Befolkningseksponering Kildebidrag Utslippskilder Luftsonekart

#### Årsmiddel for Oslo, Oslo

Målestasjoner **Beregnet**

Velg komponent: **PM<sub>10</sub>** NO<sub>2</sub> PM<sub>2,5</sub> Velg tidsrom: 2020

Beregnet årsmiddelkonsentrasjon av NO<sub>2</sub>

Kilde: Meteorologisk institutt / CC-BY-4.0

Kartet viser beregnet gjennomsnittlig konsentrasjon i løpet av et år (årsmiddelkonsentrasjon) av nitrogendioksid (NO<sub>2</sub>). Årsmiddelet er et gjennomsnitt av alle døgnkonsentrasjoner gjennom hele kalenderåret. Velges en periode på flere år, vises et gjennomsnitt av årsmidlene.

Last ned

## Fagbrukertjeneste for luftkvalitet

Oversikt over lokal luftkvalitet i Norge for kommuner og andre fagbrukere.

### Emissions

Søk etter en kommune

Årsmiddel Korttidsmiddel Befolkningseksponering Kildebidrag **Utslippskilder** Luftsonekart

#### Utslippskilder for Oslo, Oslo

Velg komponent: **PM<sub>10</sub>** PM<sub>2,5</sub> NO<sub>x</sub> Velg visning: **Graf** Tabell

Utslippskilder til PM<sub>10</sub> innenfor kommunegrensen (tonn per år)

År	Ekstern	Svevestøv	Vedfyring	Skip	Industri
2016	~20	~100	~250	~10	~10
2017	~20	~100	~250	~10	~10
2018	~20	~100	~250	~10	~10
2019	~20	~100	~250	~10	~10
2020	~20	~100	~250	~10	~10

Kilde: Meteorologisk institutt / CC-BY-4.0

Graf og tabell viser årlige utslipp (tonn/år) av svevestøv (PM<sub>10</sub>) fra ulike kilder innenfor kommunegrensen. Informasjon om oppdaterte utslipp for 2020 finner du [her](#).

Hvor mye de enkelte kildene bidrar til konsentrasjonen av luftforurensning i luften vil puster inn, avhenger av hvor og når utslippene finner sted, topografi og meteorologiske forhold. Gå til fanen **kildebidrag** for å se hvor mye de ulike kildene bidrar til konsentrasjonen ved bakken.

- [Her kan du lese om ulike typer forurensning og hvor den kommer fra](#)

+ Les mer om dataene

Last ned

## Fagbrukertjeneste for luftkvalitet

Oversikt over lokal luftkvalitet i Norge for kommuner og andre fagbrukere.

### Exposure

Søk etter en kommune

Årsmiddel Korttidsmiddel **Befolkningseksponering** Kildebidrag Utslippskilder Luftsonekart

#### Befolkningseksponering for Oslo, Oslo

Velg komponent: **PM<sub>10</sub>** NO<sub>2</sub> PM<sub>2,5</sub> Velg visning: **Populasjon** Kilde Tabell Velg tidsrom: 2020

Beregnet befolkningseksponering for NO<sub>2</sub>

Konsentrasjonsnivå (µg/m³)	Personer eksponert
<=0	~650,000
<=5	~650,000
<=10	~550,000
<=15	~200,000
>=20	~50,000
>=25	~10,000
>=30	~5,000
>=35	~2,000
>=40	~1,000

Kilde: Meteorologisk institutt / CC-BY-4.0

Her vises, med ulike framstillinger, hvor mange som er beregnet å være utsatt (eksponert) for nitrogendioksid (NO<sub>2</sub>) på sine bostedsadresser i kommunen.

Tallene er beregnet ved hjelp av en modell og er estimater basert på de beste tilgjengelige dataene. Selv om tallene er basert på de beste tilgjengelige dataene, så er de beheftet med en viss usikkerhet.

I tillegg vil forurensningsnivåene variere fra år til år og som følge av variasjoner i meteorologiske forhold. Dette medfører at antall eksponerte kan variere svært mye fra år til år, og være forskjellig fra de tallene som presenteres her.

Siden beregningene kun inkluderer bostedsadresse inkluderes ikke eksponering som skjer andre steder enn bosted, for eksempel på reise og aktiviteter som foregår utenfor hjemmet.

Informasjon om oppdaterte utslipp for 2020 finner du [her](#).

Populasjonsvisning

Grafen viser hvor mange personer som blir utsatt for ulike nivåer av NO<sub>2</sub> ved sitt bosted (gjennomsnittlig konsentrasjon gjennom et år).

Kildevisning

Last ned

# Scenario calculator

<https://www.miljodirektoratet.no/tjenester/tiltakskalkulator-for-luftkvalitet/>

### Tiltakskalkulator for luftkvalitet

I tiltakskalkulatoren kan kommunene teste effekten av tiltak for å redusere lokal luftforurensning.

## Difference maps

Årsmiddel for Oslo, Oslo Oslo, Oslo 2018

Velg komponent:  
 PM<sub>10</sub>  NO<sub>2</sub>  PM<sub>2,5</sub>

Beregnet årsmiddelkonsentrasjon av NO<sub>2</sub> i 2018, med og uten tiltak

Med tiltak Uten tiltak

µg/m<sup>3</sup> med tiltak

- 0 - 20 µg/m<sup>3</sup>
- 20 - 40 µg/m<sup>3</sup>
- 40 - 60 µg/m<sup>3</sup>
- 60 - 100 µg/m<sup>3</sup>

µg/m<sup>3</sup>

- 0 - 20 µg/m<sup>3</sup>
- 20 - 40 µg/m<sup>3</sup>
- 40 - 60 µg/m<sup>3</sup>
- 60 - 100 µg/m<sup>3</sup>

Årsmiddel sammenligning Last ned

### Korttidsmiddel for Oslo, Oslo

Velg komponent:  
 PM<sub>10</sub>

### Befolkningseksponering for Oslo, Oslo

## Change in exposure

Velg komponent:  PM<sub>10</sub>  NO<sub>2</sub>  PM<sub>2,5</sub> Velg visning:  Graf  Tabell

Beregnet befolkningseksponering for NO<sub>2</sub> i 2018, med og uten tiltak

Personer

Med tiltak Uten tiltak

Med tiltak Uten tiltak Grenseverdi 40,5 µg/m<sup>3</sup> Nasjonalt mål 40 µg/m<sup>3</sup>

Last ned

### Kildebidrag for Oslo, Oslo

## Change in source contributions

Velg komponent:  PM<sub>10</sub>  NO<sub>2</sub>  PM<sub>2,5</sub> Velg visning:  Graf  Tabell

Kildebidrag i µg/m<sup>3</sup> til NO<sub>2</sub>-forurensning i 2018, med og uten tiltak

Uten tiltak Med tiltak

Belgirunn Buss Vedfyring Skip Industri

Last ned

### Utslippskilder for Oslo, Oslo

## Change in emissions

Velg komponent:  PM<sub>10</sub>  PM<sub>2,5</sub>  NO<sub>x</sub> Velg visning:  Graf  Tabell

Utslippskilder til PM<sub>10</sub>-forurensning i 2018 (i tonn/år), med og uten tiltak

Med tiltak Uten tiltak

Buss Vedstov Vedfyring Skip Industri

Last ned

### Luftsonekart for Oslo, Oslo

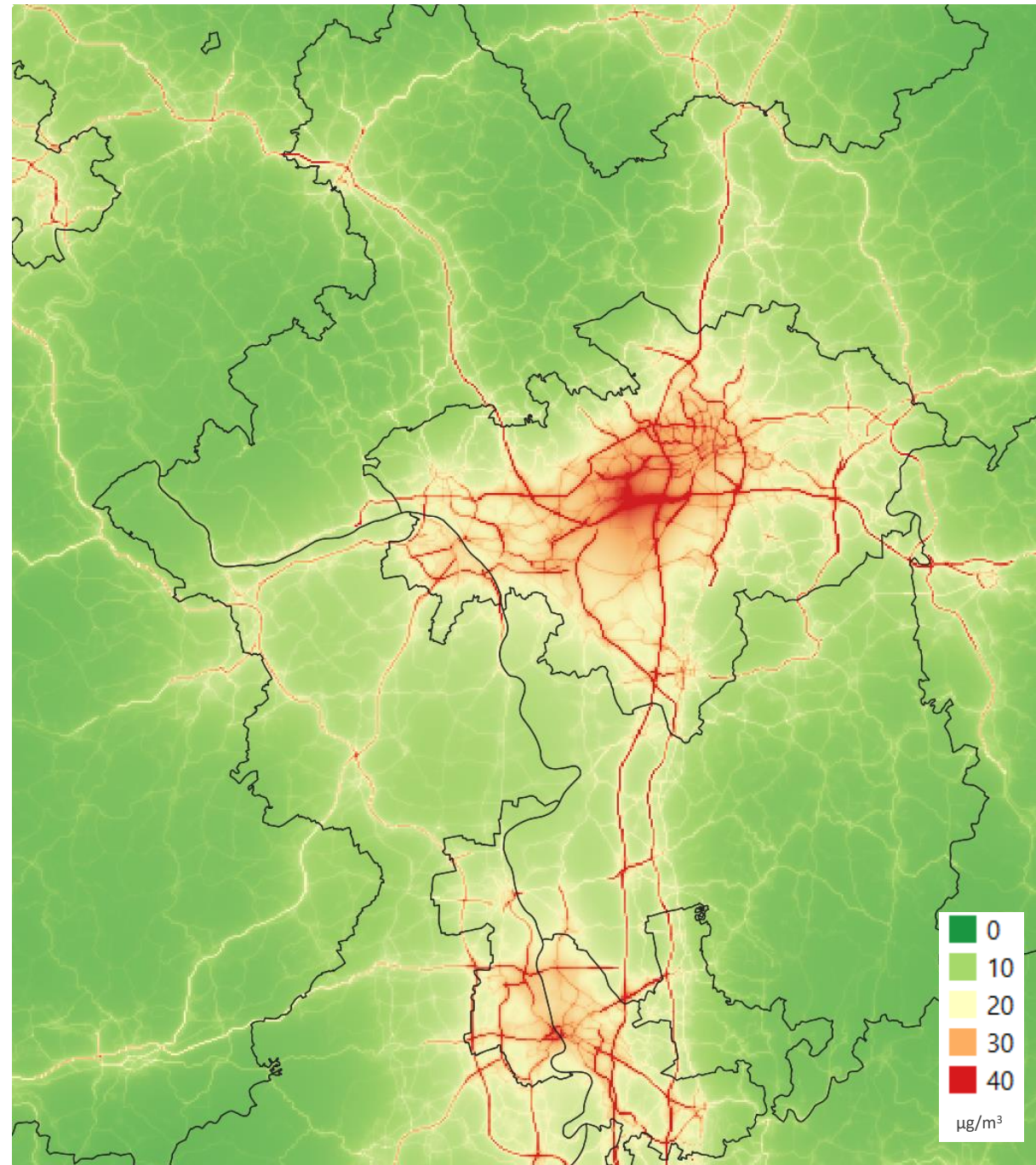
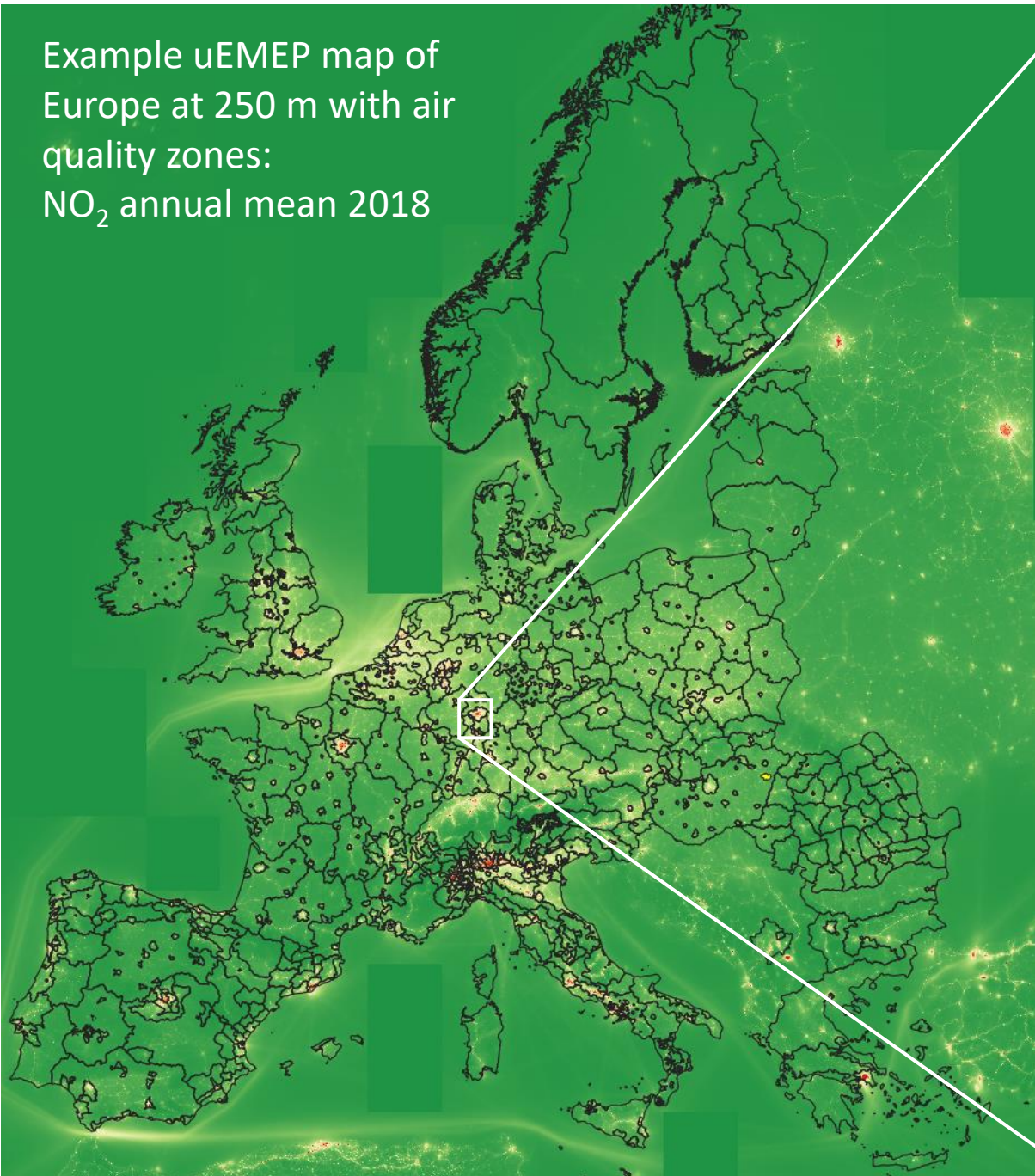
## Change in air quality zone maps

Luftsonekart basert på meteorologi i 2018, med og uten tiltak

Med tiltak Uten tiltak

# Activities in FAIRMODE

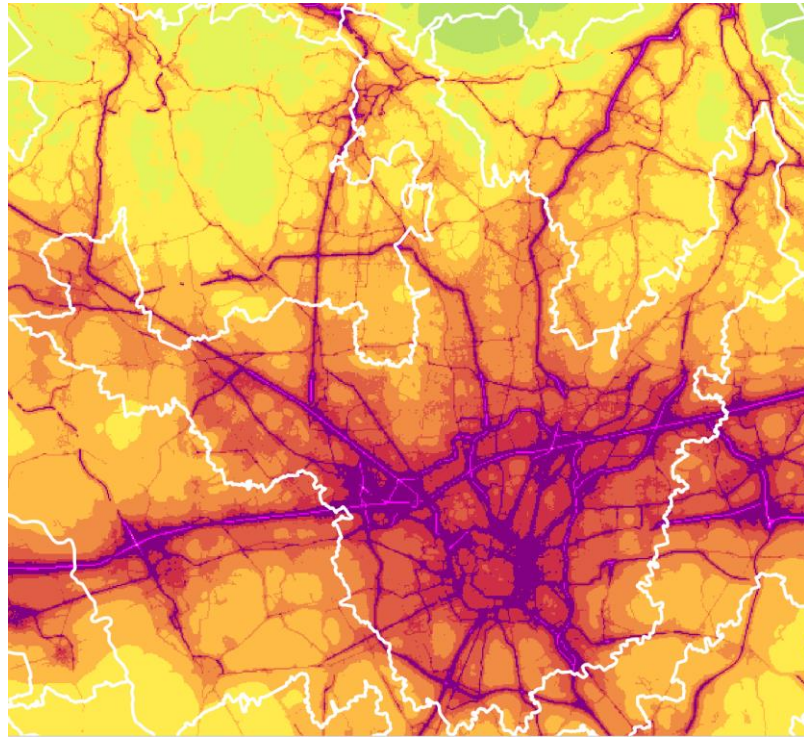
Example uEMEP map of Europe at 250 m with air quality zones:  
NO<sub>2</sub> annual mean 2018



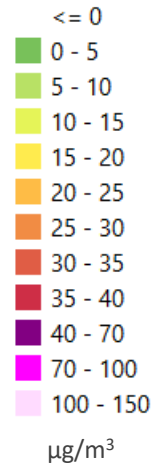
# Spatial representativeness area (SRA)

- Use of models to calculate spatial representativeness of monitoring sites
- Many possible ways of defining this but a simple method has been chosen
- The monitoring station's SRA is the area within an airquality zone with the same concentration,  $\pm$  a threshold value, as at the monitoring site
- Varying thresholds tested include 20%, 10%, 5% for NO<sub>2</sub> and PM<sub>2.5</sub>
- Advantage of uEMEP is the calculation can be made at all sites in Europe in a homogenous way
- Disadvantage is that at 100 m it still does not resolve street canyons and other micro hotspots
- Results shown as frequency distributions

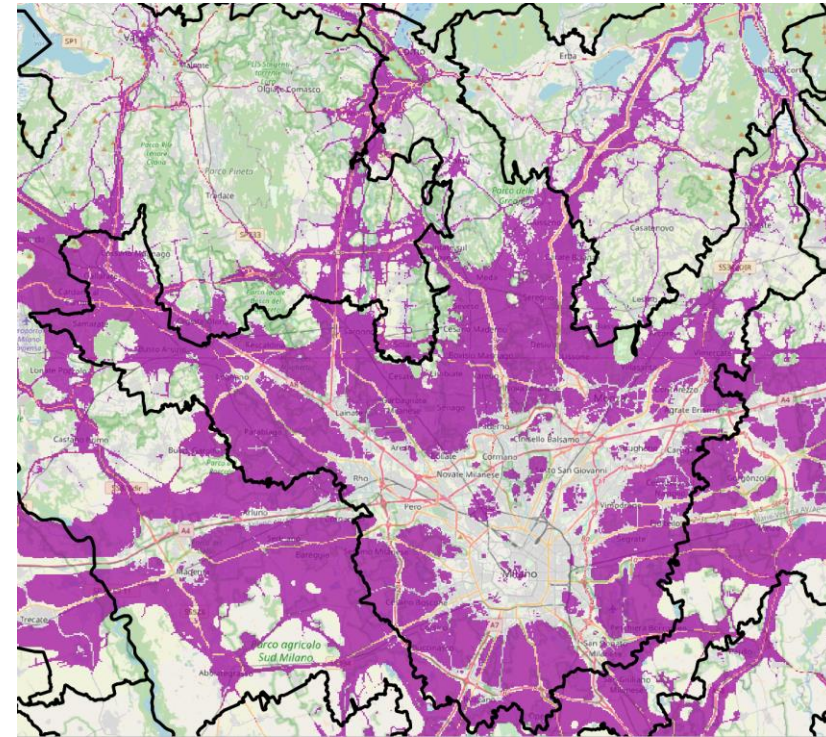
# 100 m resolution spatial representativeness NO<sub>2</sub>



Contour map for NO<sub>2</sub> (2018) Milan air quality zone.



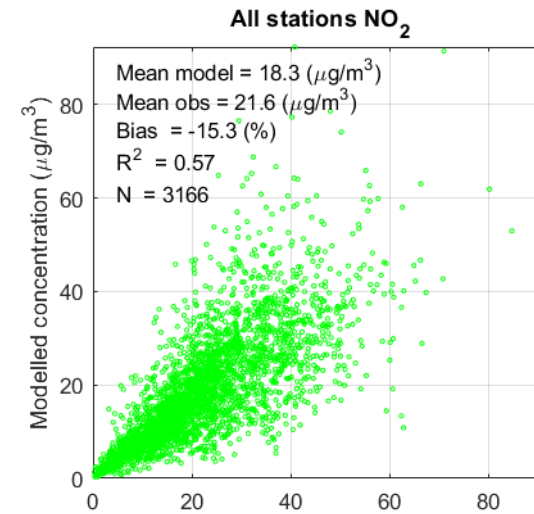
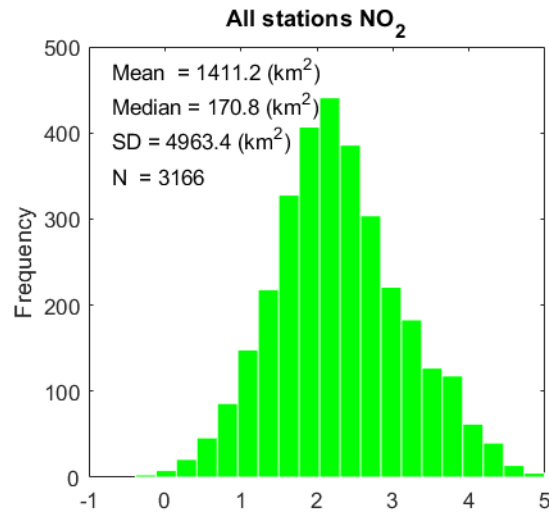
Threshold 20%



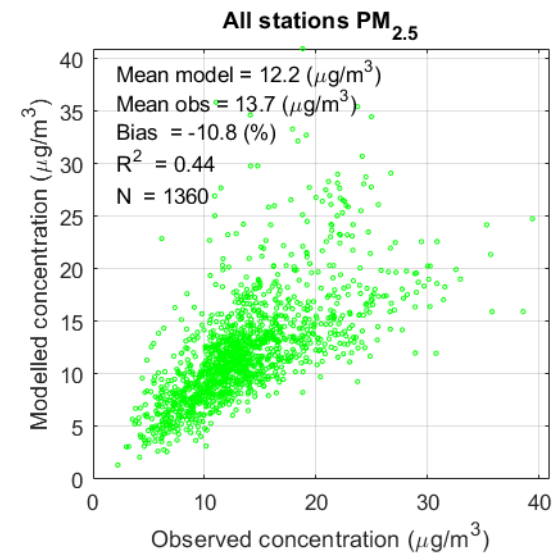
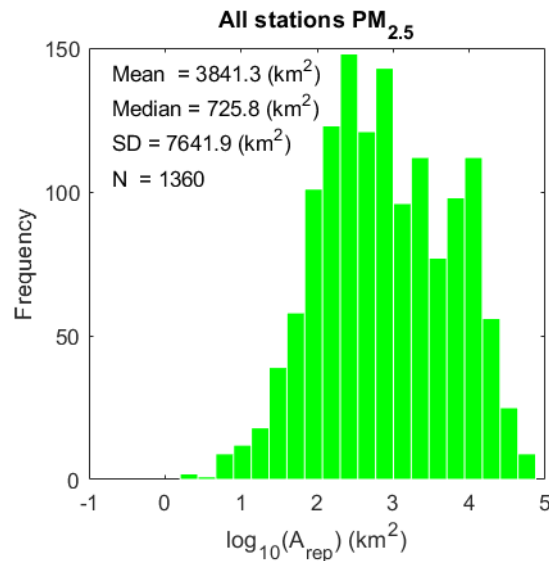
A measurement station somewhere in the Milan AQ zone that measures 30 µg/m<sup>3</sup>

# Spatial representativeness area ( $\pm 20\%$ ) for all stations in Europe, $\text{NO}_2$ and $\text{PM}_{2.5}$

$\text{NO}_2$



$\text{PM}_{2.5}$

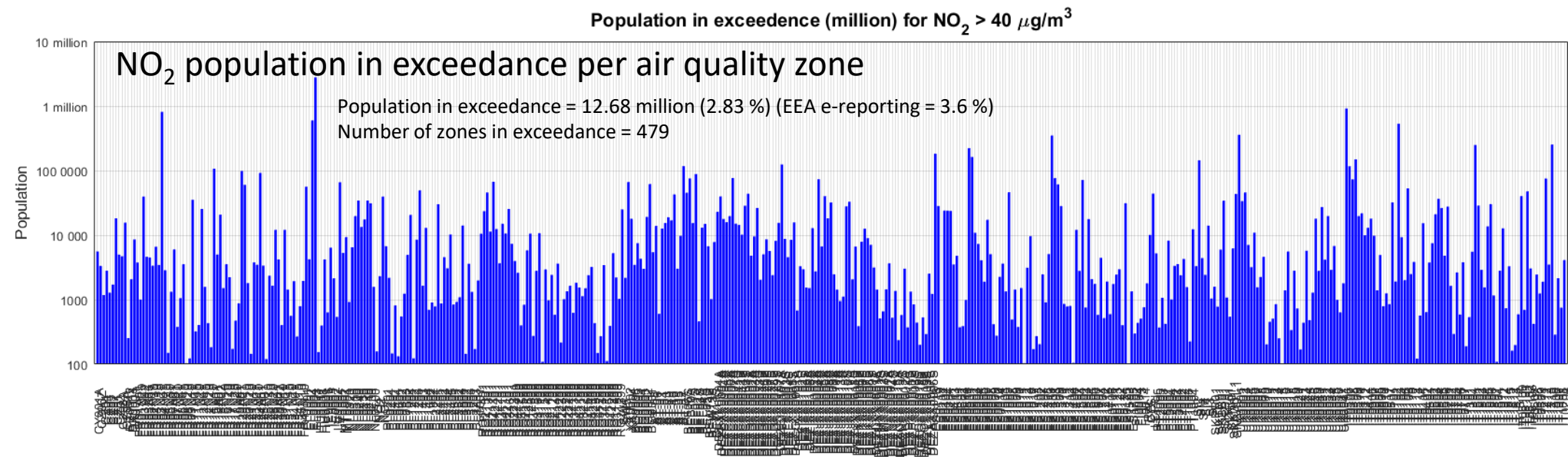
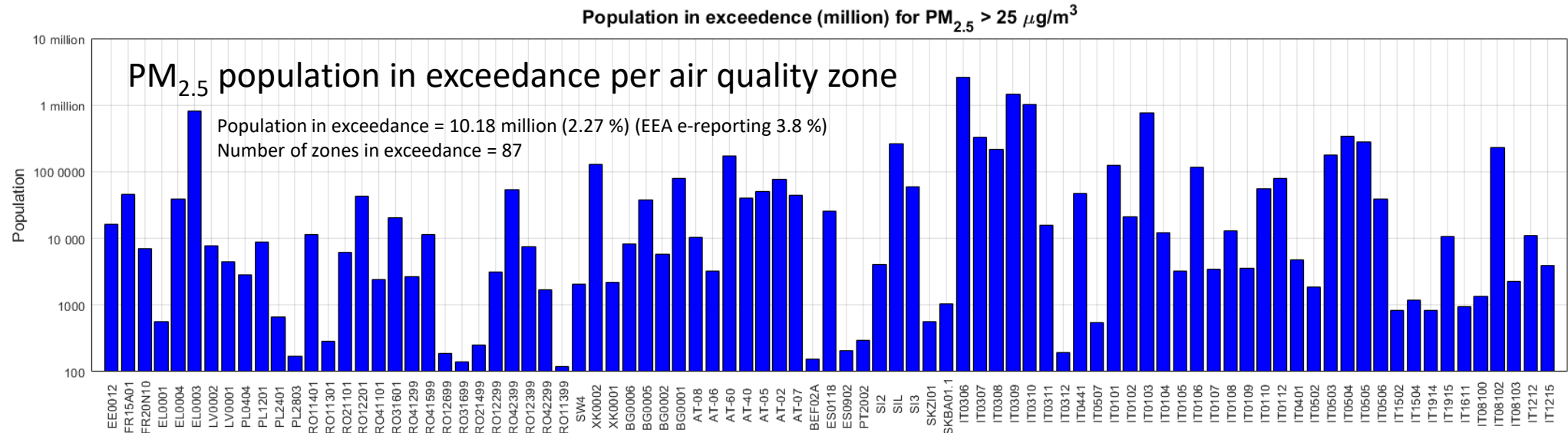


# Exceedance reporting

- When measurements indicate exceedances then the area, the population and the length of road in exceedance must be reported from within that air quality zone
- As an exercise we assessed the population and area in exceedance for all air quality zones (668) in Europe based on uEMEP 100 m calculations
- PM<sub>2.5</sub>: 87 of the zones were in exceedance and 10.2 million people were exposed above the limit value ( $> 25 \mu\text{g}/\text{m}^3$ ). Area in exceedance is 6506 km<sup>2</sup>
- NO<sub>2</sub>: 479 of the zones were in exceedance and 12.7 million people were exposed above the limit value ( $> 40 \mu\text{g}/\text{m}^3$ ). Area in exceedance is 4806 km<sup>2</sup>



# Population in exceedance for EU air quality zones



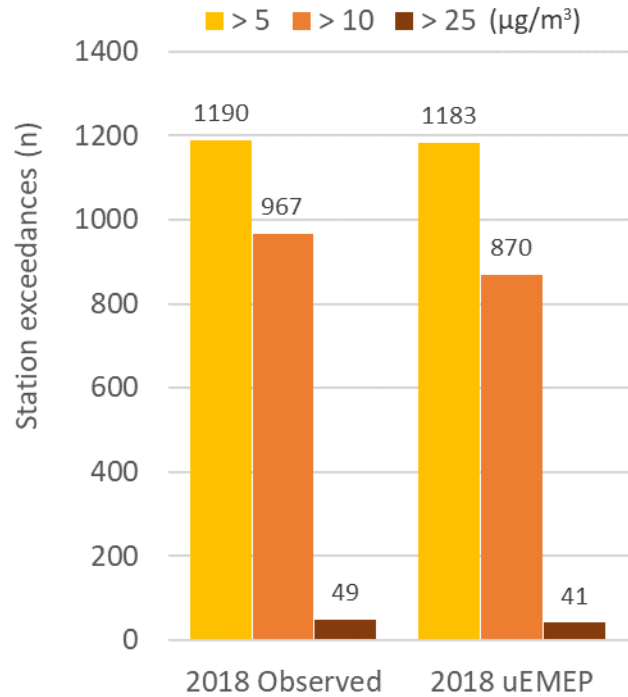
Activities for the European Commission

# Review of the Ambient air quality directive

- Part of a consortium contracted by DGENV to assess air quality guidelines for the coming review of the AAQD
- A number of scenarios are produced by IIASA using GAINS that will optimise costs for background PM<sub>2.5</sub> concentrations
- EMEP is then applied to these scenarios for a wider range of pollutants
- uEMEP is used to downscale these scenarios for improved exposure and exceedance calculations for the EU27
- Still in progress but a preparatory analysis was presented at the September 22'nd workshop organised by the commission
- A base case with all planned measures (Base) and a Maximum feasible reduction (MFR) were calculated for 2020, 2030 and 2050

# PM<sub>2.5</sub> exceedance calculations at **monitoring sites** (25 m) using EMEP/uEMEP: validation using country submitted emissions

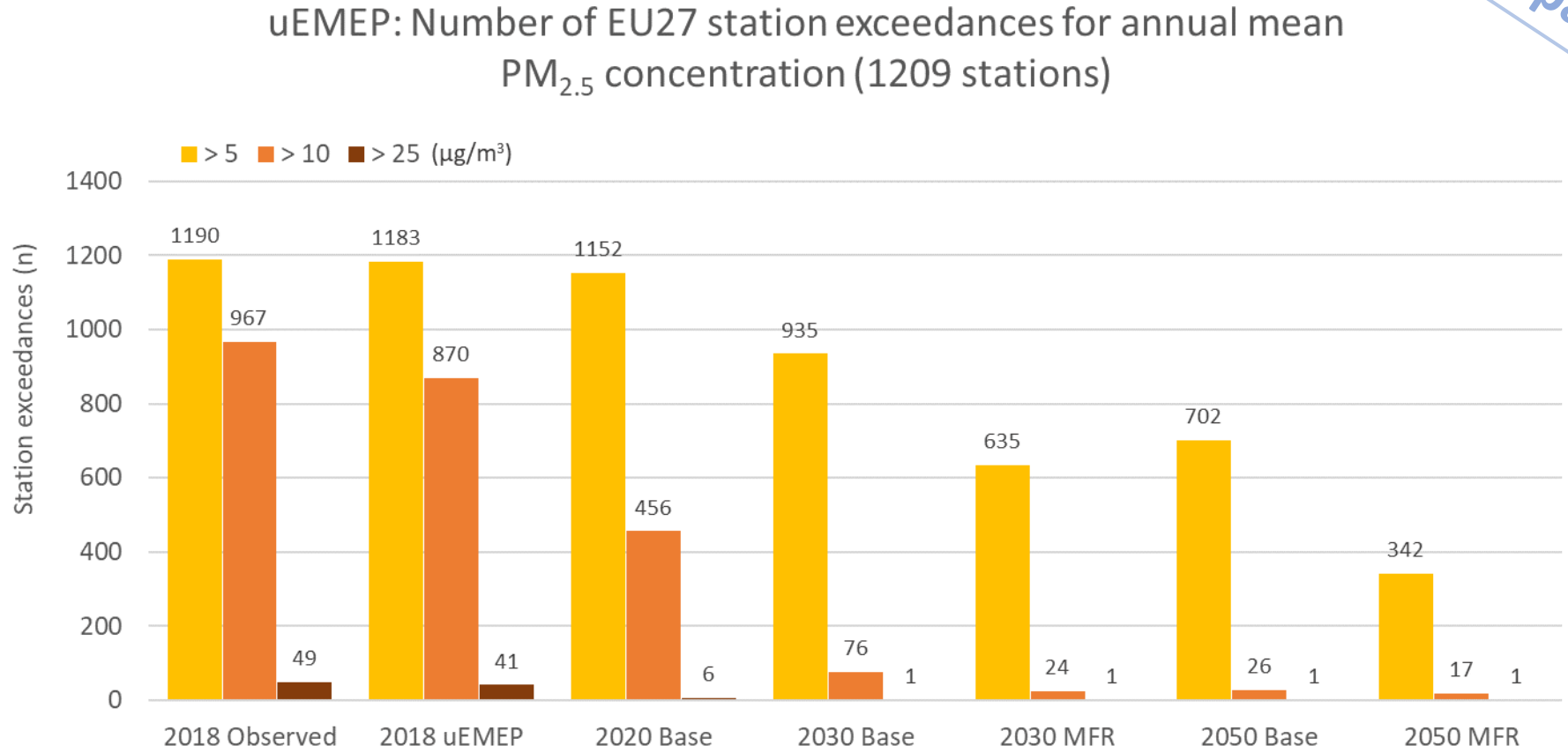
uEMEP: Number of EU27 station exceedances for annual mean PM<sub>2.5</sub> concentration (1209 stations)



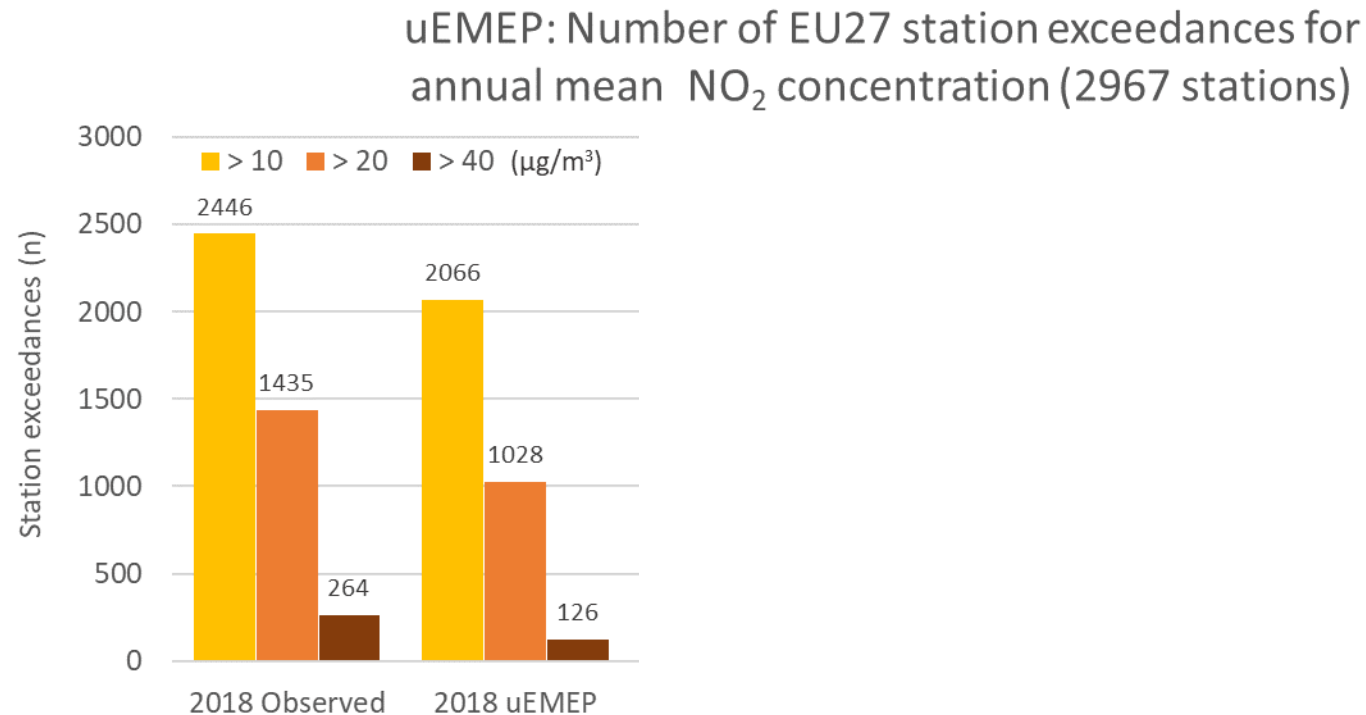
uEMEP bias = -9%

# PM<sub>2.5</sub> exceedance calculations at monitoring sites (25 m) using EMEP/uEMEP: scenarios using GAINS emissions

Preparatory analysis



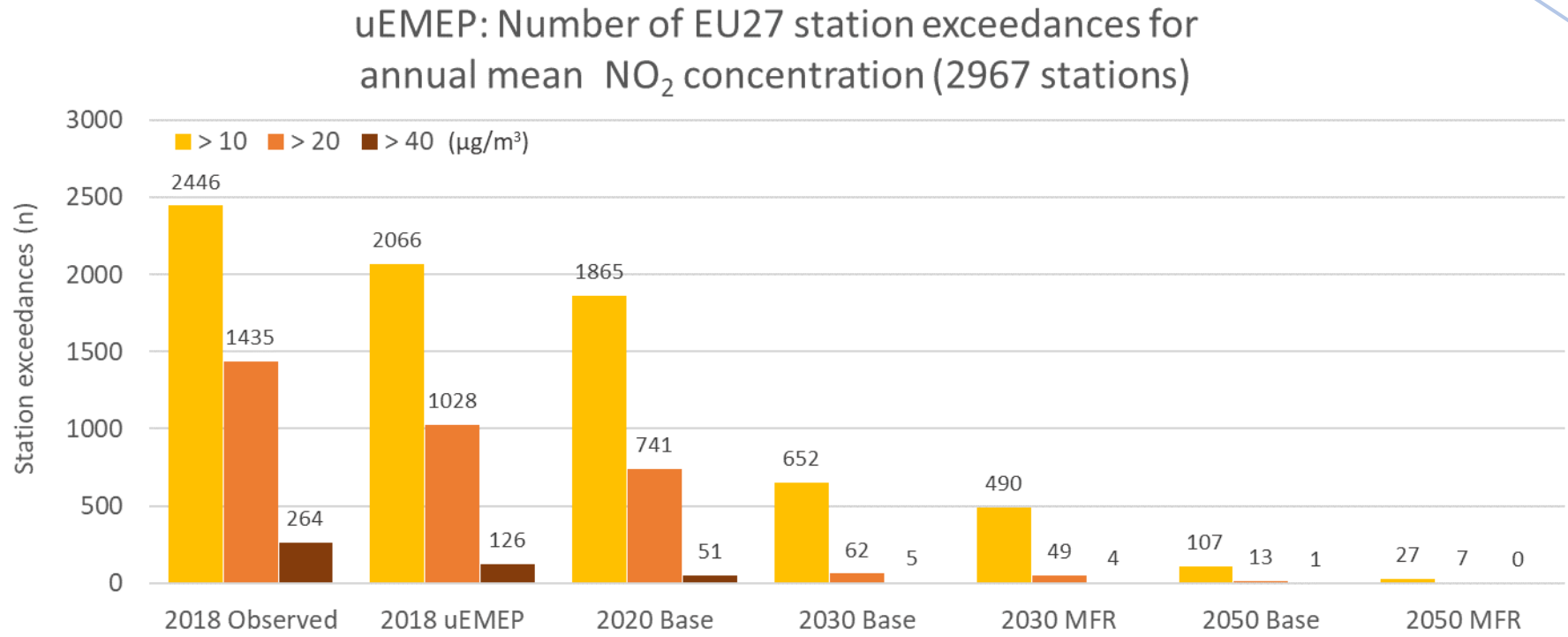
# NO<sub>2</sub> exceedance calculations at **monitoring sites** (25 m) using EMEP/uEMEP: validation using country submitted emissions



uEMEP bias = -18%

# NO<sub>2</sub> exceedance calculations at **monitoring sites** (25 m) using EMEP/uEMEP: scenarios using GAINS emissions

Preparatory analysis



Relevance for EPCAC



# Advantages of uEMEP in Europe

- Provides a consistent modelling methodology across Europe, covering all cities, large or small and provides insight into differences between countries and reported country emissions
- Provides source contributions for downscaled sectors that are emitted locally, allowing the impact of local measures to be quickly assessed by post-processing
- In combination with EMEP source receptor calculations using 'local fractions' uEMEP/EMEP can provide source contributions across all scales
- Can provide a reference/benchmark for EPCAC European city studies

# Disadvantages of uEMEP in Europe

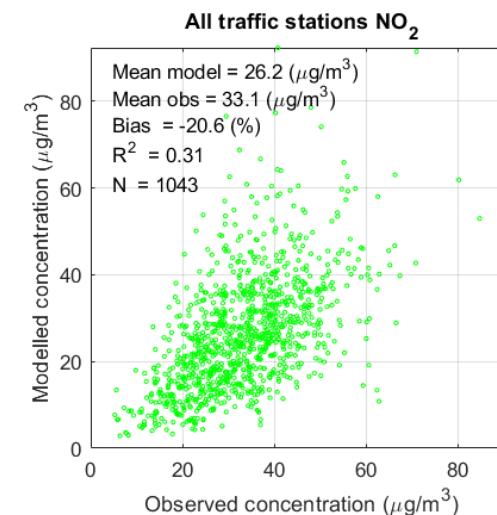
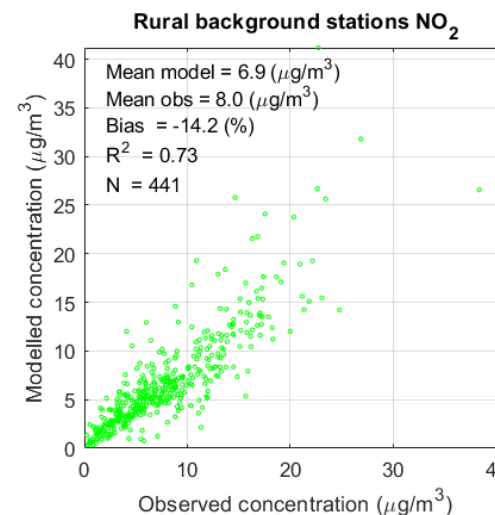
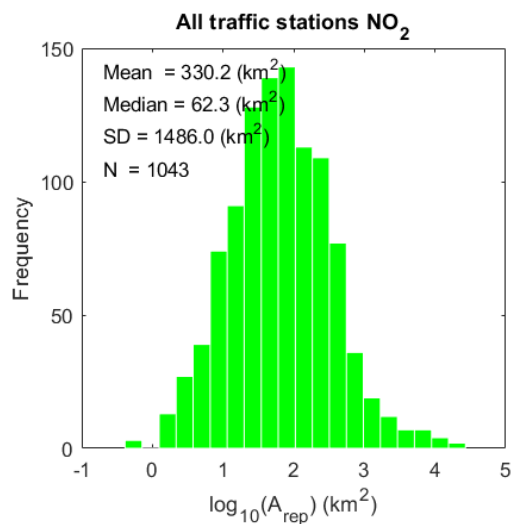
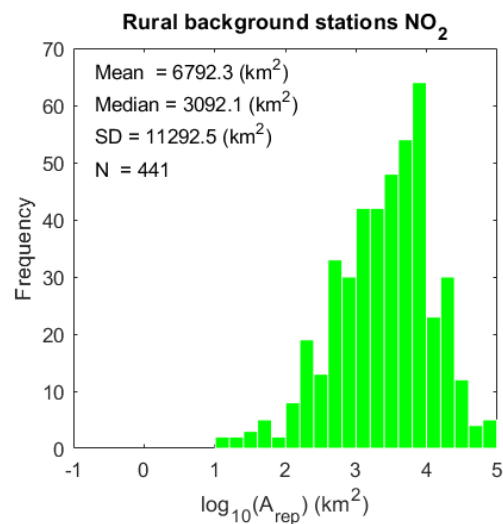
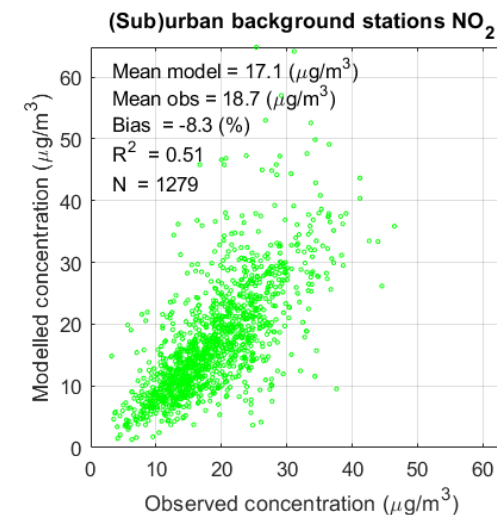
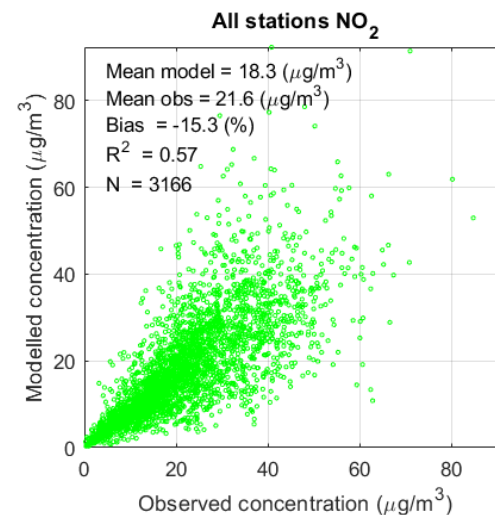
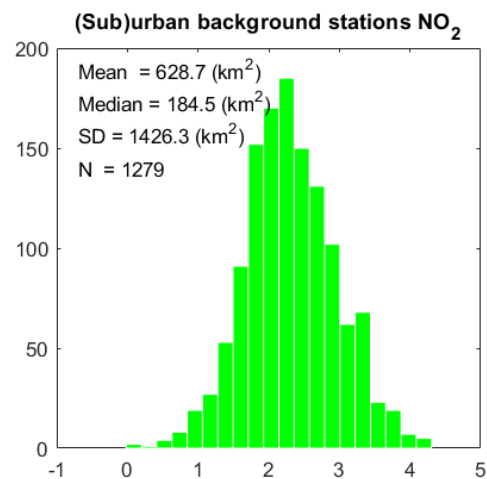
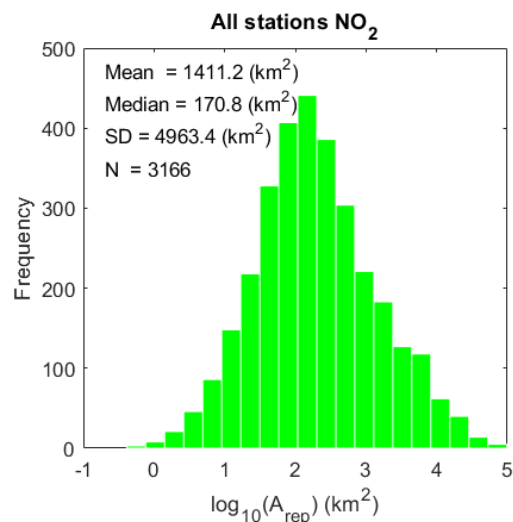
- Room for improvement in the uEMEP proxy data and/or the EMEP emission data for PM
- Uses basic proxy data to redistribute emissions that are globally available. Local modelling should have better high resolution emission data and hence results (as seen in Norway)
- Can only downscale primary emissions
- Annual mean concentrations do not provide information on percentiles. Hourly calculations for all of Europe at 100 m are computationally prohibitive but for individual cities this is possible.

# Documentation, data and models

- **Regional scale model:** EMEP MSC-W model rv4.34 (0.1° x 0.1°)
  - <https://github.com/metno/emep-ctm>
- **Downscaling model:** uEMEP v6 (250 – 25 m)
  - <https://github.com/metno/uEMEP>
- **Regional scale emissions:** EMEP 0.1° with GNFR3 replaced by TNO Ref2 emissions including condensables
  - <https://www.ceip.at/webdab-emission-database>
- **Downscaling population data:** GHS-POP, Global Human Settlement-Population, (9 arcsec)
  - [https://ghsl.jrc.ec.europa.eu/ghs\\_pop2019.php](https://ghsl.jrc.ec.europa.eu/ghs_pop2019.php)
- **Downscaling traffic data:** Open street maps
  - <https://www.openstreetmap.org/>
- **uEMEP model description and Norwegian application:**
  - <https://gmd.copernicus.org/articles/13/6303/2020/>
- **EMEP local fraction model description:**
  - <https://gmd.copernicus.org/articles/13/1623/2020/>
- **uEMEP application in Europe:** EMEP report 2020 and GMD article in review
  - [https://emep.int/publ/reports/2020/EMEP\\_Status\\_Report\\_1\\_2020.pdf](https://emep.int/publ/reports/2020/EMEP_Status_Report_1_2020.pdf)
  - <https://gmd.copernicus.org/preprints/gmd-2021-198/>

Extra slides

# Spatial representativeness area NO<sub>2</sub>



# Spatial representativeness area PM<sub>2.5</sub>

