Recent applications of uEMEP for fine scale modelling in Europe

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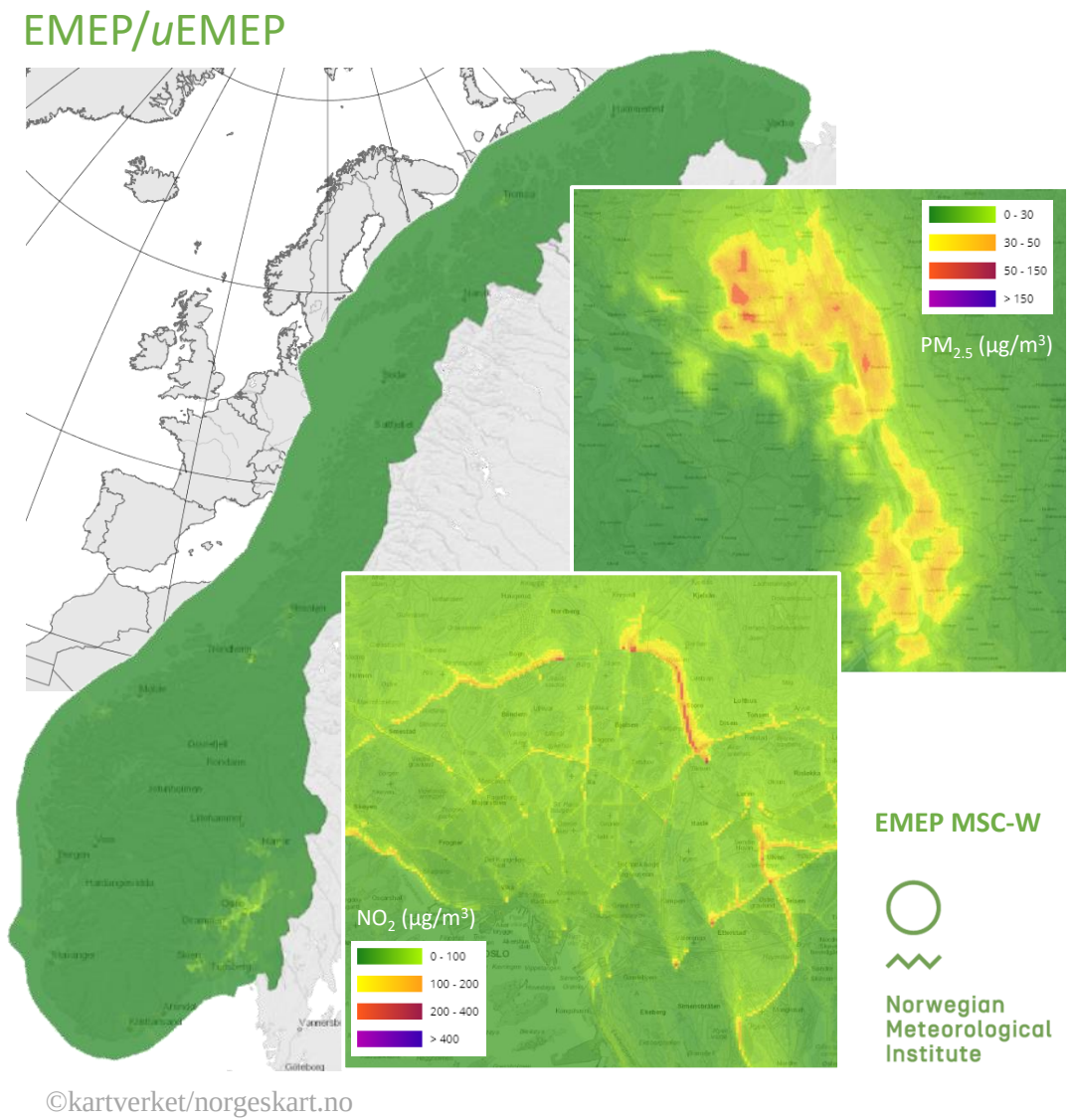
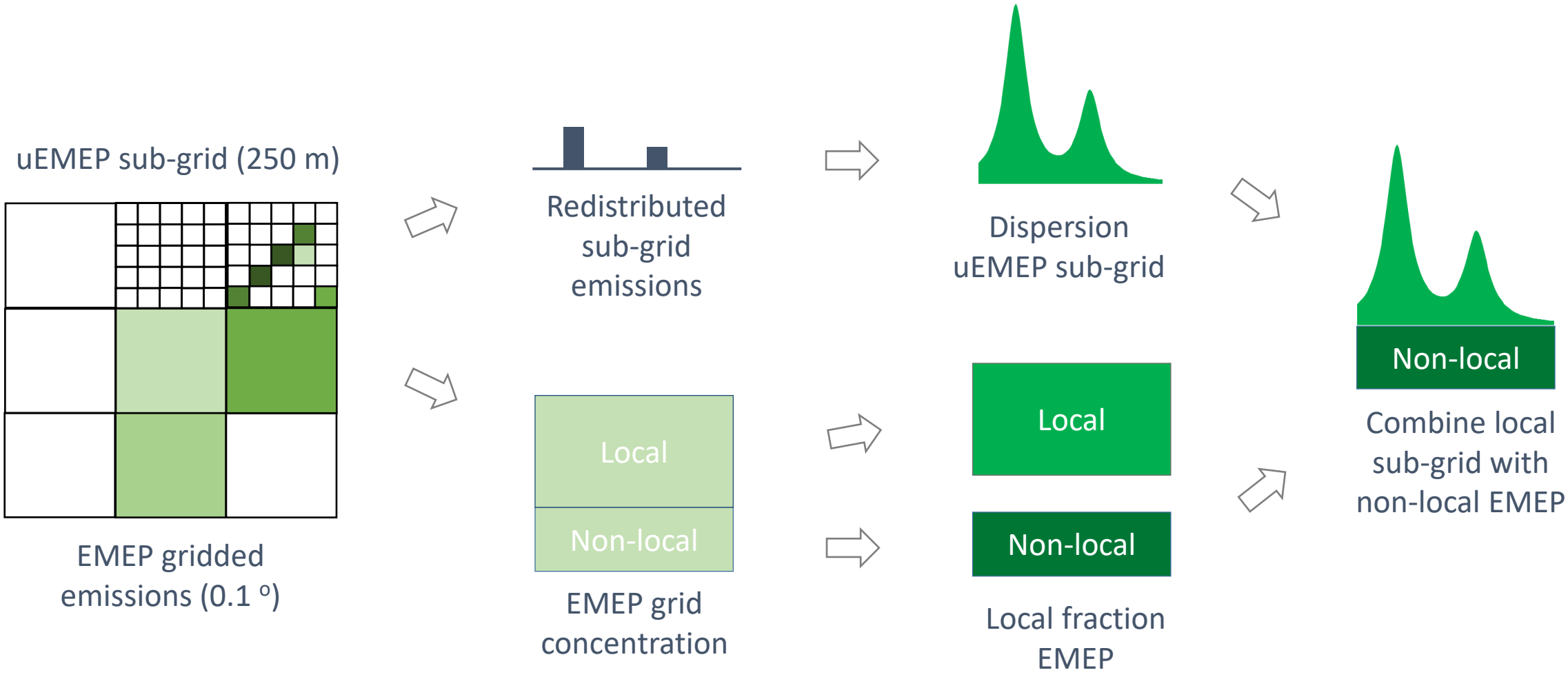


What is uEMEP?

- 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 ?

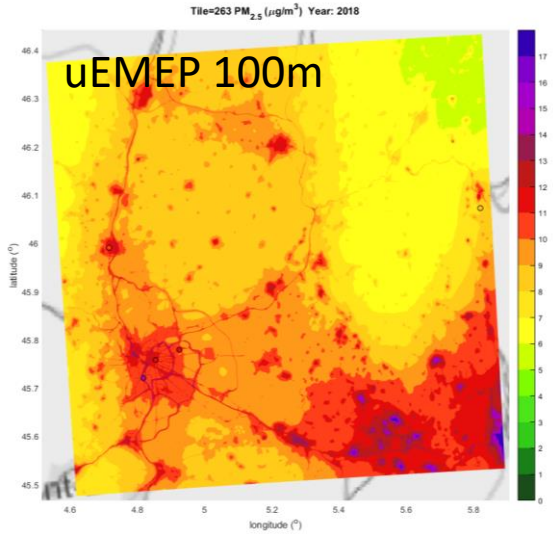


Some points

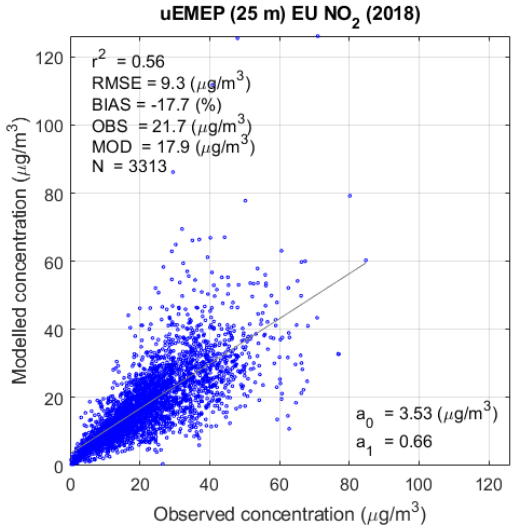
- Currently downscaled sources include traffic, residential heating, shipping, off road, aviation
- The uEMEP ‘local’ downscaling calculation extends over a limited region. In the European application this is ± 0.1^{o} . The uEMEP calculations represent all sub-grid emissions within these regions
- Outside of this region, or for sectors that are not downscaled, EMEP provides the ‘non-local’ contribution
- Downscaling is limitted to primary emissions (NO_X is downscaled and converted to 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

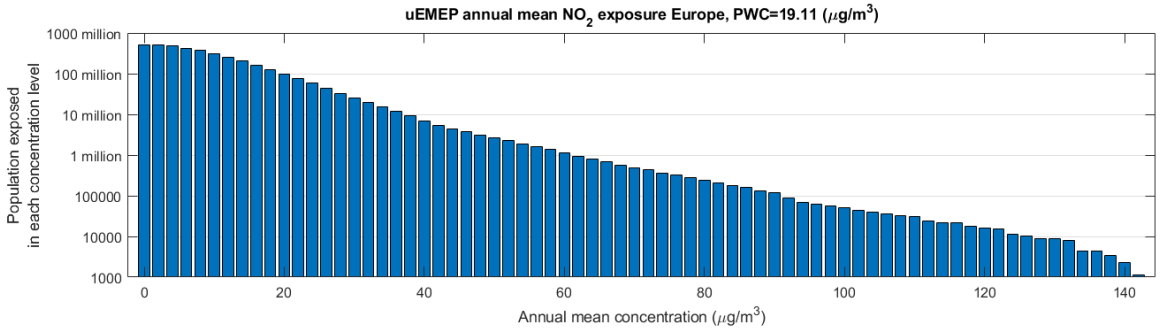
- Example maps for Europe



- Validation for NO_2 and $PM_{2.5}$



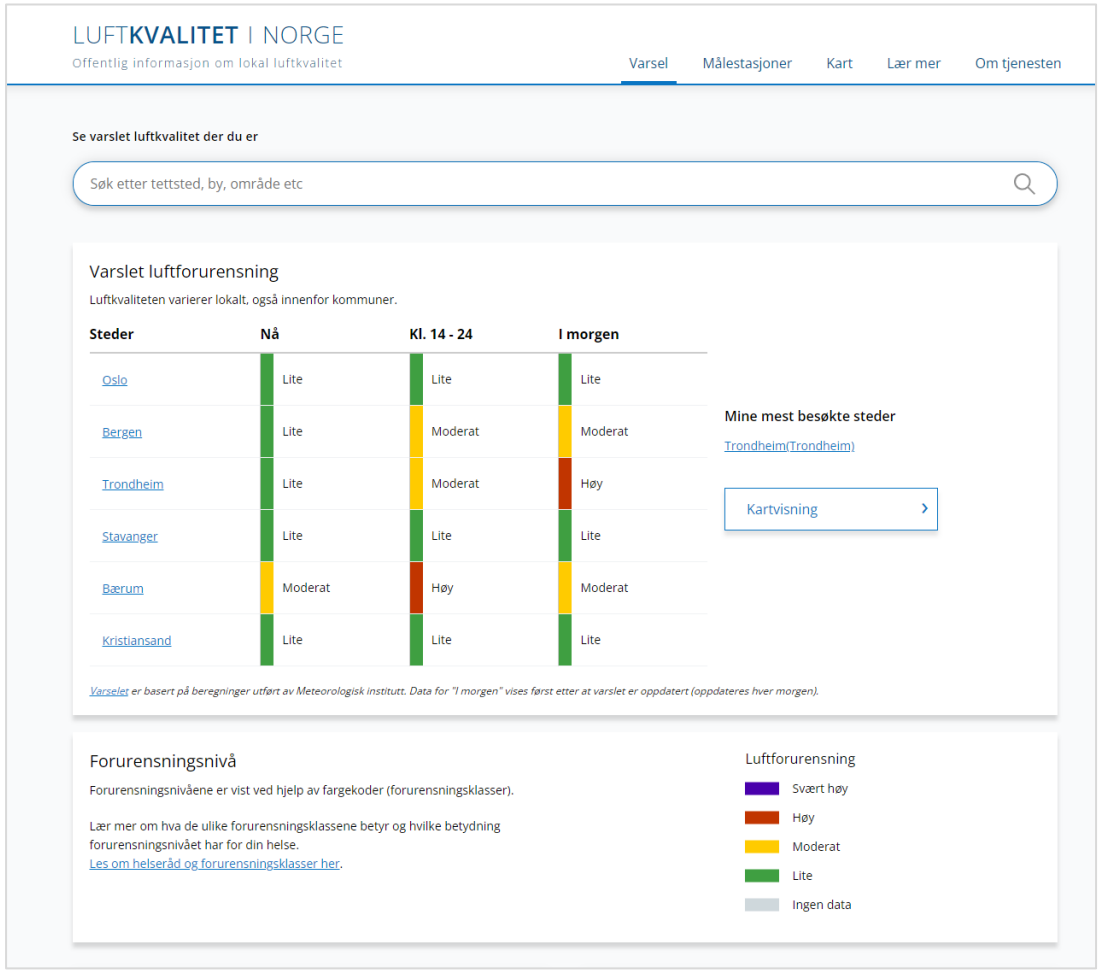
- Exposure in Europe

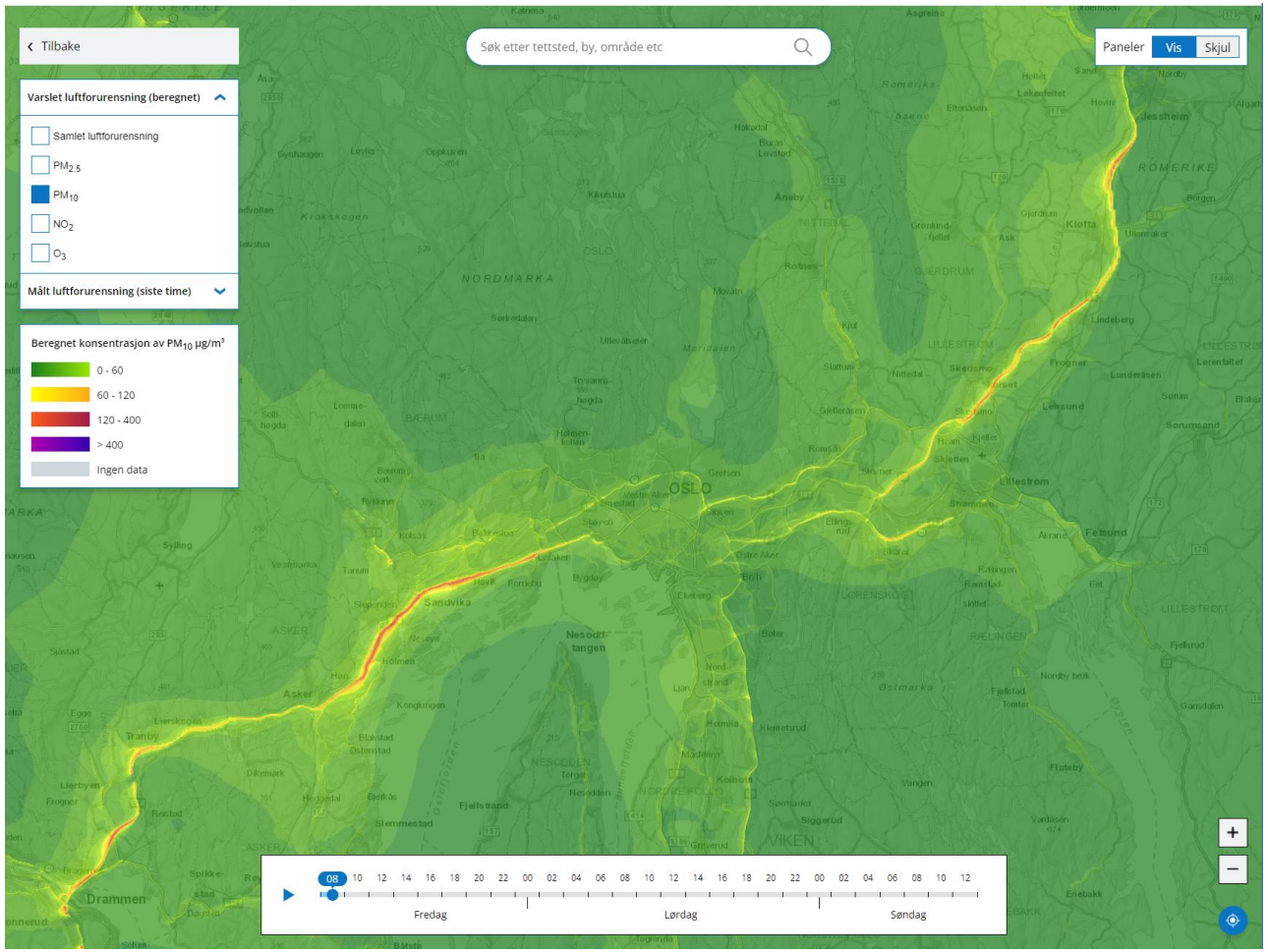


Activities in Norway

Air quality forecasting service

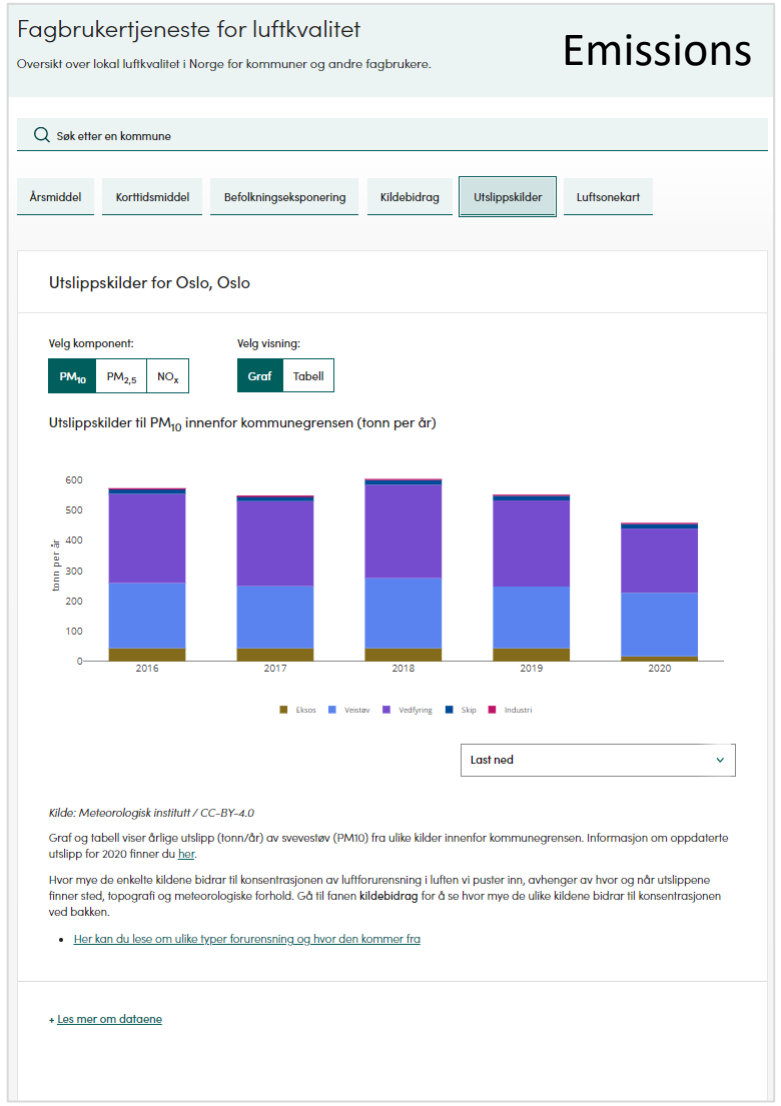
https://luftkvalitet.miljodirektoratet.no/

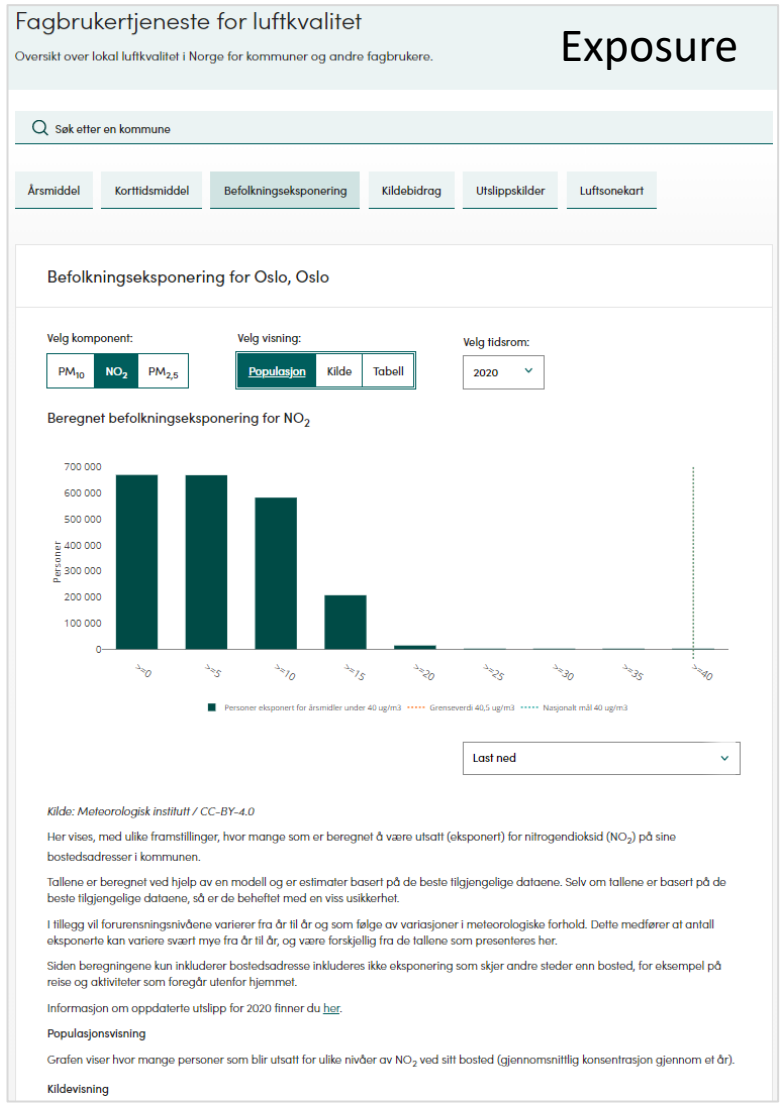




Expert user service: maps/exposure/sources/emissions for all municipalities

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





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

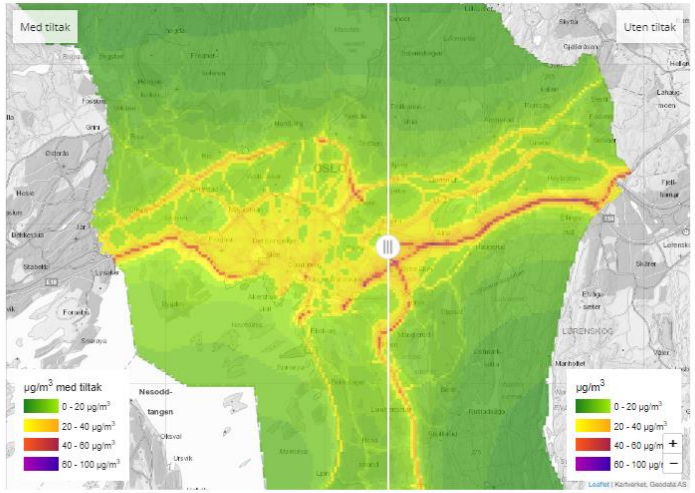
Årsmiddel for Oslo, Oslo

Oslo, Oslo 2018

Velg komponent:

PM_{10} | NO_2 | $PM_{2,5}$

Beregnet årsmiddelkonsentrasjon av NO_2 i 2018, med og uten tiltak



Årsmiddel sammenligning

Last ned

Korttidsmiddel for Oslo, Oslo

Velg komponent:

PM_{10}

Befolkningseksponering for Oslo, Oslo

Change in exposure

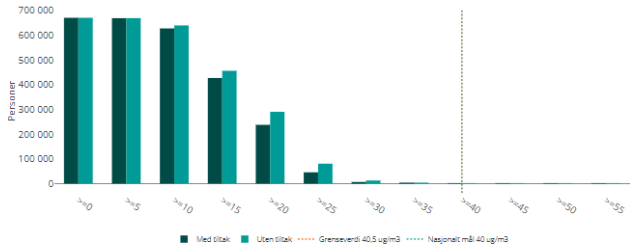
Velg komponent:

PM_{10} | NO_2 | $PM_{2,5}$

Velg visning:

Graf | Tabell

Beregnet befolkningseksponering for NO_2 i 2018, med og uten tiltak



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Kildebidrag for Oslo, Oslo

Change in source contributions

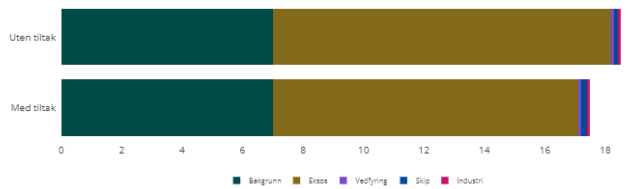
Velg komponent:

PM_{10} | NO_2 | $PM_{2,5}$

Velg visning:

Graf | Tabell

Kildebidrag i µg/m³ til NO_2-forurensning i 2018, med og uten tiltak



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Utslippskilder for Oslo, Oslo

Change in emissions

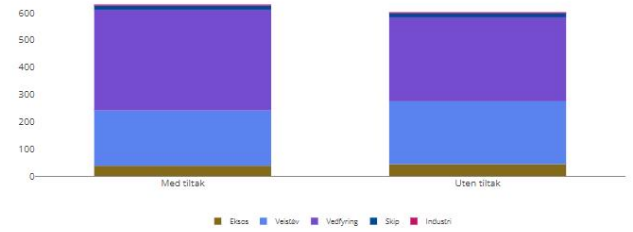
Velg komponent:

PM_{10} | $PM_{2,5}$ | NO_x

Velg visning:

Graf | Tabell

Utslippskilder til PM_{10}-forurensning i 2018 (i tonn/år), med og uten tiltak



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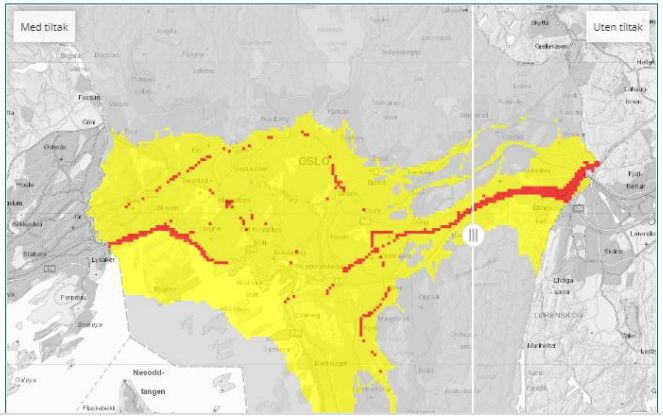
Luftsonekart for Oslo, Oslo

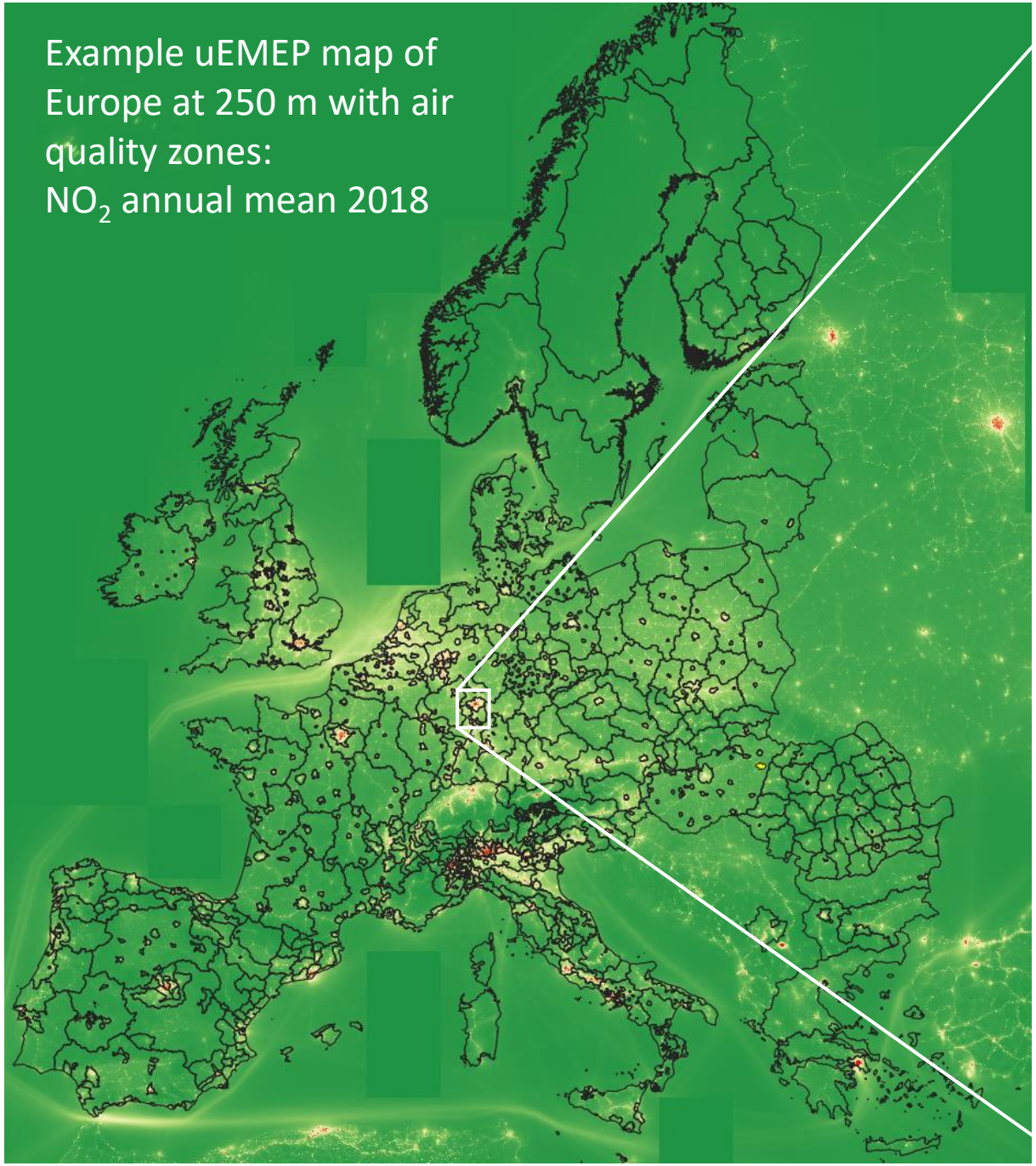
Change in air quality zone maps

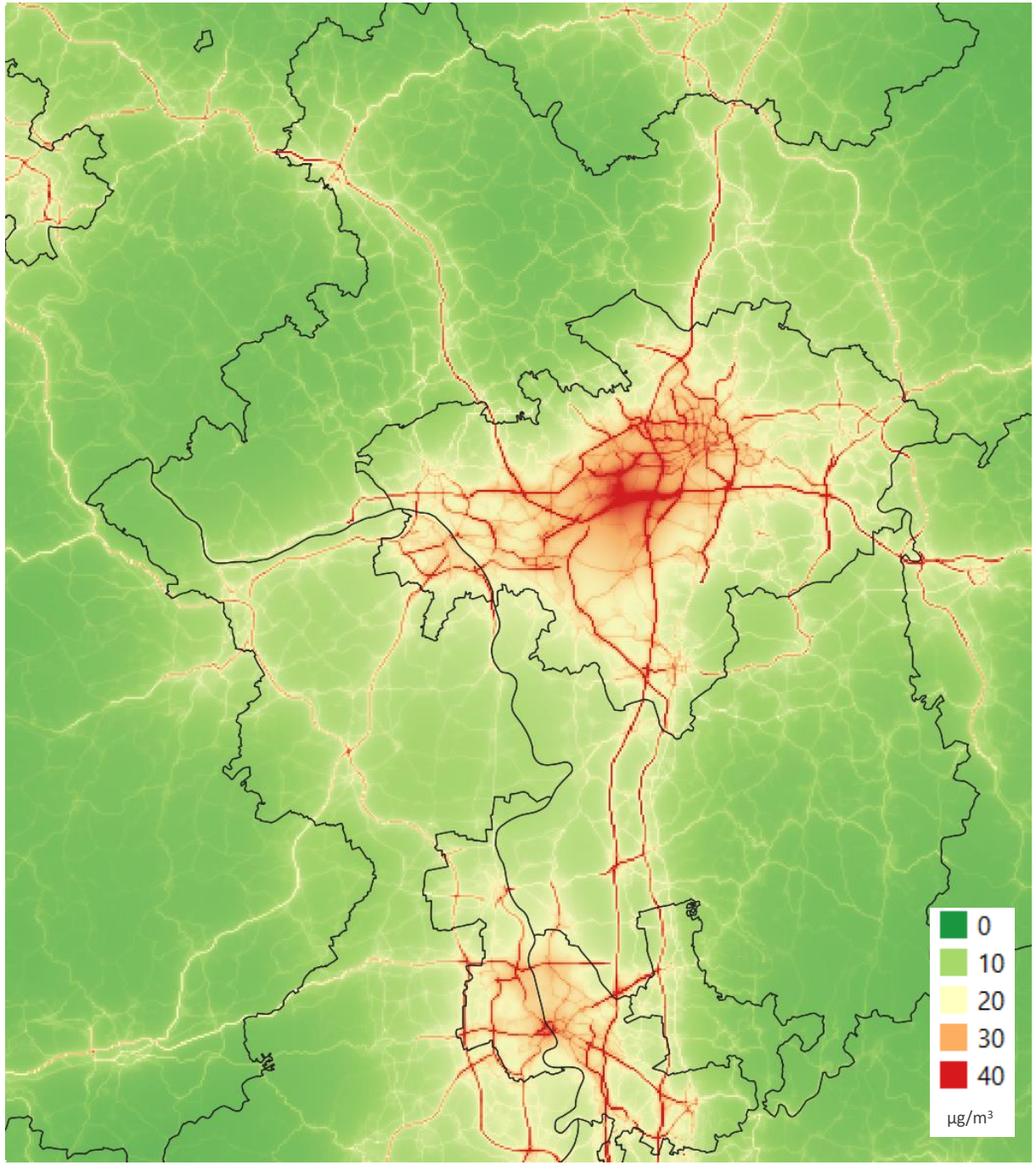
Luftsonekart basert på meteorologi i 2018, med og uten tiltak



Activities in FAIRMODE

Example uEMEP map of Europe at 250 m with air quality zones:
NO_2 annual mean 2018

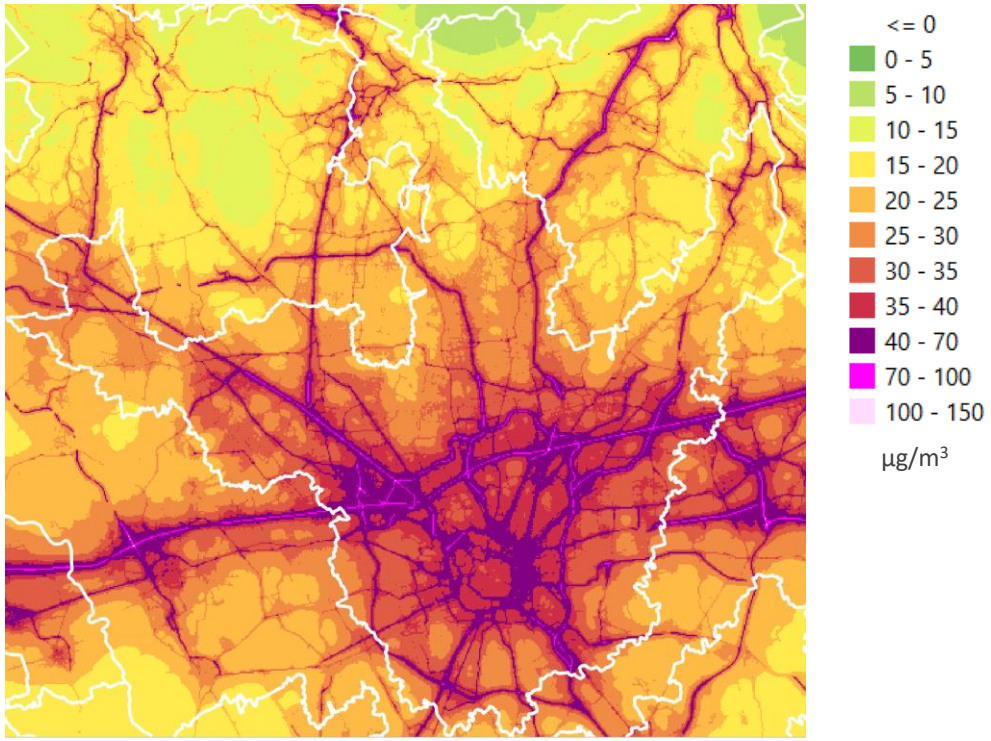




Spatial representativeness area (SRA)

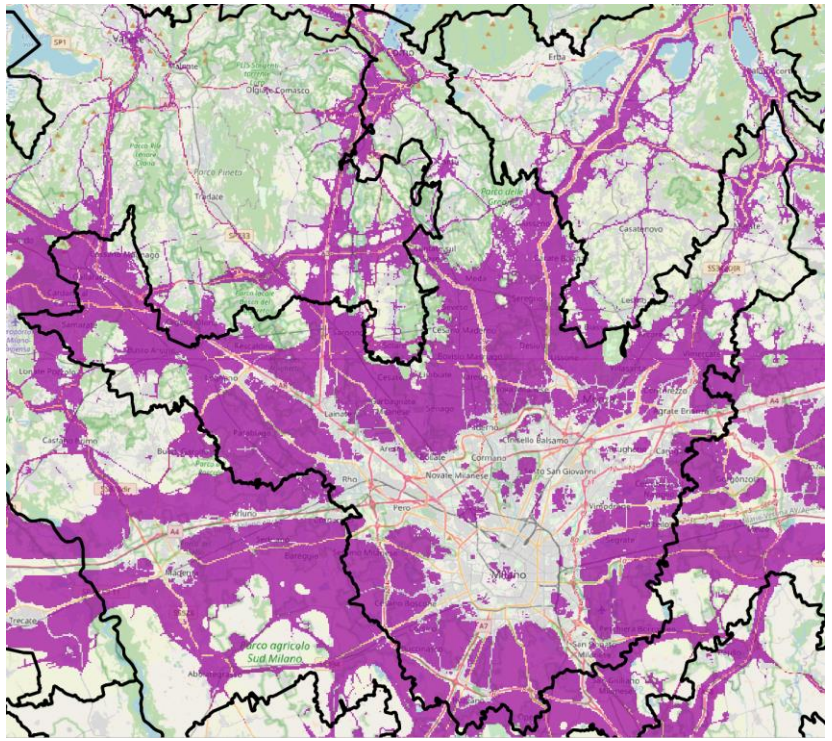
- Use of models to calculate spatial representativeness of monitoring sites
- Many possible ways of defining this but a simple method has been chosen
- The monitoring station's SRA is the area within an airquality zone with the same concentration, ± a threshold value, as at the monitoring site
- Varying thresholds tested include 20%, 10%, 5% for NO_2 and $PM_{2.5}$
- 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_2



Contour map for NO_2 (2018) Milan air quality zone.

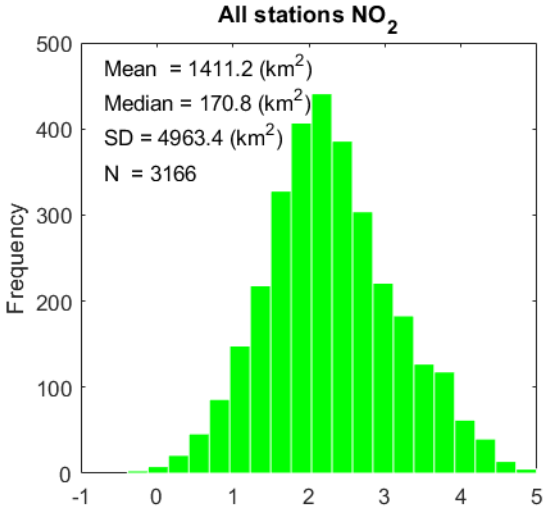
Threshold 20%

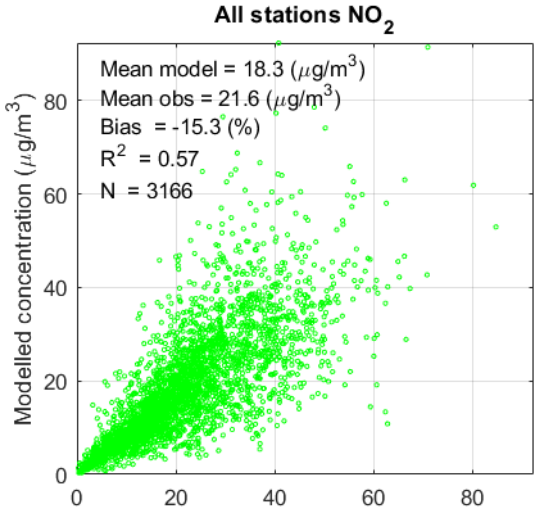


A measurement station somewhere in the Milan AQ zone that measures 30 µg/m³

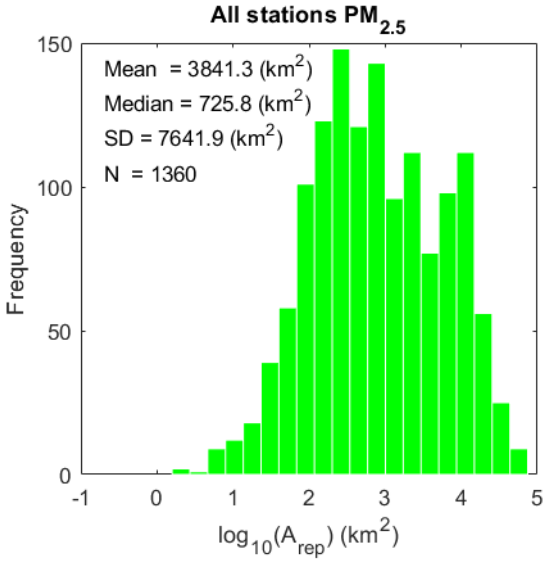
Spatial representativeness area (±20%) for all stations in Europe, NO_2 and $PM_{2.5}$

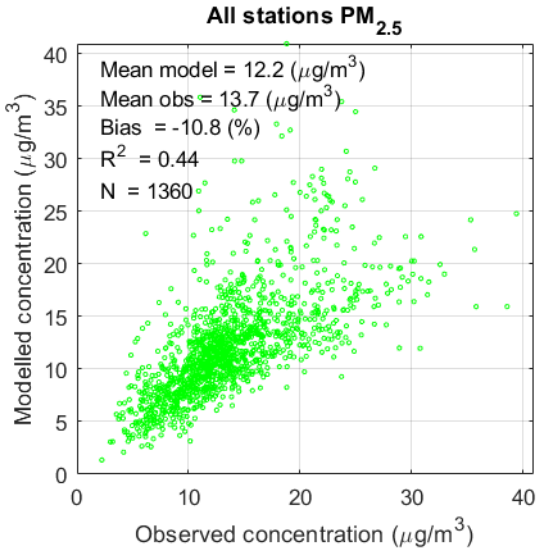
NO_2





$PM_{2.5}$





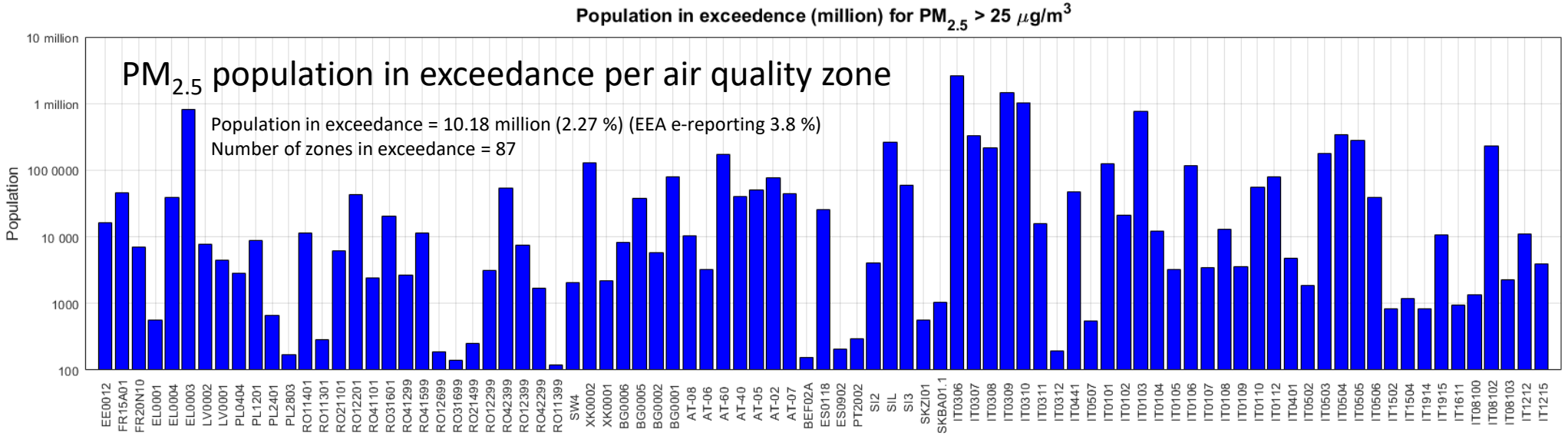
Exceedance reporting

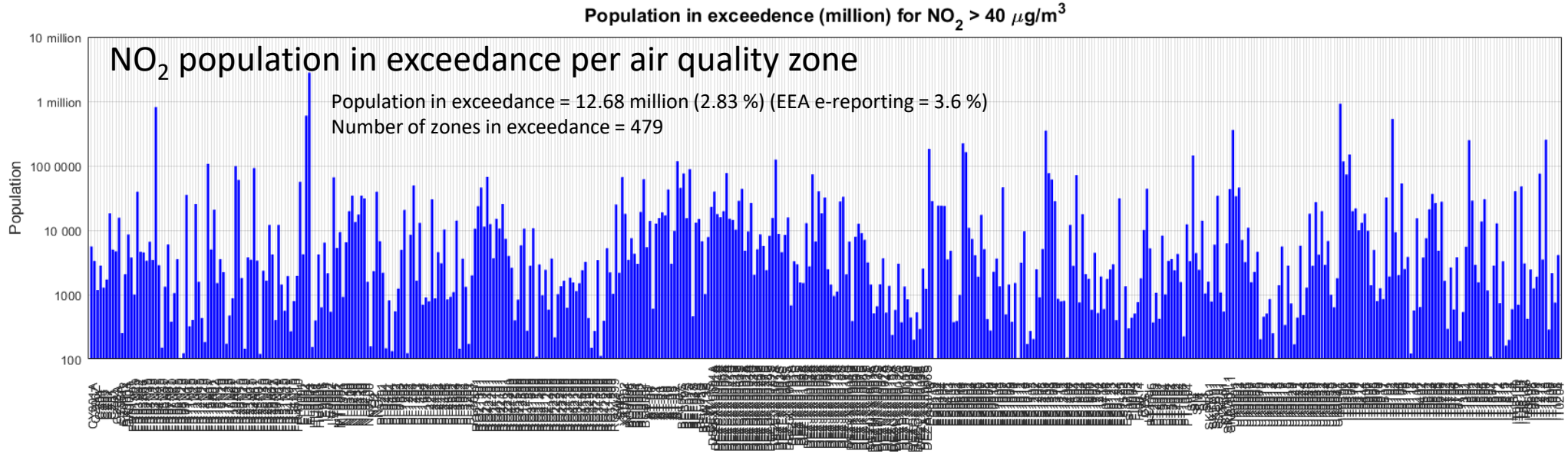
- When measurements indicate exceedances then the area, the population and the length of road in exceedance must be reported from within that air quality zone
- As an excercise we assessed the population and area in exceedance for all air quality zones (668) in Europe based on uEMEP 100 m calculations

- $PM_{2.5}$: 87 of the zones were in exceedance and 10.2 million people were exposed above the limit value (> 25 µg/m^3). Area in exceedance is 6506 km^2

- NO_2: 479 of the zones were in exceedance and 12.7 million people were exposed above the limit value (> 40 µg/m^3). Area in exceedance is 4806 km^2

Population in exceedance for EU air quality zones



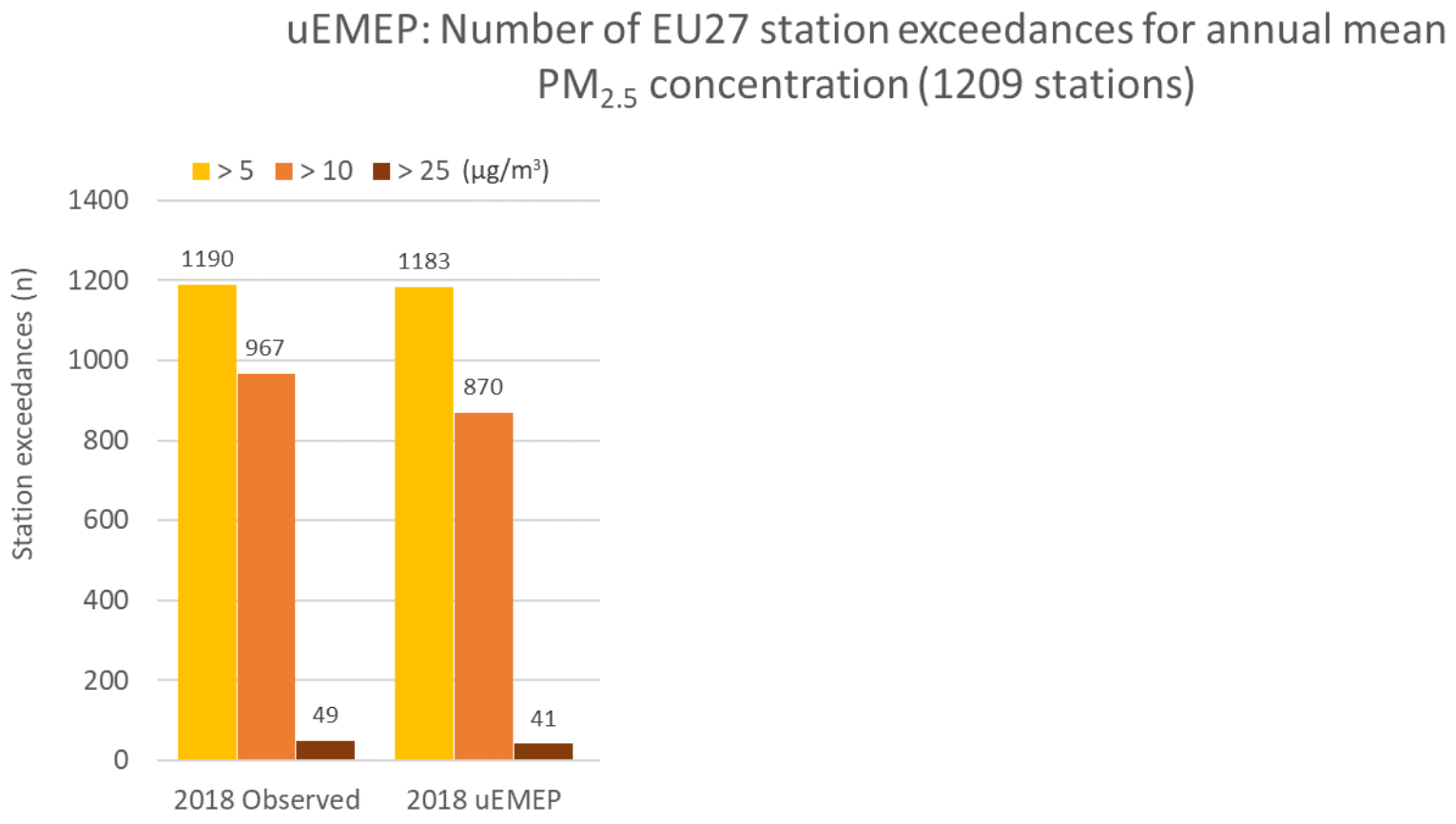


Activities for the European Commission

Review of the Ambient air quality directive

- Part of a consortium contracted by DGENV to assess air quality guidlines for the coming review of the AAQD
- A number of scenarios are produced by IIASA using GAINS that will optimise costs for background $PM_{2.5}$ 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 preporatory 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

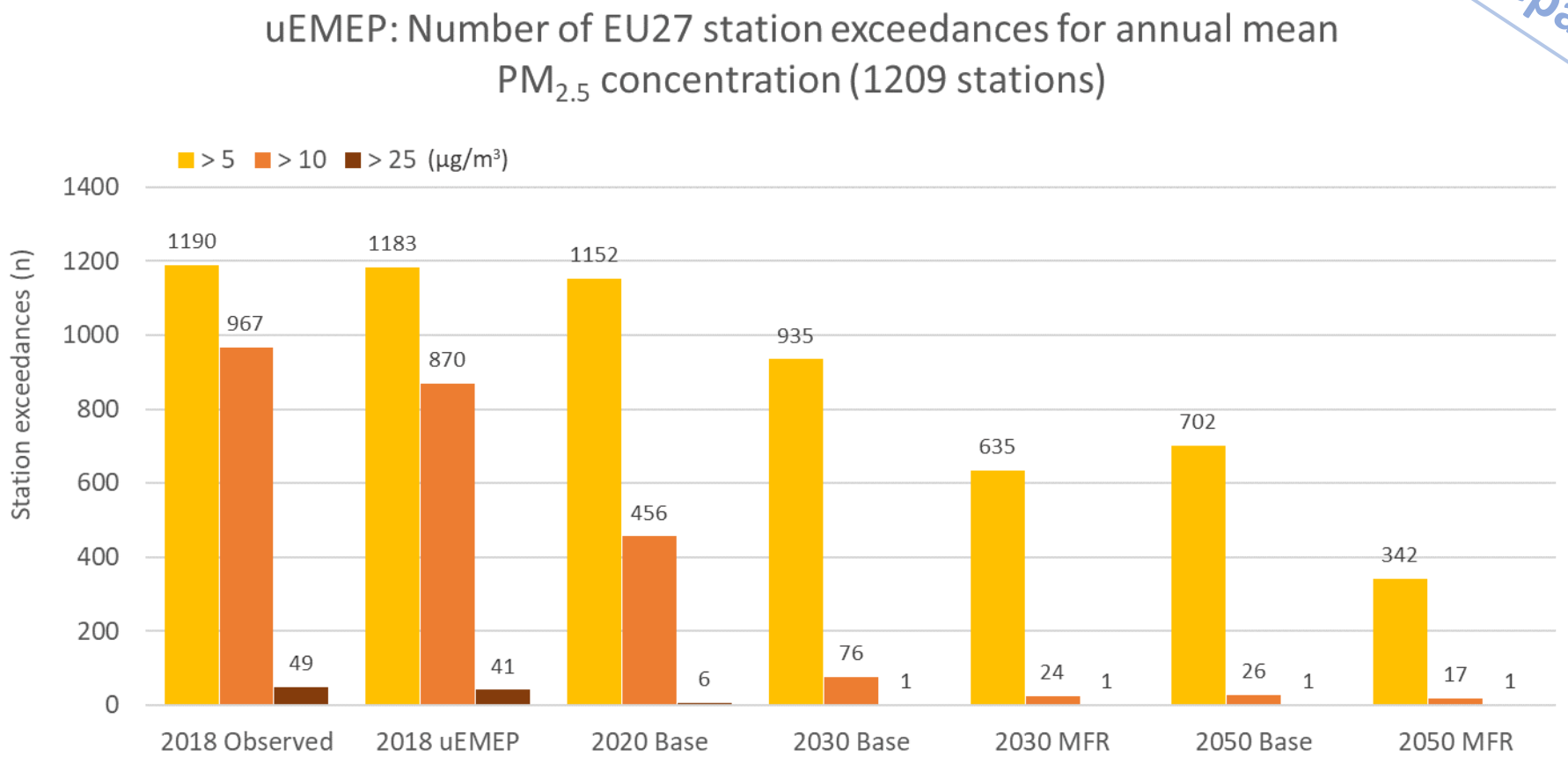
$PM_{2.5}$ exceedance calculations at **monitoring sites** (25 m) using EMEP/uEMEP: validation using country submitted emissions



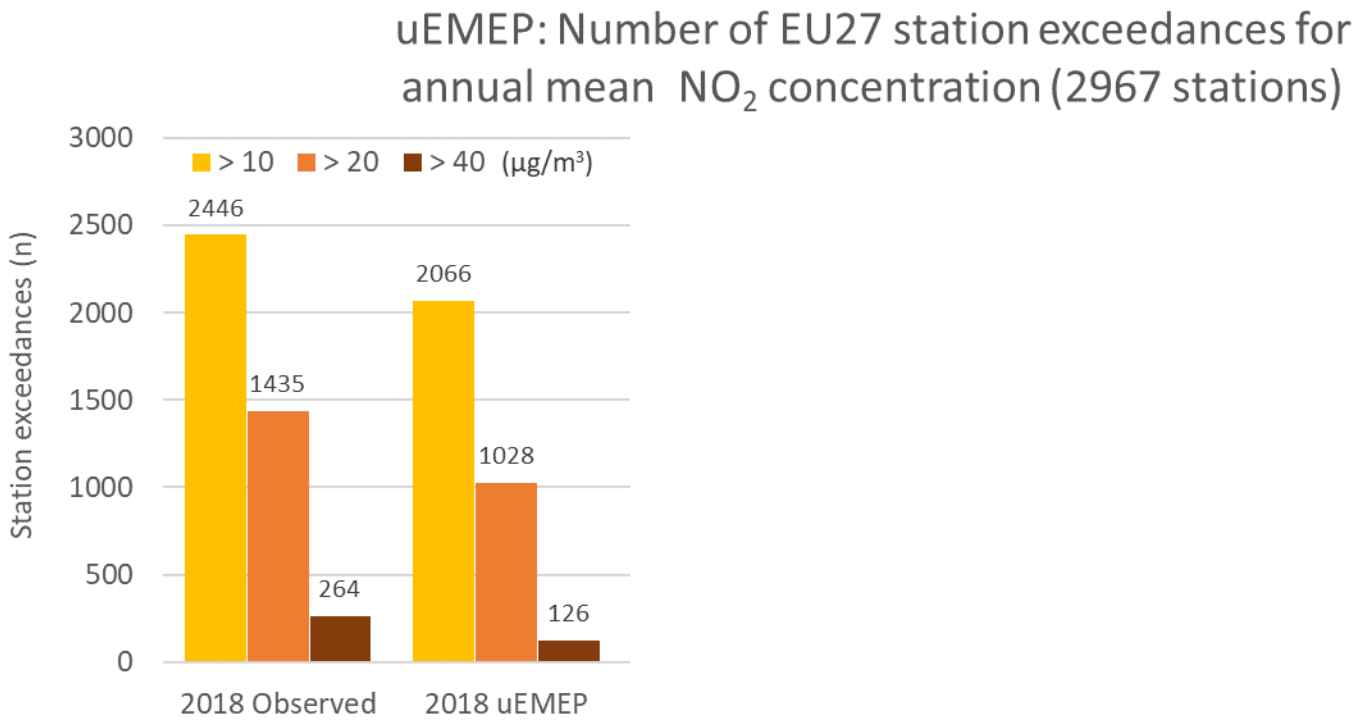
uEMEP bias = -9%

$PM_{2.5}$ exceedance calculations at **monitoring sites** (25 m) using EMEP/uEMEP: scenarios using GAINS emissions

Preparatory analysis



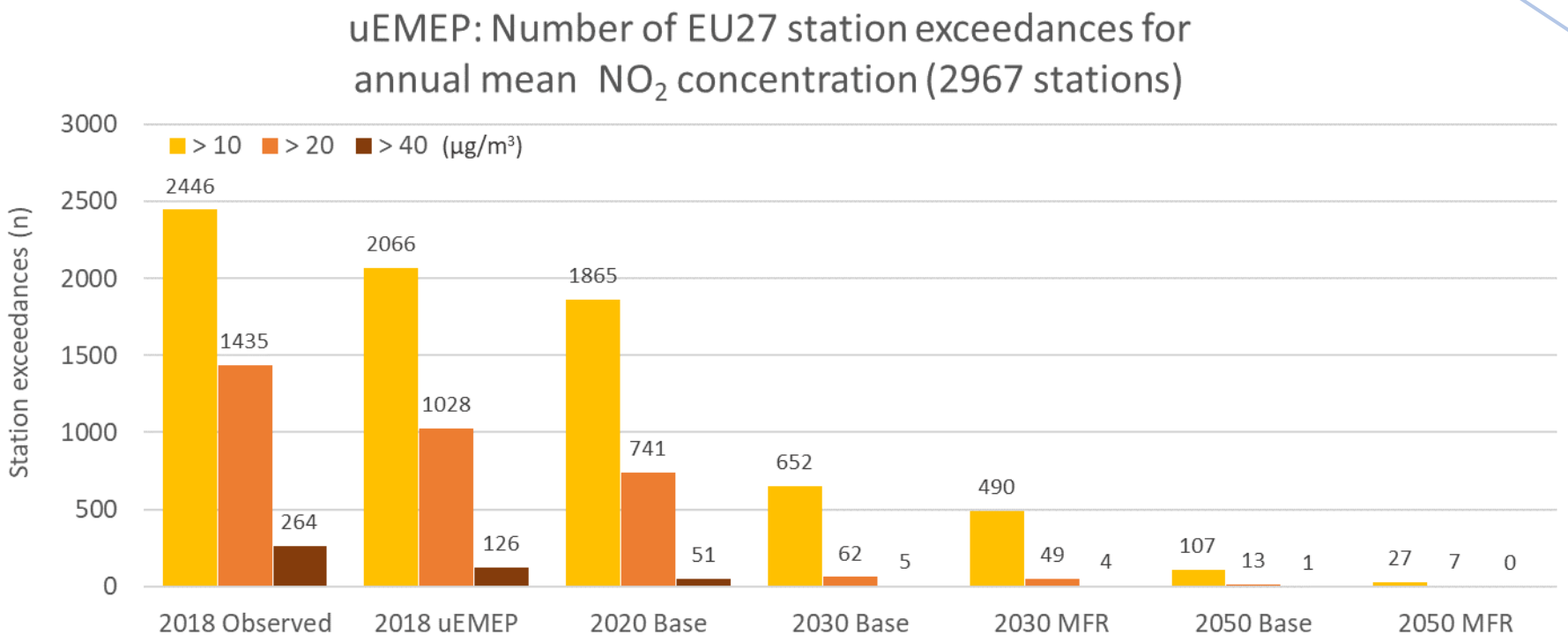
NO_2 exceedance calculations at **monitoring sites** (25 m) using EMEP/uEMEP: validation using country submitted emissions



uEMEP bias = -18%

NO_2 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

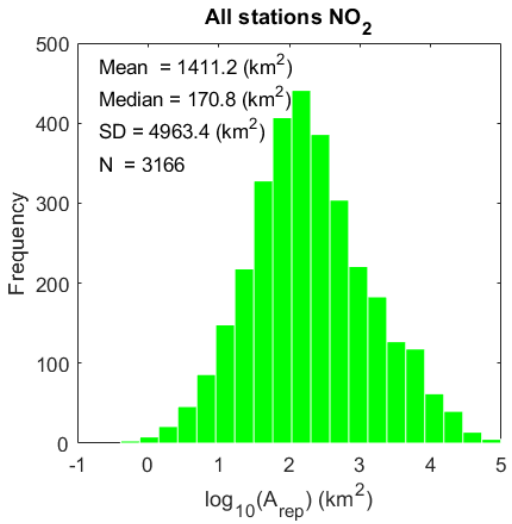
- Room for improvement in the uEMEP proxy data and/or the EMEP emission data for PM
- Uses basic proxy data to redistribute emissions that are globally available. Local modelling should have better high resolution emission data and hence results (as seen in Norway)
- Can only downscale primary emissions
- 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.

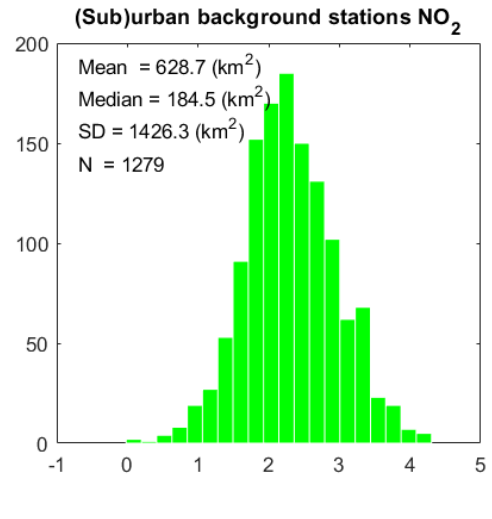
Documentation, data and models

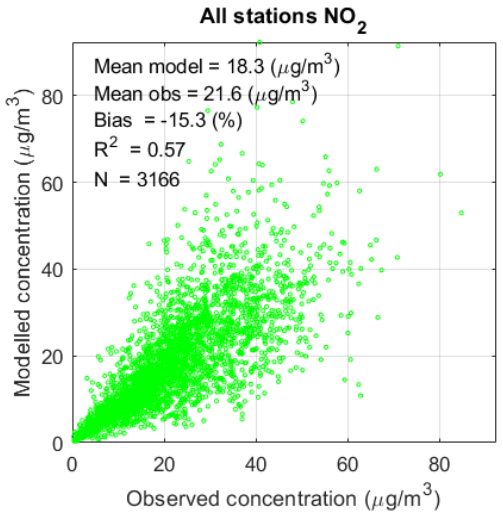
- **Regional scale model:** EMEP MSC-W model rv4.34 (0.1° x 0.1°)
  - https://github.com/metno/emep-ctm
- **Downscaling model:** uEMEP v6 (250 – 25 m)
  - https://github.com/metno/uEMEP
- **Regional scale emissions:** EMEP 0.1º with GNFR3 replaced by TNO Ref2 emissions including condensables
  - https://www.ceip.at/webdab-emission-database
- **Downscaling population data:** GHS-POP, Global Human Settlement-Population, (9 arcsec)
  - https://ghsl.jrc.ec.europa.eu/ghs_pop2019.php
- **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://gmd.copernicus.org/preprints/gmd-2021-198/

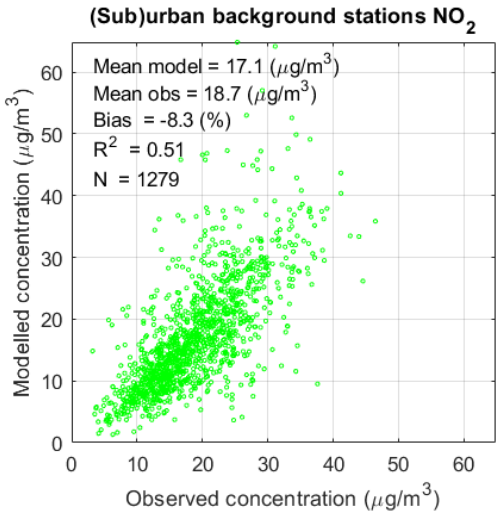
Extra slides

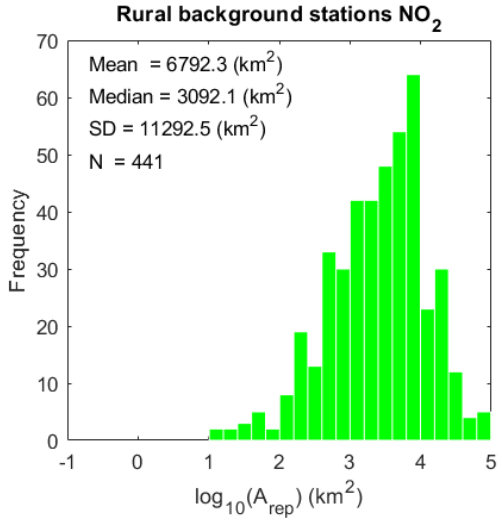
Spatial representativeness area NO_2

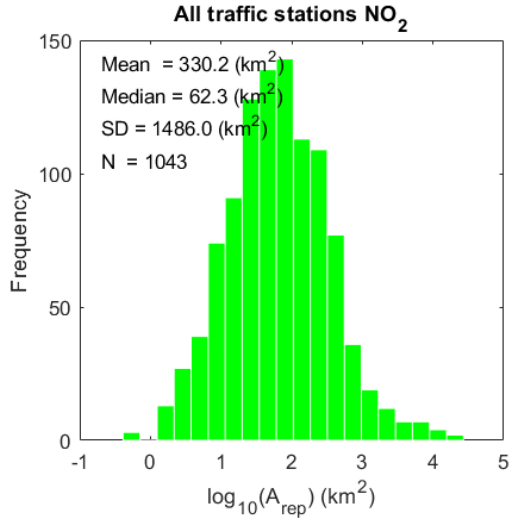


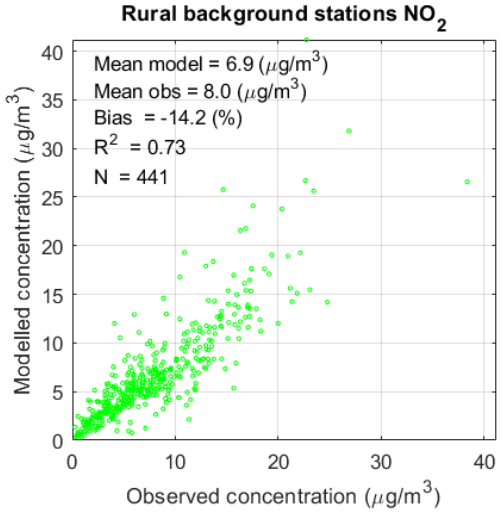


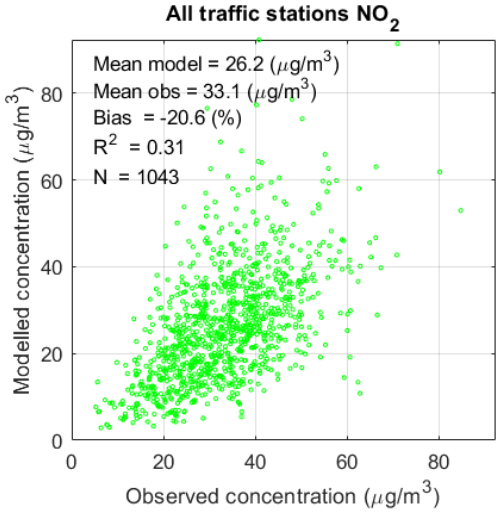












Spatial representativeness area $PM_{2.5}$