Norwegian Meteorological Institute

# Application of EMEP/uEMEP for the AAQD review process

Bruce Rolstad Denby, Agnes Nyeri, Qing Mu, Hilde Fargeli

TFIAM 07.04.2022

# Content

- Preface
  - Background
  - The emissions
  - A summary about the EMEP/uEMEP methodology
- Calculations at Airbase station sites
- Scenarios and exceedances at stations
- Scenarios and exposure calculations
- Summary
- Bias adjustment

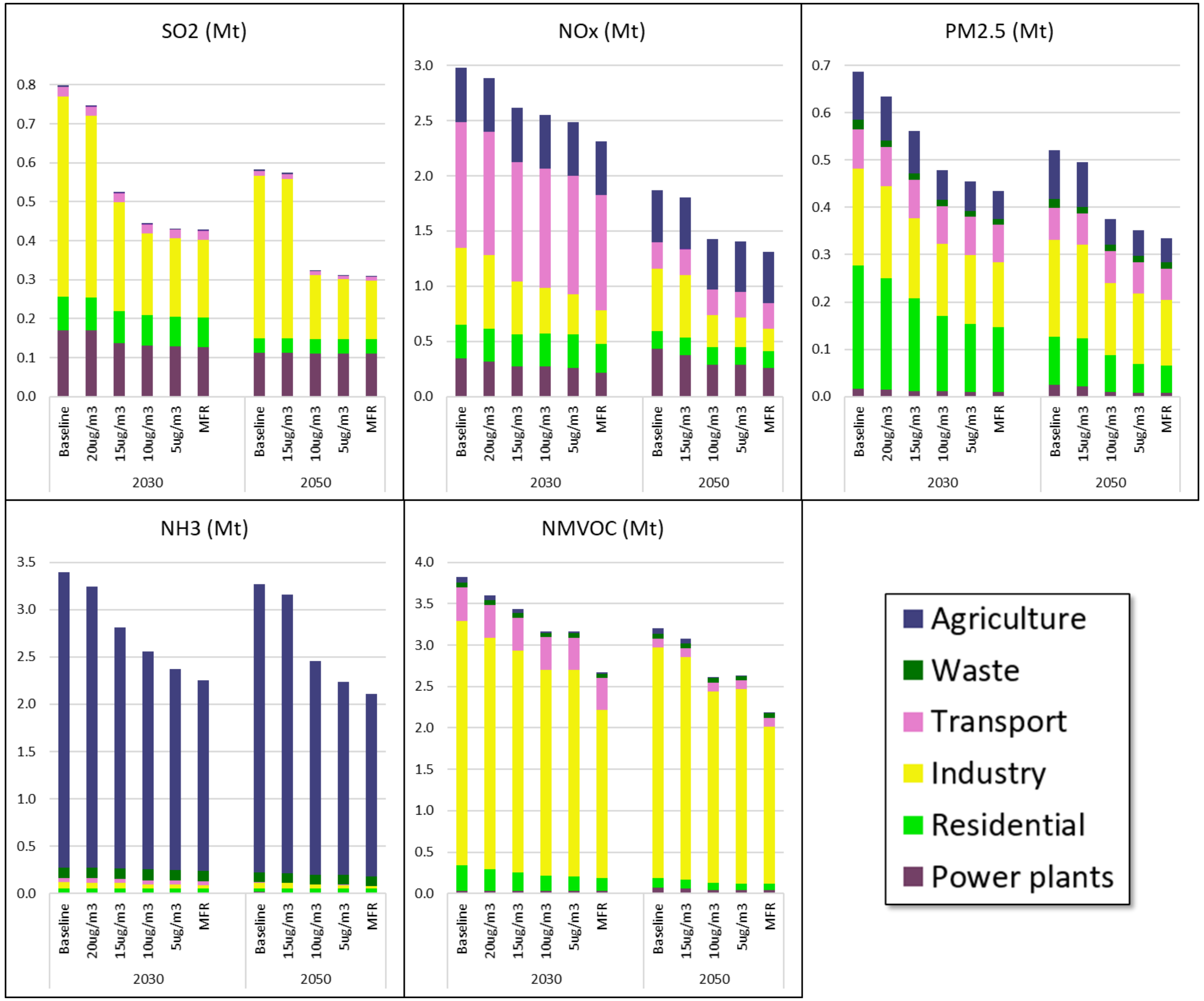
# Preface

# Background

- Consortium consisting of Trinomics, Ricardo, Vito, IIASA and MET Norway are consulting for the Commission in their review of the European Ambient Air Quality Directives (AAQD)
- Our task (MET Norway) is to take a range of future scenarios produced by IIASA with GAINS and calculate concentrations with EMEP and uEMEP for EU27 countries
- The concentrations are used for health and economic impact assessment and to see the achievability of reaching the recently published WHO guidelines
- Scenarios include Baseline and Maximum Feasible Technological Reduction (MFR) scenarios for the years 2015, 2020, 2030 and 2050 and a range of optimised scenarios derived from GAINS to achieve concentration levels for $PM_{2.5}$ (5, 10, 15 and 20 $ug/m^3$)
- Pollutants include $PM_{2.5}$, $PM_{10}$, $NO_2$, $O_3$, BaP, CO, $SO_2$ and Benzene
- Concentration fields are provided further to Vito and Ricardo for health and economic evaluation
- Do not ask me any questions about the emissions

# Emission trends (all scenarios, including optimized cases)

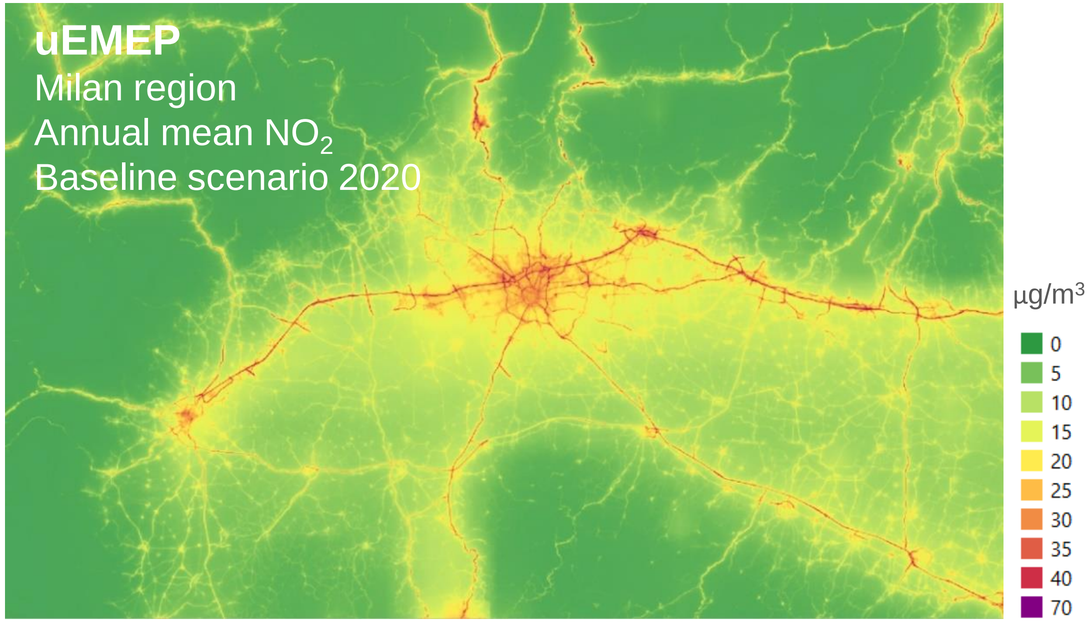
Change in total EU-27 emissions by sector

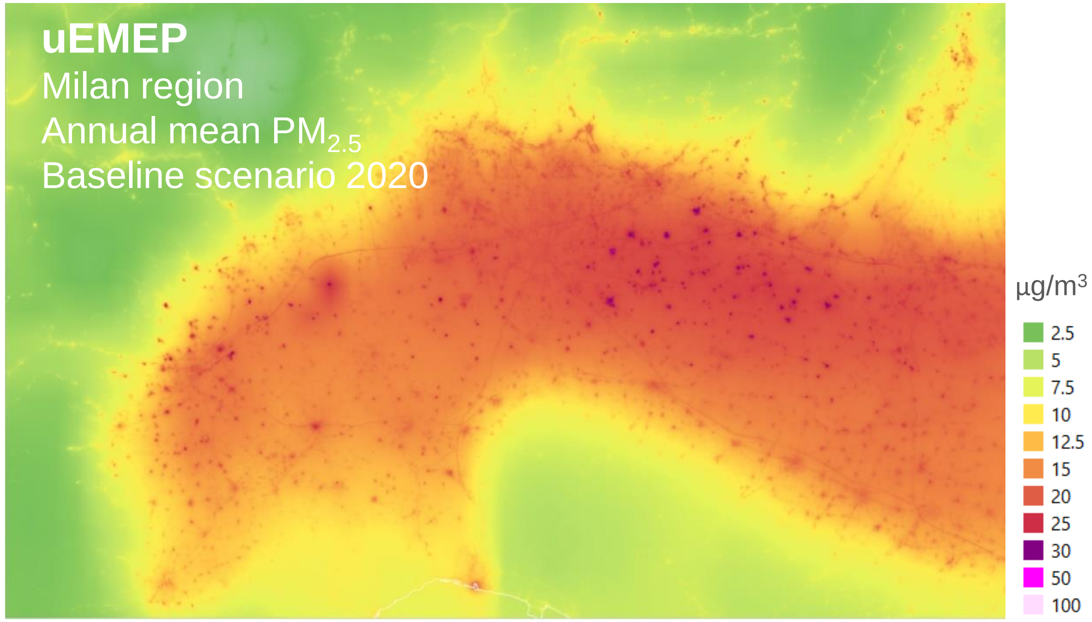



- Relates to 'background' concentrations – the indicated levels shall be met everywhere (if feasible according to the GAINS model assessment)
- ‘Attaining’ 20 and 15 µg/m$^3$ $PM_{2.5}$ concentration targets appears feasible and does not require significant additional reductions neither in 2050 nor 2030
- Additional mitigation needs to increase strongly to ‘attain’ the more ambitious targets of 10 and 5 µg/m$^3$ and reaches often near MFR levels for several pollutants
- Key further reductions seem achievable in
  - Residential sector ($PM_{2.5}$)
  - Industry ($SO_2$, NOx, VOC)
  - Agriculture ($NH_3$)
- Feasibility in some regions is an issue, both in 2030 and 2050, especially for 5 µg/m$^3$ target

# Modelling methodology

- Concentrations are calculated using the EMEP model (0.1°) and then downscaled for selected sources using uEMEP
- Downscaling is carried out at:
  - 25 m resolution at Airbase station sites for exceedance calculations
  - 250 m resolution for mapping and exposure calculations
- Emission scenarios for the concentration calculations are provided by GAINS per country and these are spatially distributed using the gridded EMEP emissions (country submitted)
- Calculations are made for the Baseline, MFR and OPTimised scenarios for the years 2015, 2020, 2030 and 2050



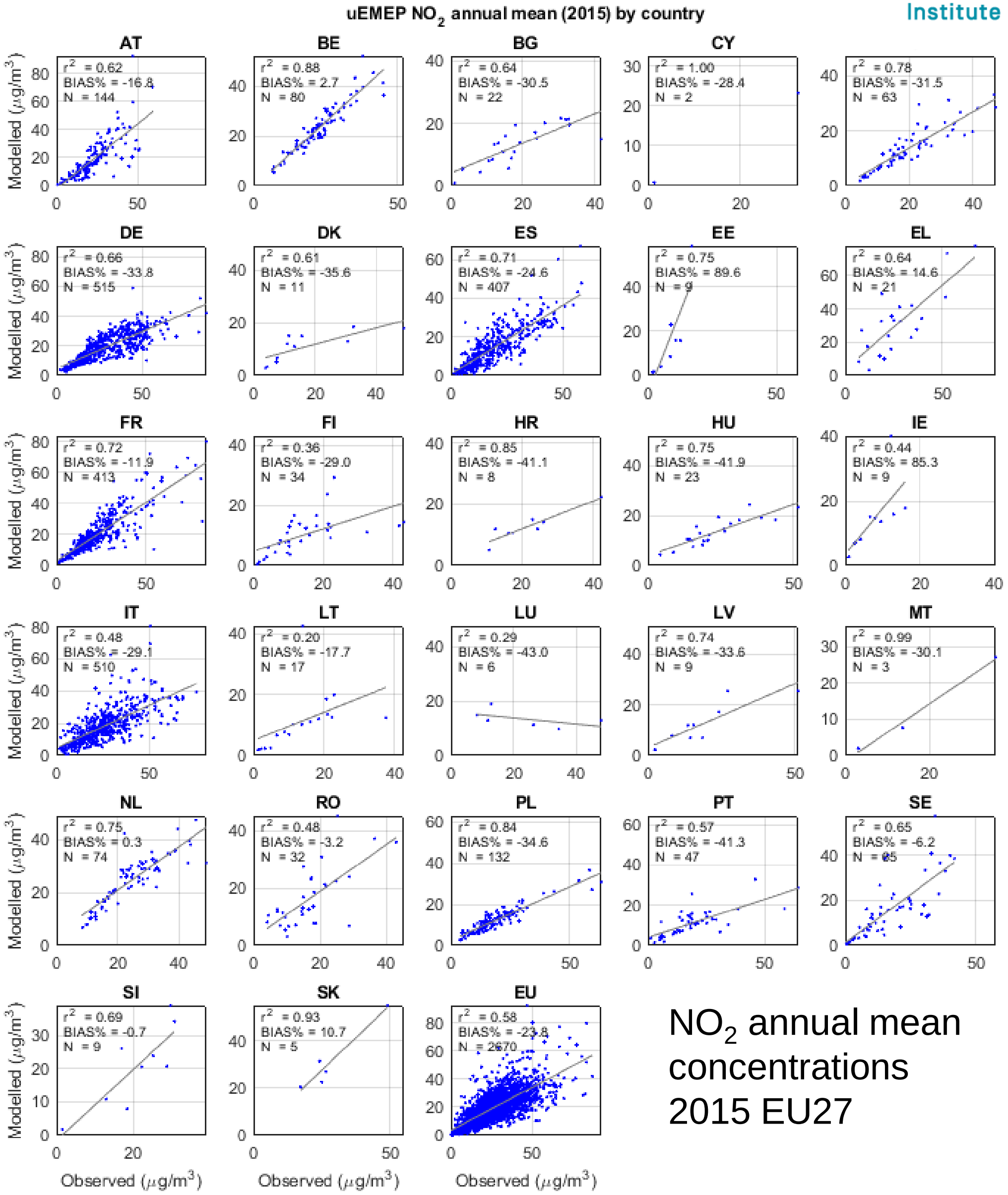



# Calculations at station sites

# Station calculations

Norwegian Meteorological Institute

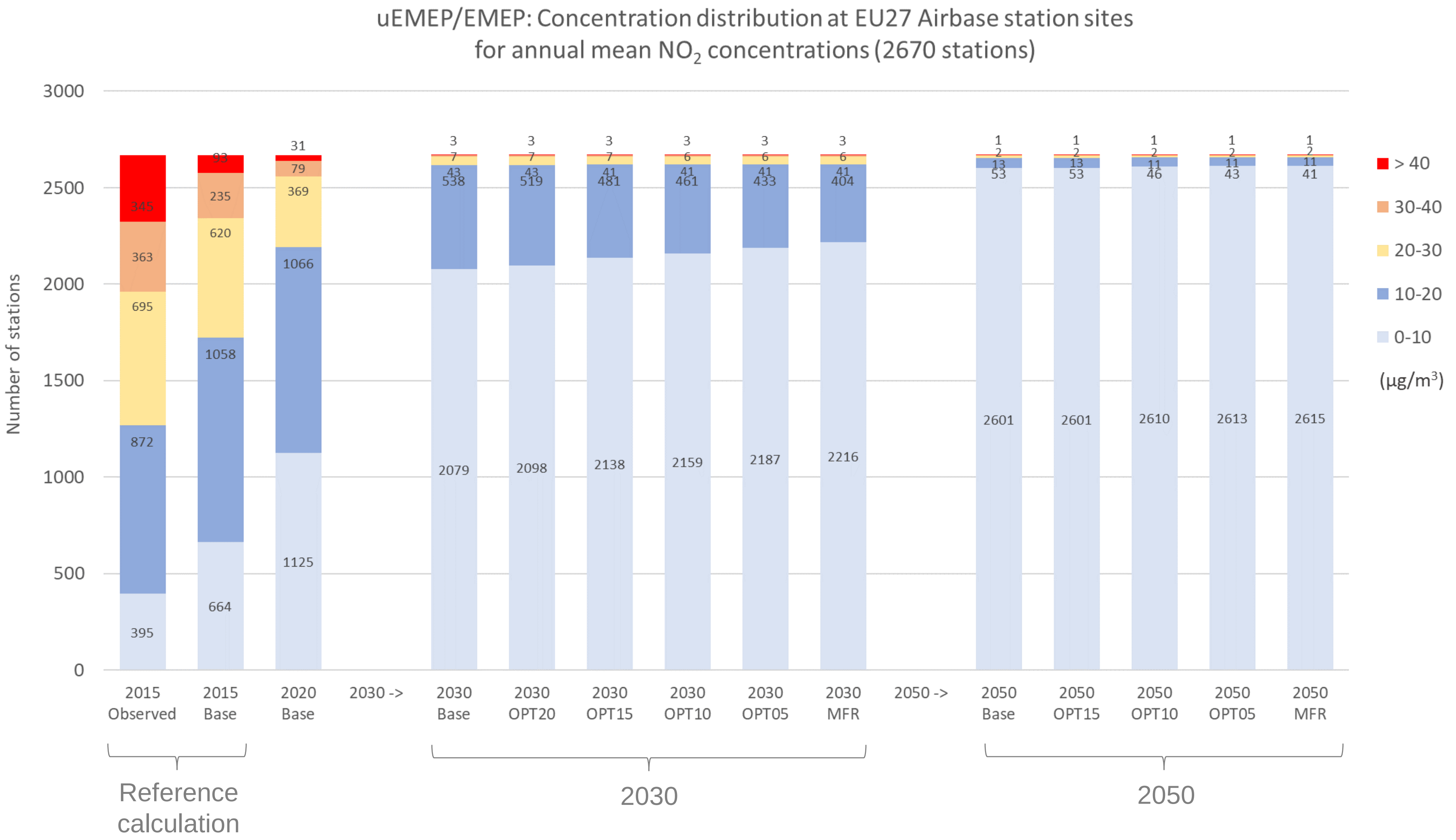
- Comparison of modelled and observed concentrations at all Airbase sites for the reference year 2015
  - Station bias for pollutants presented here:
    - $NO_2$ = -23%
    - $PM_{2.5}$ = -19%
    - SOMO35 = +1%
    - BaP = +11%
  - Bias for other pollutants calculated:
    - $PM_{10}$ = -33%
    - CO = -44%
    - Benzene = -53%
    - $SO_2$ = -26%
    - $O_3$ $26^{th}$ daymax = -23%
- Significant negative bias for a number of pollutants
- Impact of model/emission bias on the scenario calculations is addressed with a bias adjustment for $NO_2$ and $PM_{2.5}$




NO2 annual mean concentrations 2015 EU27

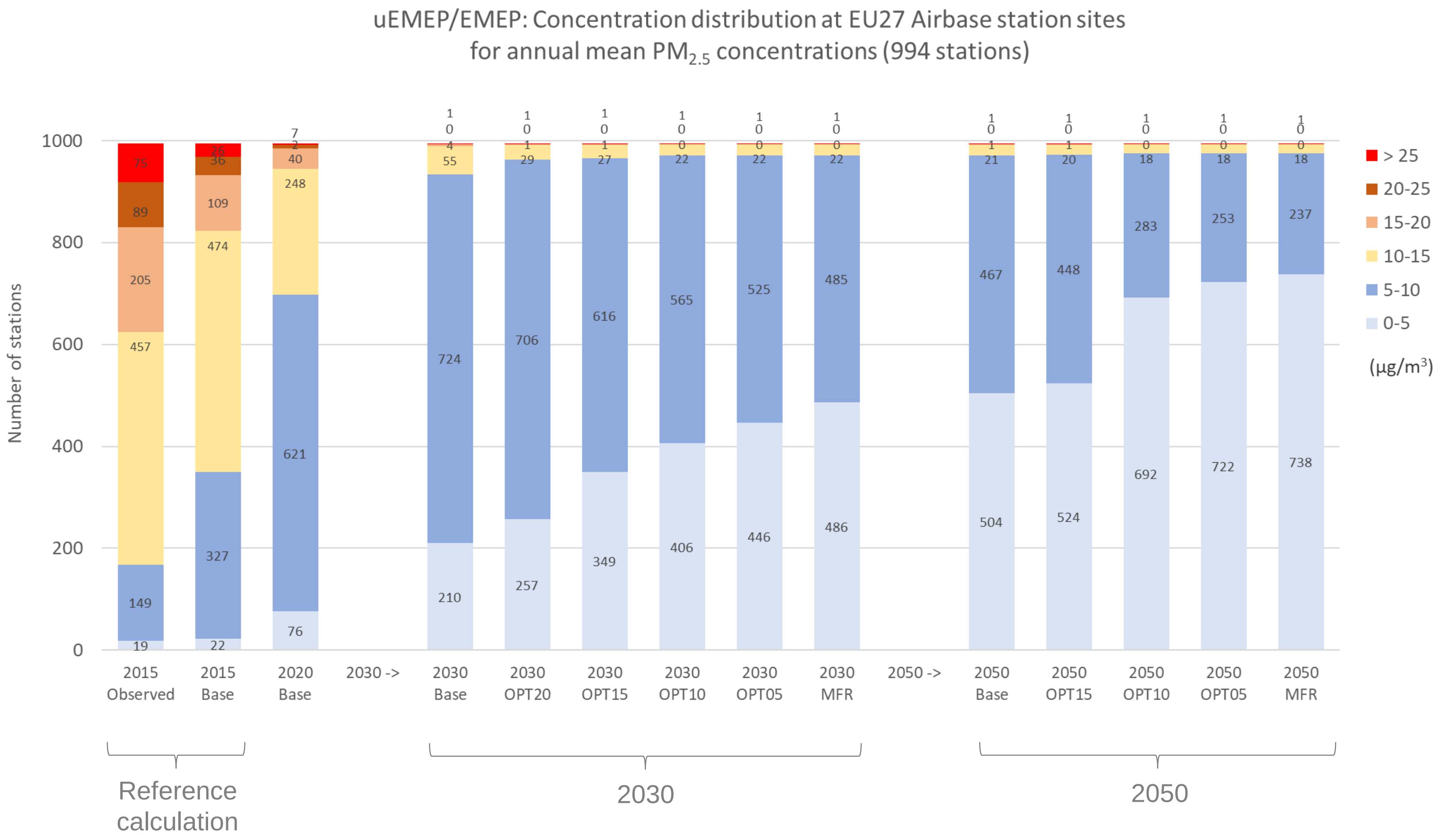
# Station exceedances $NO_2$

- Bias in reference calculation is clearly seen
- Large reductions in traffic $NO_X$ emissions is the main driver for scenario reductions
- In 2030 hardly any exceedances > 40 µg/m$^3$
- In 2050 few exceedances > 10 µg/m$^3$
- Persistent exceedances in 2030 and 2050 are at sites near Mediterranean ports
- Little difference between baseline and MFR for $NO_2$



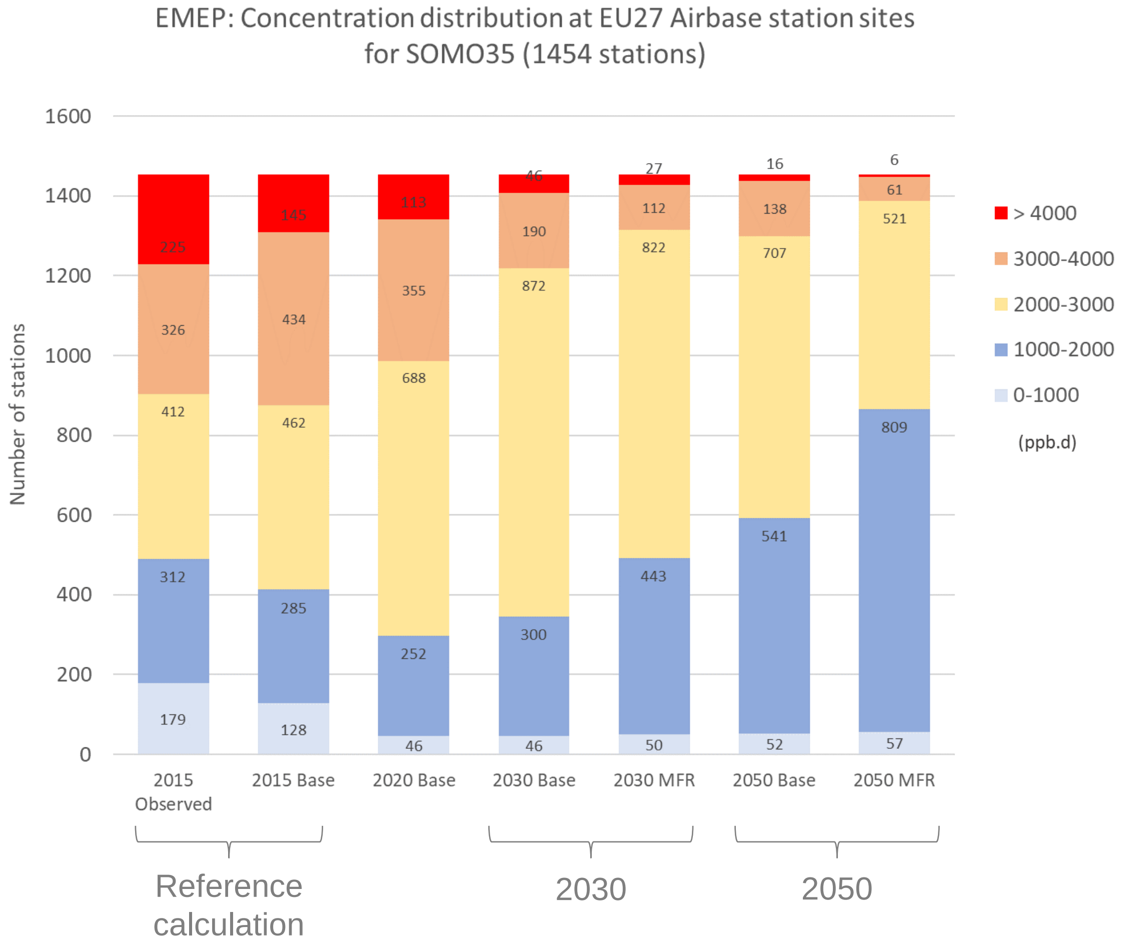
# Station exceedances $PM_{2.5}$

- Bias in reference calculation is clearly seen
- In 2030 few exceedances > 15 µg/m$^3$
- In 2050 few exceedances > 10 µg/m$^3$
- In 2030 and 2050 significant exceedances > 5 µg/m$^3$
- The one persistent exceedance in 2030 and 2050 is a traffic site in Stockholm (non-exhaust emissions)
- Some difference between baseline and MFR

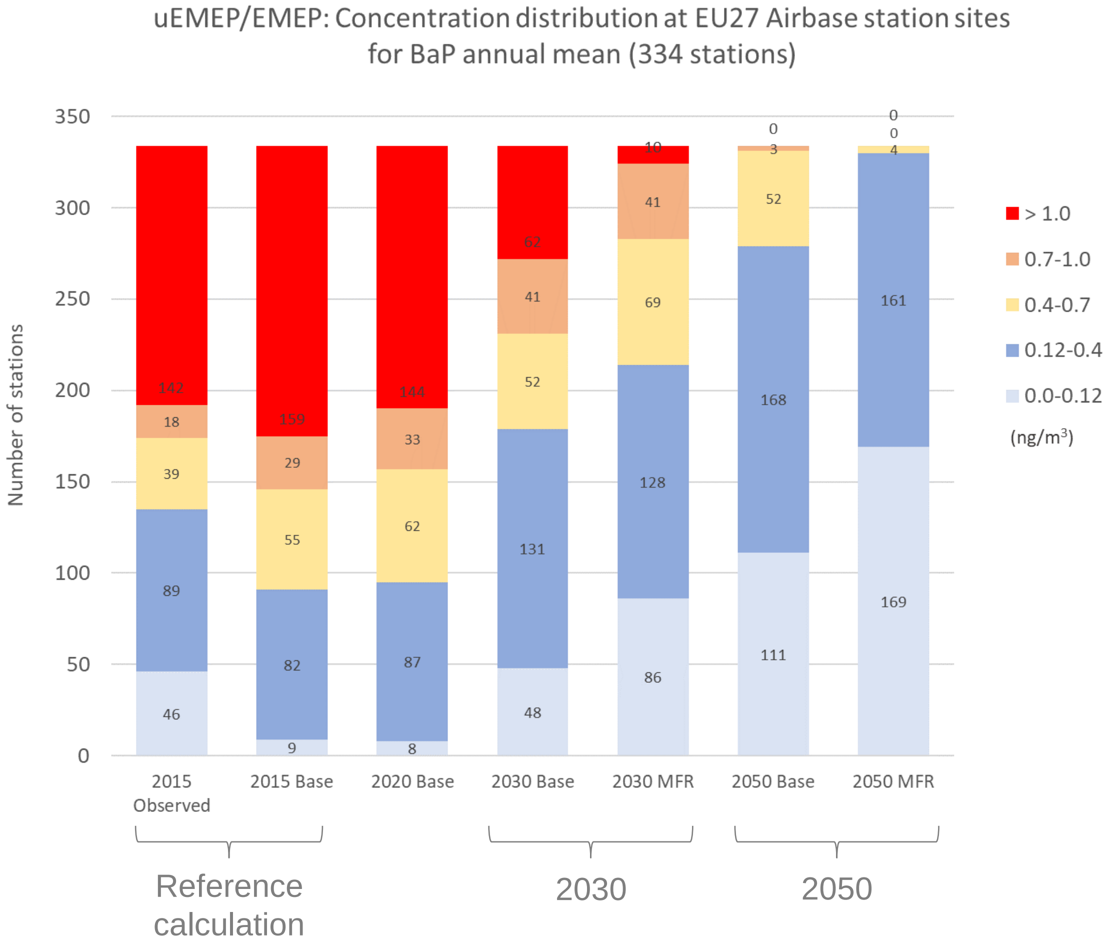


# Station exceedances SOMO35 and BaP

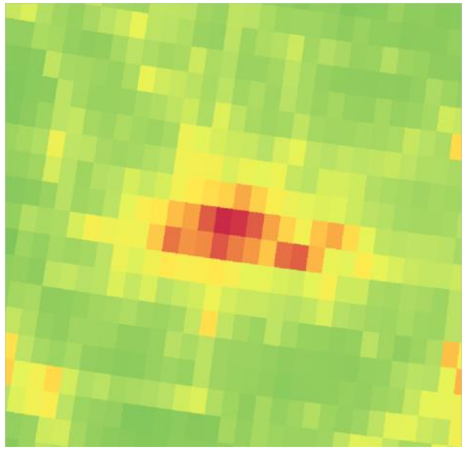
## SOMO35: health indicator

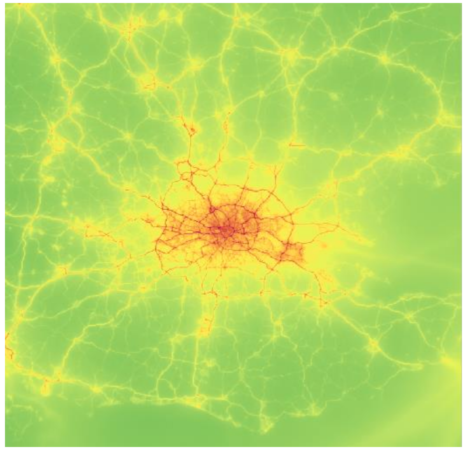



## BaP: EU limit 1 ng/m$^3$, WHO 0.12 ng/m$^3$

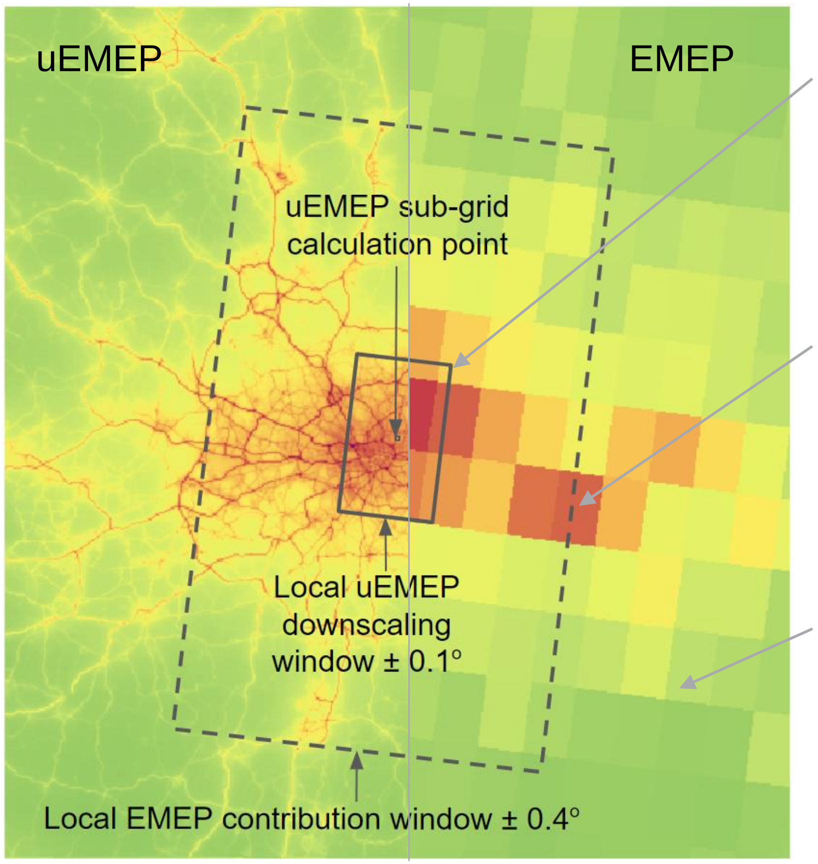


# Mapping and exposure

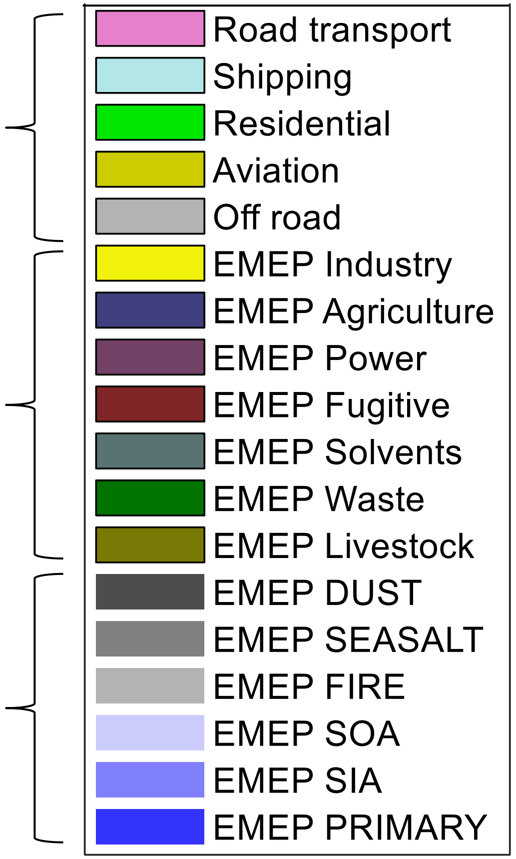




# Explanation of the source contributions in EMEP and uEMEP



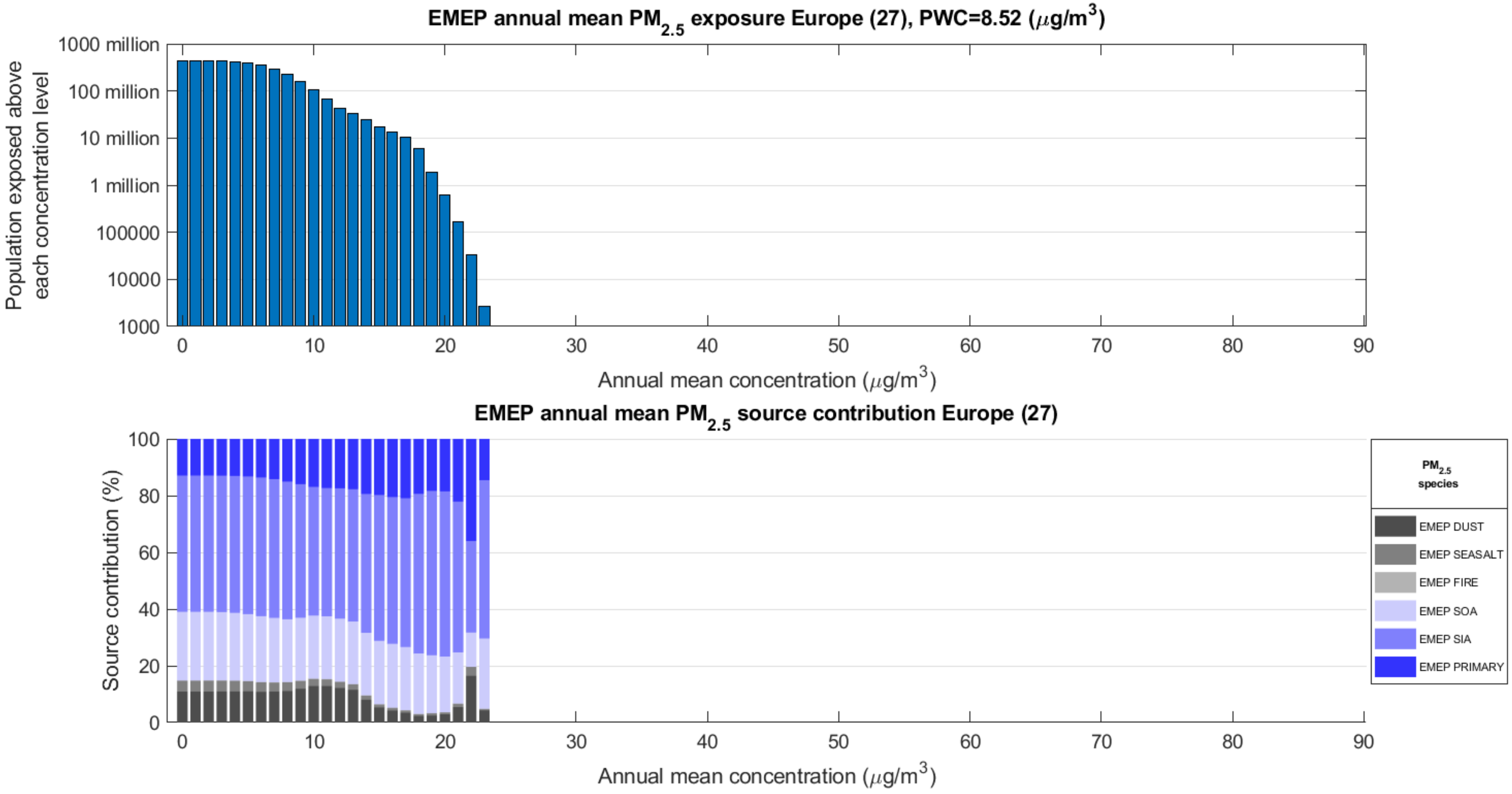

- Local downscaled uEMEP
  - Downscaled source contributions from within a ± 0.1º window around the calculation point
  - The major source for primary $PM_{2.5}$ is residential combustion
- Local EMEP
  - Tracked EMEP contributions from within a ± 0.4º window around the calculation point, in addition to any downscaling
  - Roughly 2/3 of all primary $PM_{2.5}$ comes from within this local region
- Non-local EMEP species
  - Non-local $PM_{2.5}$ species are from outside this ± 0.4º region
  - Major natural source contributions are dust and sea salt
  - Secondary $PM_{2.5}$ makes up the majority of non-local contributions



# EMEP: Baseline 2020 annual mean $PM_{2.5}$

Population exposed above a given concentration (log scale)

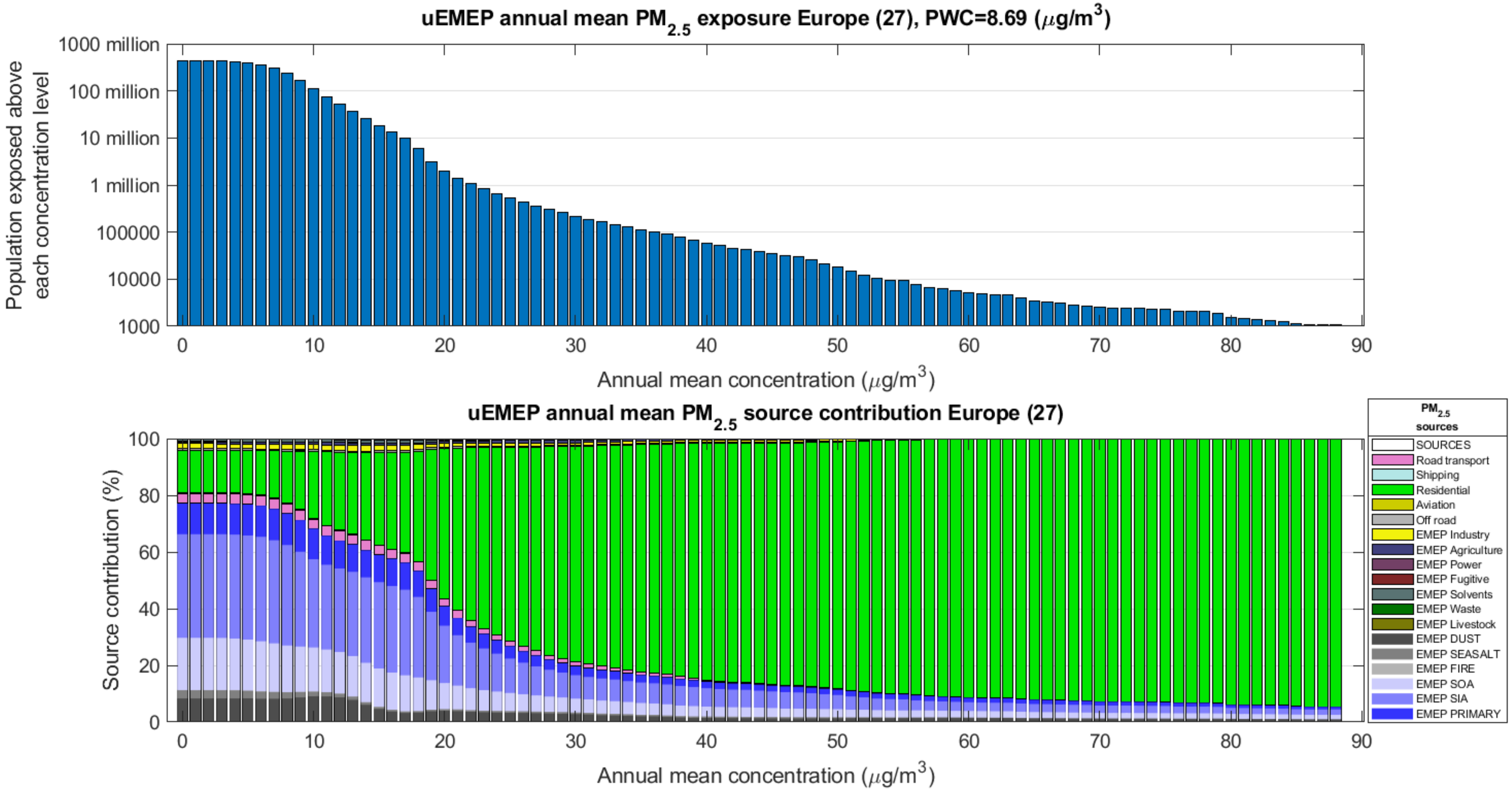
Population exposure distribution, source contribution (%)



# uEMEP: Baseline 2020 annual mean $PM_{2.5}$

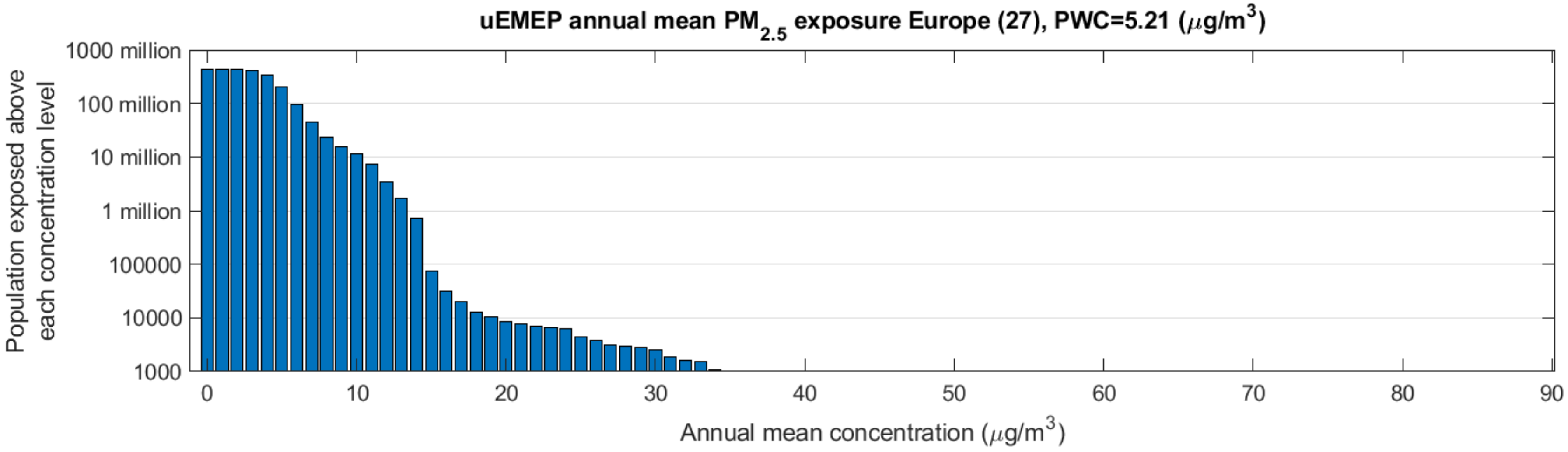
Population exposed above a given concentration (log scale)

Population exposure distribution, source contribution (%)

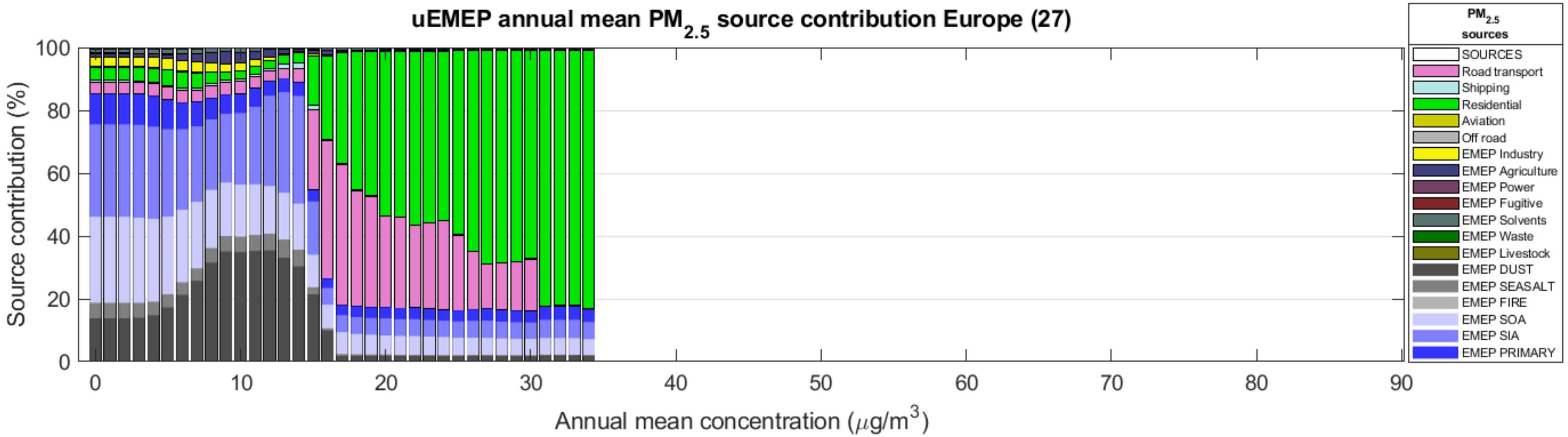


# uEMEP: Baseline 2050 annual mean $PM_{2.5}$

Population exposed above a given concentration (log scale)

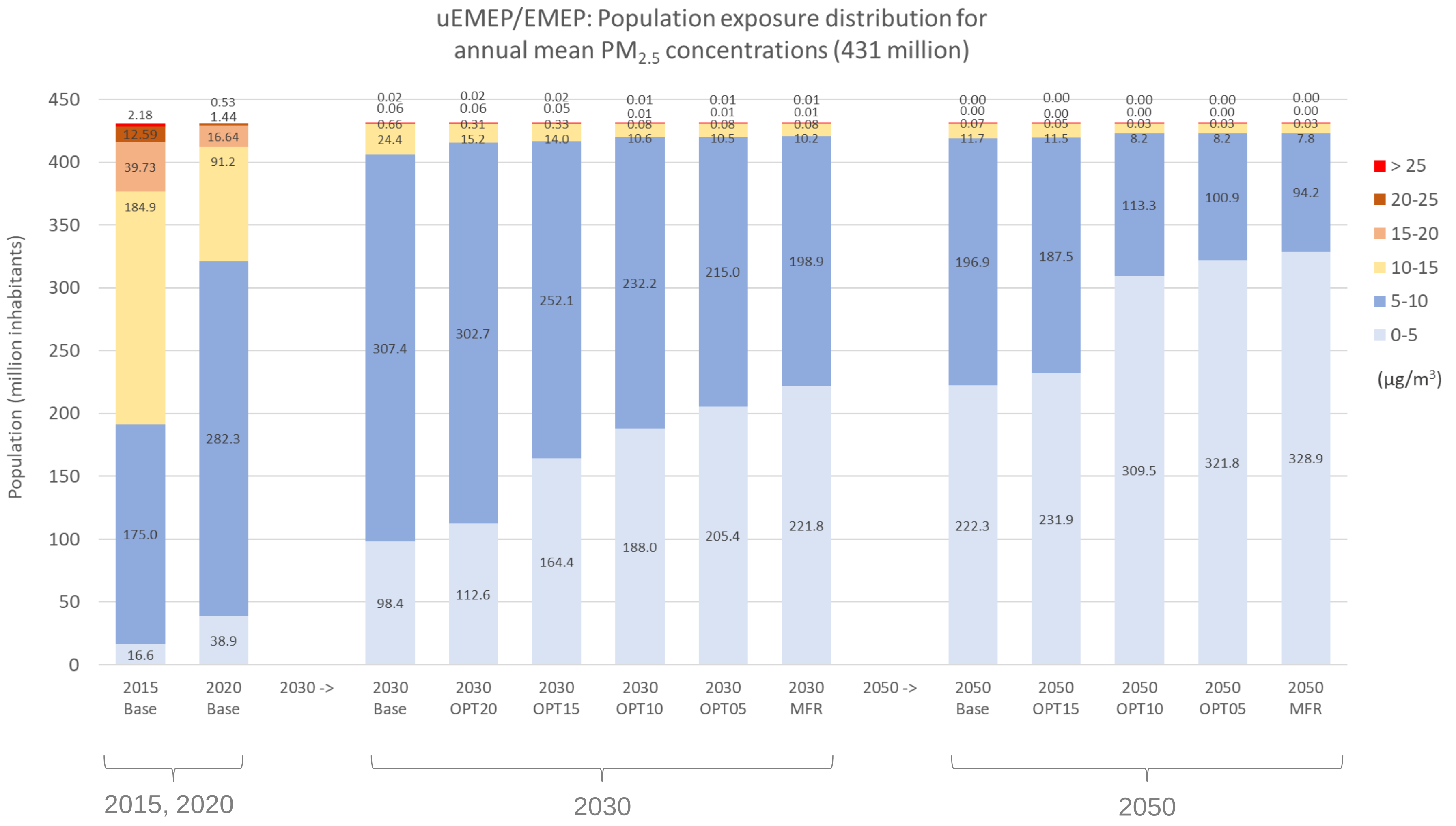



Population exposure distribution, source contribution (%)



# Population exposure $PM_{2.5}$

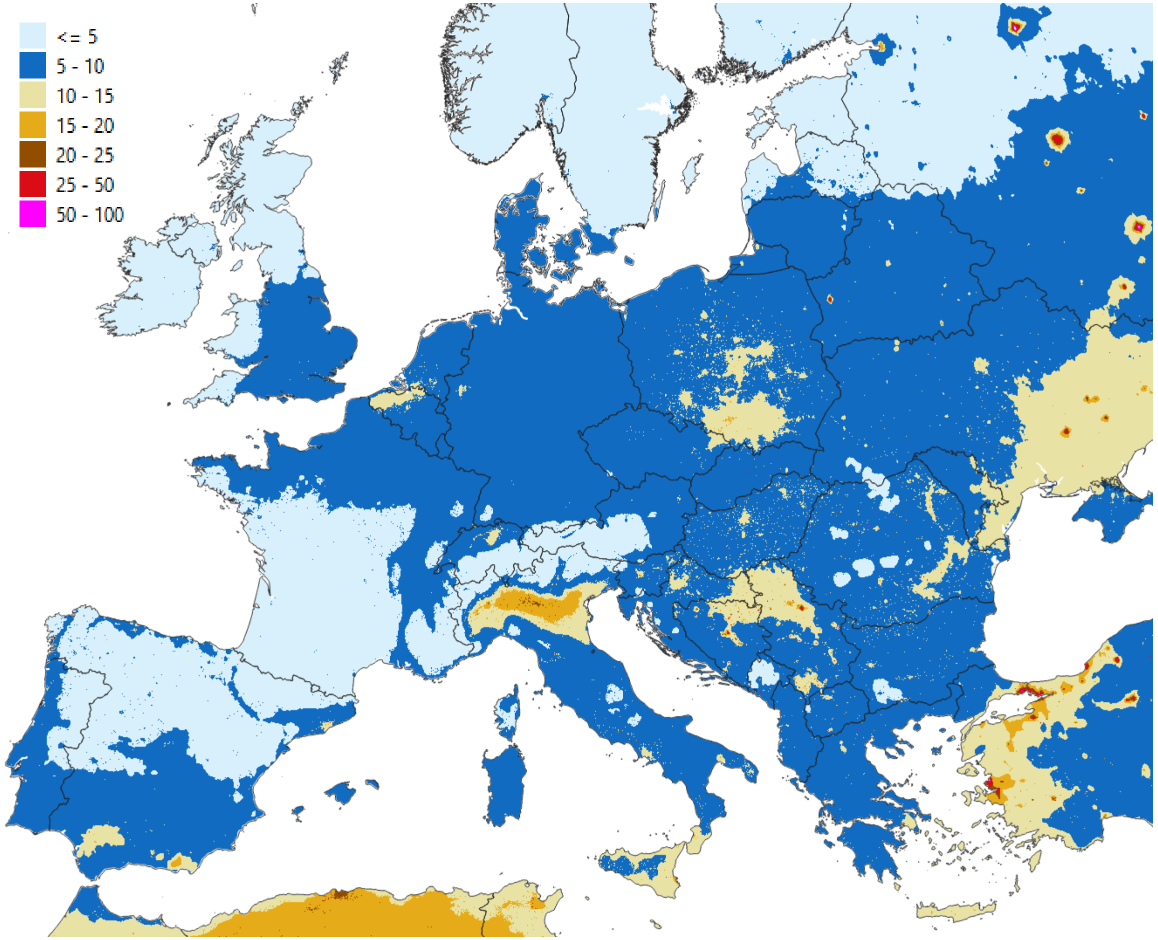
- A general decrease in concentrations with years and optimised measures
- In 2030 between 25 and 11 million inhabitants > 10 µg/m³
- In 2050 between 12 and 8 million inhabitants > 10 µg/m³
- In 2030 and 2050 significant exceedances > 5 µg/m³



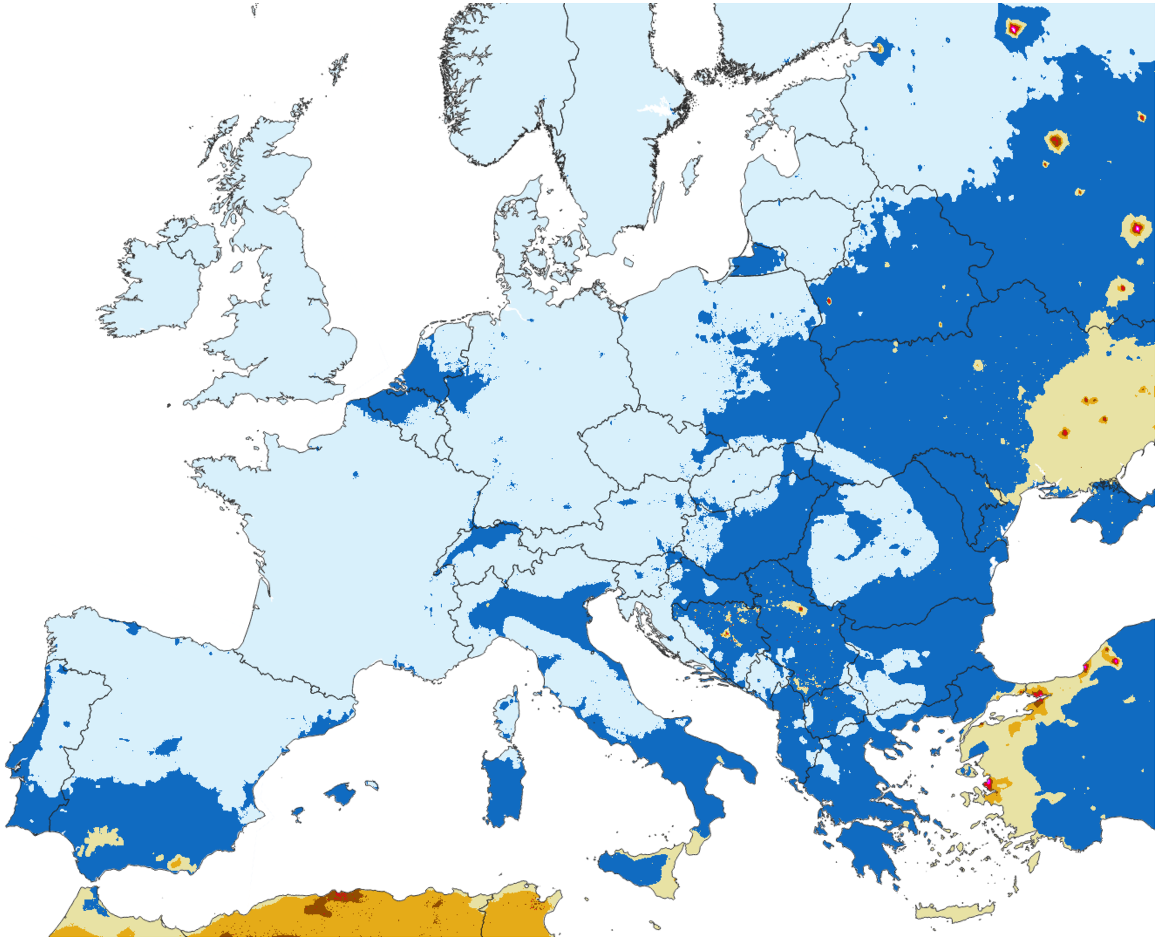
# $PM_{2.5}$ maps for Baseline 2020 and 2050

Norwegian Meteorological Institute

Baseline 2020



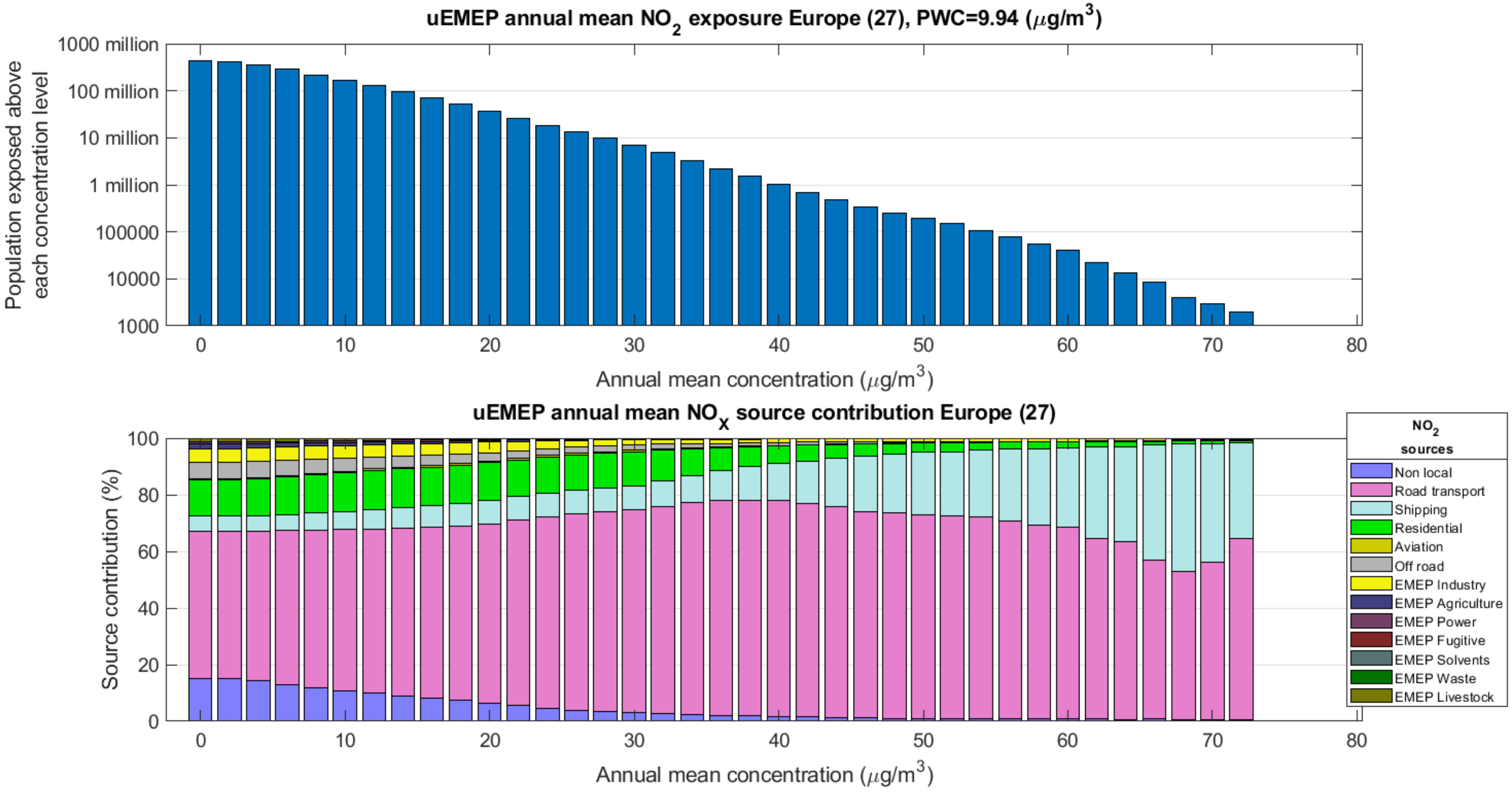

Baseline 2050



# Baseline 2020 annual mean $NO_2$

Population exposed above a given concentration (log scale)

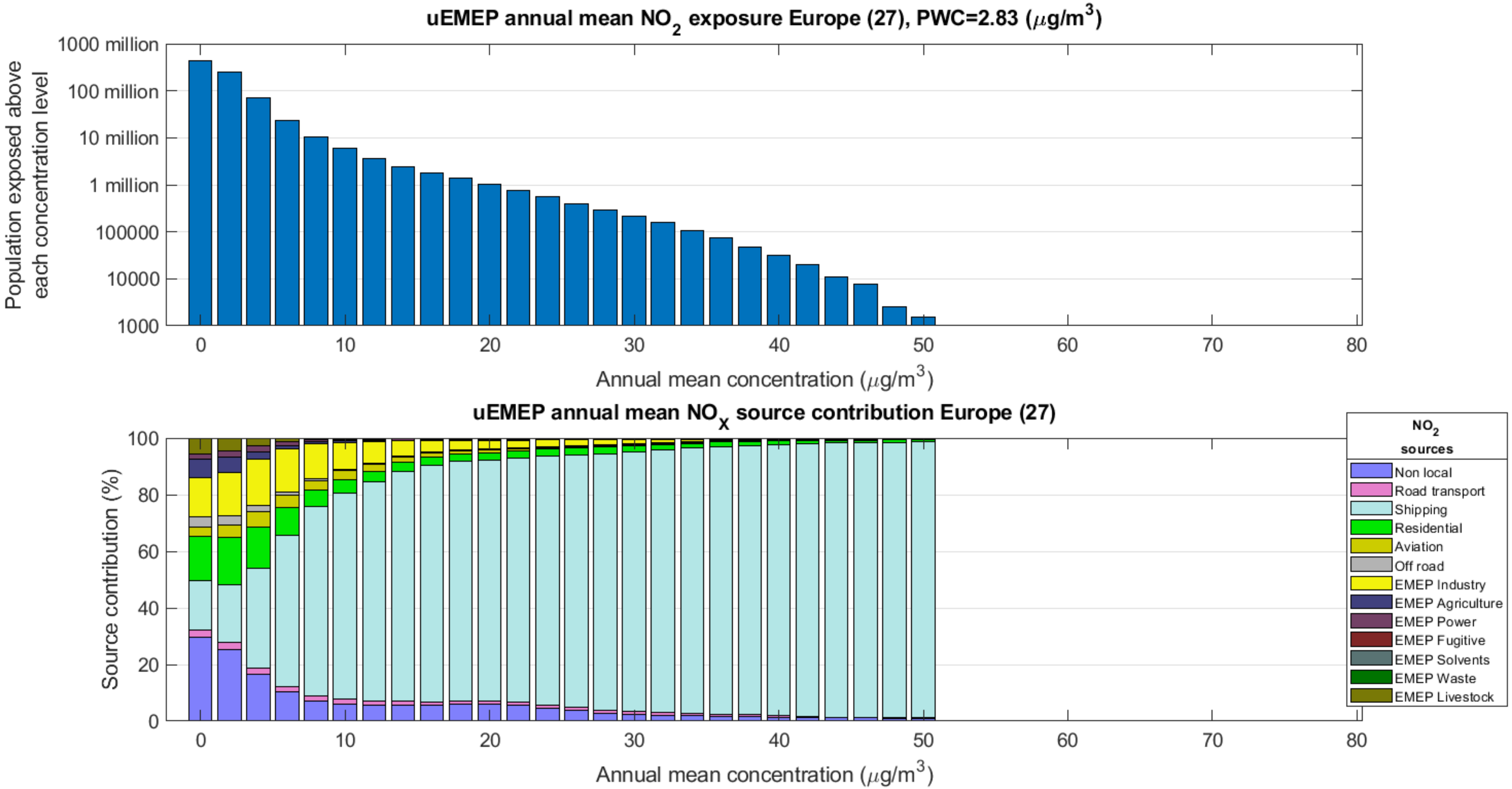
Population exposure distribution, source contribution (%)



# Baseline 2050 annual mean $NO_2$

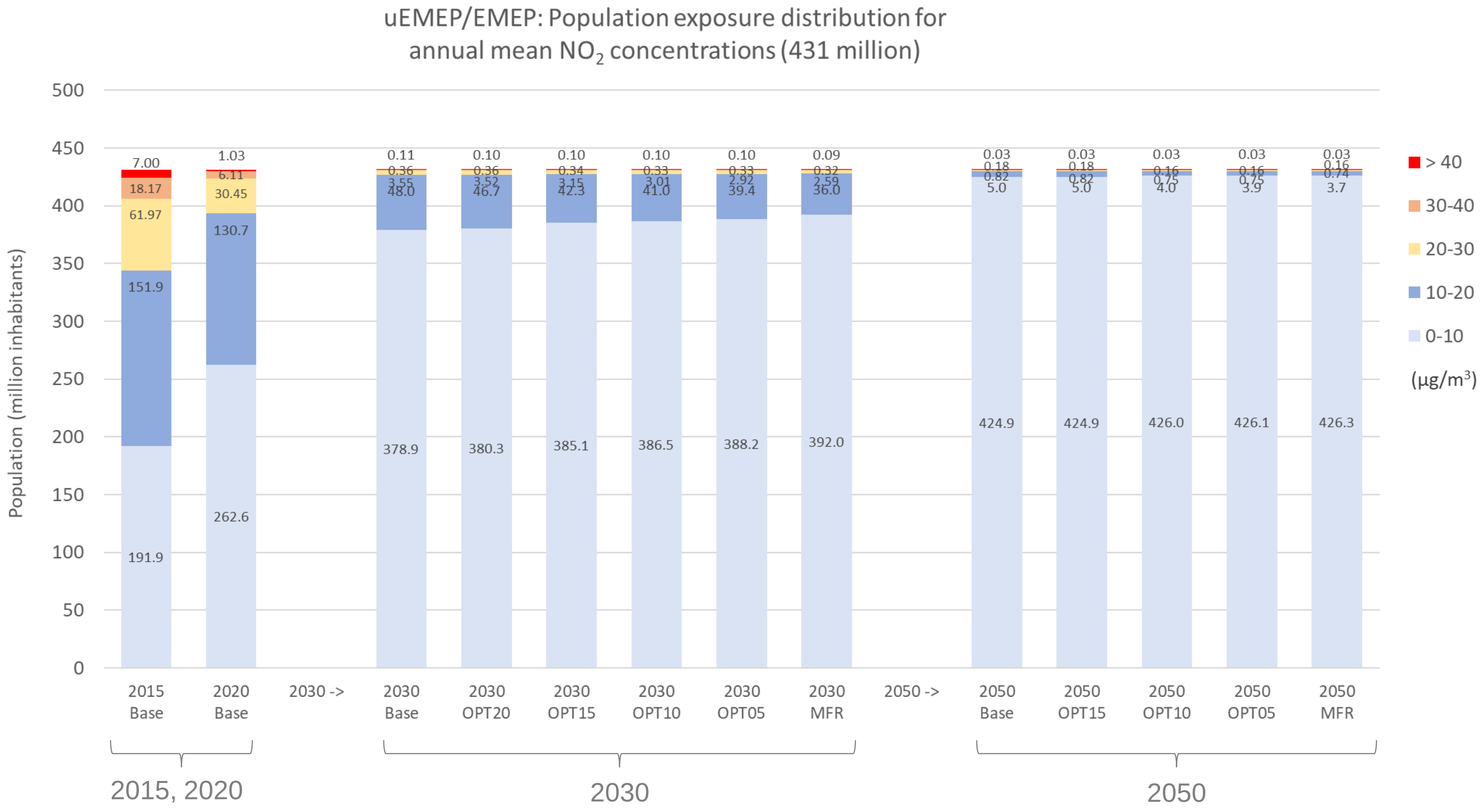
Population exposed above a given concentration (log scale)

Population exposure distribution, source contribution (%)



# Population exposure $NO_2$

- Similar distributions to the station calculations but with more lower concentrations
- In 2030 hardly any exceedance > 40 µg/m$^3$
- In 2050 4 million inhabitants > 10 µg/m$^3$
- Persistent exceedances in 2030 and 2050 are at sites near Mediterranean ports (review national shipping emissions)
- Little difference between baseline and MFR

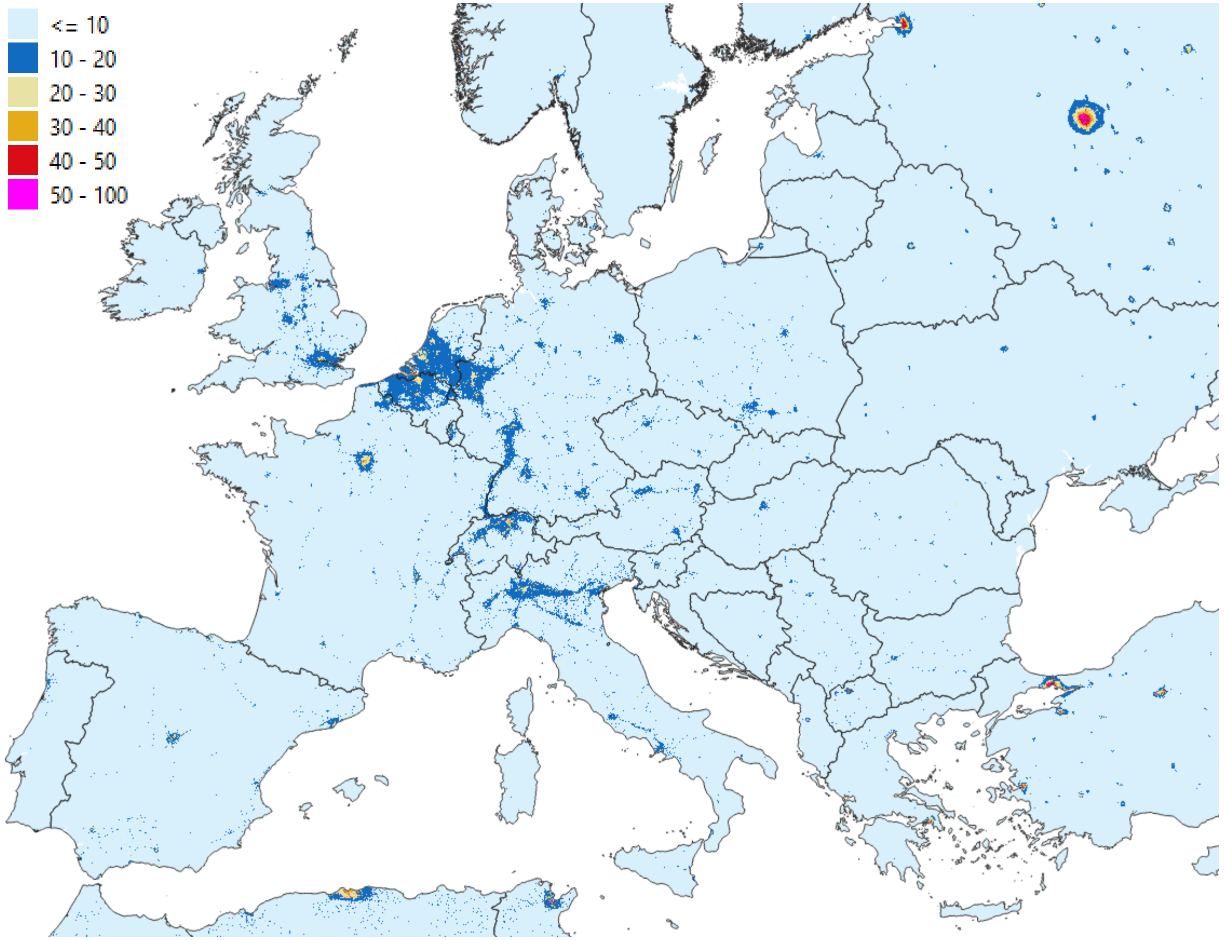



Norwegian Meteorological Institute

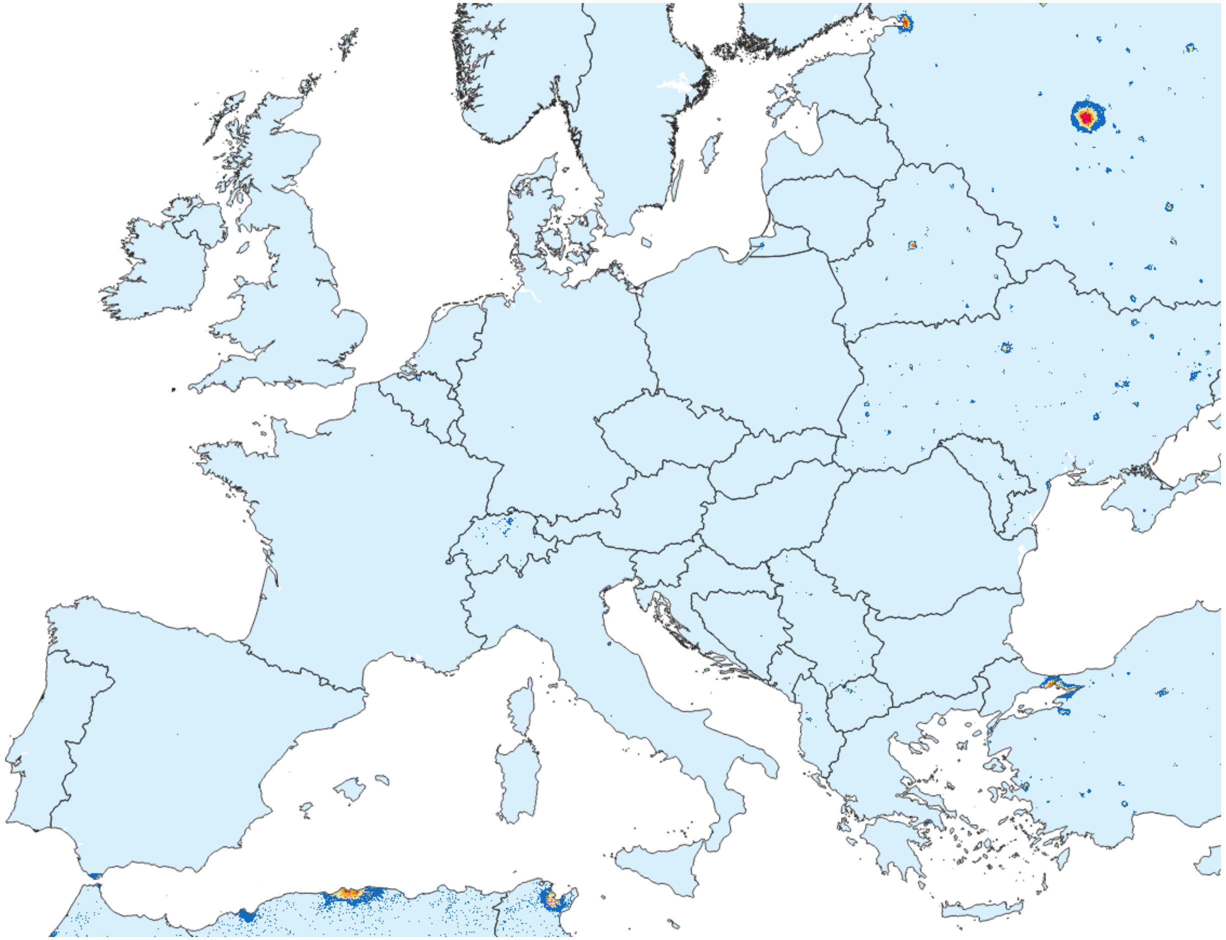
# $NO_2$ maps for Baseline 2020 and 2050

Norwegian Meteorological Institute

Baseline 2020

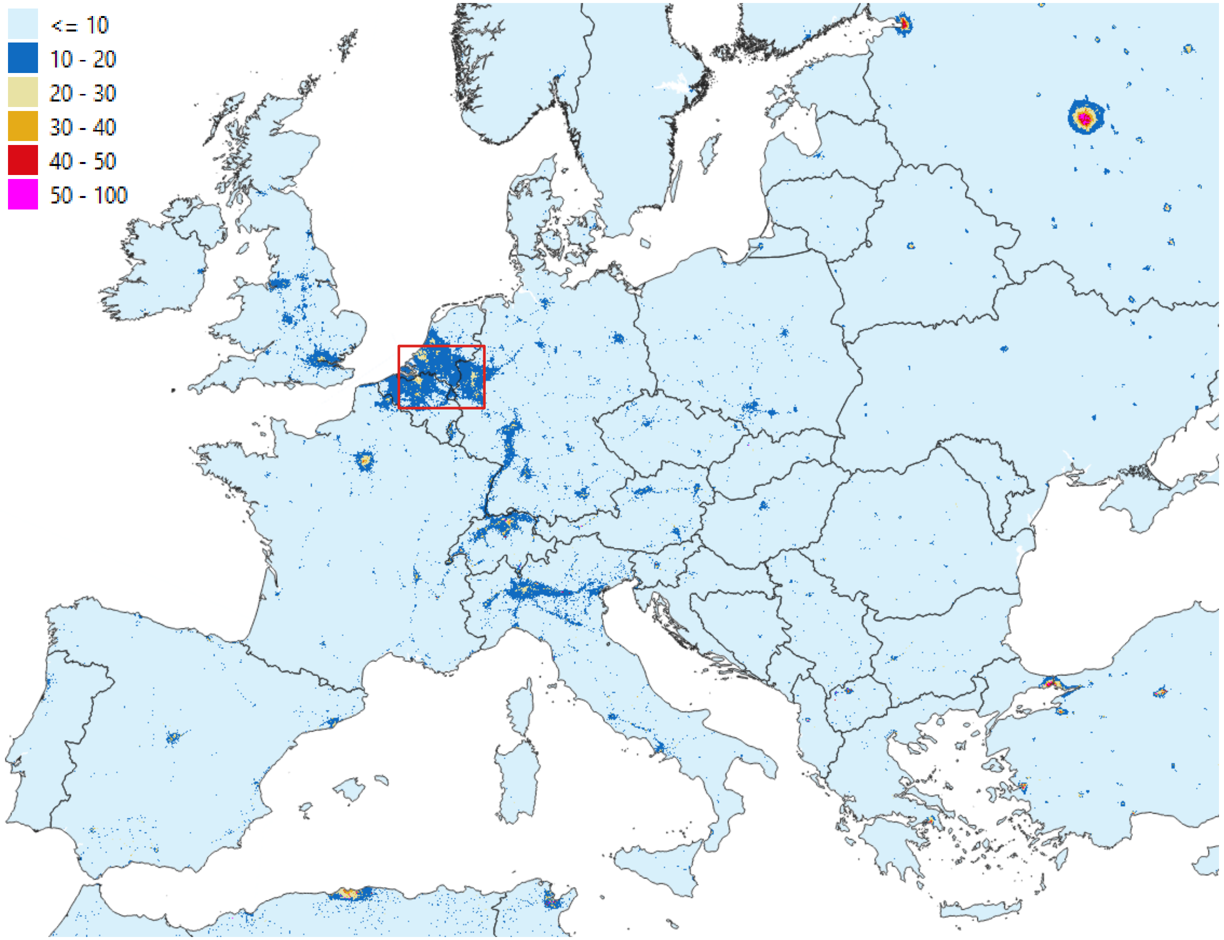



Baseline 2050

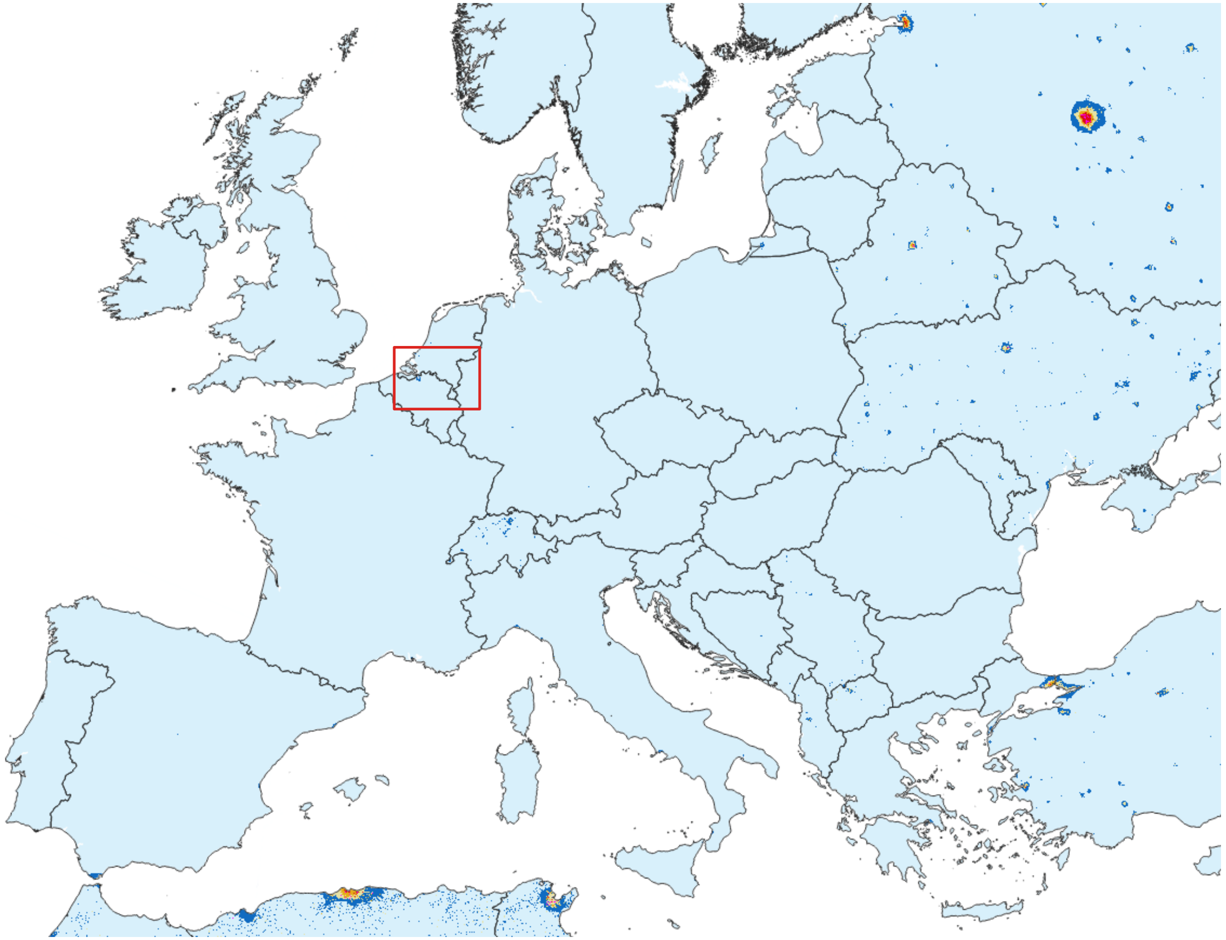


# $NO_2$ maps for Baseline 2020 and 2050

Baseline 2020



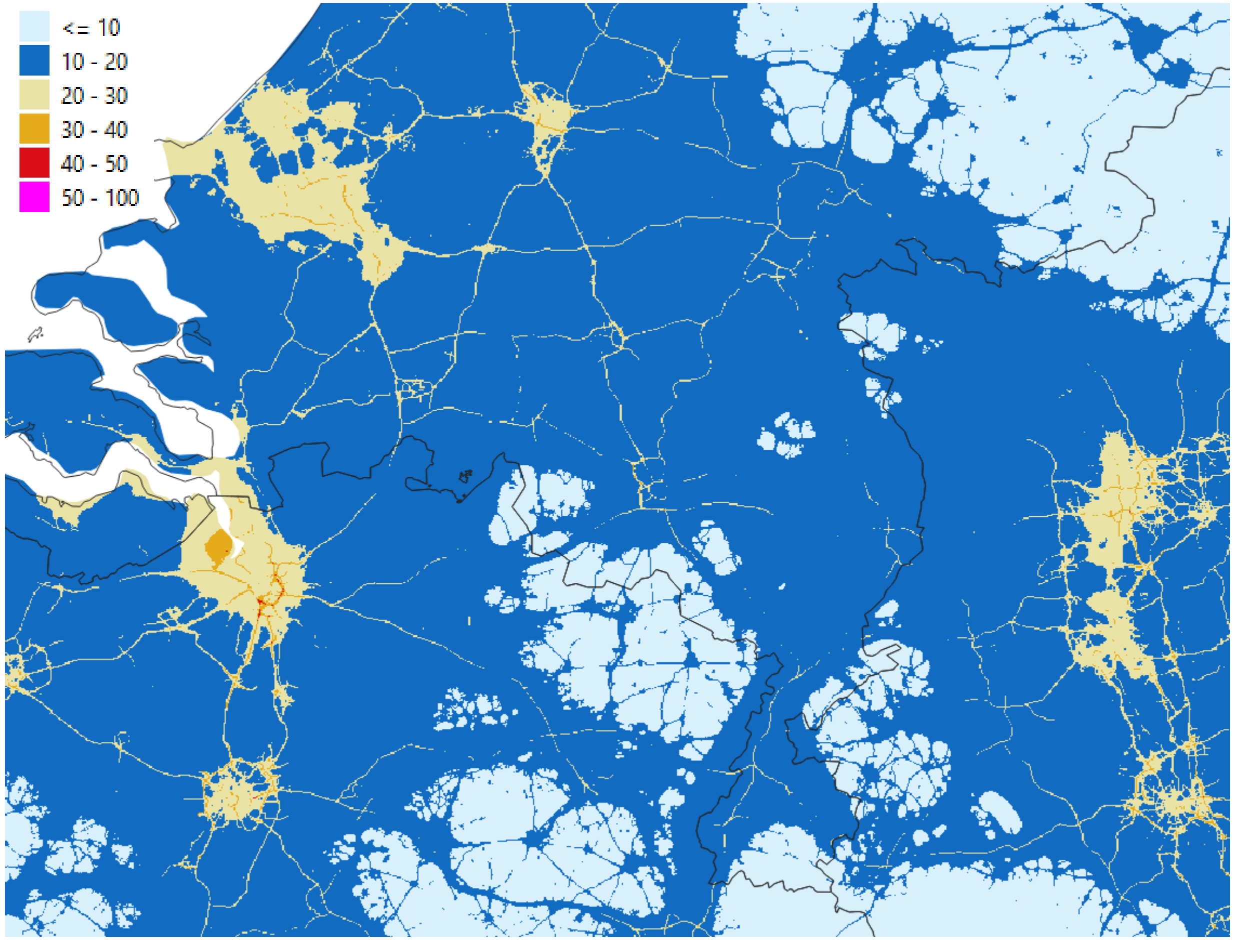

Baseline 2050



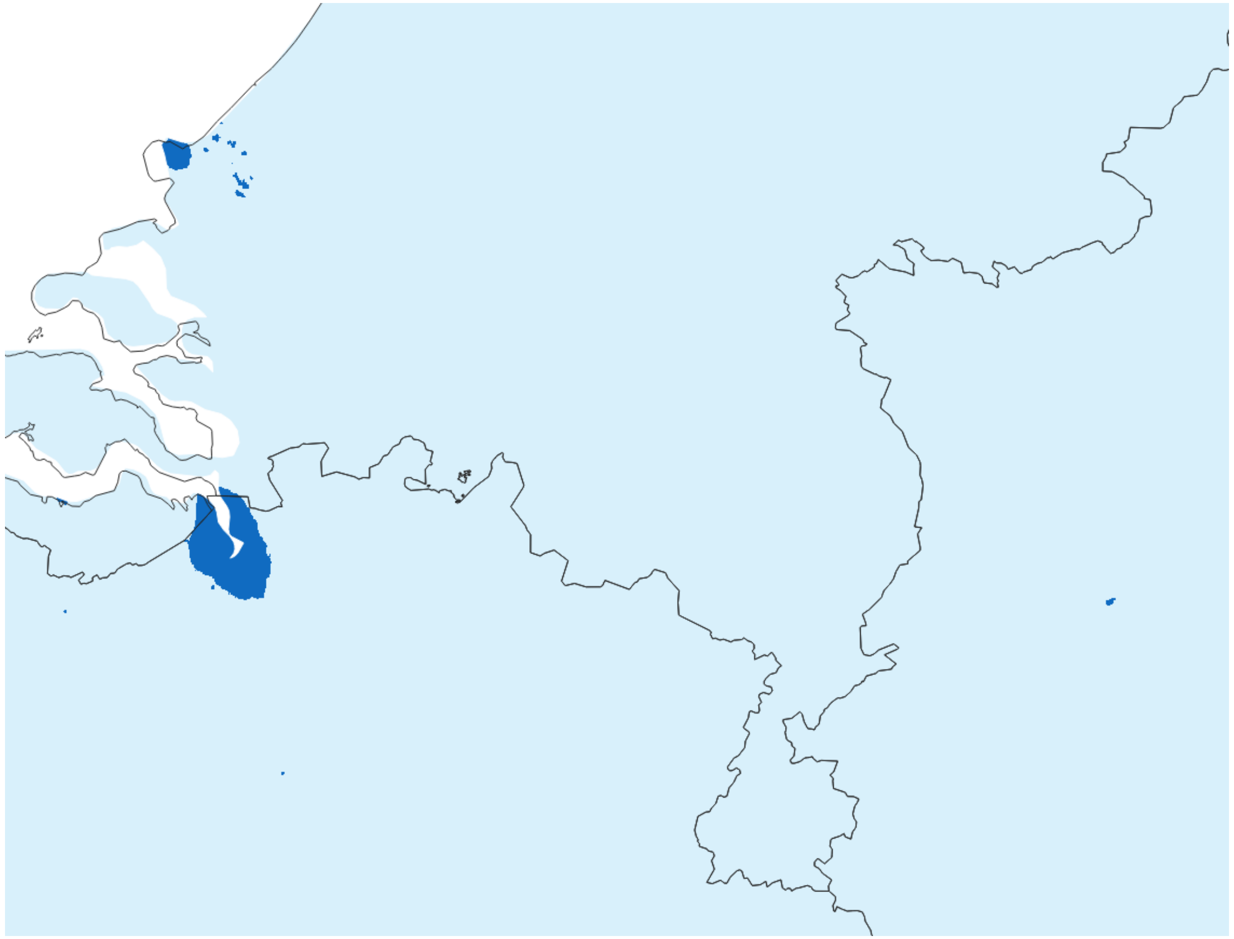
# $NO_2$ maps for Baseline 2020 and 2050

Norwegian Meteorological Institute

Baseline 2020




Baseline 2050

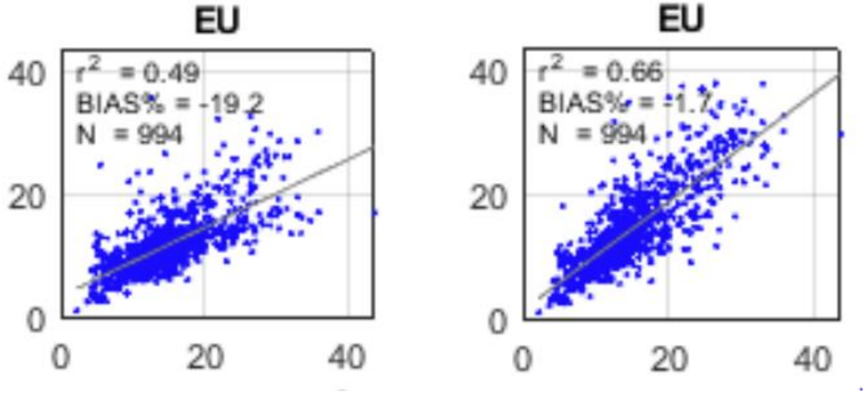


# Summary

- The $NO_2$ station exceedance calculations indicate that:
  - Currently ~4% of $NO_2$ stations measure annual mean concentrations > 40 $\mu g/m^3$
  - This will be close to 0 in 2030 and 2050
  - In 2030 ~40% of $NO_2$ stations will measure annual mean concentrations > 10 $\mu g/m^3$
  - In 2050 this will be ~5%
- In the present day, road traffic exhaust emissions dominate the $NO_2$ concentrations. A significant decrease in these emissions is expected over the coming decades and other sources will begin to dominate
- The $PM_{2.5}$ exposure calculations indicate that:
  - Currently ~100 million inhabitants are exposed to $PM_{2.5}$ concentrations > 10 $\mu g/m^3$
  - In 2050 this will reduce to ~10 million inhabitants
  - In 2050 between 100 to 200 million inhabitants will still be exposed to $PM_{2.5}$ concentrations > 5 $\mu g/m^3$
- When concentrations approach lowered threshold values then local emission sources, not always well defined in the emission inventories, become important and will need to be addressed individually at the local level.
- There are still some inconsistencies in the national emissions and their spatial distribution that affect details in the results
  - National shipping in the Mediterranean
  - Residential combustion emissions in various countries
  - Non-exhaust emissions in Nordic countries (not included in the scenarios)

# Additional slides not to be used

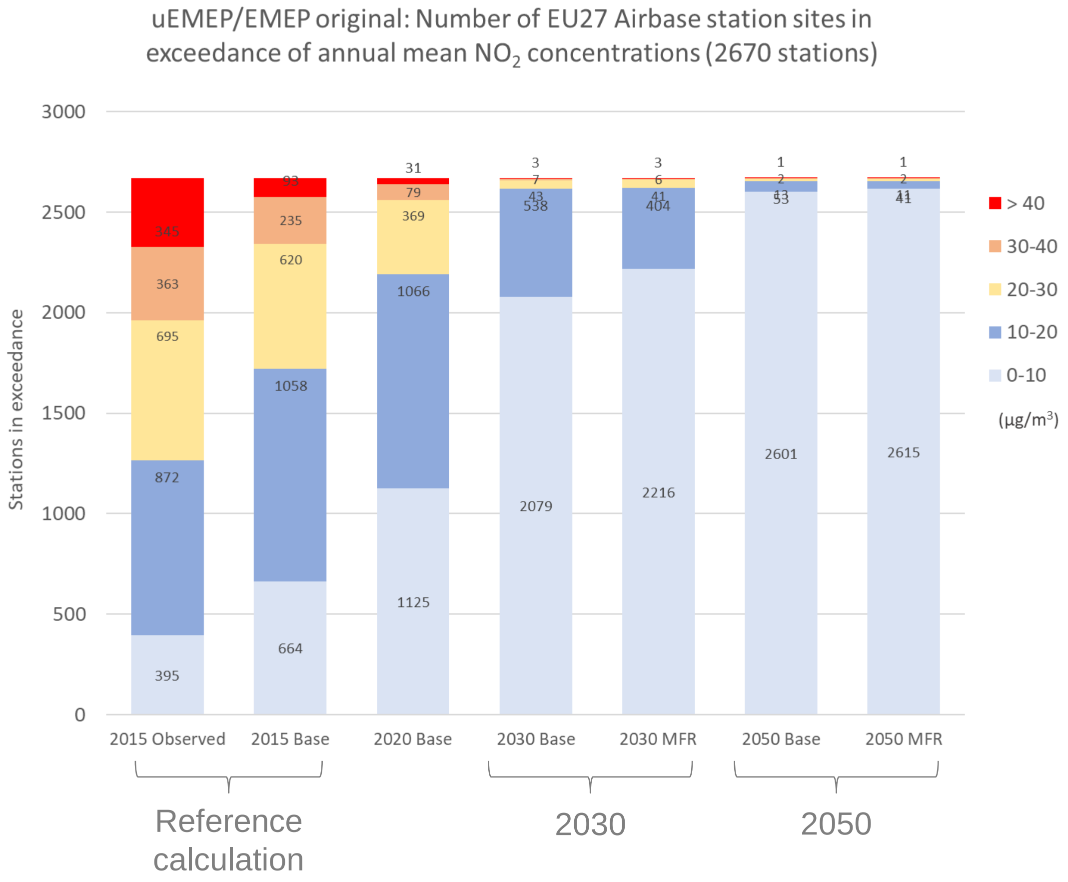
# Bias adjustment



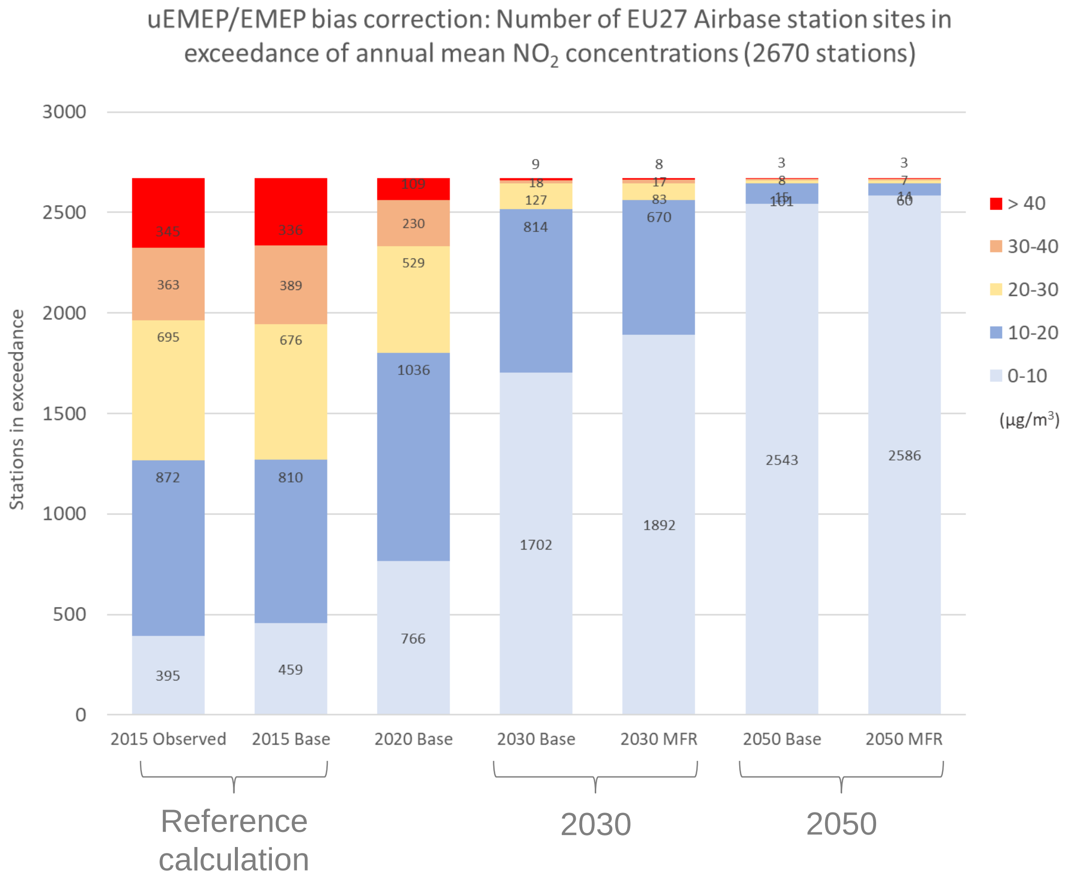
# Bias adjustment $NO_2$

- Bias adjustment is applied per country (EU27) to reflect country specific emission reporting. The same scaling factors are used for all scenarios. Scaling is applied to $NO_2$ and $PM_{2.5}$

## Original Base and MFR scenarios $NO_2$



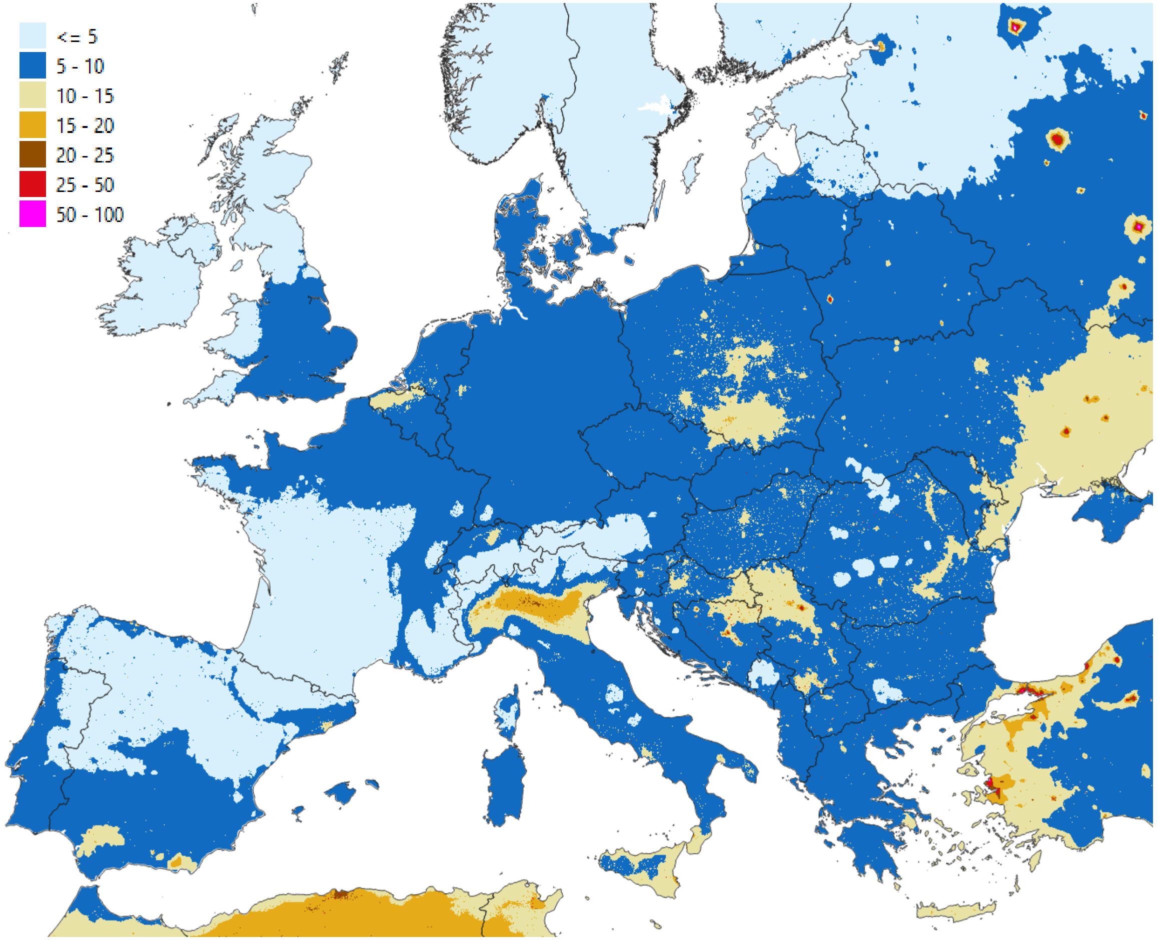

## Bias corrected Base and MFR scenarios $NO_2$



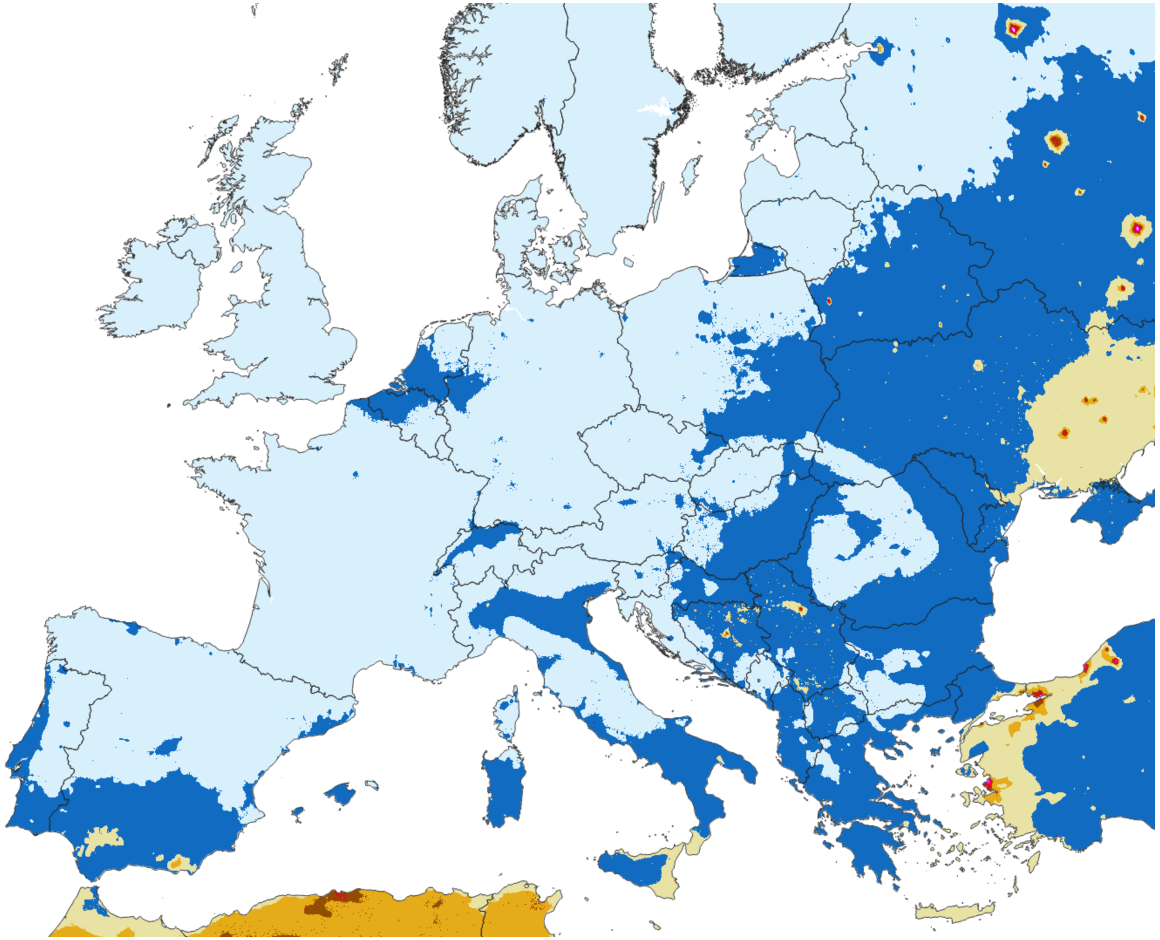
# $PM_{2.5}$ maps for Baseline 2020 and 2050

Norwegian Meteorological Institute

Baseline 2020



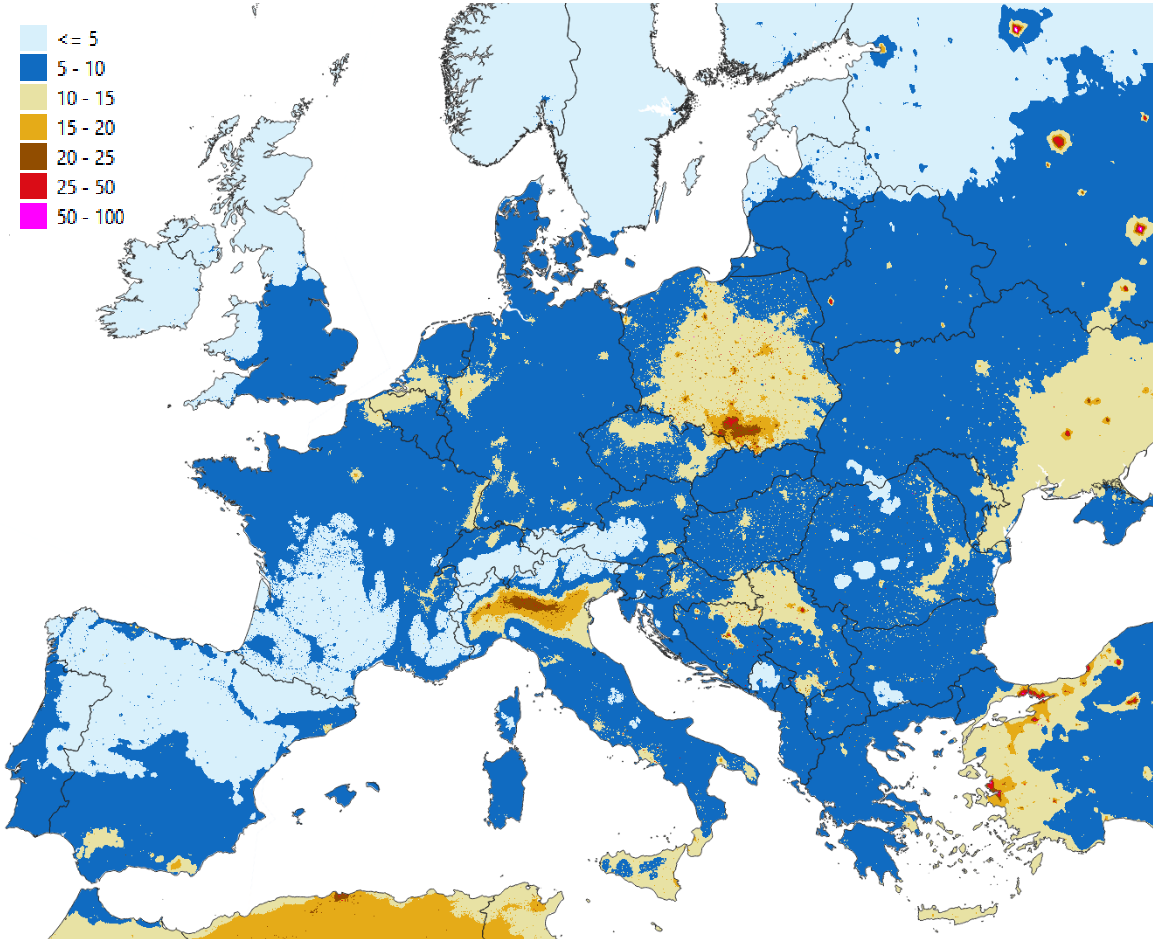

Baseline 2050



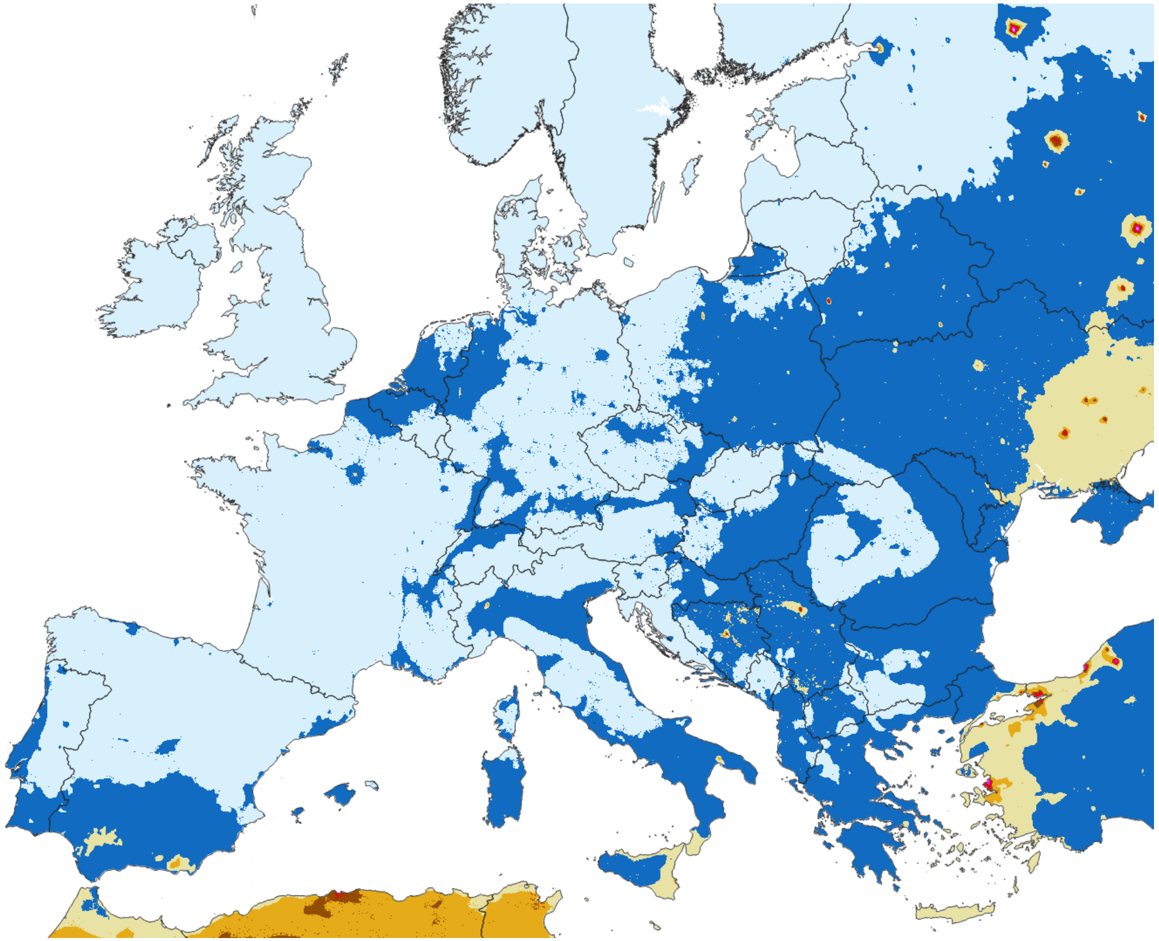
# PM$_{2.5}$ maps for Baseline 2020 and 2050: bias corrected

Norwegian Meteorological Institute

Baseline 2020 bias corrected



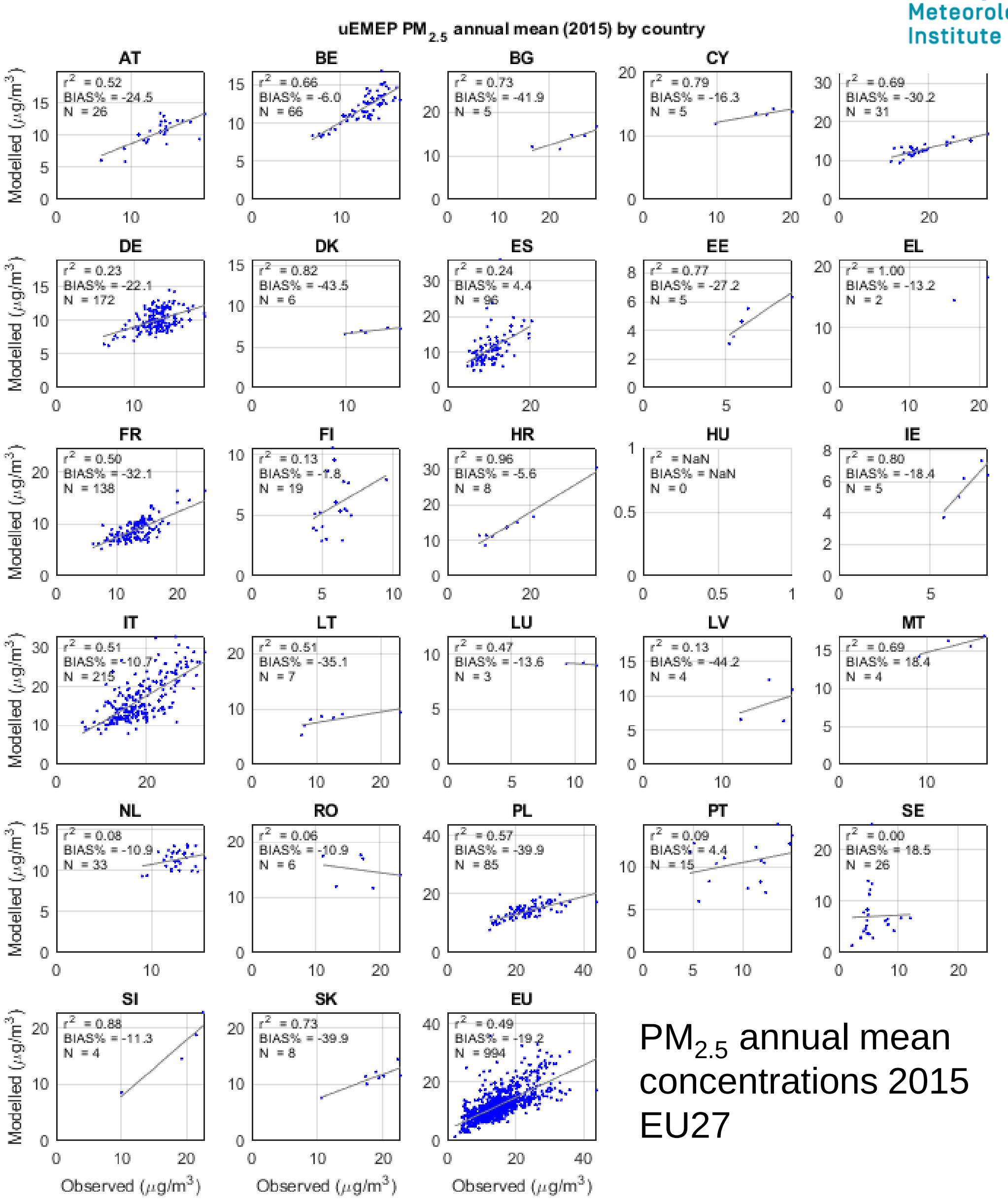

Baseline 2050 bias corrected



# Indicator 1 – air pollutant concentrations and exposure: station calculations

Norwegian Meteorological Institute

- Comparison of modelled and observed concentrations at all Airbase sites for the reference year 2015
  - Station bias for pollutants addressed here:
    - $NO_2$ = -23%
    - $PM_{2.5}$ = -19%
    - SOMO35 = +1%
  - Bias for other pollutants calculated:
    - BaP = +11%
    - $PM_{10}$ = -33%
    - CO = -44%
    - Benzene = -53%
    - $SO_2$ = -26%
    - $O_3$ 26th daymax = -23%
- Large negative bias for a number of pollutants
- Impact of model/emission bias on the scenario calculations is addressed with a bias adjustment for $NO_2$ and $PM_{2.5}$




$PM_{2.5}$ annual mean concentrations 2015 EU27