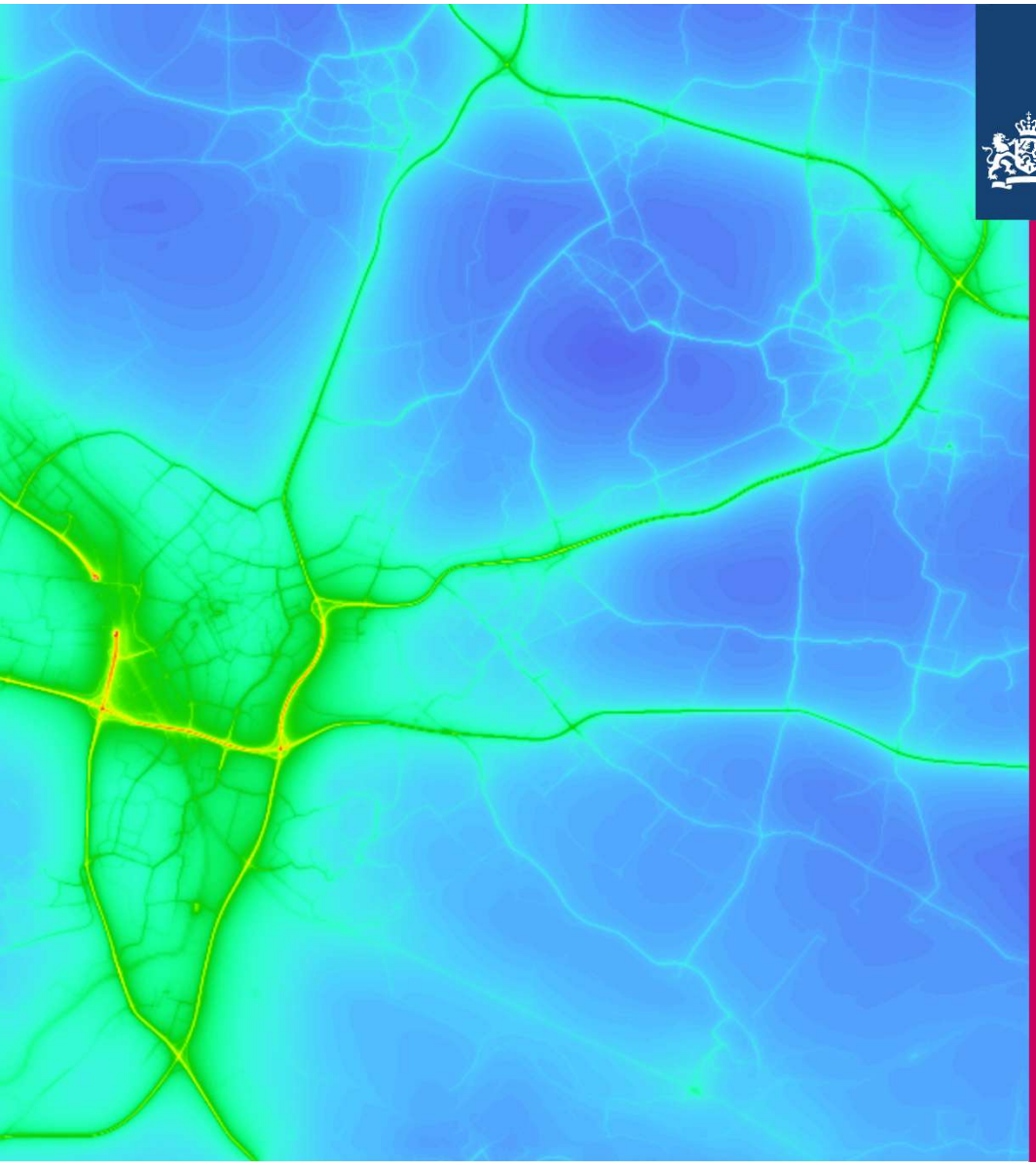

National Institute for Public Health
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Modelling NO_2 concentrations around the city of Utrecht (the Netherlands) with uEMEP

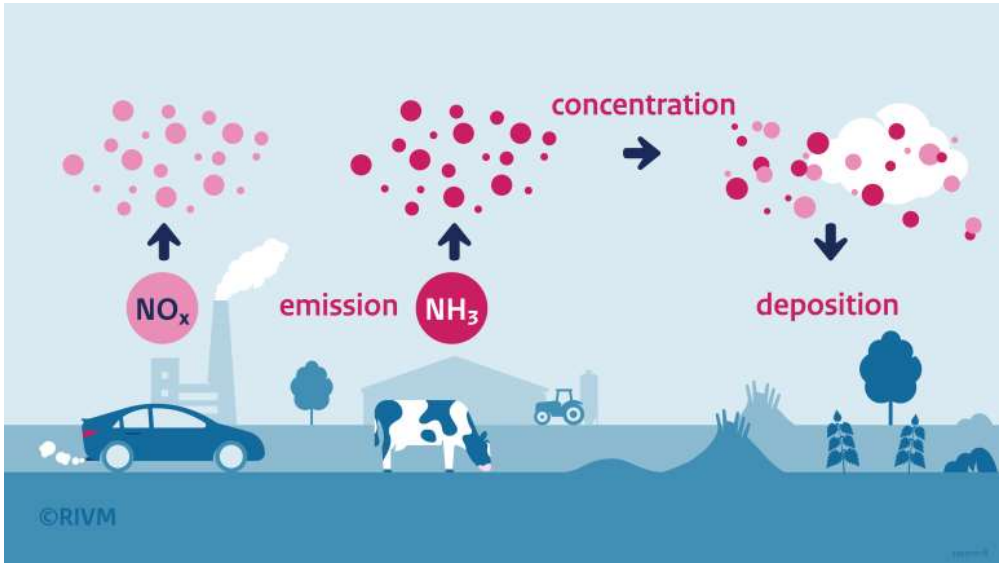
comparison with measurements and Dutch monitoring results

Shelley van der Graaf, Pam Witsenboer, Joost Wesseling, Eric van der Swaluw

HARMO23 – T1: Approaches to model evaluation and quality assurance – 18-09-2025

Introduction

- Monitoring NO_2 levels using measurements and models are important to improve air quality, to ensure European limits are not exceeded, and to keep track of effectiveness of measures
- Dutch national air quality cooperation program
  - Air quality monitor (NSL monitor)
  - Air quality calculations based on reported data from local authorities (e.g., traffic numbers, types of vehicles)
  - Calculations validated against several dense urban measurement networks

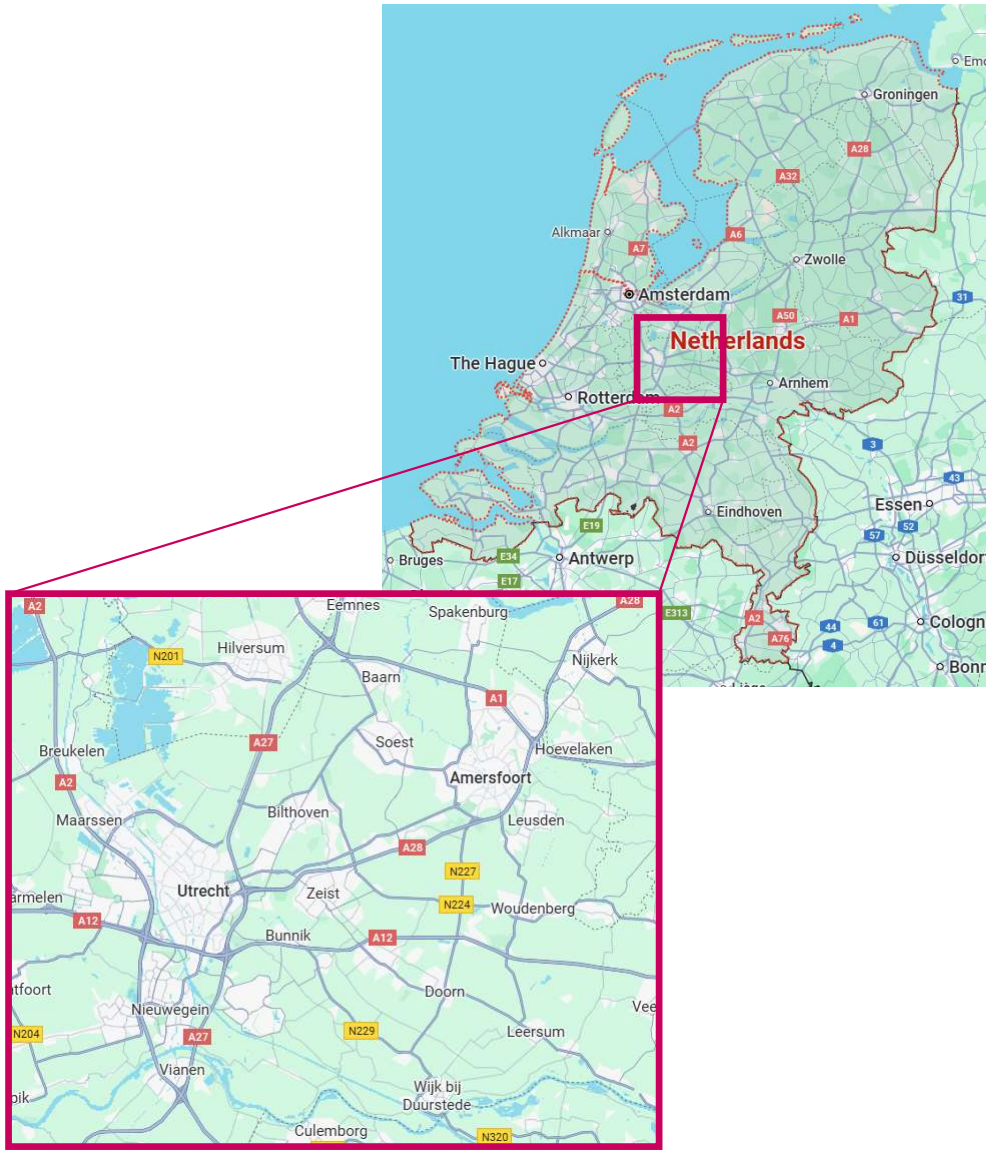


This study

- Evaluation of the modelled NO_2 concentrations from the urban EMEP (uEMEP) model by

1. Comparison to measurements (hourly and annual mean)
2. Comparison to results of the Dutch air quality monitor (NSL monitor)

- Focus on the area around the city of Utrecht

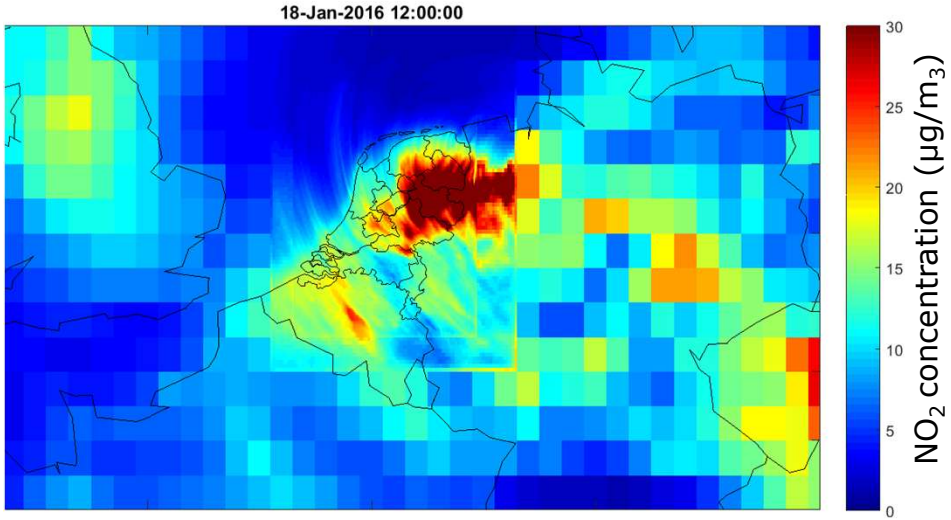


Three modelling systems

	NSL monitor	EMEP4NL	uEMEP
Modelling principle	Different dispersion models based on emission type (e.g., SRM for traffic)	Eulerian chemical transport model (3D-grid)	Downscaling model coupled to EMEP/MSC-W. Based on Gaussian principles
Spatial scale	Up to ~10 meters	Up to kilometers	Up to ~10 meters
Temporal resolution	Annual	Hourly	Hourly or annual
Focus region	Specifically for the Netherlands	European domain	European domain

EMEP4NL

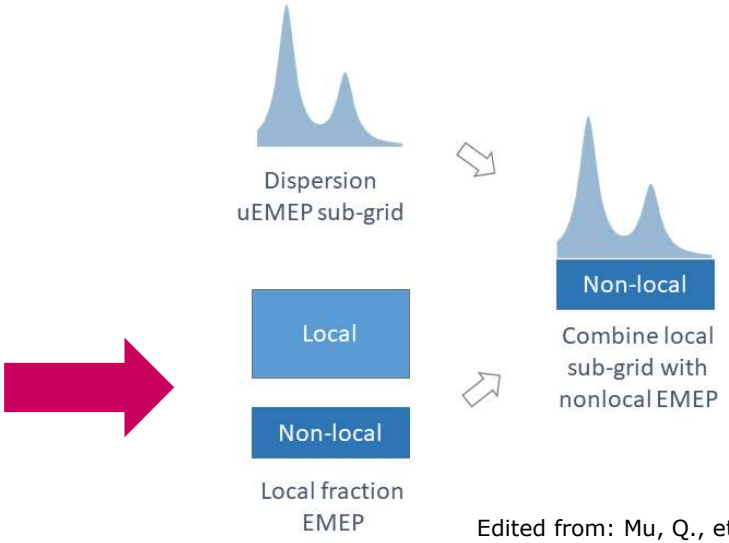
- Version of the EMEP MSC-W model (Simpson et al., 2012), with grid configuration specific for the Netherlands
- Eulerian chemical transport model (3D-grid)
- Driven by WRF meteorology
- Embedded grids, finest spatial resolution ~1200 x 2100 meters



Source: Eric van der Swaluw

uEMEP

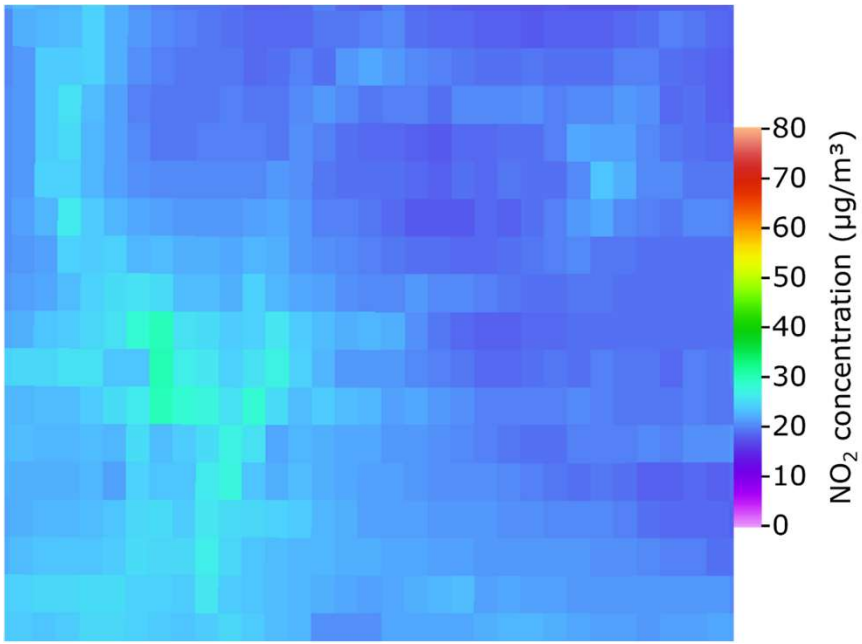
- urban EMEP model (Denby et al., 2020)
- Air quality downscaling model, local-fractions approach
- Local dispersion with Gaussian plume model
- Same meteorological input as EMEP4NL
- Same emissions but on highest possible resolution (e.g., not gridded)



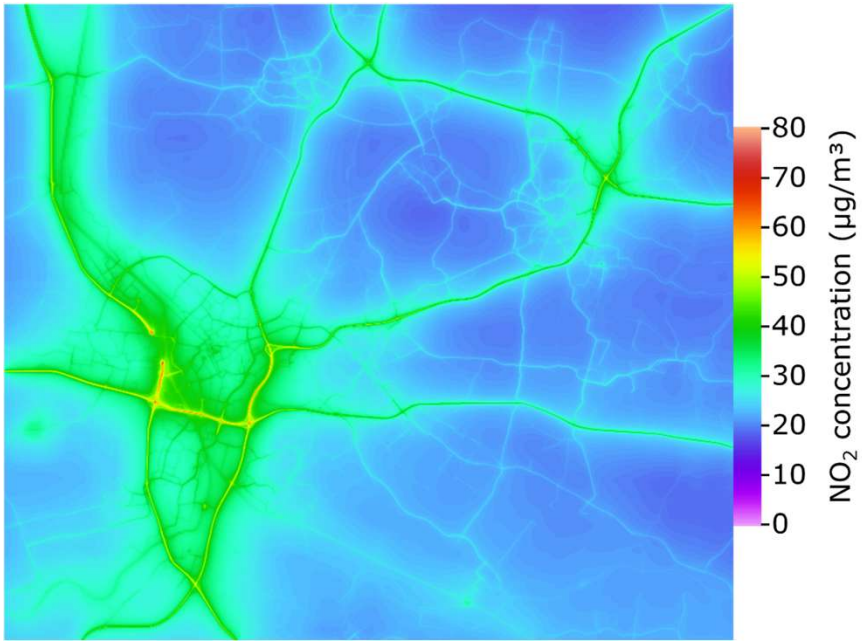
Edited from: Mu, Q., et al., 2022

Modelled NO_2 concentrations (2019)

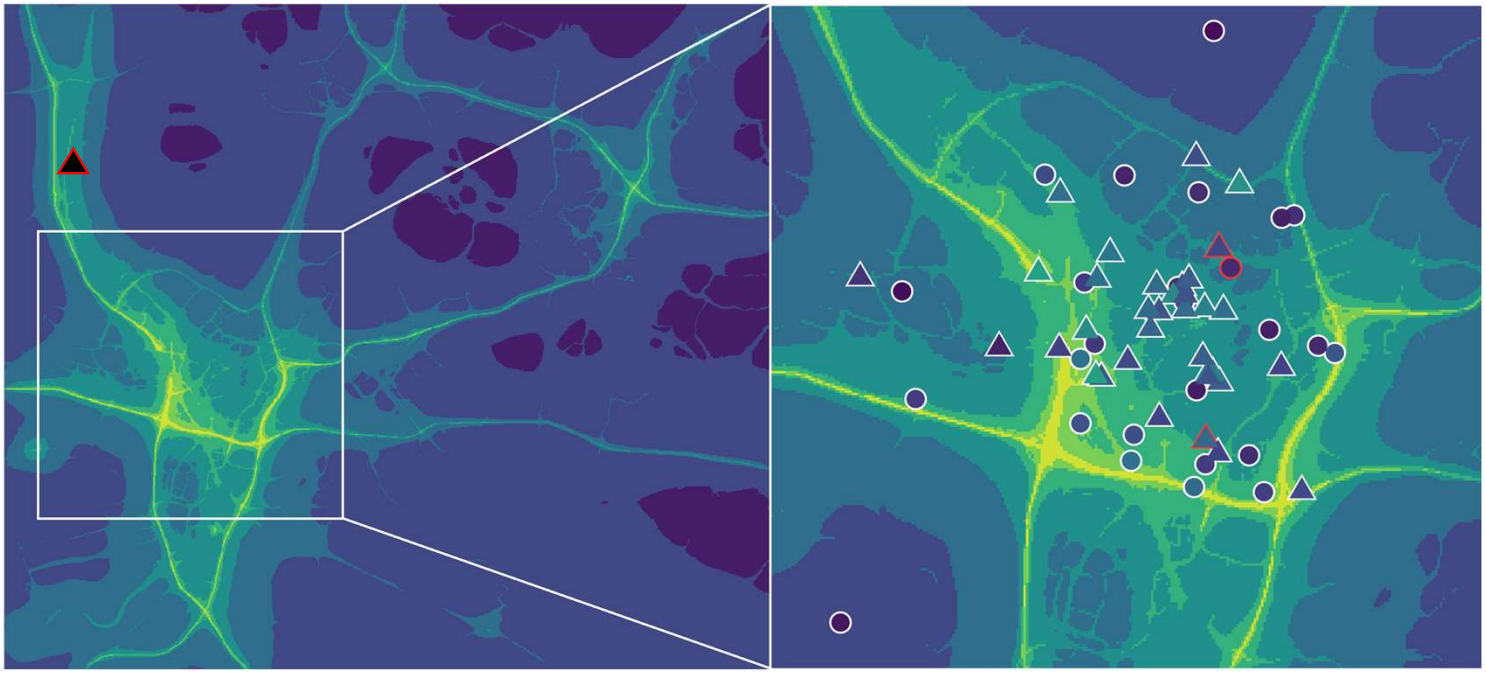
EMEP4NL



UEMEP



Measurements



NO_2

50
45
40
35
30
25
20
15

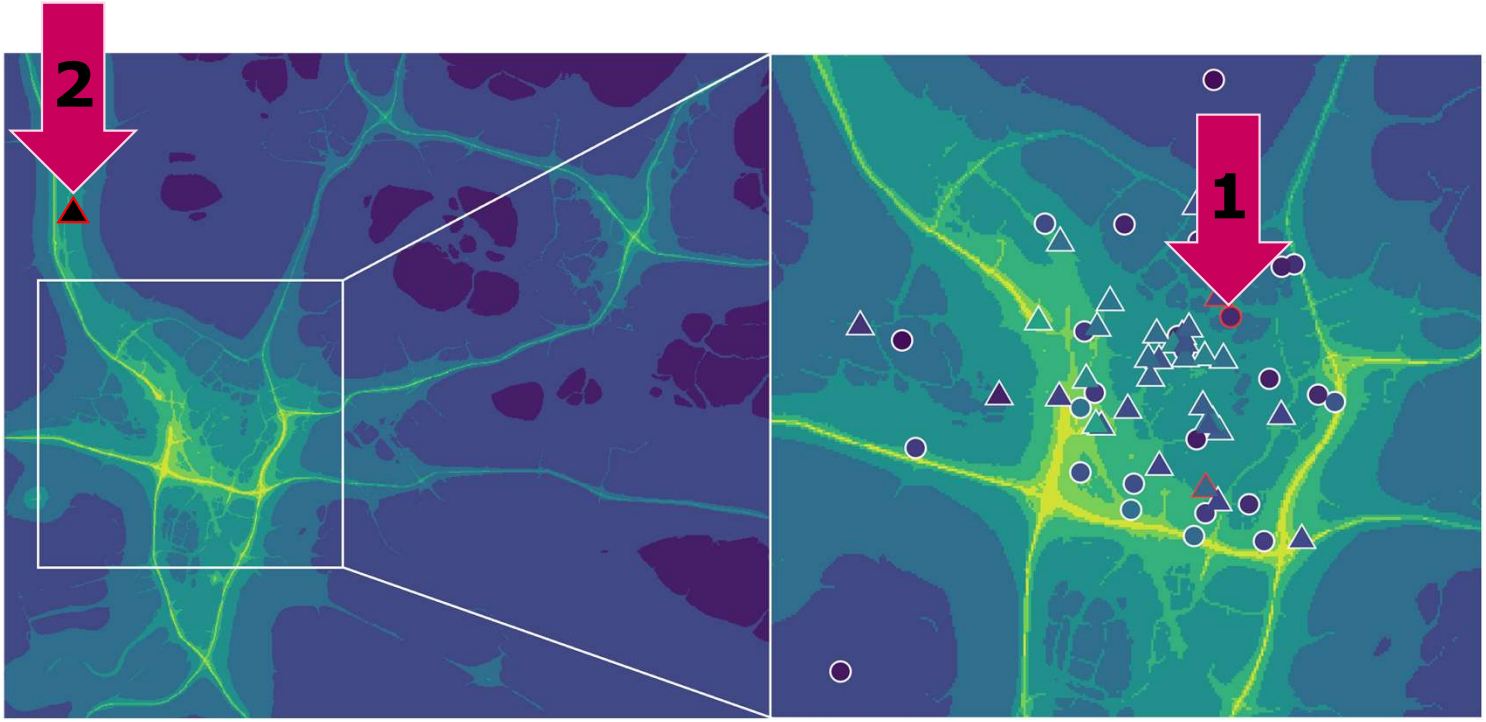
type

Background

Traffic

Red – hourly
White - monthly

Measurements



NO_2

50
45
40
35
30
25
20
15

type

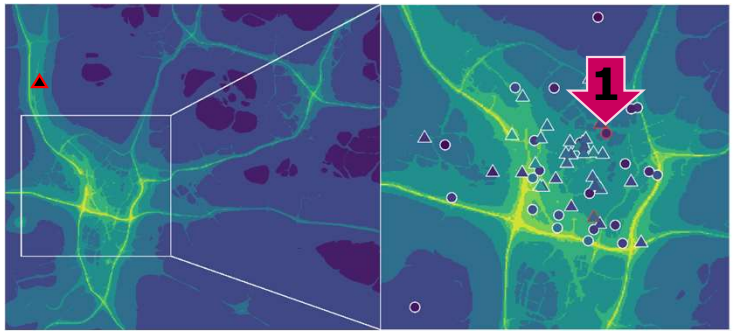
Background

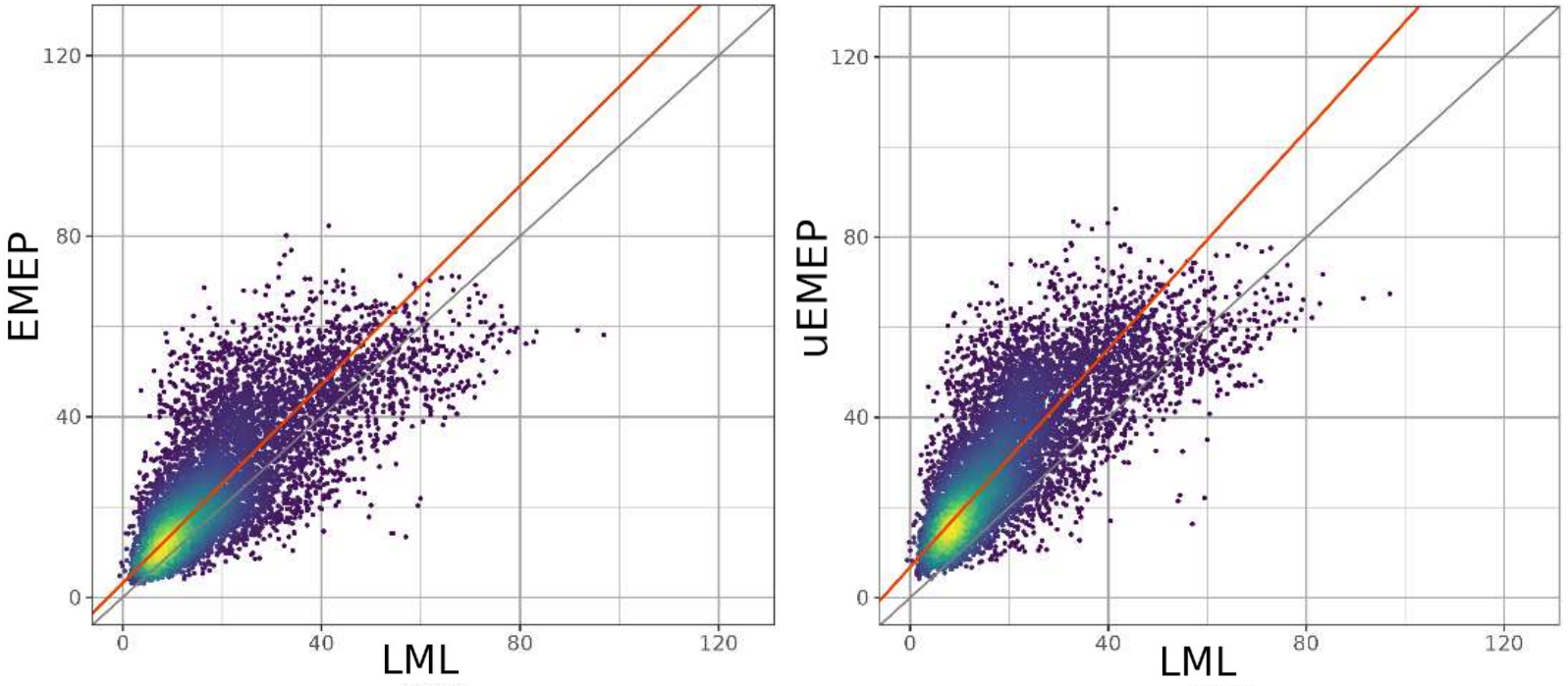
Traffic

Red – hourly
White - monthly

Comparison to hourly measurements

1 Utrecht Griftpark (background)

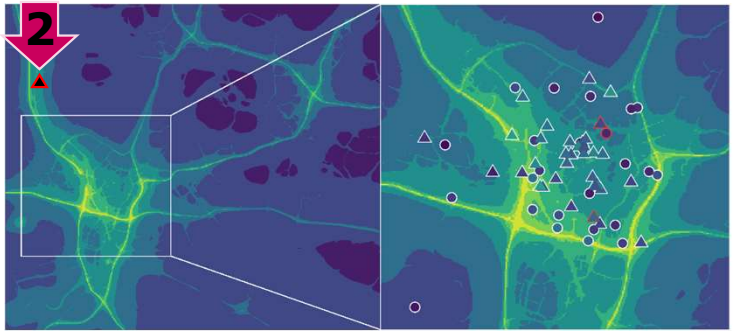


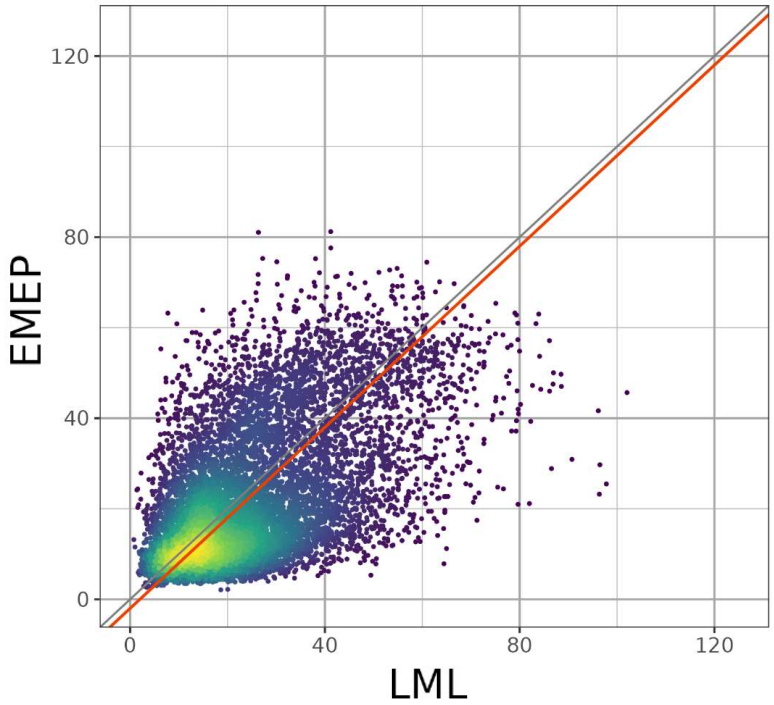


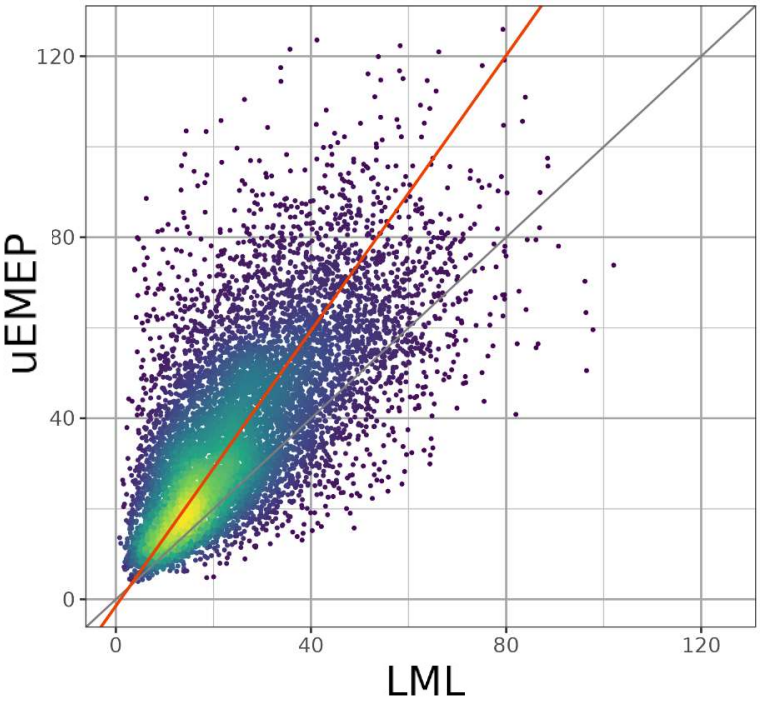
Figures: Comparison of observed (LML) and modelled (EMEP4NL and uEMEP) hourly NO_2 concentrations (in µg/m³) at Utrecht-Griftpark in 2019.

Comparison to hourly measurements

2 Breukelen-Snelweg (traffic)



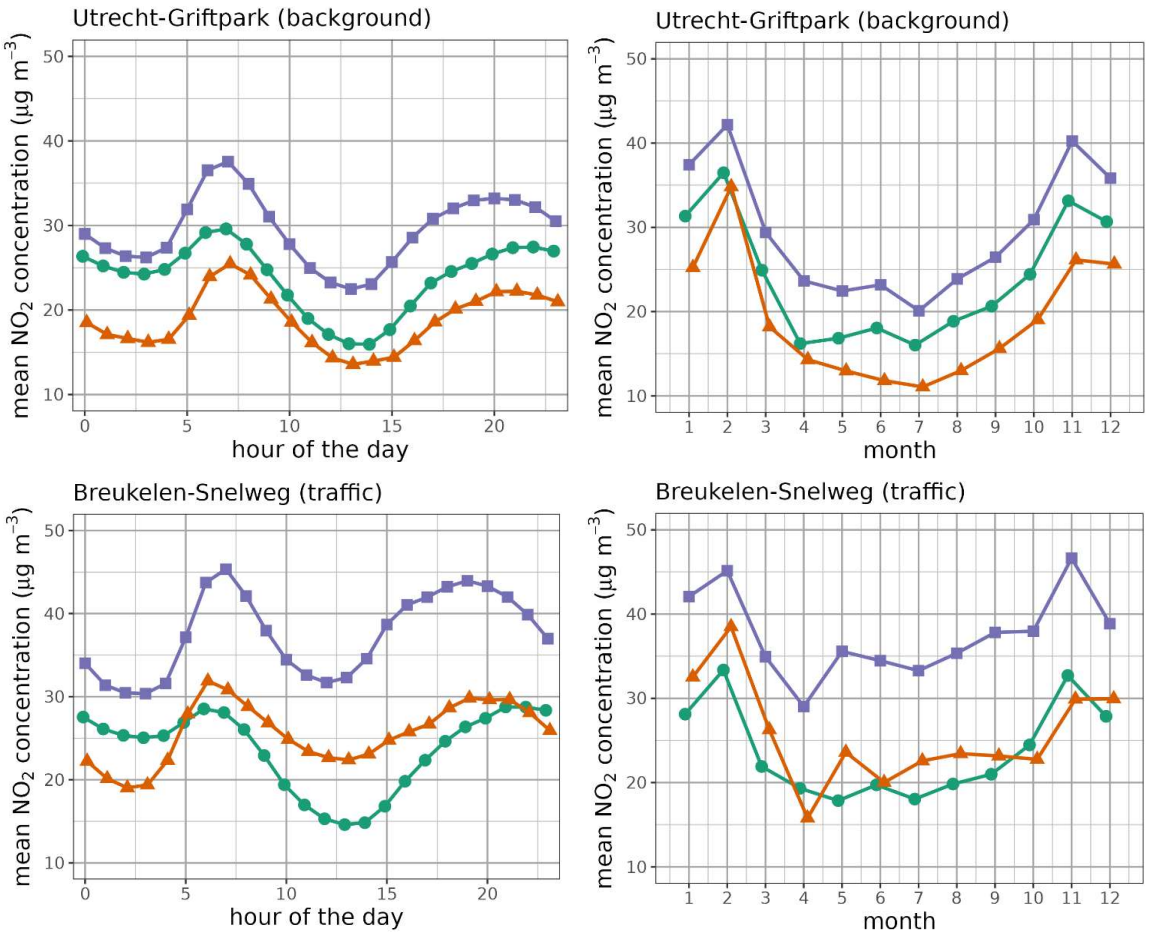




Figures: Comparison of observed (LML) and modelled (EMEP4NL and uEMEP) hourly NO_2 concentrations (in µg/m³) in 2019 at Breukelen-Snelweg.

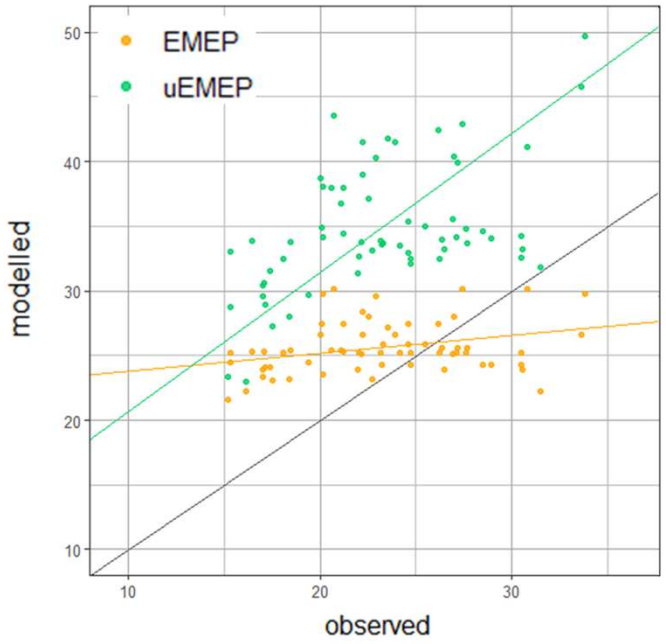
Diurnal and monthly cycles

- EMEP4NL
  - On average closer to observations (LML)
  - Modelled NO_2 at night too high
- uEMEP
  - Higher correlation, diurnal and monthly cycle better represented
  - Modelled NO_2 too high



Annual mean NO_2 values

- EMEP4NL
  - Little variation within domain (~25 µg/m_3)
  - Average NO_2 at background sites too high
- uEMEP
  - More variation, higher correlation, slope closer to 1:1
  - Modelled NO_2 too high
- Background calibration uEMEP necessary
  - Based on comparison mean NO_2 at two regional background sites with the lowest concentrations

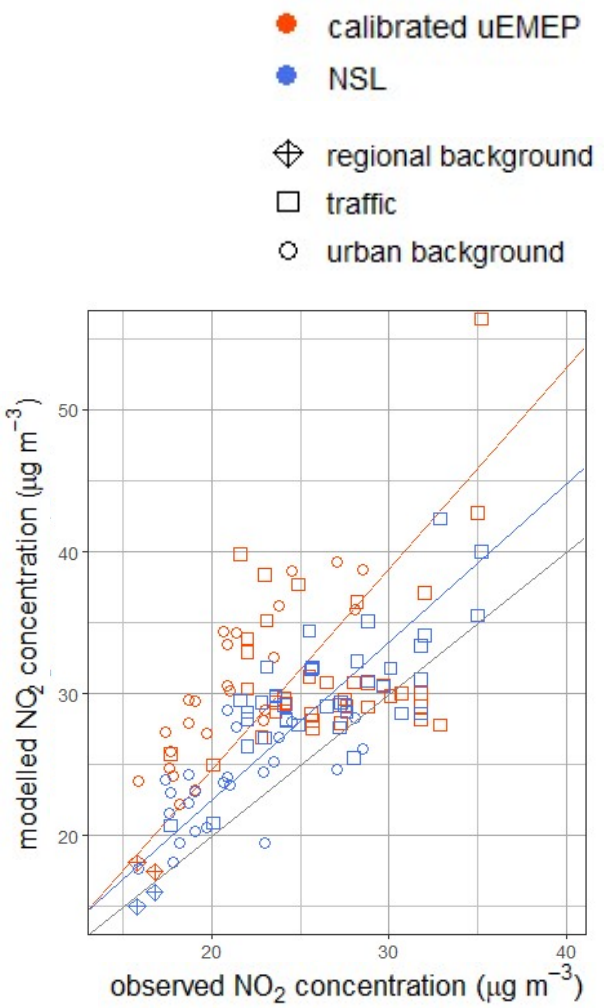


	RMSE	Bias	Intercept	Slope	r	N
EMEP4NL	**5.17**	**2.42**	22.34	0.14	0.28	63
uEMEP	12.59	11.69	**9.90**	**1.08**	**0.53**	63

Comparison to Dutch air quality monitor

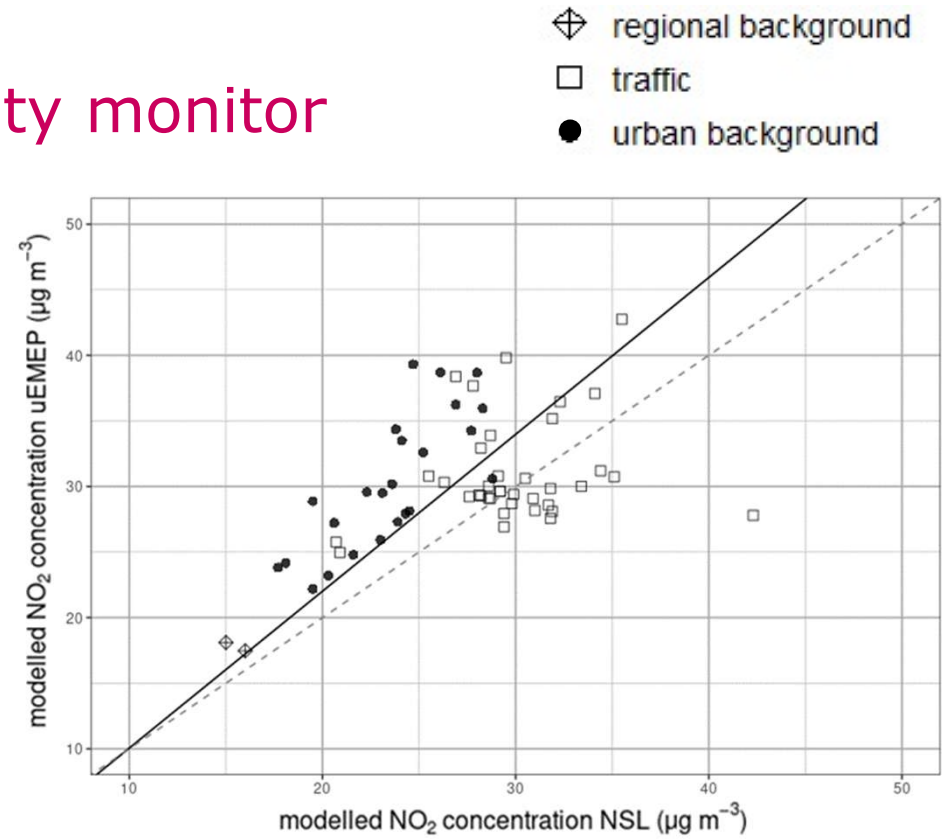
- Comparison of the two models and observations at the measurement locations
- Overall better performance Dutch air quality monitor (NSL) (smaller differences and higher overall correlation to measurements)
- NO_2 concentrations uEMEP still largely overestimated after calibration, especially at urban background

	RMSE	Bias	Intercept	Slope	r
uEMEP	13.14	12.06	1.97	1.42	0.54
uEMEP calibrated	8.32	6.48	-3.61	1.42	0.54
NSL monitor	**4.33**	**3.04**	**0.26**	**1.11**	**0.82**



Comparison to Dutch air quality monitor

- Direct comparison of the two models at measurement sites
- Overall moderate correlation (r=0.56), uEMEP ~20% higher than NSL monitor
- Stronger correlation between the two models at (mostly) urban background sites
- Weaker correlation at traffic-influenced sites
- Street canyon parameterization included in NSL monitor, not in uEMEP



Summary results

1. Comparison to measurements

- Improved correlation uEMEP-measurements compared to EMEP4NL-measurements, but NO_2 overestimated
- Calibration of may be necessary to eliminate spatial biases from EMEP4NL

2. Comparison to Dutch air quality monitor

- Clustering visible, high correlation (urban) background, lower at traffic influenced
- uEMEP less representative in case of street canyon effects. This is effectively captured in NSL monitor

Recommendations

- Suggested model adjustments that may improve uEMEP model performance:
  - Routines that differentiate between different types of traffic emissions and roads
  - Varying emission characteristics (e.g., initial dispersion, emission height) per type of road to approximate street canyon effects
  - Implementation of more emission subsectors for traffic with distinct emission characteristics
  - Other suggestions?

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