

Spatial Representativeness (SR) analysis in 3 cities in Sweden

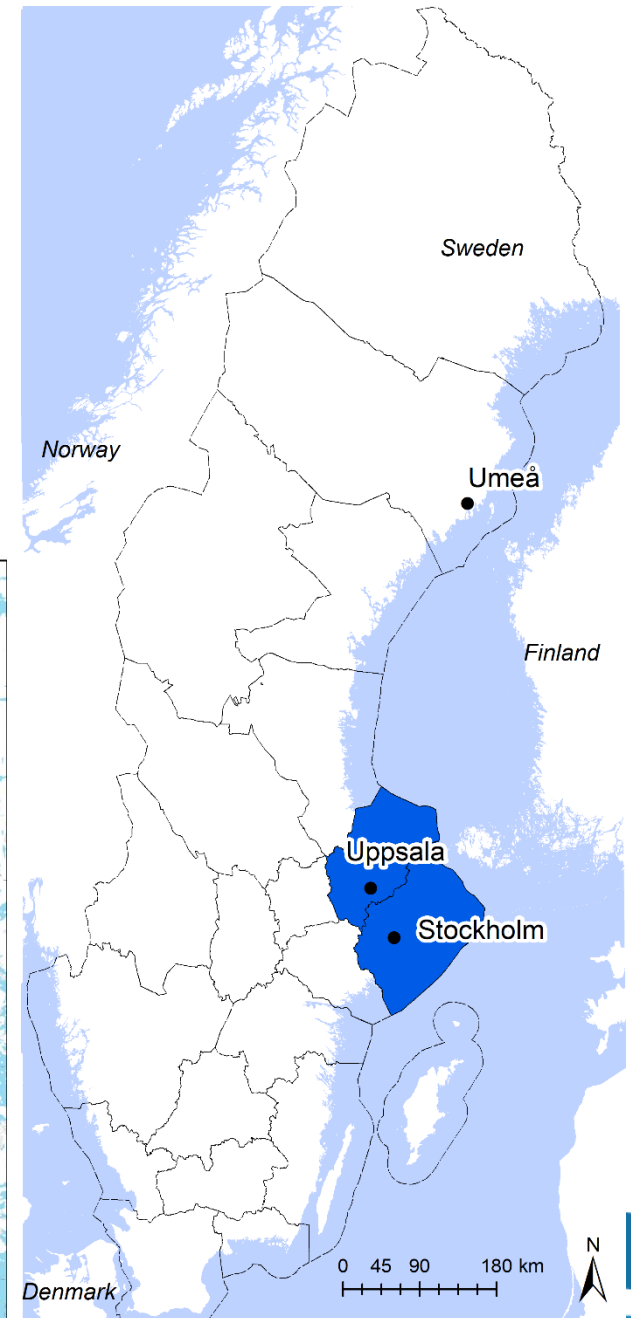
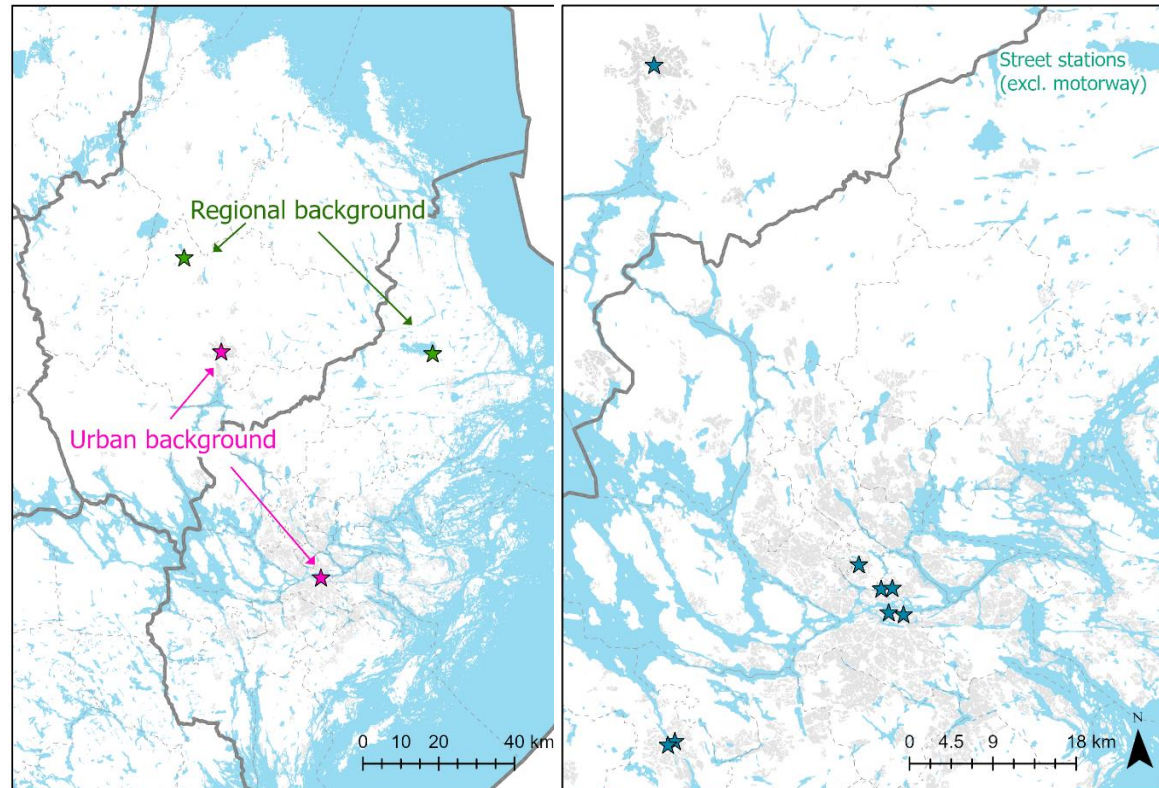
Stockholm , Uppsala and Umeå

Kristina Eneroth, City of Stockholm

Matthew Ross-Jones & Hilma Engholm, Swedish Environmental Agency

Study area

- Stockholm, capital and largest city in Sweden
- Uppsala, 4th largest city
- Umeå, 13th largest city



Specification of the model data – Stockholm & Uppsala

Emission data

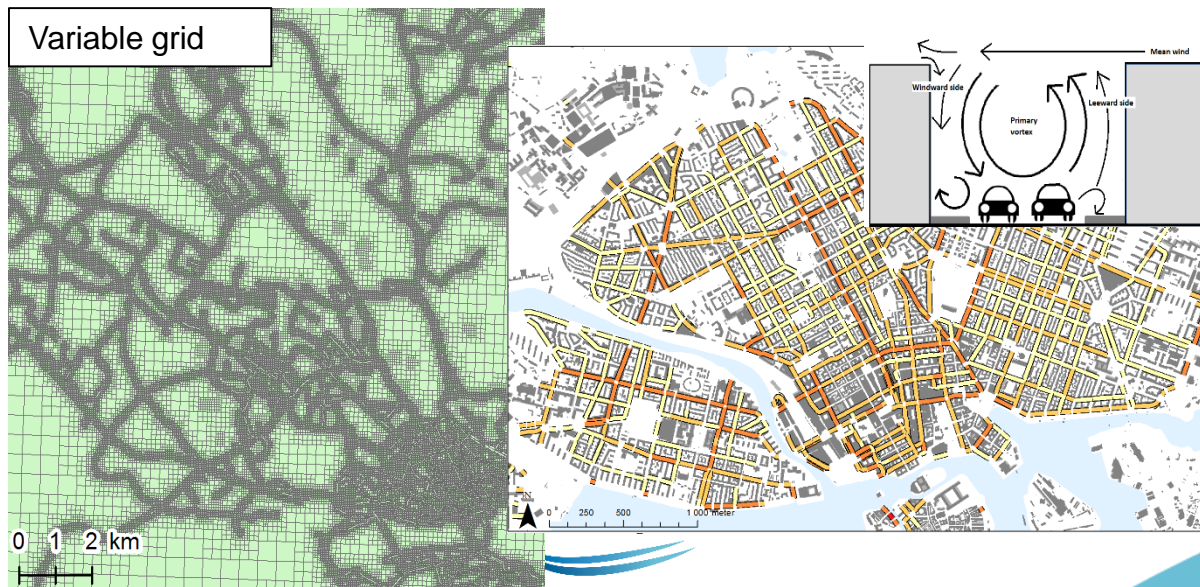
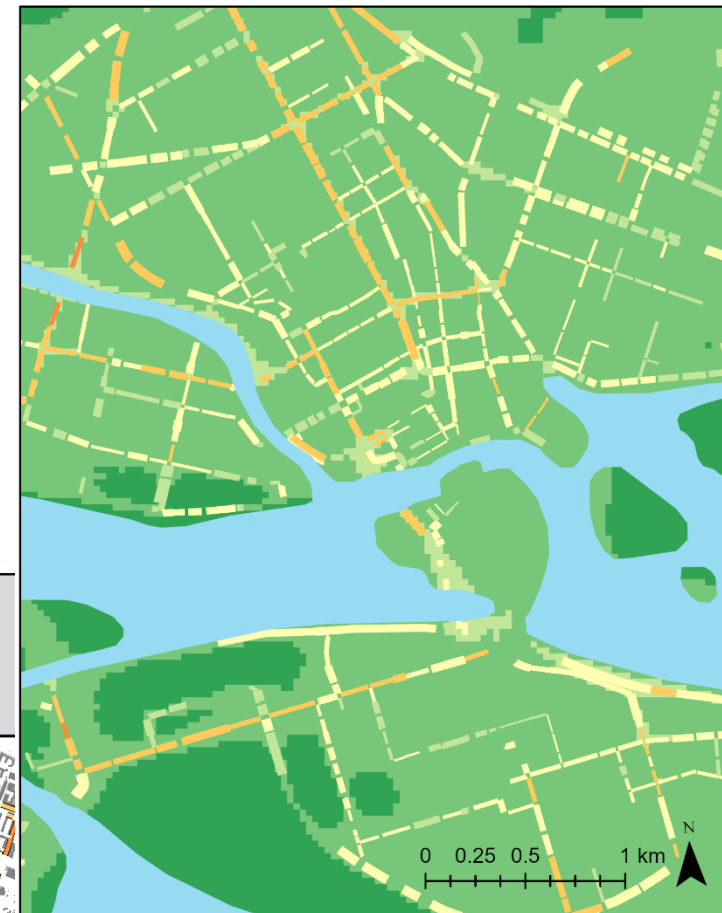
- Local emission data (mostly bottom-up data)

Models

- Airviro Gaussian model with a variable grid (35-500 m)
- Airviro OSPM (Open Street Pollution Model)

NERI, Department of Atmospheric Environment in Denmark

- Simplification: the same concentration on both sides of the street canyon (the highest)



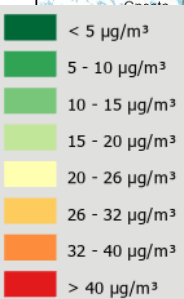
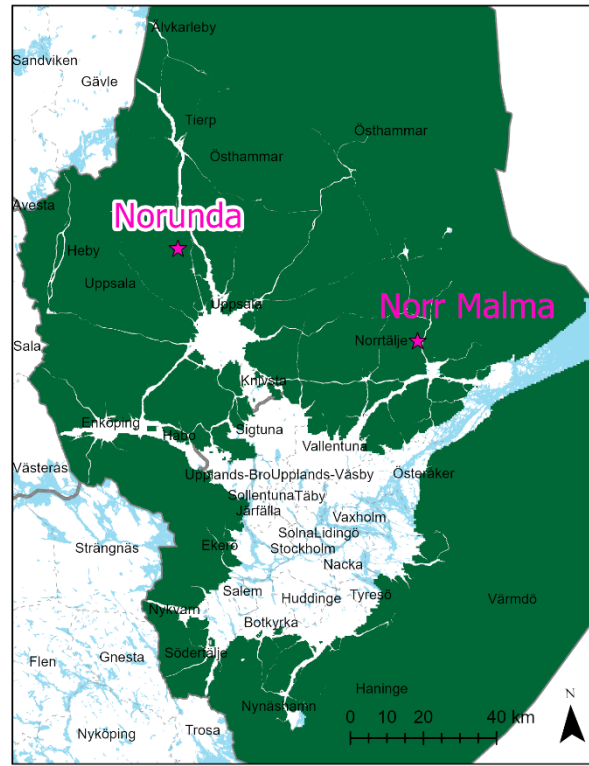
NO2 year regional background

Norunda

- NO₂ yearly mean: 2.8 µg/m³
- ± 20 %: 2.2 – 3.3 µg/m³

Norr Malma

- NO₂ yearly mean: 2.9 µg/m³
- ± 20 %: 2.3 – 3.5 µg/m³



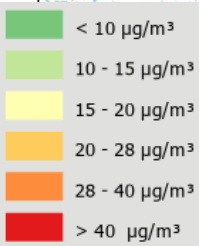
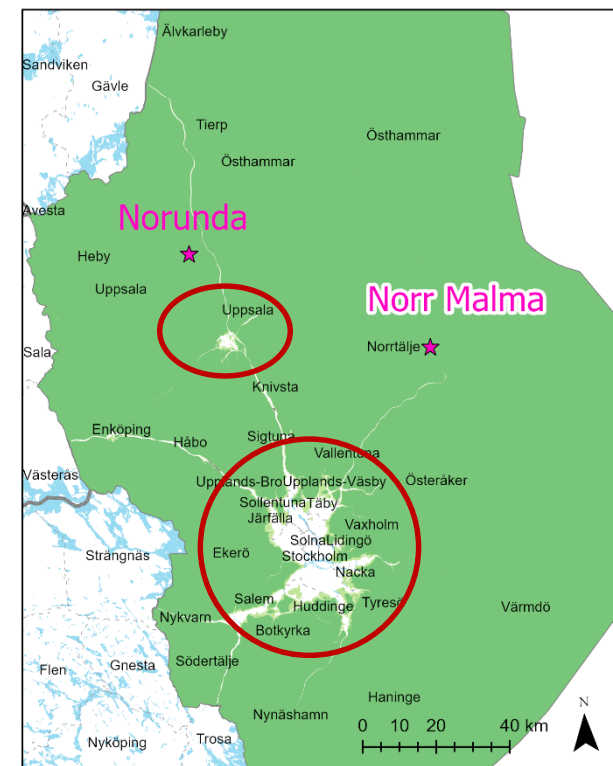
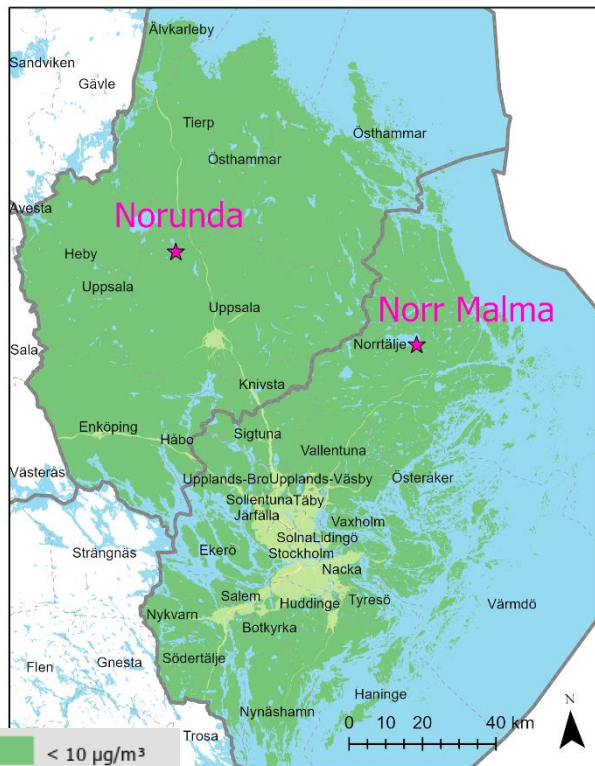
PM10 year regional background

Norunda

- PM10 yearly mean: $8.6 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $6.9 - 10.4 \mu\text{g}/\text{m}^3$

Norr Malma

- PM10 yearly mean: $8.7 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $6.9 - 10.4 \mu\text{g}/\text{m}^3$



Parts of Uppsala and Stockholm urban areas are included within the SR areas of the regional background stations.

PM10 year regional background

Norr Malma

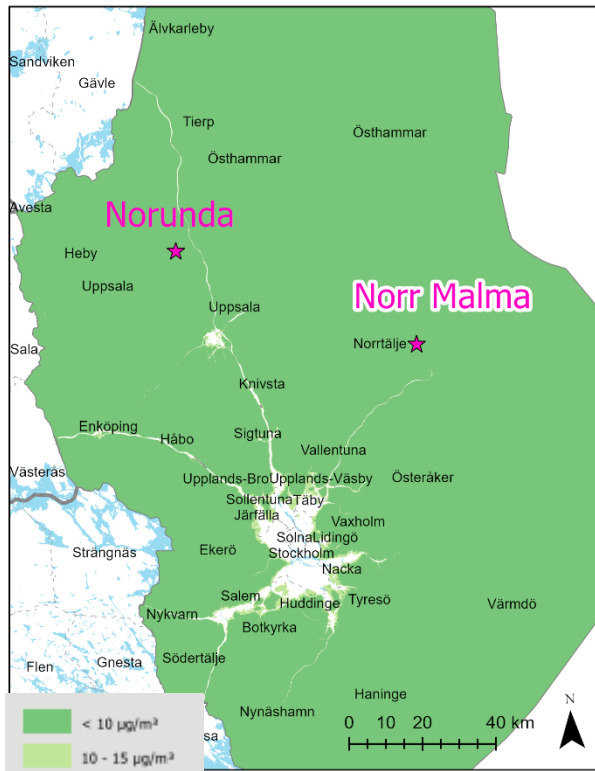
- PM10 yearly mean: $8.7 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $6.9 - 10.4 \mu\text{g}/\text{m}^3$

Norr Malma

- PM10 yearly mean: $8.7 \mu\text{g}/\text{m}^3$
- $\pm 10 \%$: $7.8 - 9.5 \mu\text{g}/\text{m}^3$

Norr Malma

- PM10 yearly mean: $8.7 \mu\text{g}/\text{m}^3$
- $\pm 5 \%$: $8.2 - 9.1 \mu\text{g}/\text{m}^3$



NO2 year urban background

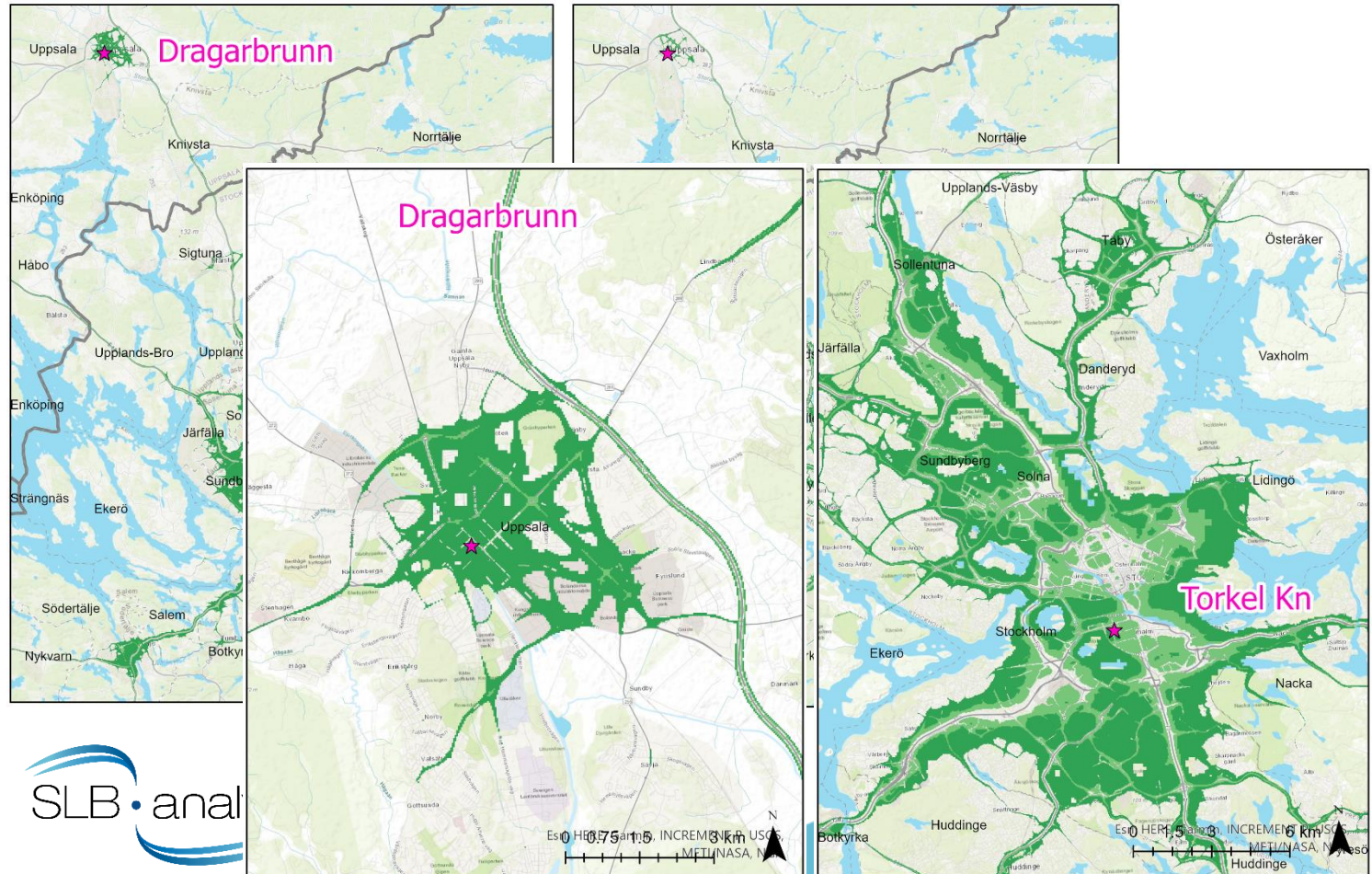
Dragarbrunnsg, Uppsala

- NO2 yearly mean: 8.5 $\mu\text{g}/\text{m}^3$
- $\pm 20\%$: 6.8 – 10.2 $\mu\text{g}/\text{m}^3$

Torkel Kn, Stockholm

- NO2 yearly mean: 10.2 $\mu\text{g}/\text{m}^3$
- $\pm 20\%$: 8.2 – 12.2 $\mu\text{g}/\text{m}^3$

Some overlap between the two cities urban background stations SR areas



PM10 year urban background

Dragarbrunnsg, Uppsala

- PM10 yearly mean: $10.8 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $8.6 - 12.9 \mu\text{g}/\text{m}^3$

Torkel Kn, Stockholm

- PM10 yearly mean: $11.2 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $8.9 - 13.4 \mu\text{g}/\text{m}^3$

Large overlap between the two cities urban background stations SR areas.

The SR area for Uppsala UB background station (Dragarbrunn) also includes areas for the regional background stations.



PM10 year urban background

Torkel Kn, Stockholm

- PM10 yearly mean: $11.2 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $8.9 - 13.4 \mu\text{g}/\text{m}^3$

Torkel Kn, Stockholm

- PM10 yearly mean: $11.2 \mu\text{g}/\text{m}^3$
- $\pm 10 \%$: $10.1 - 12.3 \mu\text{g}/\text{m}^3$

Torkel Kn, Stockholm

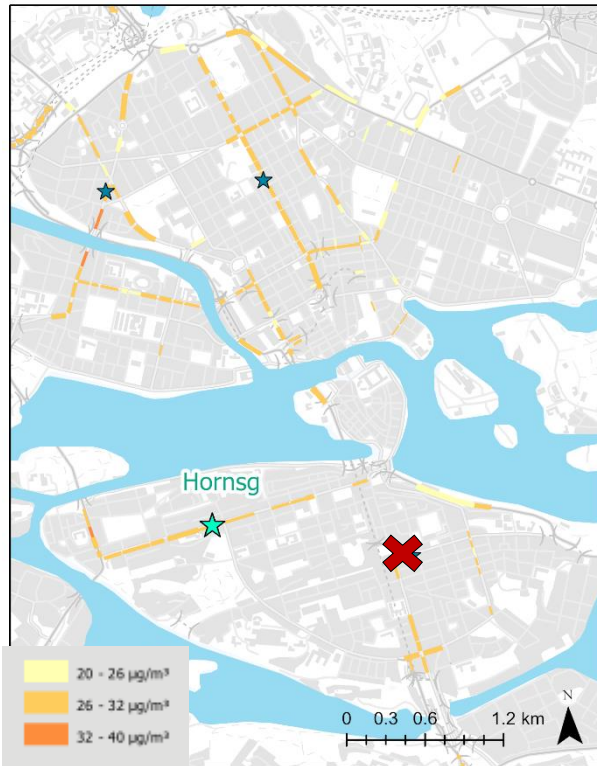
- PM10 yearly mean: $11.2 \mu\text{g}/\text{m}^3$
- $\pm 5 \%$: $10.6 - 11.7 \mu\text{g}/\text{m}^3$



NO₂ year Hornsgatan street stations in Stockholm city

Hornsgatan, Stockholm

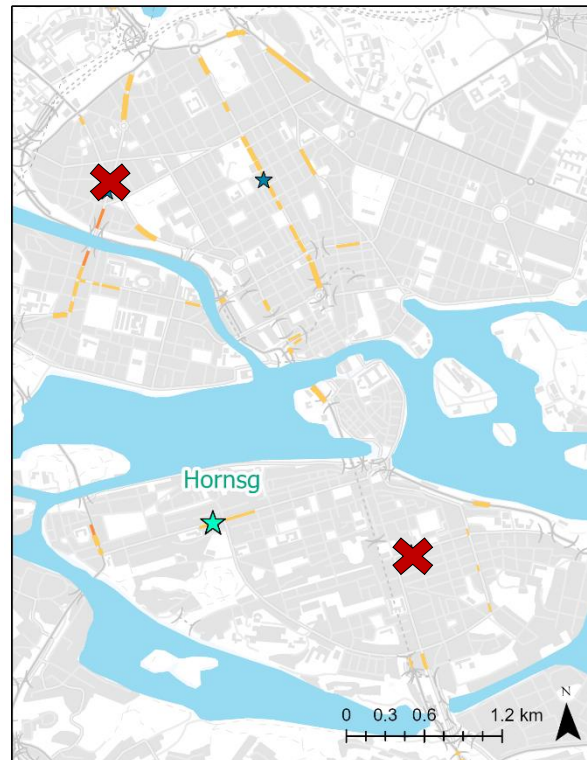
- NO₂ yearly mean: 31.3 µg/m³
- ± 20 %: 25.0 – 37.6 µg/m³



2 of 3 street canyon stations are within SR area of Hornsgatan

Hornsgatan, Stockholm

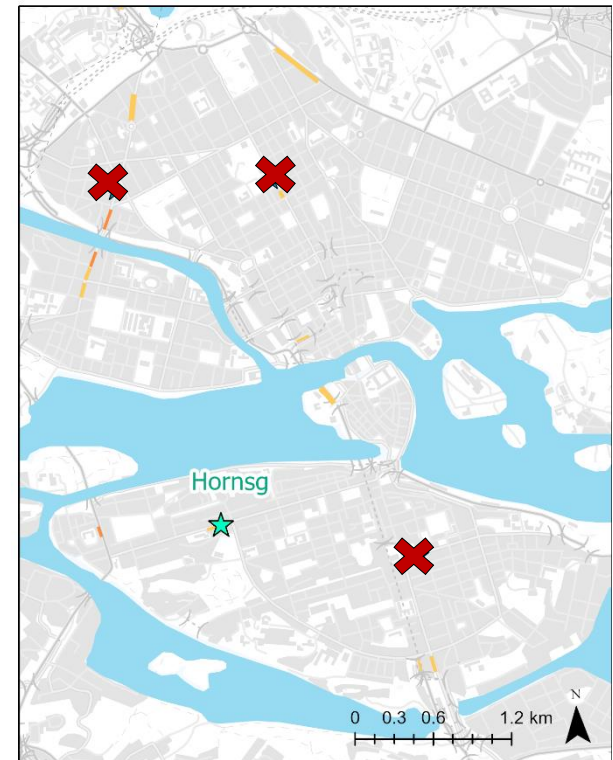
- NO₂ yearly mean: 31.3 µg/m³
- ± 10 %: 28.2 – 34.4 µg/m³



1 of 3 street canyon stations are within SR area of Hornsgatan

Hornsgatan, Stockholm

- NO₂ yearly mean: 31.3 µg/m³
- ± 5 %: 29.7 – 32.9 µg/m³



None of the other 3 street canyon stations are within SR area of Hornsgatan

NO₂ year Hornsgatan street stations in whole study area

Hornsgatan, Stockholm

- NO₂ yearly mean: 31.3 µg/m³
- ± 20 %: 25.0 – 37.6 µg/m³



5 of 7 street canyon stations are within SR area of Hornsgatan

Hornsgatan, Stockholm

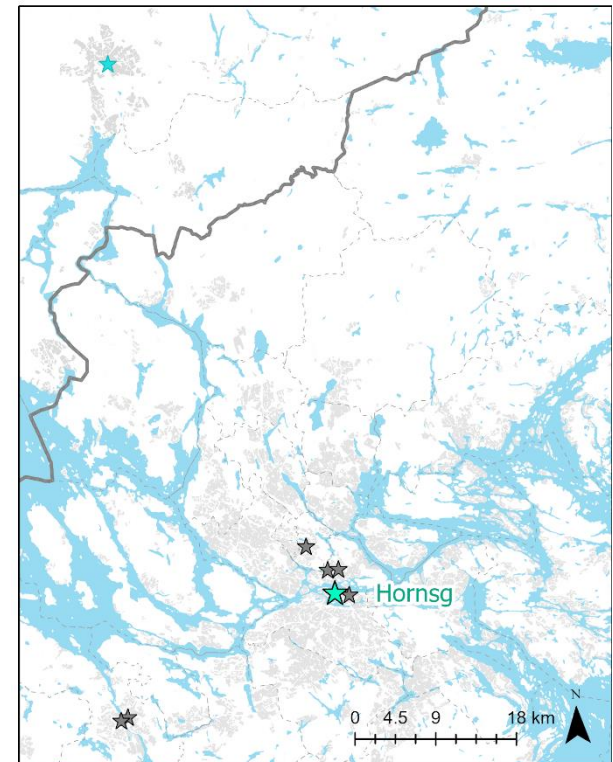
- NO₂ yearly mean: 31.3 µg/m³
- ± 10 %: 28.2 – 34.4 µg/m³



2 of 7 street canyon stations are within SR area of Hornsgatan

Hornsgatan, Stockholm

- NO₂ yearly mean: 31.3 µg/m³
- ± 5 %: 29.7 – 32.9 µg/m³

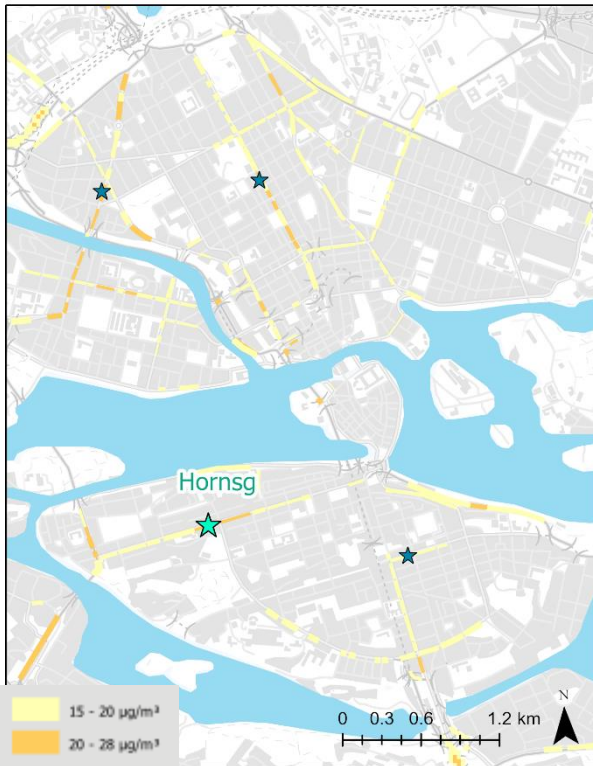


1 of 7 street canyon stations are within SR area of Hornsgatan

PM10 year Hornsgatan street stations in Stockholm city

Hornsgatan, Stockholm

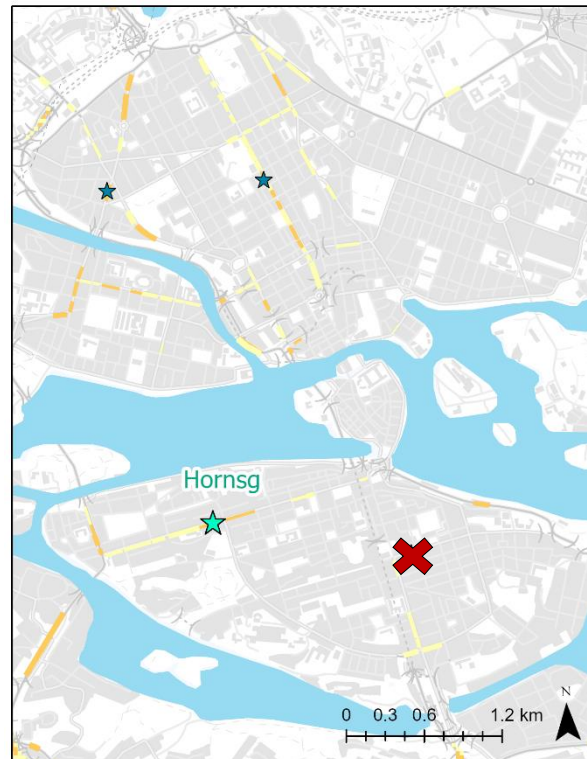
- PM10 yearly mean: $20.8 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $16.6 - 24.9 \mu\text{g}/\text{m}^3$



All other 3 street canyon stations are within SR area of Hornsgatan

Hornsgatan, Stockholm

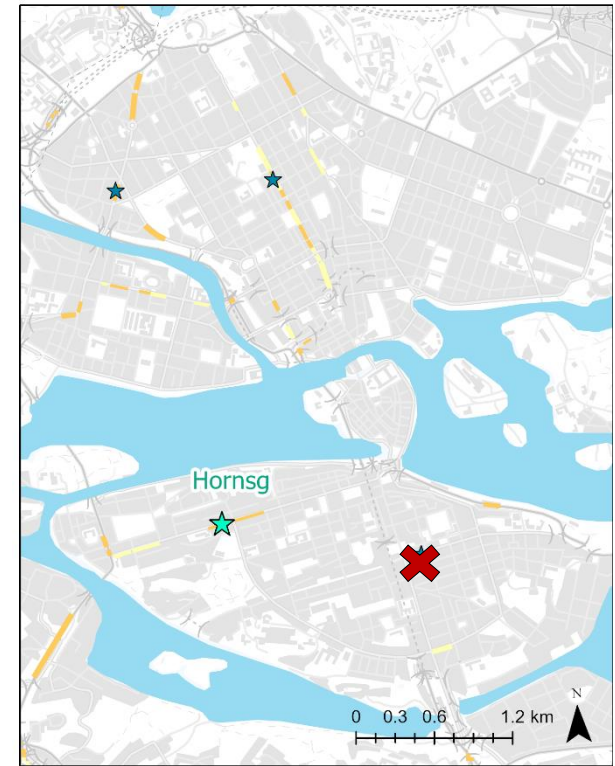
- PM10 yearly mean: $20.8 \mu\text{g}/\text{m}^3$
- $\pm 10 \%$: $18.7 - 22.8 \mu\text{g}/\text{m}^3$



2 of 3 street canyon stations are within SR area of Hornsgatan

Hornsgatan, Stockholm

- PM10 yearly mean: $20.8 \mu\text{g}/\text{m}^3$
- $\pm 5 \%$: $19.7 - 21.8 \mu\text{g}/\text{m}^3$



2 of 3 street canyon stations are within SR area of Hornsgatan

PM10 year Hornsgatan street stations in whole study area

Hornsgatan, Stockholm

- PM10 yearly mean: $20.8 \mu\text{g}/\text{m}^3$
- $\pm 20 \%$: $16.6 - 24.9 \mu\text{g}/\text{m}^3$

Hornsgatan, Stockholm

- PM10 yearly mean: $20.8 \mu\text{g}/\text{m}^3$
- $\pm 10 \%$: $18.7 - 22.8 \mu\text{g}/\text{m}^3$

Hornsgatan, Stockholm

- PM10 yearly mean: $20.8 \mu\text{g}/\text{m}^3$
- $\pm 5 \%$: $19.7 - 21.8 \mu\text{g}/\text{m}^3$



6 of 7 street canyon stations are within SR area of Hornsgatan



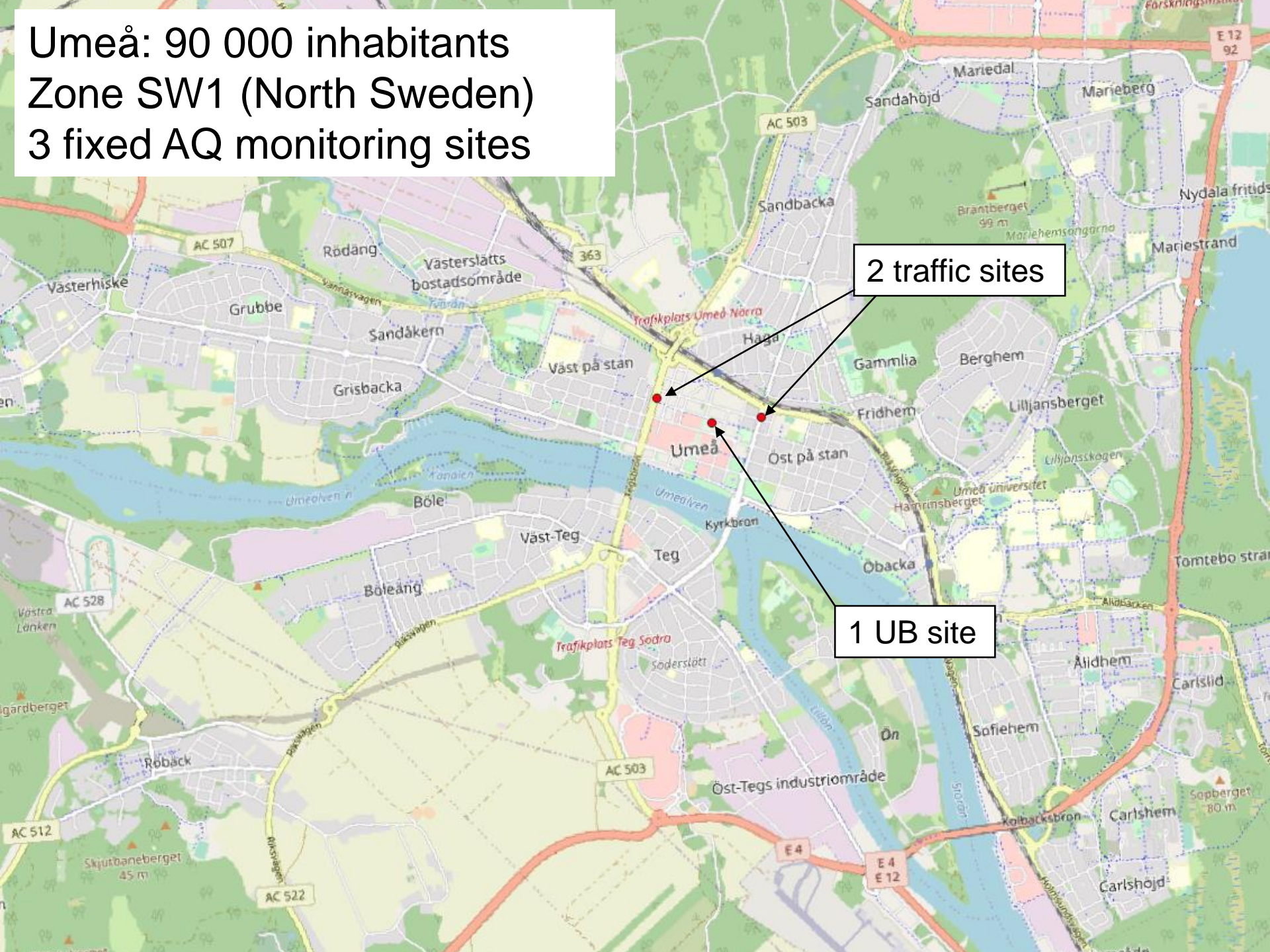
5 of 7 street canyon stations are within SR area of Hornsgatan



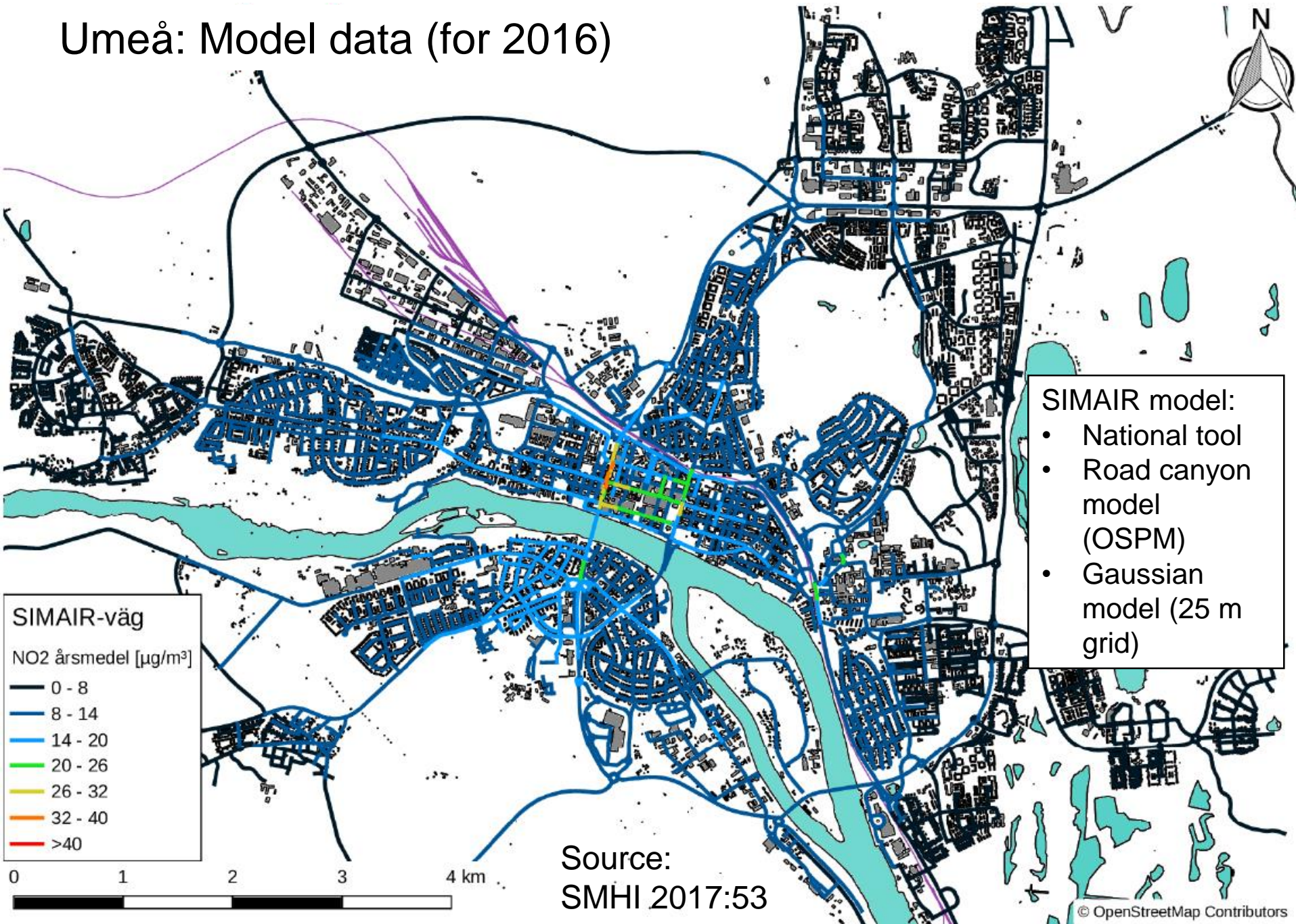
5 of 7 street canyon stations are within SR area of Hornsgatan

Spatial representativeness in Umeå

Umeå: 90 000 inhabitants
Zone SW1 (North Sweden)
3 fixed AQ monitoring sites



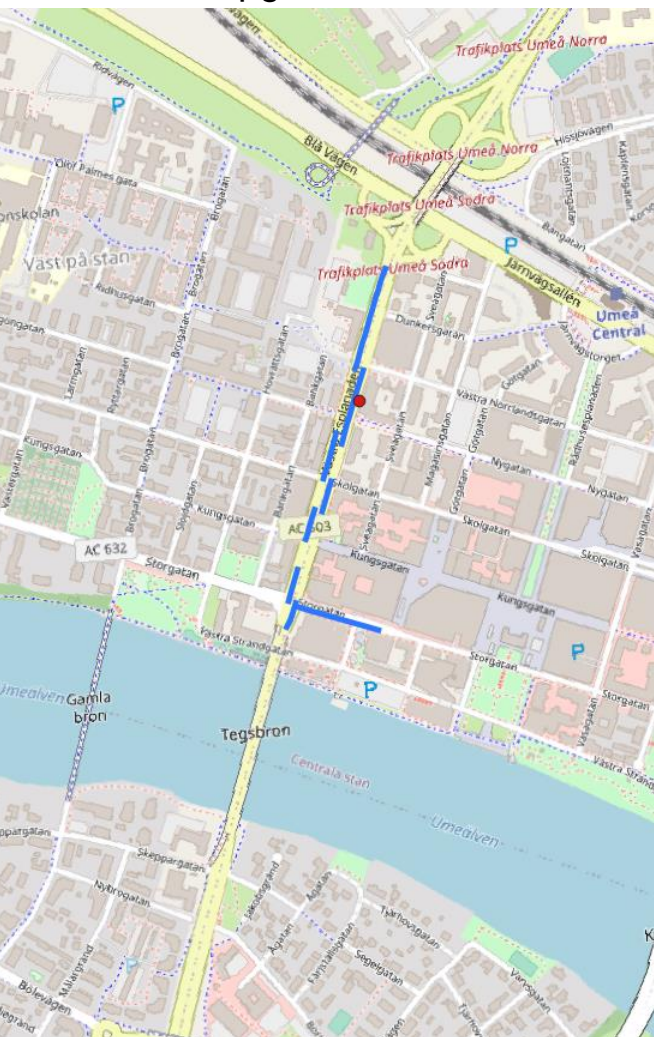
Umeå: Model data (for 2016)



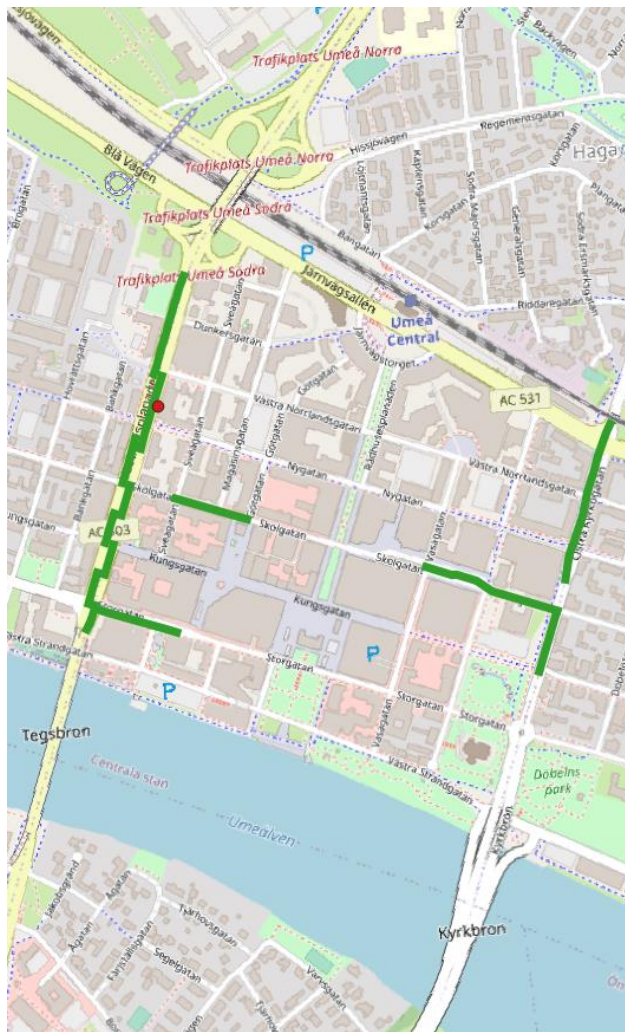
NO₂ annual mean, Umeå V. Esplanaden (traffic site)

Annual mean (2016): 33.9 µg/m³

Representative area ±20%
27.1 – 40.7 µg/m³



Representative area ±30%
23.6 – 44.1 µg/m³



Representative area ±40%
20.4 – 47.5 µg/m³



NO₂ daily mean, Umeå V. Esplanaden (traffic site)

98th percentile daily means (2016): 83.7 µg/m³

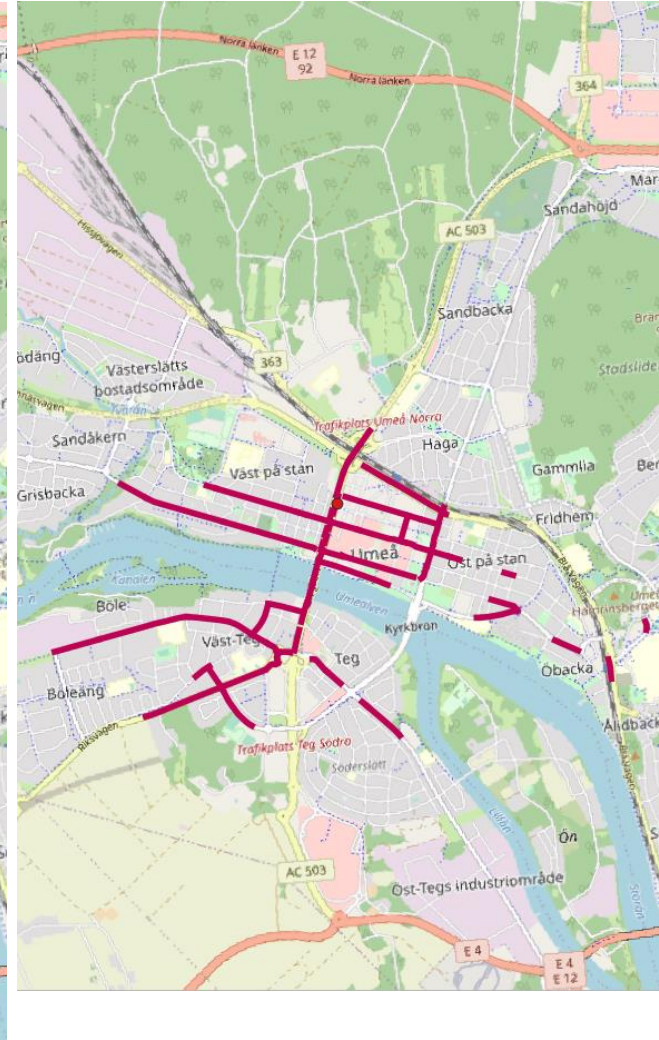
Representative area ±20%
67.0 – 100.5 µg/m³



Representative area ±30%
58.6 – 108.8 µg/m³



Representative area ±40%
50.2 – 117.2 µg/m³



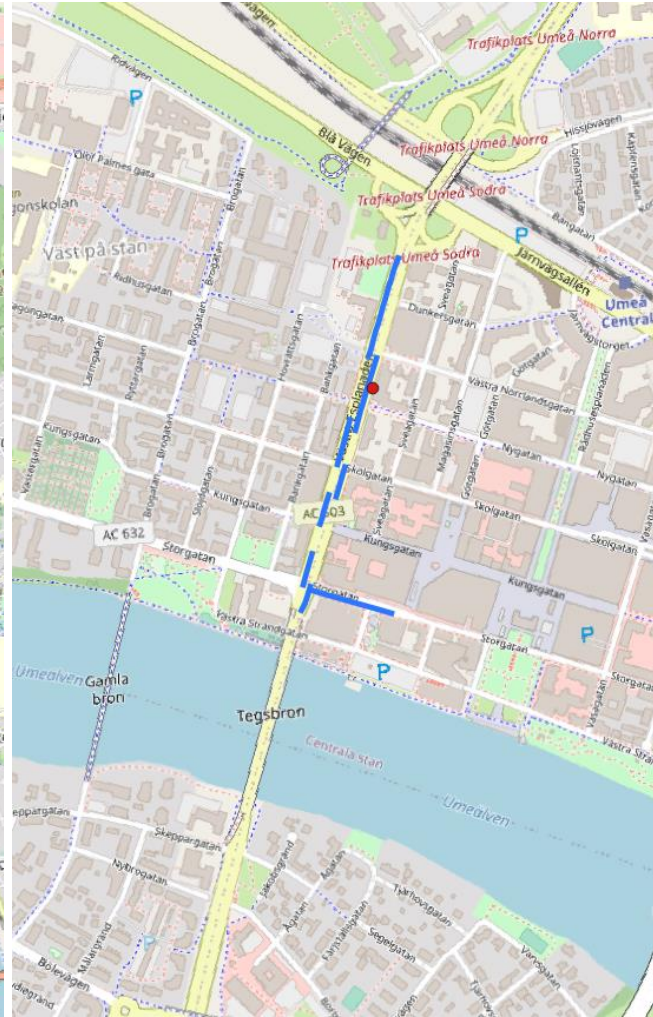
Representative areas vs Area of exceedance (NO₂)

Umeå exceeds Swedish LV 60 µg/m³ (Max 6 days / 98th %ile)

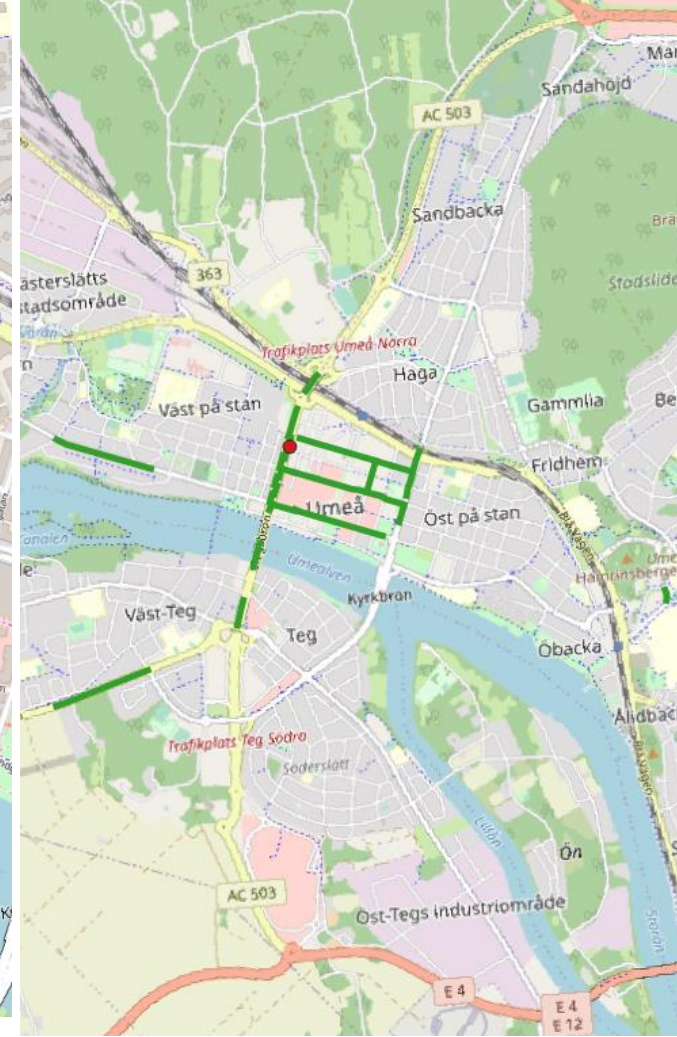
Area of exceedance
>60 µg/m³ (98 %ile daily means)



Representative area annual mean
±20% (50.2 – 117.2 µg/m³)



Representative area daily means ±30%
58.6 – 108.8 µg/m³



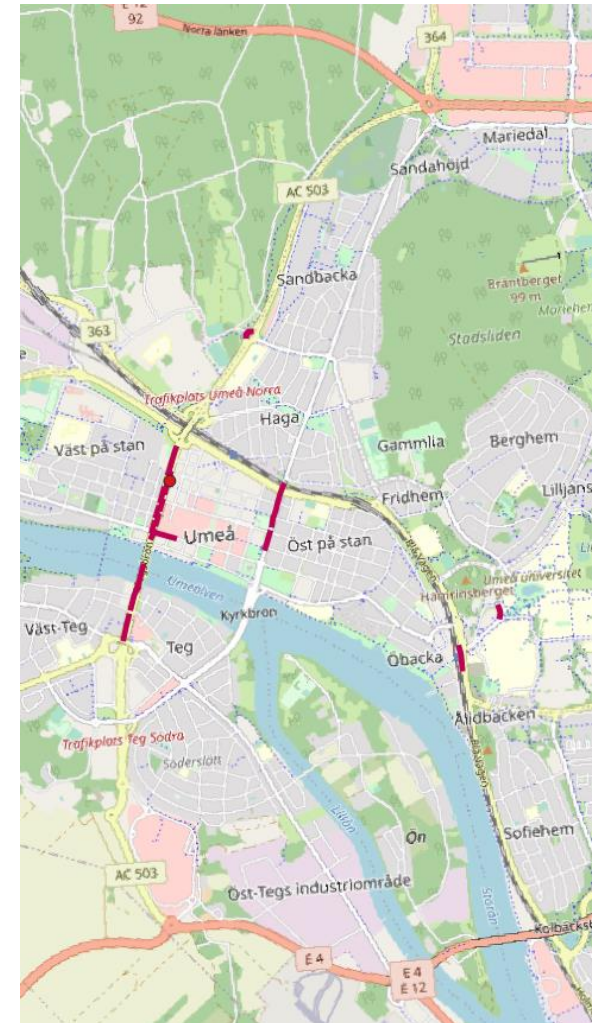
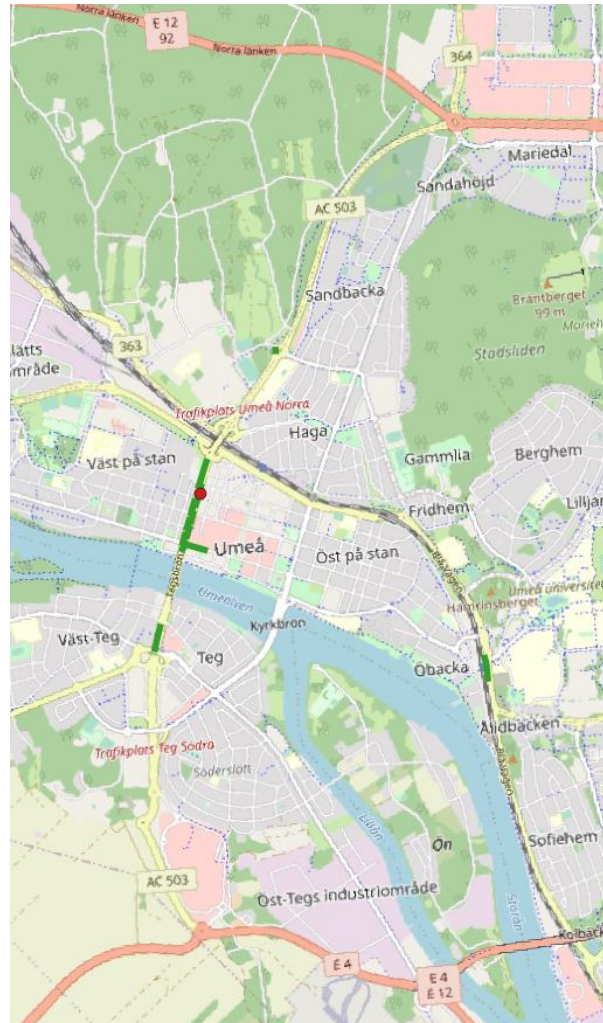
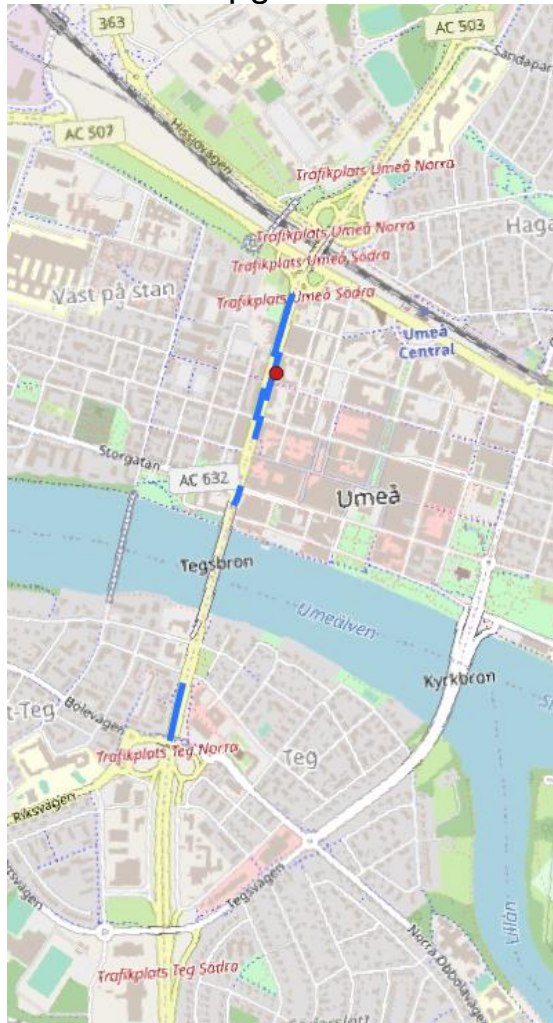
PM10 annual mean, Umeå V. Esplanaden (traffic site)

Annual mean (2016): $15.1 \mu\text{g}/\text{m}^3$

Representative area $\pm 20\%$
 $12.1 - 18.1 \mu\text{g}/\text{m}^3$

Representative area $\pm 30\%$
 $10.6 - 19.7 \mu\text{g}/\text{m}^3$

Representative area $\pm 40\%$
 $9.1 - 21.2 \mu\text{g}/\text{m}^3$



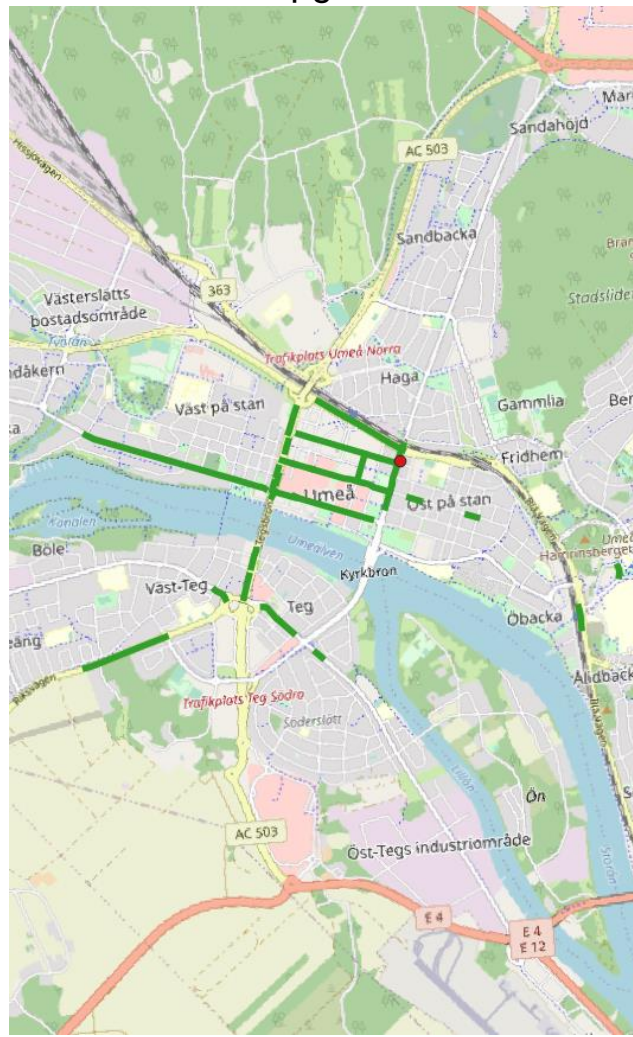
NO₂ annual mean, Umeå Ö. Kyrkogårdsgatan (traffic site)

Annual mean (2016): 25.9 µg/m³

Representative area ±20%
20.7 – 31.1 µg/m³



Representative area ±30%
18.2 – 33.7 µg/m³



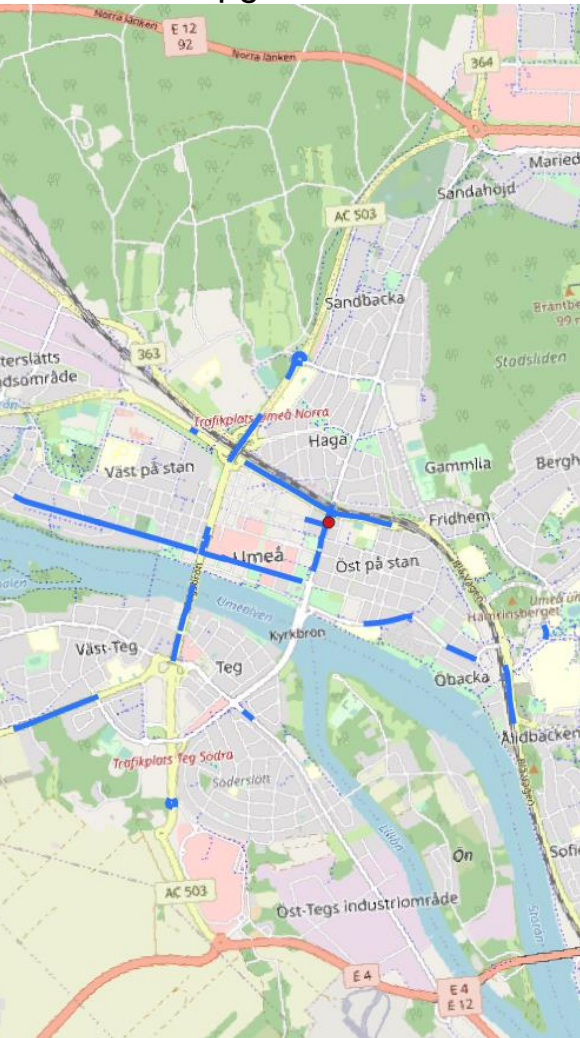
Representative area ±40%
15.6 – 36.3 µg/m³



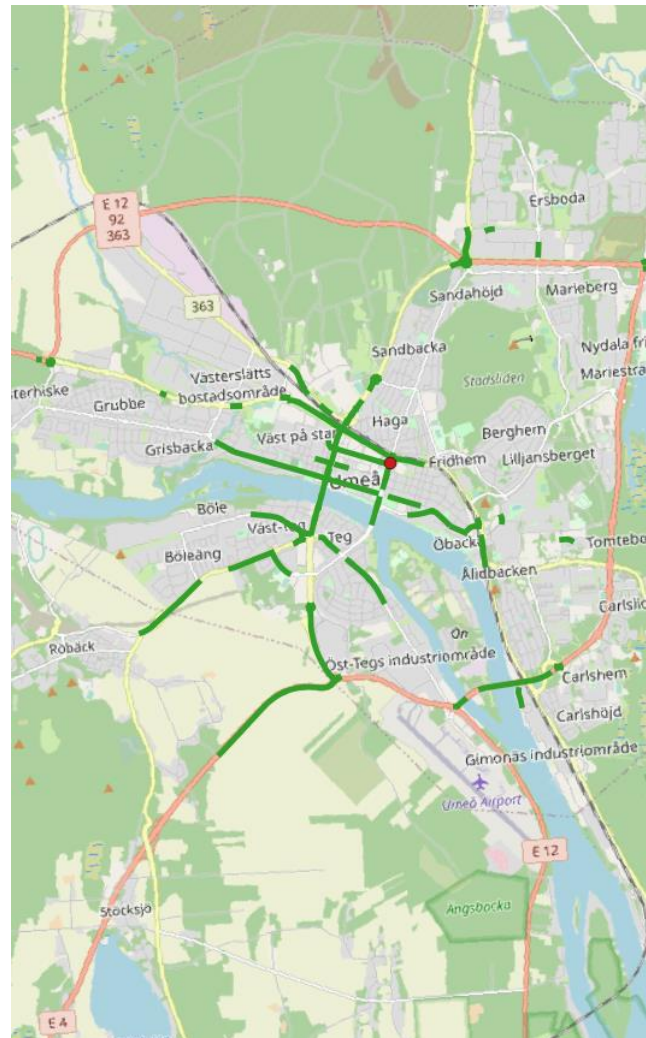
PM10 annual mean, Umeå Ö. Kyrkogårdsgatan (traffic site)

Annual mean (2016): $10.1 \mu\text{g}/\text{m}^3$

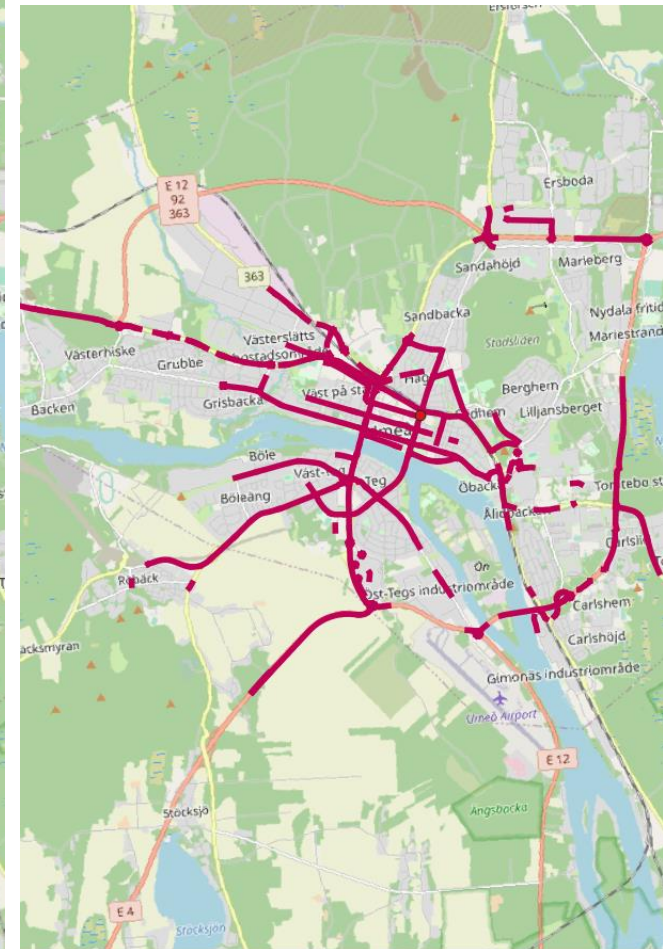
Representative area $\pm 20\%$
 $8.1 - 12.1 \mu\text{g}/\text{m}^3$



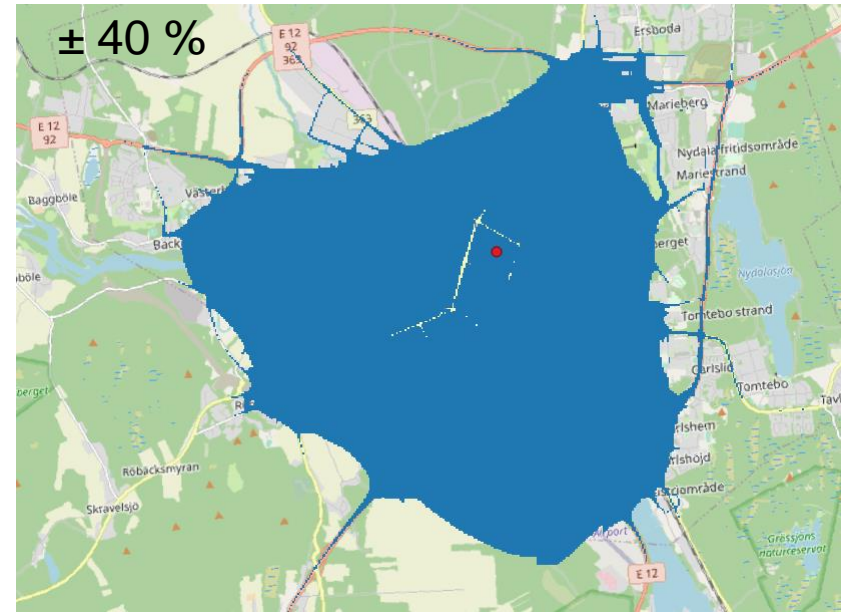
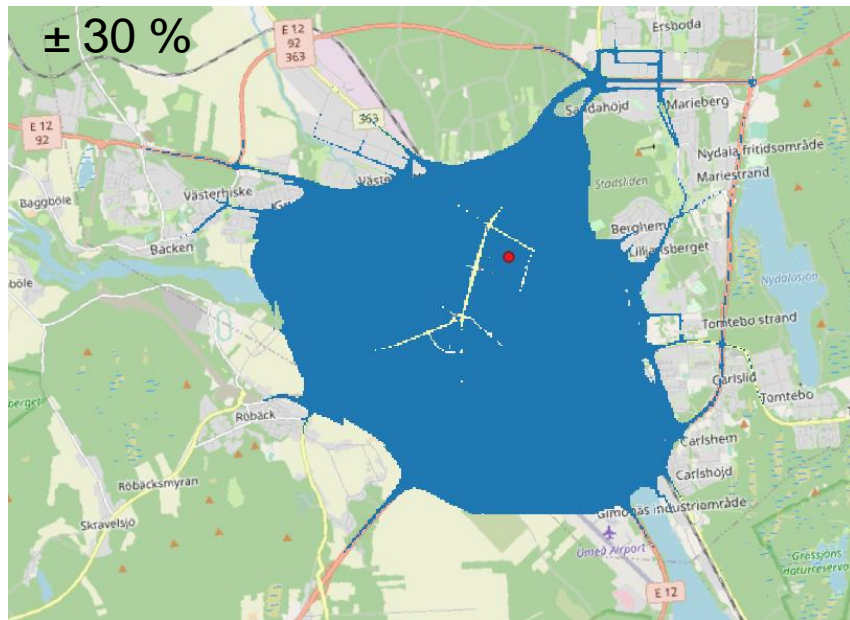
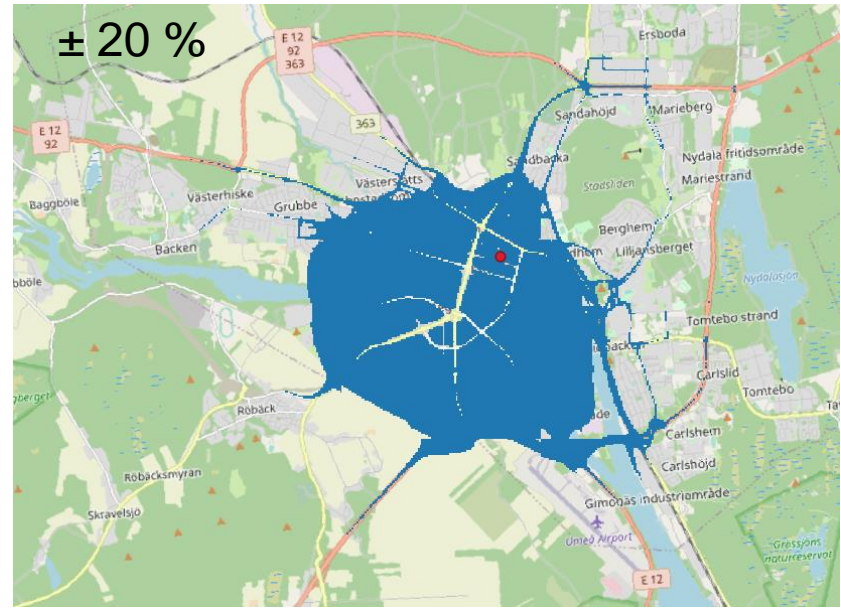
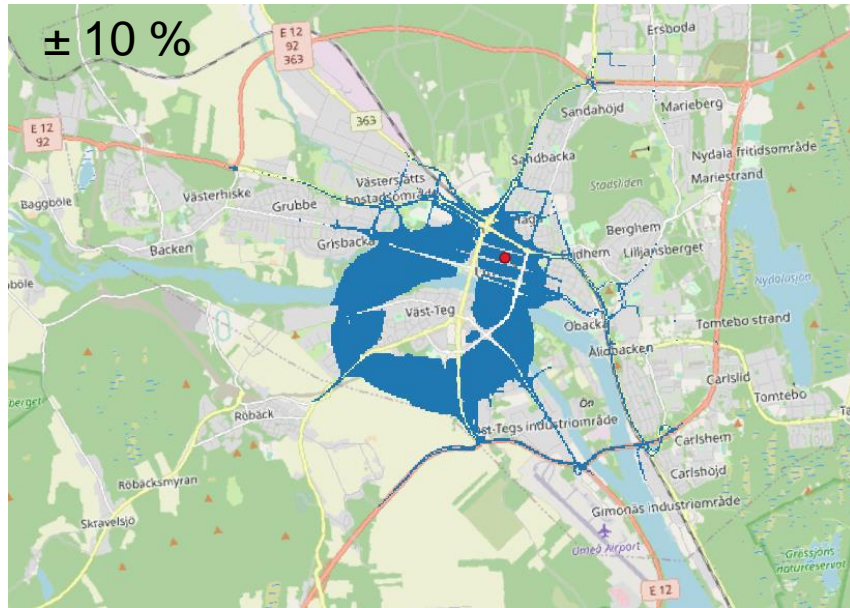
Representative area $\pm 30\%$
 $7.1 - 13.1 \mu\text{g}/\text{m}^3$



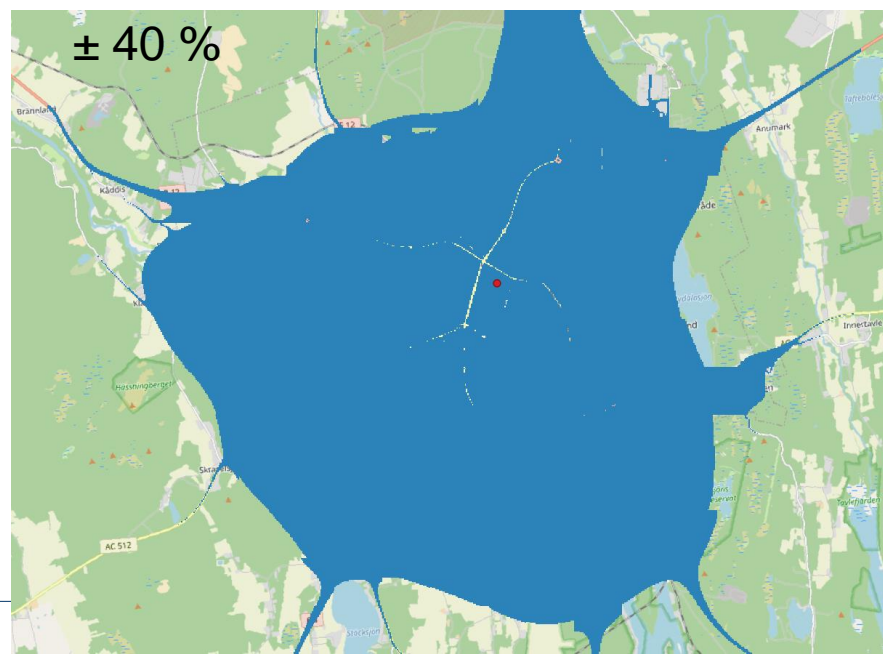
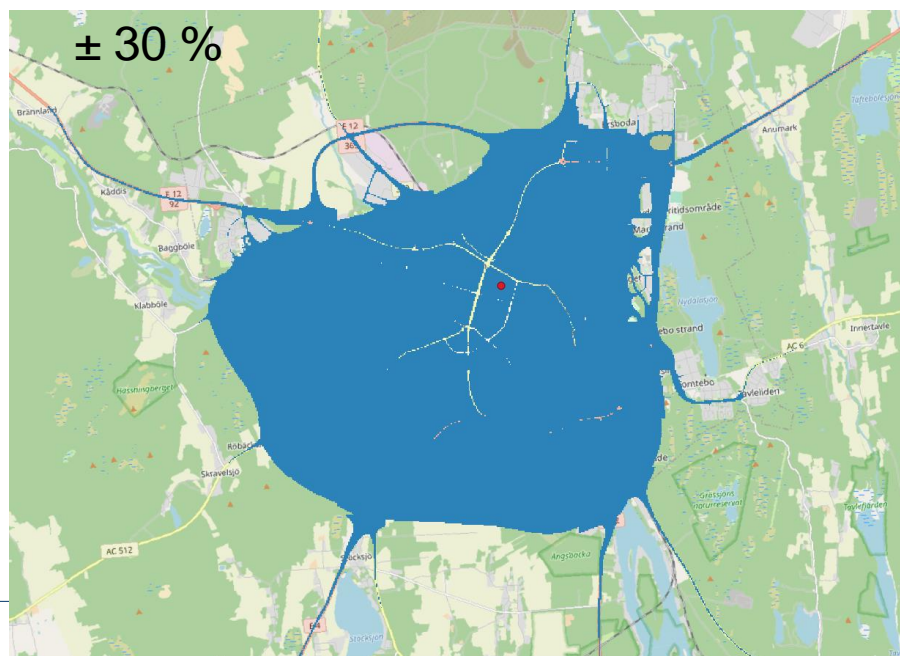
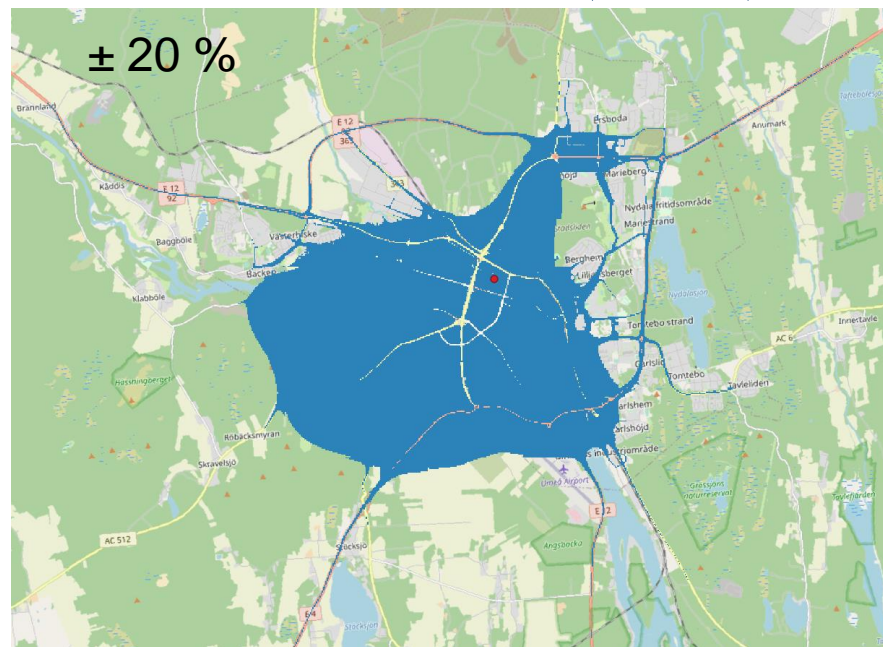
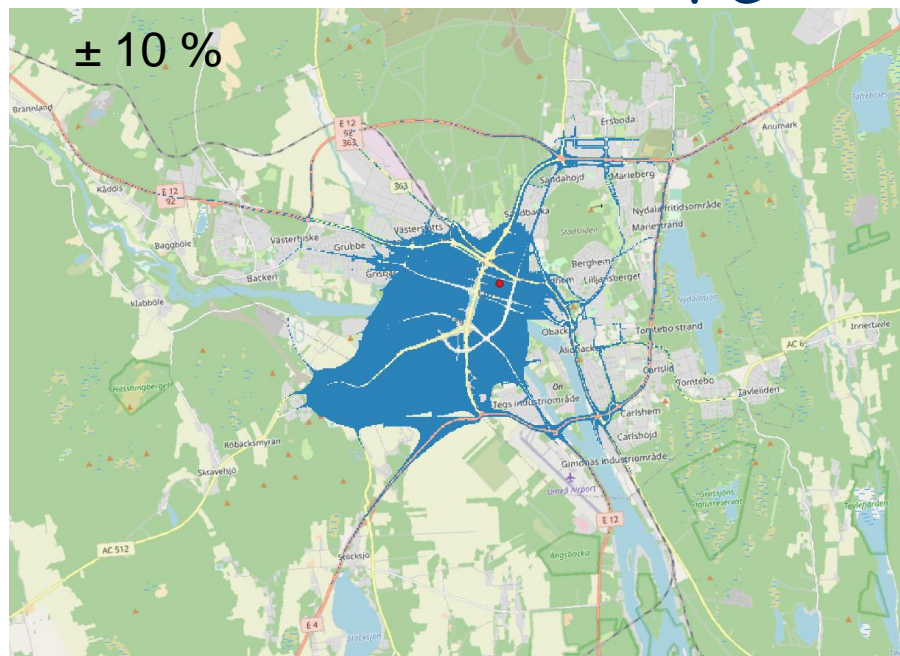
Representative area $\pm 40\%$
 $6.1 - 14.2 \mu\text{g}/\text{m}^3$



Umeå: UB station, $11.5 \mu\text{g}/\text{m}^3$ NO_2 annual mean (2016)



Umeå: UB station, $6.4 \mu\text{g}/\text{m}^3$ PM10 annual mean (2016)



Reflections / Feedback

- Discontiguous approach is preferred, but...
 - Limit to within city for urban stations?
 - Proposed zone-based limits not so useful in Sweden
- $\pm 20\%$ on annual mean OK for traffic stations in Umeå
 - Gives overlapping SR areas for Stockholm's traffic stations
- $\pm 10\%$ more appropriate for background stations (particularly for PM10)
- Need for further (optional?) similarity criteria?
 - Take account of different road types (inner city, motorways, etc)
 - Areas types (roadside, industrial, UB, rural).
- Annual mean and short-term means/percentiles can give quite different results.
 - Option to use percentiles if considered more relevant?