Spatial Representativeness Areas

Webminar 14 December 2023

Testing SRA definitions on different countries

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Introduction

- **Question**: Do the measurements at air quality stations give a good idea of the air quality in an air quality zones (AQZ)?

- **Procedure**:
  1. Define the Spatial Representativeness Area (SRA) of a station in an air quality zone (several definitions)
  2. Determine the SRA for each station in an AQZ
  3. Superpose SRAs to determine the Coverage of the AQZ according to an SRA definition

- **Test case**: 4 countries for which ATMO-Street maps at 10m-resolution are available

Spatial Representativeness definitions in the running

- Current definition: (Tol10or20_LCO2)
  - Different tolerance for Rural*/Background and Traffic/Industrial, 10% and 20%, resp
  - Lower cut-off = 2 µg/m^3 **(How to interpret the lower cut-off, symmetrical or not?)**
  - No difference between pollutants

- Simple definition: one cut-off and one tolerance (Tol15_LCO2)
  - Tolerance 15%
  - Lower cut-off = 2 µg/m^3
  - No difference between pollutants and stations

- Simple definition with symmetric cut-off (Tol15_CO2)
  - Tolerance 15%
  - Cut-off = 2 µg/m^3
  - No difference between pollutants and stations

* ‘Rural’ is a station area (like suburban and urban), not a station type (Background, Traffic, Industrial)

Input data

- Air Quality Zones (from the EEA website)
  - Pre-processing: single polygons > multi-polygons, simplifications (e.g., deleting thousands of little Irish islands)
- Air Quality Stations from e-Reporting
  - Station type and area
  - Location
  - Pollutants measured
- ATMO-street concentration maps at 10-meter resolution for NO_2, PM2.5, PM10, SO_2,O_3, BaP (depending on the country)

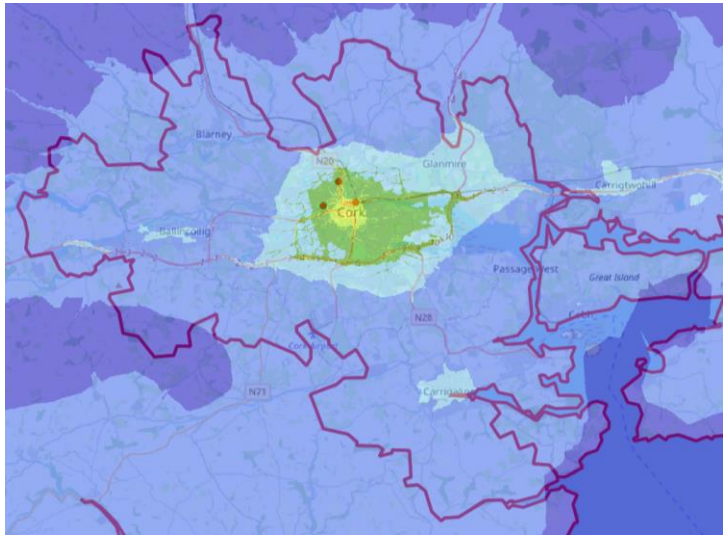
Air Quality Zones (AQZs) in BE, HR , IE and SK

- Belgium: 25 AQZs, many overlapping
  - Biggest cities: Brussels, Antwerp, Ghent, Liege, Namur, Charleroi,…
  - Other cities: one AQZ with different cities
  - Rural Flanders, Wallonia
  - Harbors and industrial sites
- Ireland: 4 non-overlapping AQZs
  - Two single cities: Dublin and Cork
  - Rural Ireland
  - Other cities

→ Is some harmonization needed?

- Croatia: 9 non-overlapping AQZs
  - 4 Cities: Zagreb, Split, Rijeka, Osijek
  - Regions: Dalmatia, Central Croatia, Istria, Slavonia, South Slavonia
- Slovakia: 13 AQZs, some overlapping
  - Cities: Bratislava, Kosice (2)
  - Regions: Banska-Bystrica, Kosice, Bratislava,…
  - SK without Bratislava

Available ATMO-Street Air Quality Maps

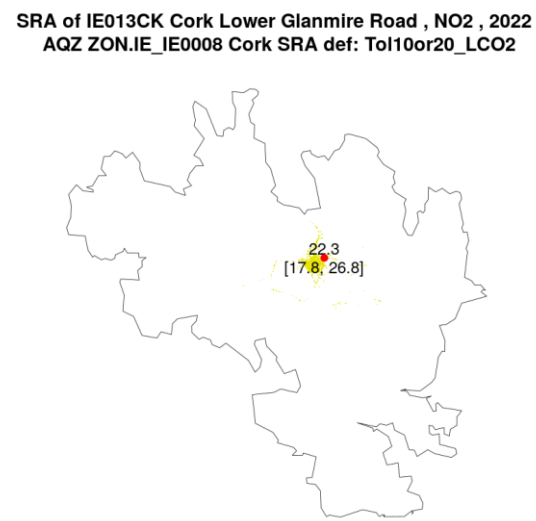


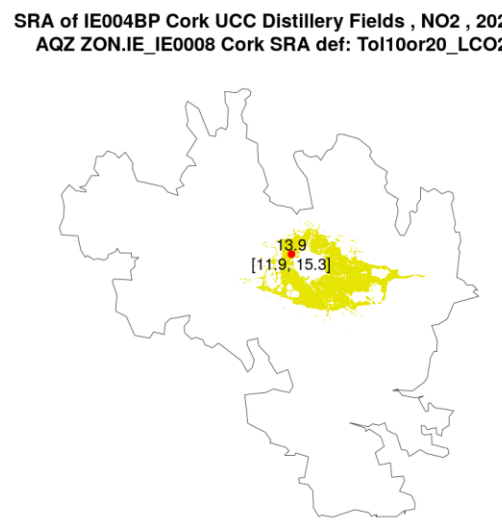
- Belgium
  - NO_2 : 2016 - 2022
  - PM2.5 : 2016 - 2022
  - PM10 : 2016 - 2022
  - O_3 : Include with RIO Data?
- Croatia
  - NO_2 : 2017
  - PM2.5 : 2017
  - PM10 : 2017
- Ireland
  - NO_2 : 2021 - 2022
  - PM2.5 : 2021 - 2022
  - PM10 : 2021 - 2022
  - O_3 : 2021 - 2022
- Slovakia
  - NO_2 : 2019
  - PM2.5 : 2019
  - PM10 : 2019
  - SO_2 : 2019
  - BAP : 2019

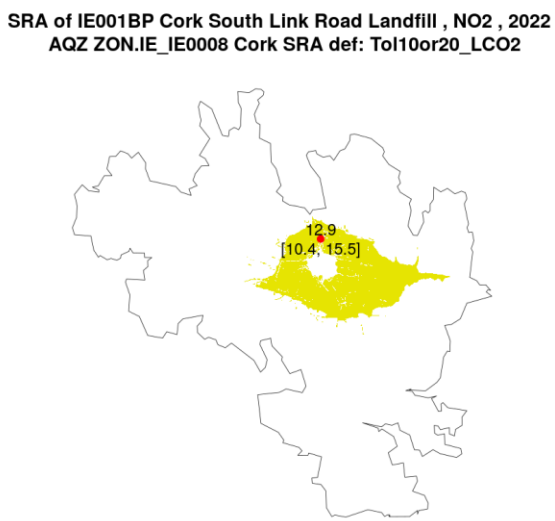
With 3 SRA definitions, many AQZs and many stations in each AQZ this leads to thousands of combinations!

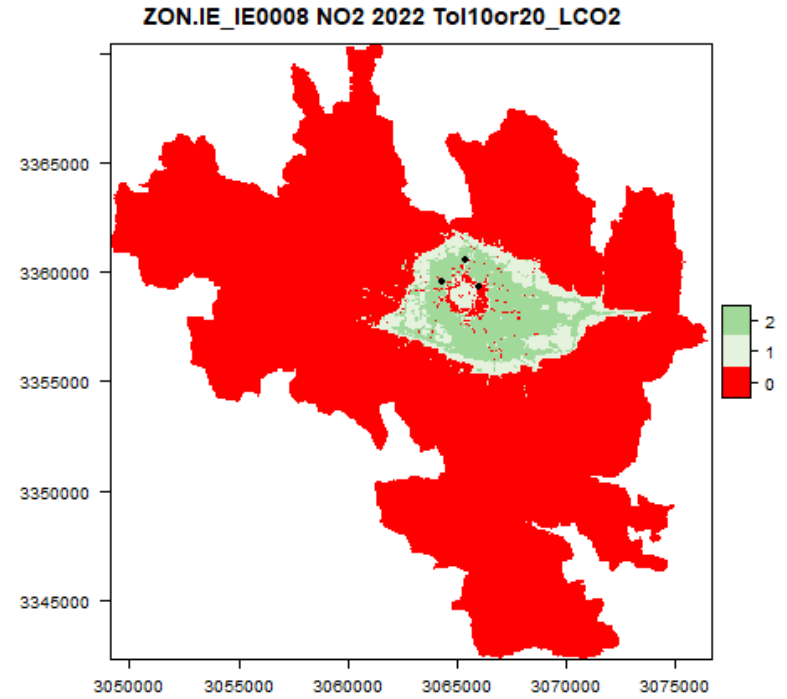
Coverage maps: an example for NO_2 in Cork (IE) in 2022

- Three AQ stations for NO_2 in the AQZ of Cork
- Each station has its spatial representativeness area
- Superposition of these 3 areas shows the coverage of Cork's AQZ for NO_2









Red: not covered

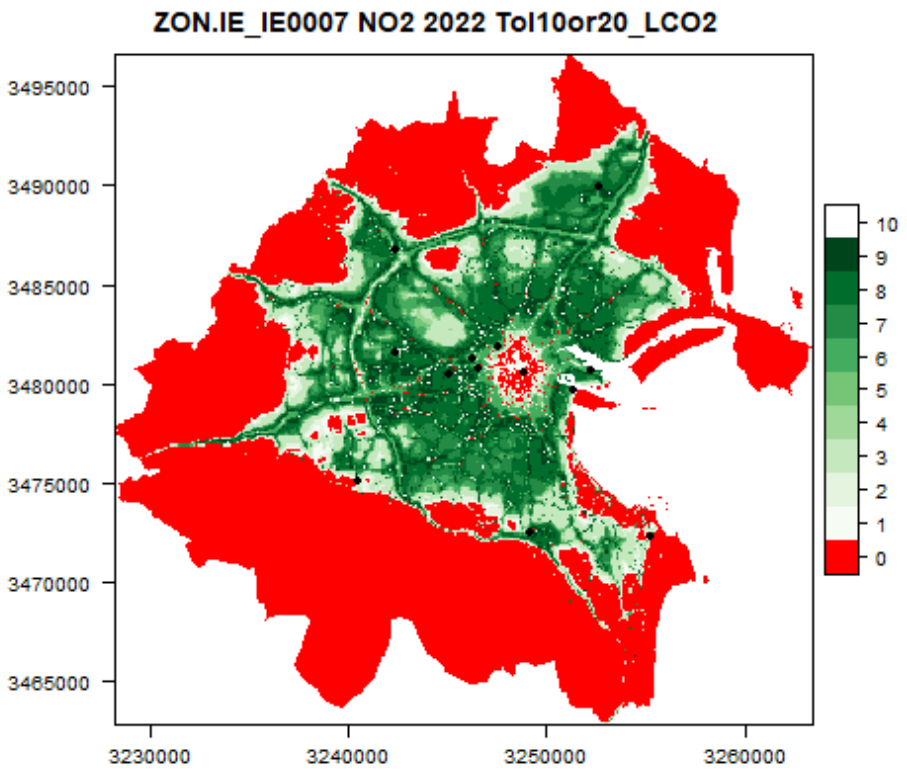
Darker green = higher coverage

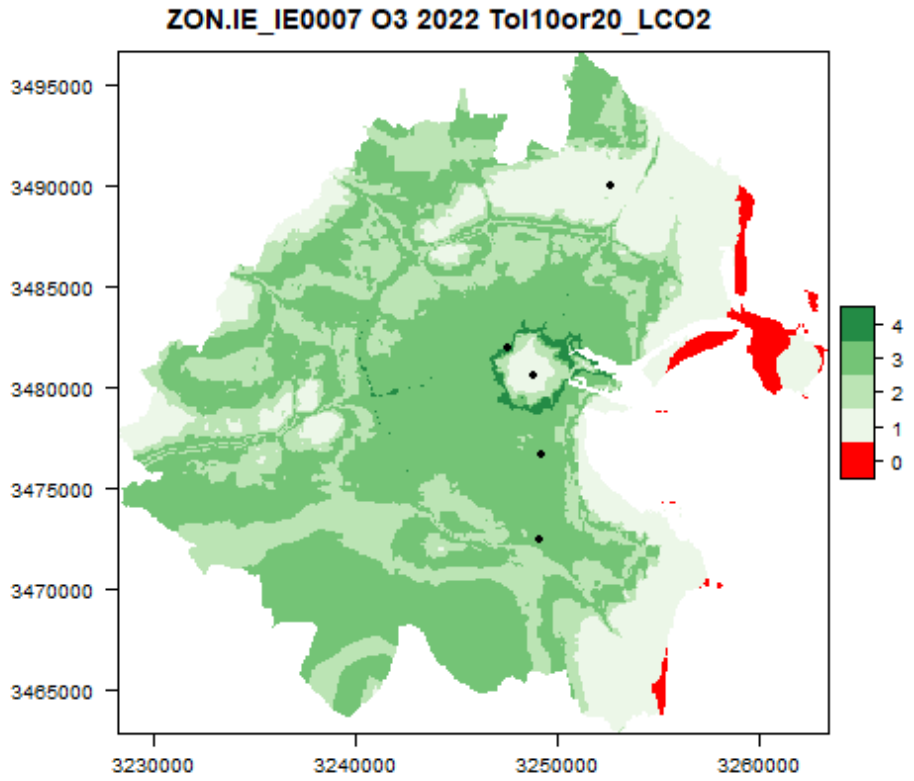
1: covered by 1 stations

2: covered by 2 stations

Coverage for NO_2, and O_3 in Dublin in 2022

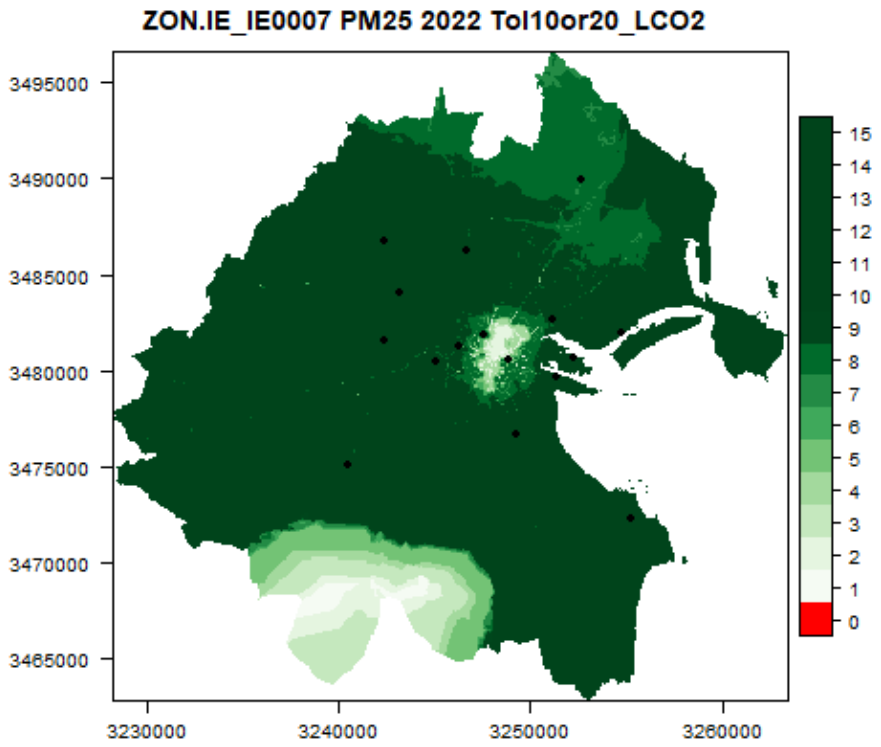
- The city is very well covered the countryside outside the city but inside the AQZ not ➔IE has no other AQZ to cover this region
- Good coverage for Ozone

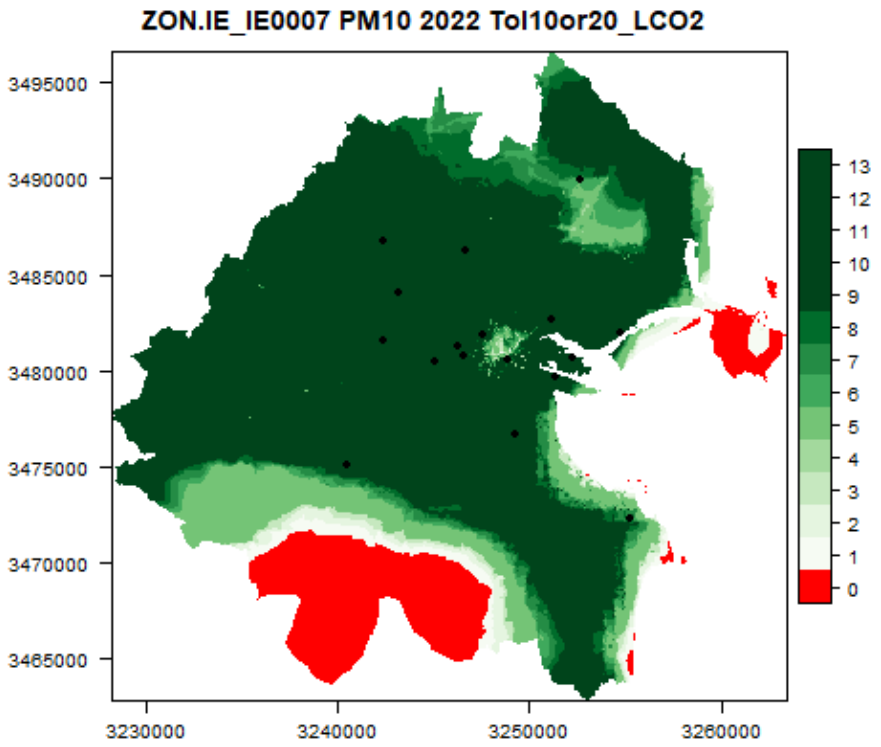




Coverage for PM2.5, and PM10 in Dublin in 2022

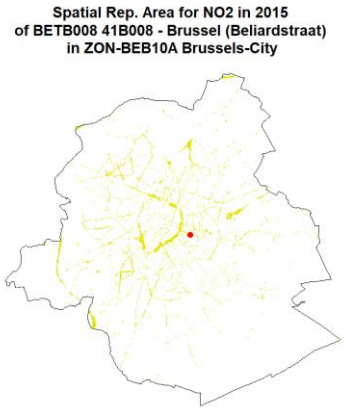
- Very good coverage, a bit less for PM10

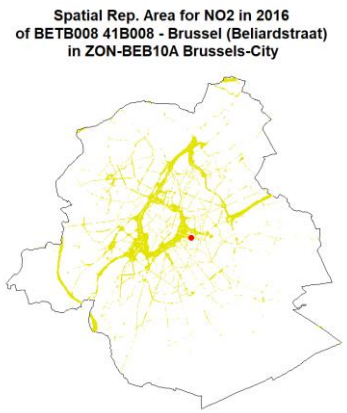


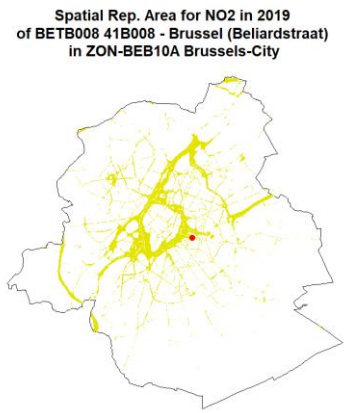


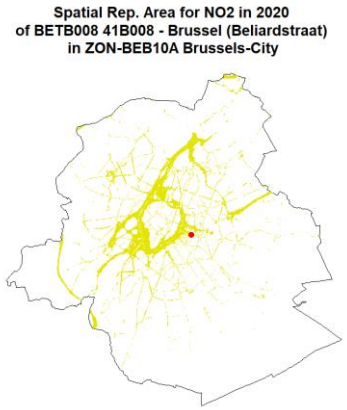
Spatial representativeness Area of a station over time

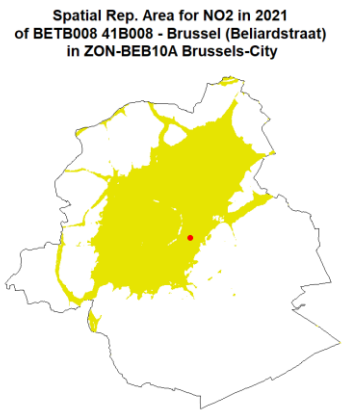
- For NO_2 the area can vary considerably from one year to the next
- Station Belliard Street (canyon) in Brussels

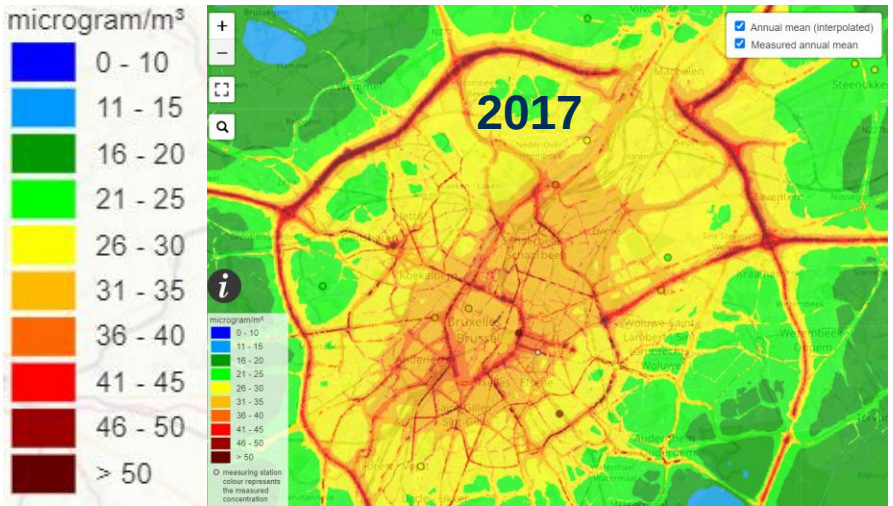


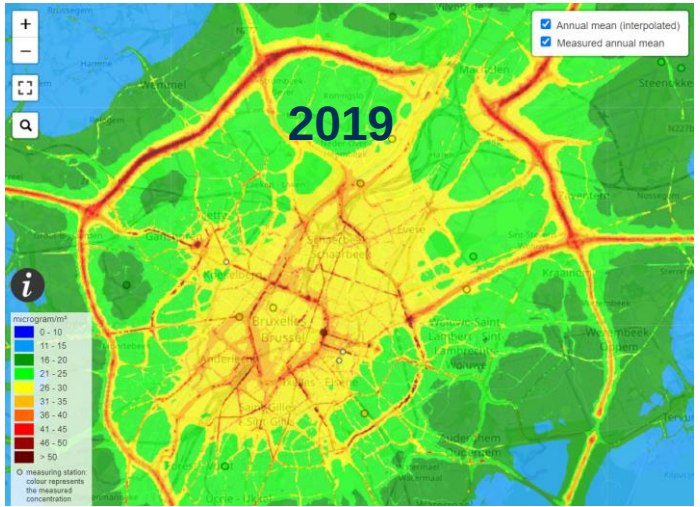


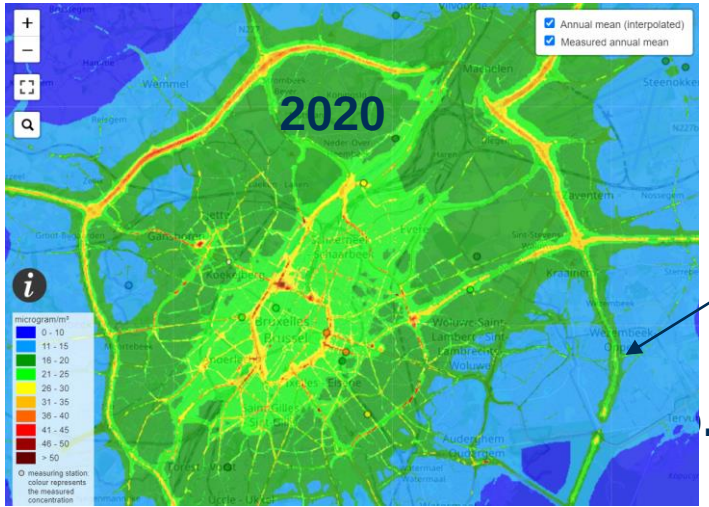






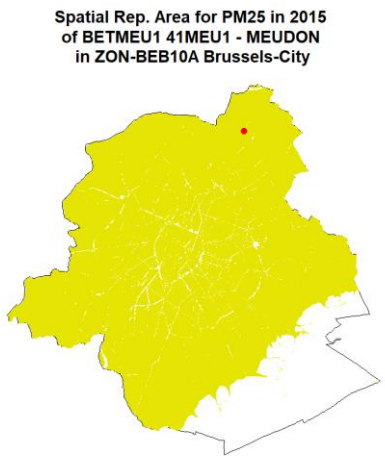


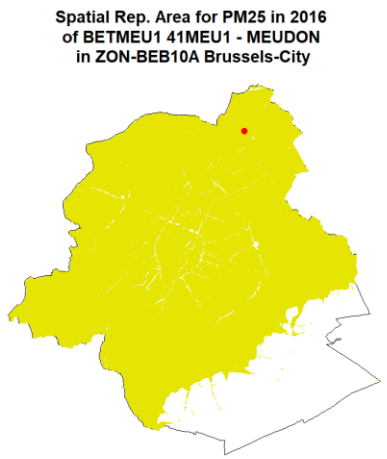


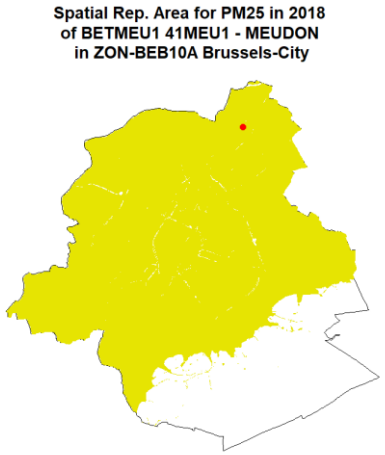


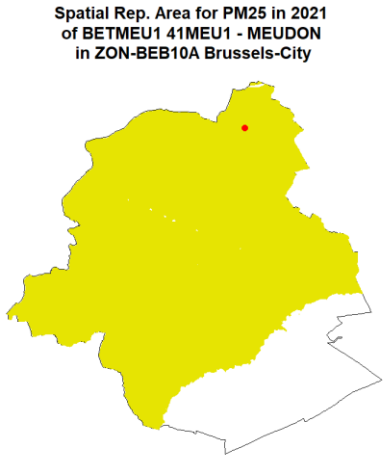
Spatial representativeness Area of a station over time

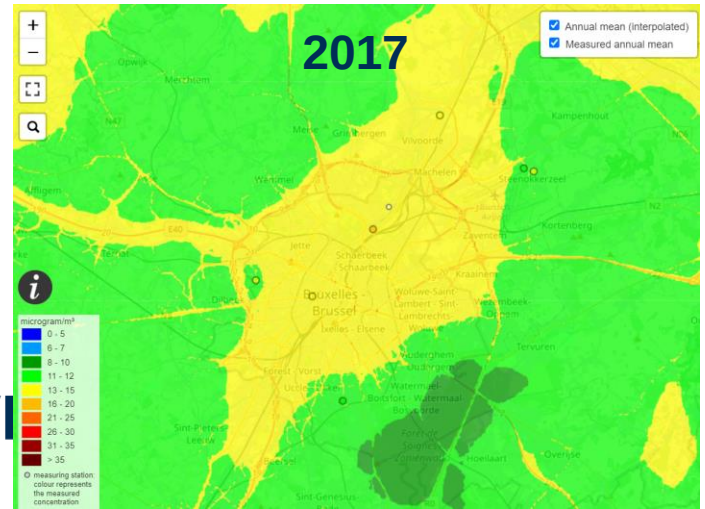
- For O_3, PM2.5 and PM10 the coverage is high and less variable
- Example PM2.5 in Meudon (Brussels)

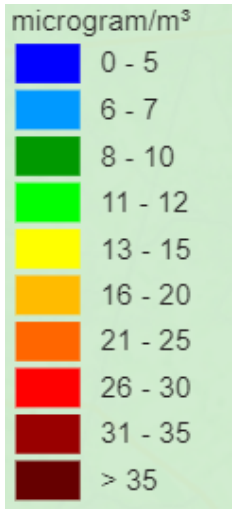


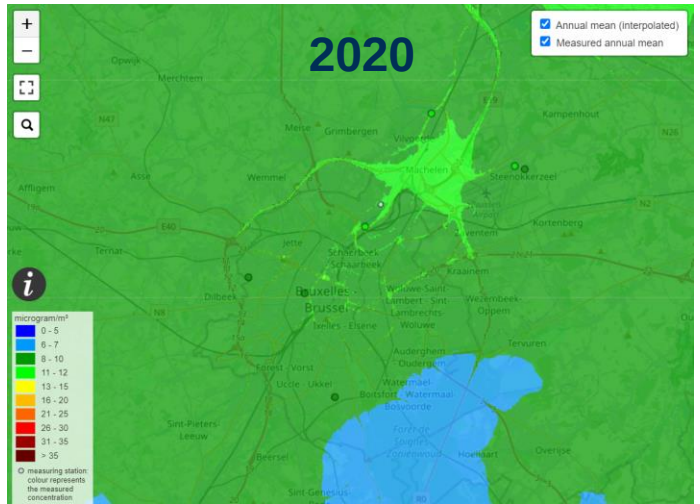






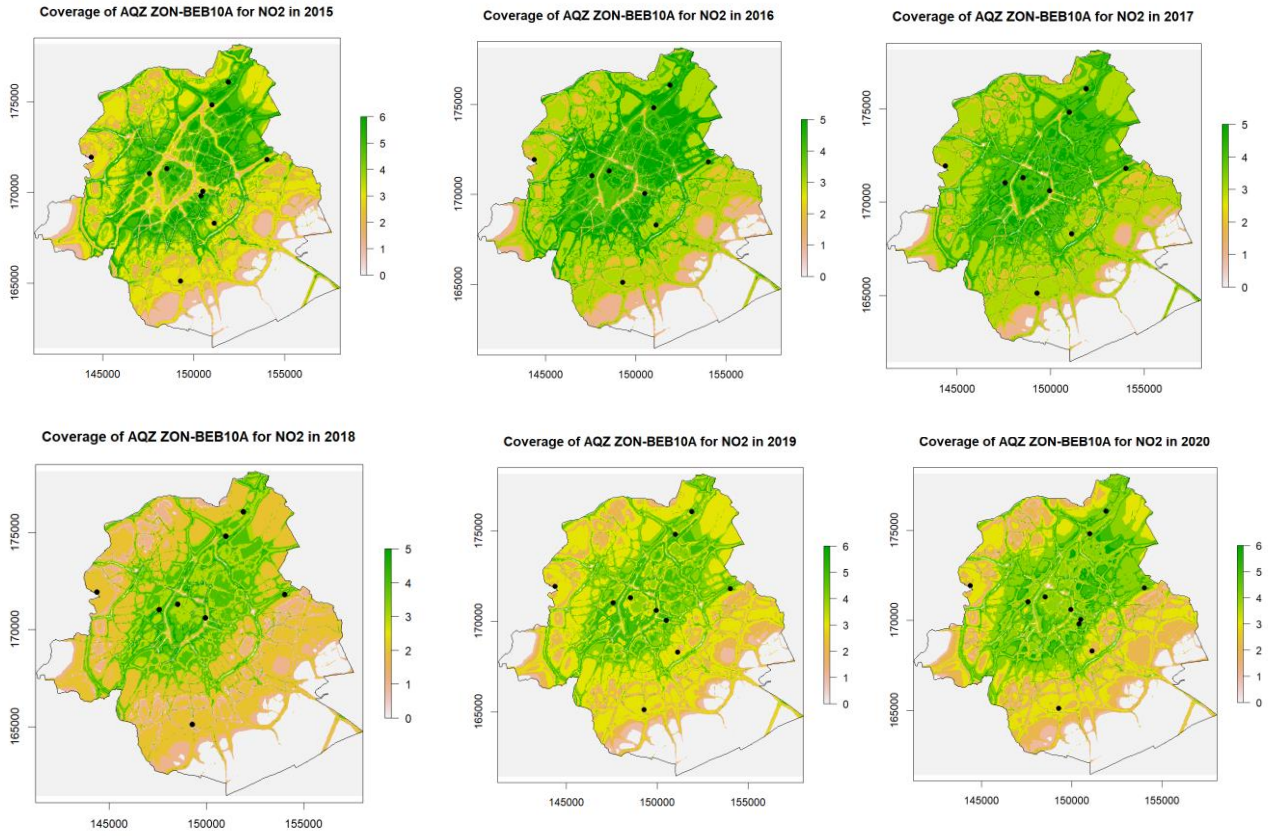


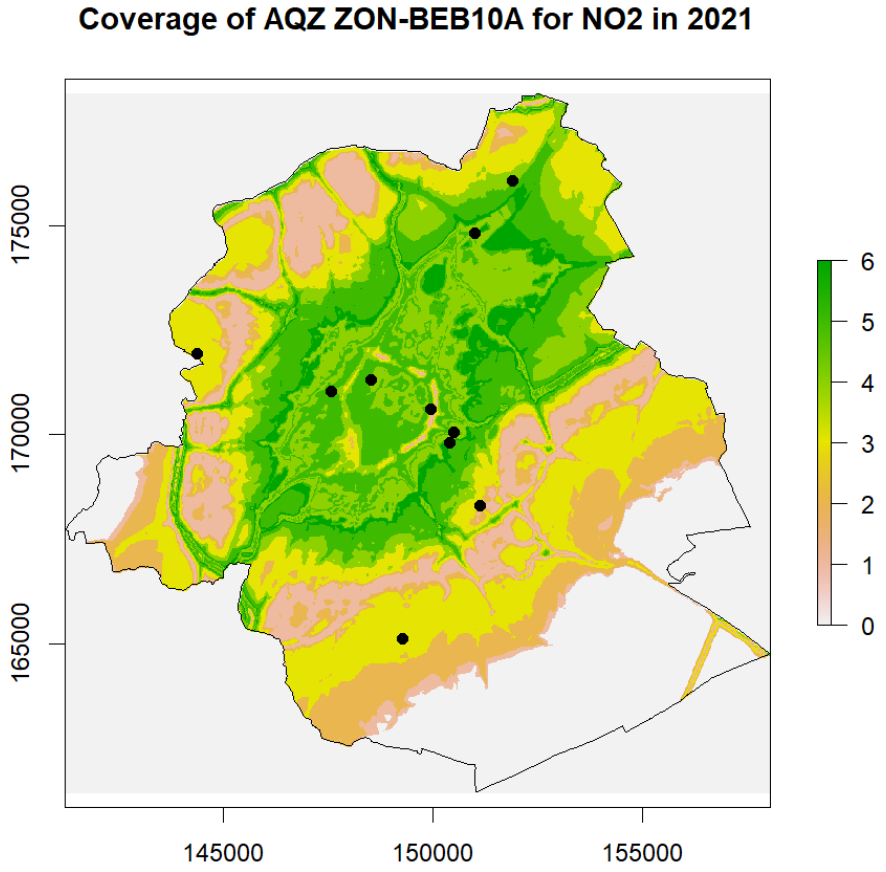




Coverage of the AQZ over time

- NO2 in Brussels is covered by 0 to 6 stations
- Coverage increases from 2015 to 2021 (canyons become less pronounced)





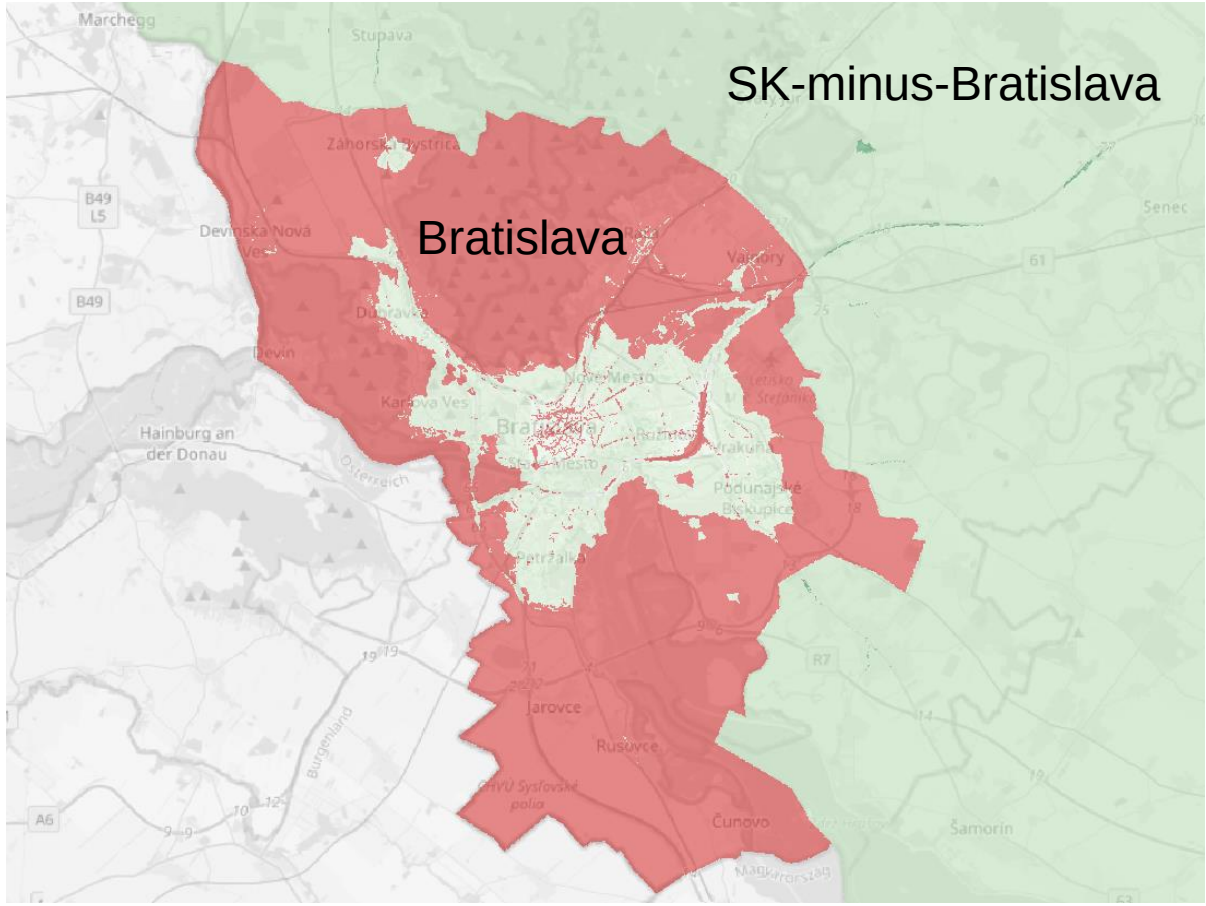
Slovakia

- Slovakia has non-overlapping AQZs for 2 cities (Bratislava and Kosice) and for all provinces.
- But also, an AQZ for the whole country minus Bratislava.

- This has the following effects for NO_2
  - The AQZ of Bratislava is only covered in the urban area
  - The AQZ of Kosice is only covered on some busy streets
  - The AQZs of provinces have a low coverage
  - The AQZ of SK-minus-Bratislava covers almost the whole country

Bratislava: coverage for NO_2

- The AQZ of Bratislava is only covered in the urban area, except some street canyons and busy highways
- In the AQZ of SK-minus-Bratislava the neighboring areas are covered for NO2

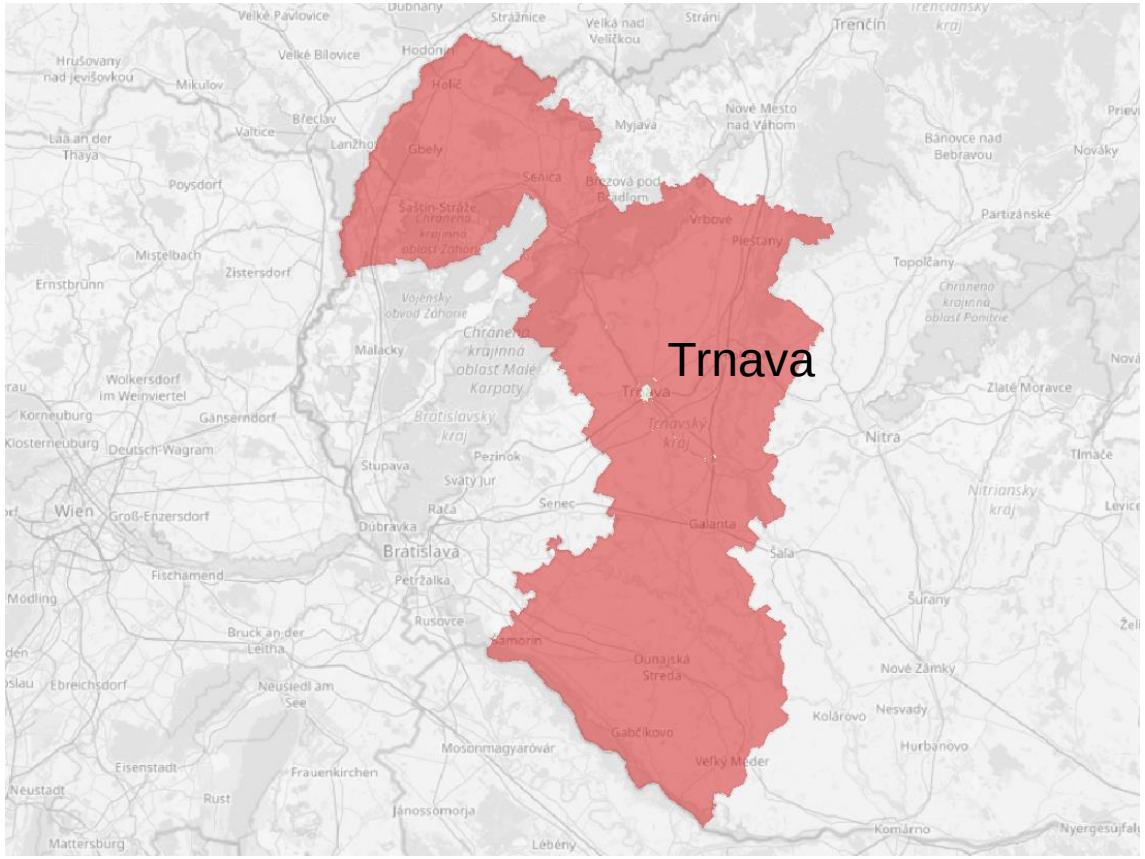


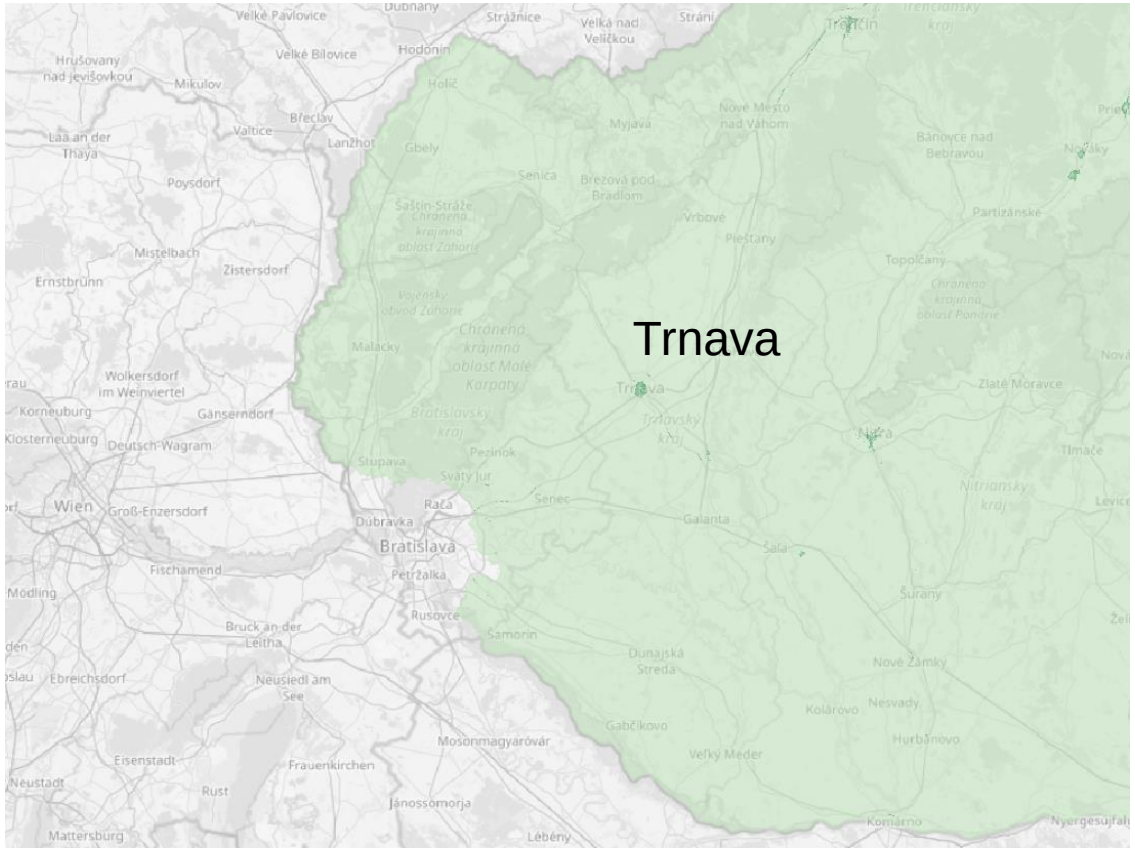
Kosice : coverage for NO_2

- The AQZ of Kosice is only covered in a few streets
- The AQZ of SK-minus-Bratislava covers most of Kosice

Trnava region : coverage for NO_2

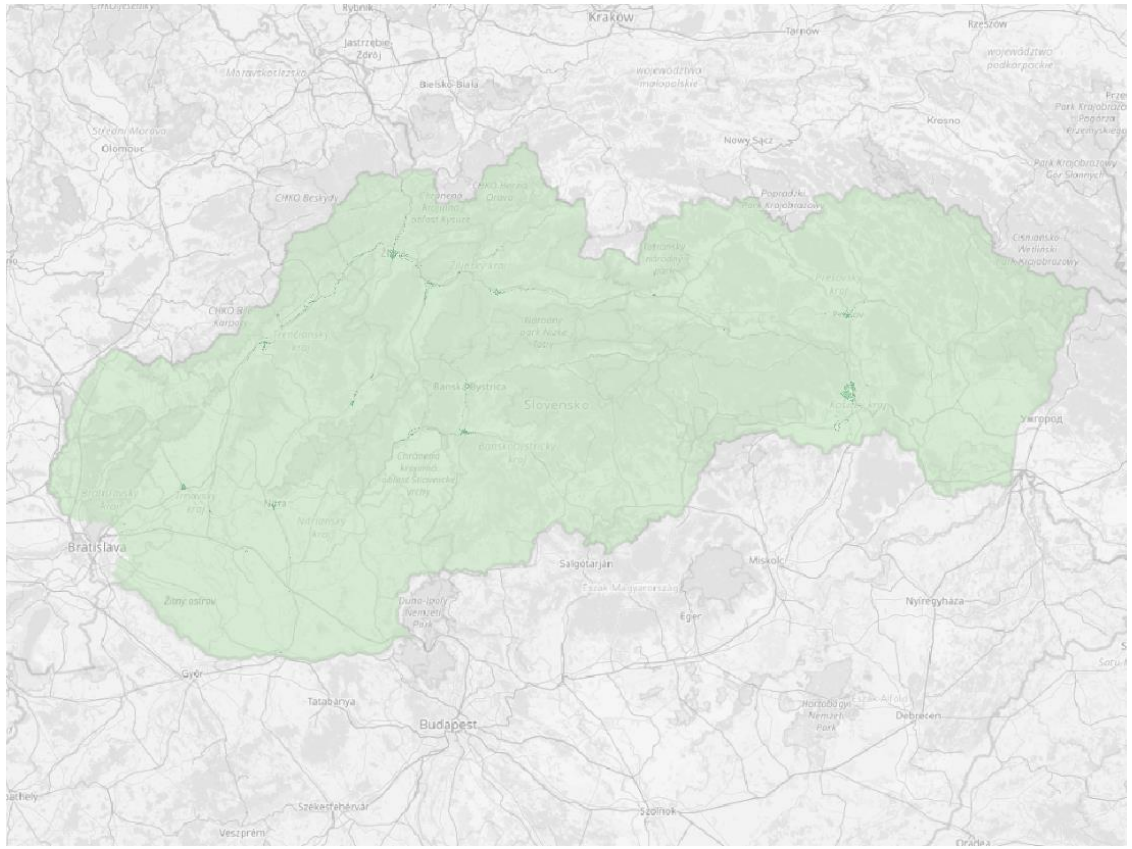
- The AQZ of Trnava is only covered in the cities
- In the AQZ of SK-minus-Bratislava covers most of Trnava region

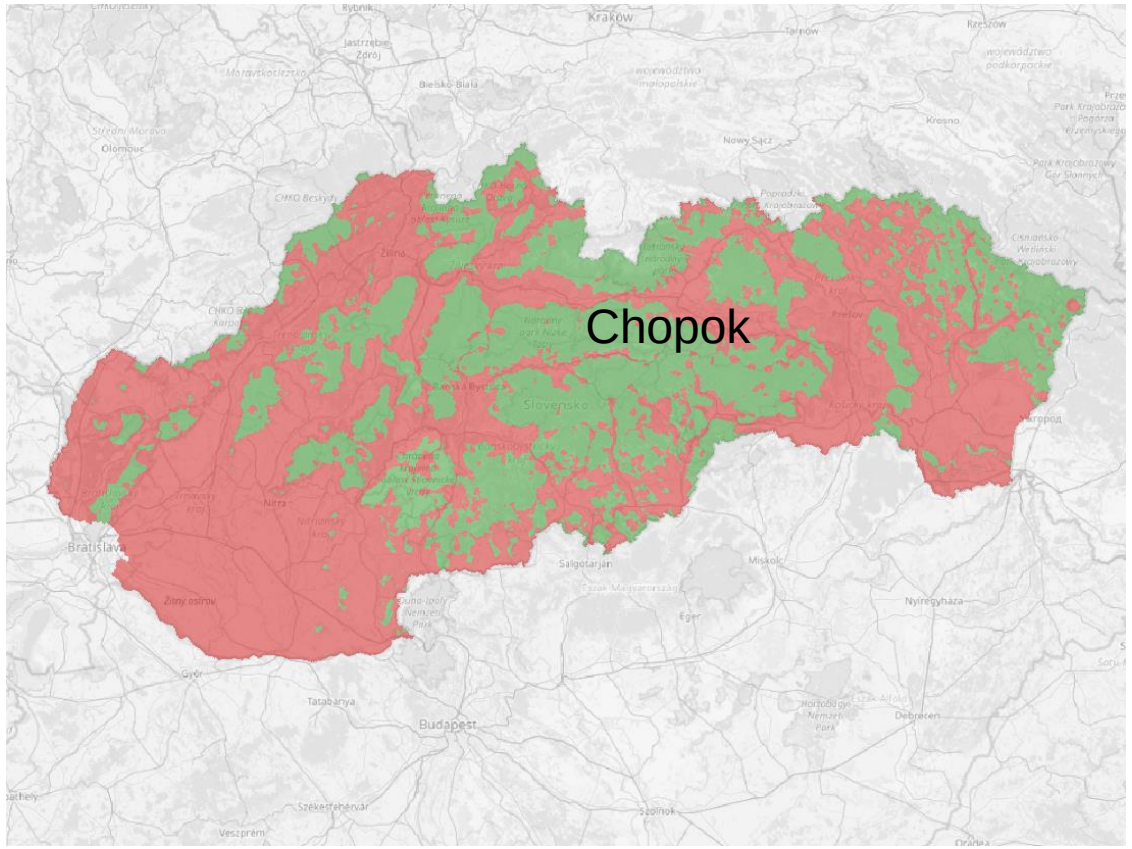




SK-minus-Bratislava: coverage for NO_2

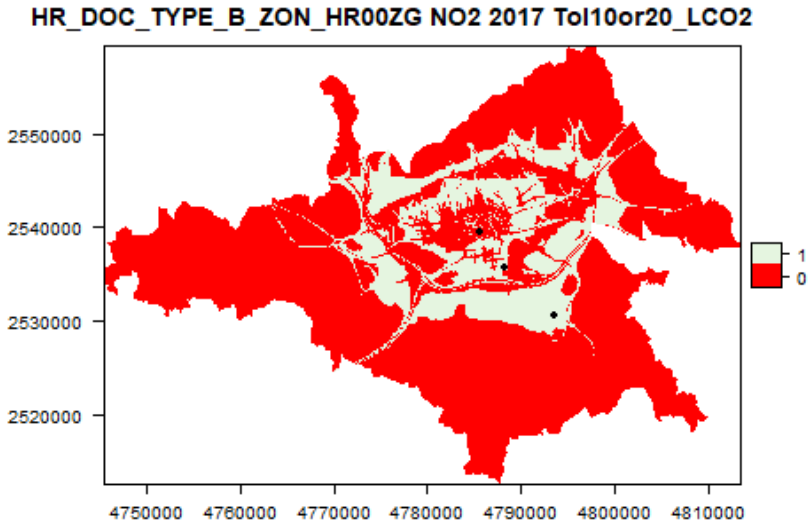
- Good coverage for NO_2
- The SRA of Station Chopok (2.1 ug/m^3 NO_2 annual average) covers half Slovakia)

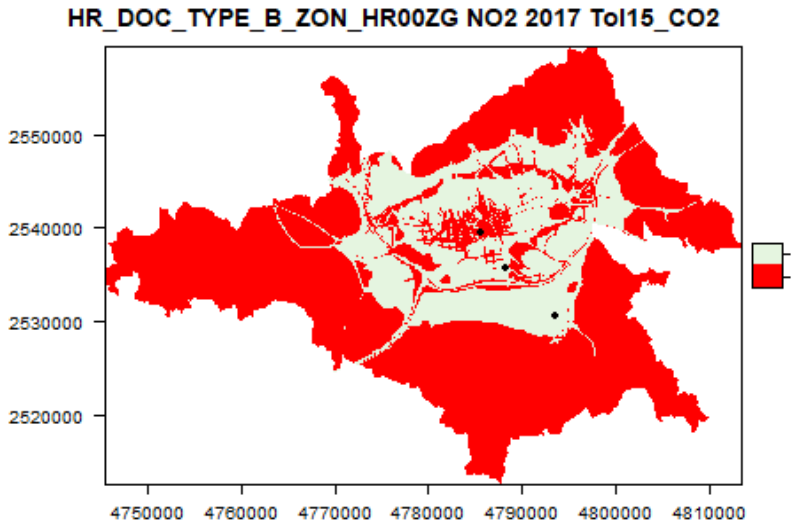


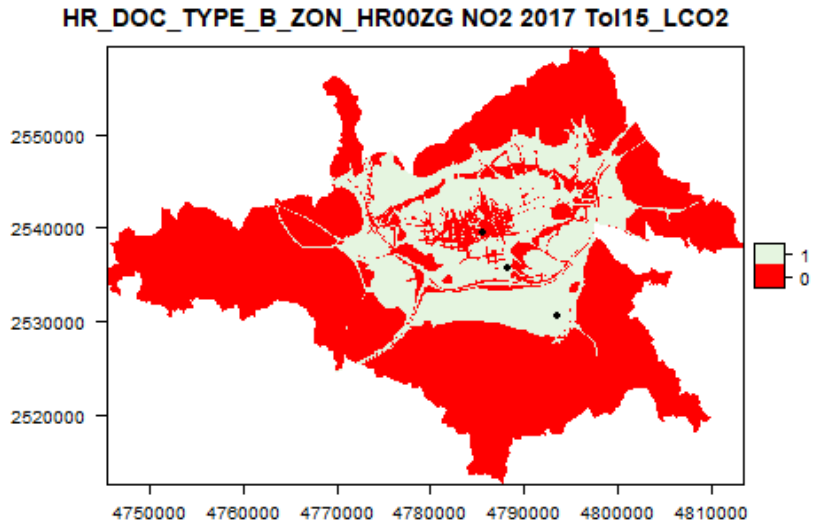


Croatia

- Some busy streets and highways not covered
- HR doesn't have overlapping AQZs ➔more rural areas outside Zagreb not covered for NO2
- No big differences between the definitions







Sofware implementation

- Some AQZs must be simplified to speed up calculations (intersection between stations or AQmaps and AQZ) ➔ remove little islands, complex borders

- First version with R raster
  - Slow, big regions/countries take minutes to half an hour to calculate

- Second implementation with Python rioxarray
  - Much faster, SK-minus-Bratislava takes less than a minute

Conclusions

- Rural regions: large areas not covered (especially for NO_2) because stations are in cities, not in the countryside. There is usually one (continental) background station per country, not per region. This leads to low coverage (except if there is an overall AQZ like in SK).
- Suburbs of cities not covered belong more to countryside AQZs: not covered inside the AQZ but by a stations outside.
- In cities some canyons with high concentrations are not covered
- To avoid misinterpretation the SRA definition should be provided as code, not in words.
- Remarks:
  - Is there a need to have more uniformity in AQZs?
  - Drop limitation to AQZ or use a distance perimeter? (Could lead to a drastic reduction of stations needed to cover a country)
  - Increase tolerance?
  - What if no high-resolution maps are available?

- ➔ More research required before fixing this in the regulation?

Spatial Representativeness study for Ireland

- **Question**: Do the air quality stations cover the air quality zones (AQZ), i.e., are the measurements representative for the concentrations in each AQZ
- **Data**: ATMO-Street concentration maps for NO2, PM2.5, PM10 and O3 for the years 2021 and 2022
- **Analysis**:
  - Currently there is no definition for the Spatial Representativeness Area (SRA) of a AQ station. Several options are in the running.
  - An SRA definition consists of the following steps:
    1. Determine the modelled pollutant concentration at the station location
    2. Determine an upper and lower bound around this concentration (e.g. 15 % or at least 2 µg/m^3)
    3. Select all locations within the AQZ with concentrations between the lower and upper bounds.
- Coverage of the AQZ:
  - Superposition of all SRAs of all stations measuring a specific pollutant in an AQZ gives an idea how well the measurements cover the air quality stations in an AQZ.