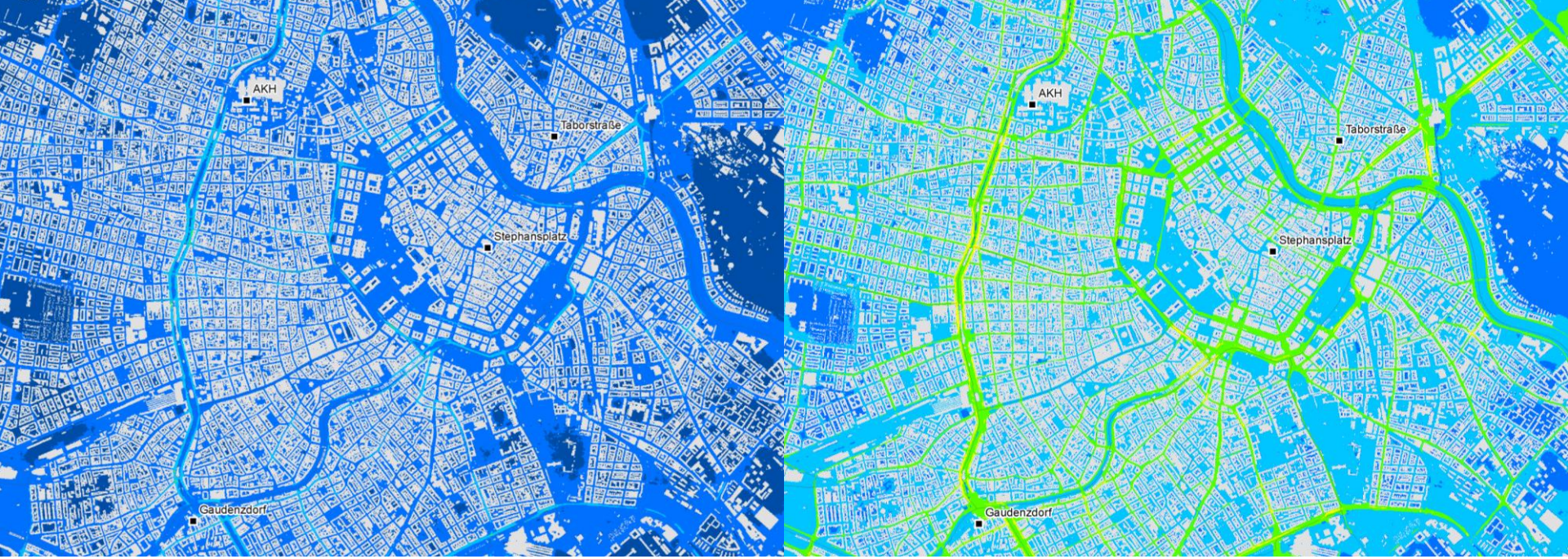


Source: Umweltbundesamt, City of Vienna

NO_2 EXPOSURE IN AUSTRIAN CITIES

COMPARISON OF DIFFERENT METHODS

ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

OBJECTIVES, METHODOLOGY OF PROJECT

OBJECTIVE

- Estimate of the NO_2 exposure of the Austrian population
- Estimate of the trend of the NO_2 exposure in the last 15 years
- Estimate of the number of people living in exceedance areas

2 GENERAL APPROACHES

1. Estimate of NO_2 exposure for whole of Austria by regional and urban background stations (by applying a representative area to each station)
2. Estimate of NO_2 exposure for 4 cities by high-resolution modelling

ASSUMPTIONS, BOUNDARY CONDITIONS

- NO_2 exposure is estimated based on the NO_2 concentration at the place of residence
- Exposure inside a house is determined by ambient air concentration right in front of the building
- Additional possible NO_2 indoor sources (stove, gas boiler, ...) are not taken into account (only in general emissions)
- Decrease in NO_2 concentration with height (floors) based on model calculations
- Only background monitoring sites points are used for the Austria-wide assessment of exposure

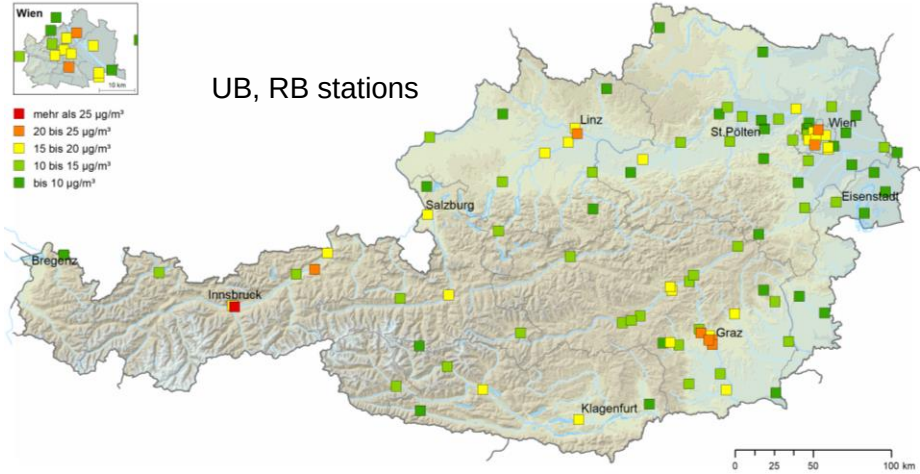
STRENGTHS, WEAKNESSES OF APPROACH 1 (REPRESENTATIVE AREAS)

STRENGTHS

- Results for whole of Austria
- Based on monitoring data, hence update and time-series are easily obtained

WEAKNESSES

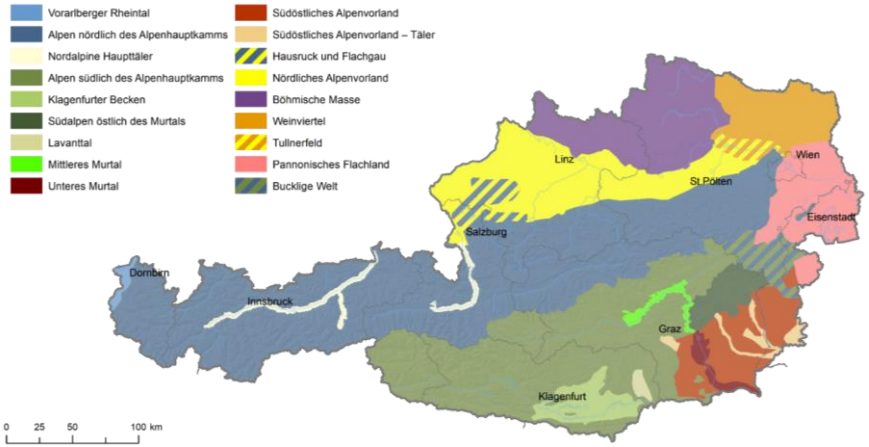
- Underestimate of exposure as only urban and regional background stations used
- Requires representative monitoring sites for whole of Austria (around 100 stations available)



REPRESENTATIVE AREAS FOR BACKGROUND STATIONS

- A representative area is delimited based on
  - Similar NO_2 levels
  - Topography, climate, dispersion conditions (see map)
  - In Alpine areas: valley and elevated terrain
  - Population of municipality
- To each area, concentration level (NO_2 annual mean) of one (or an average of several similar) monitoring sites is assigned
- Population for each area calculated

- Results
  - Average population weighted NO_2 exposure
  - Time series since 2005

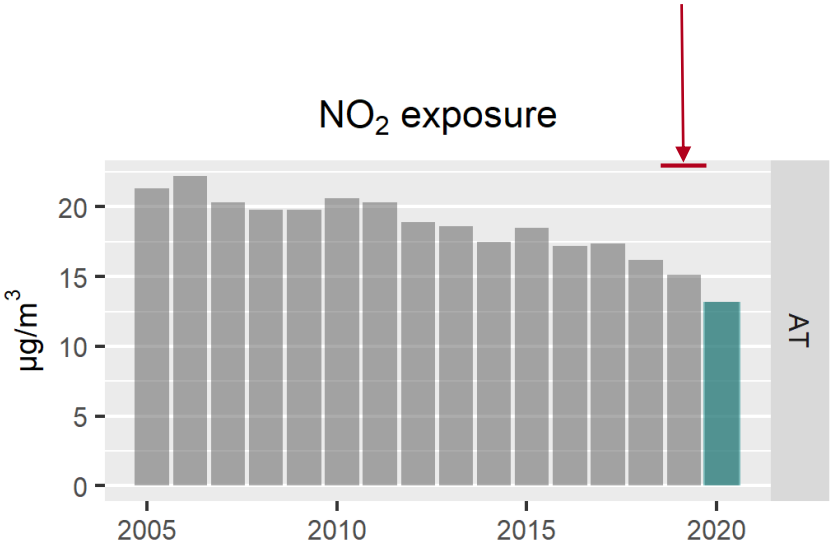


Source: Umweltbundesamt

TIME SERIES OF GENERAL EXPOSURE

- Population weighted exposure decreased from around 22 µg/m³ to 13 µg/m³
- On regional/local scale highest level above 20 µg/m³ in 2020
- On average still above WHO global air quality guideline levels (10 µg/m³)

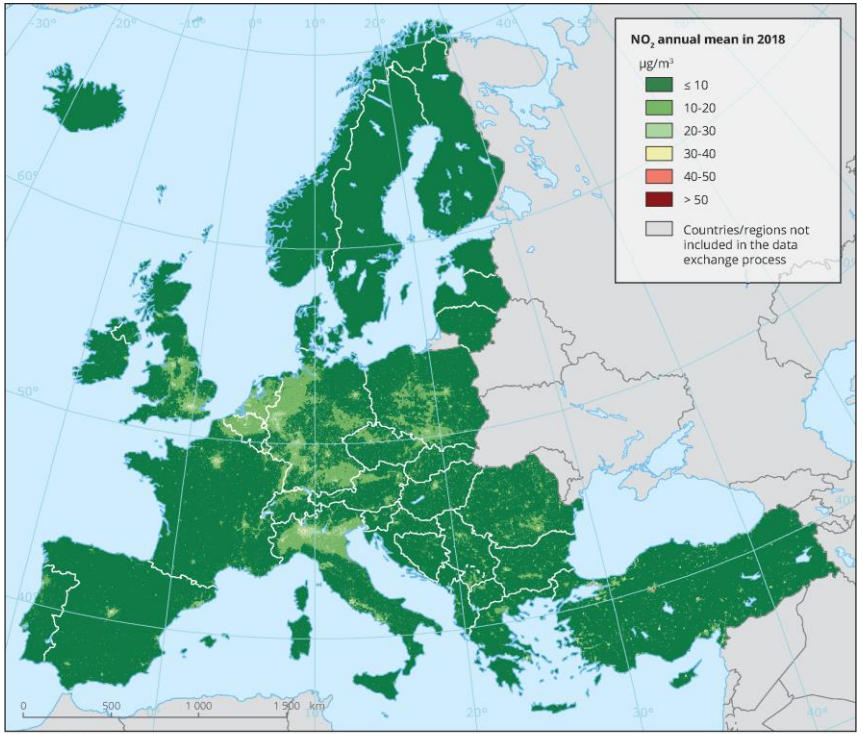
EEA 2019 estimate of Austrian population weighted NO_2 exposure



Source: Umweltbundesamt

METHOD USED BY EEA

- Method: Regression ➔ Interpolation ➔ Merging Mapping (details: ETC/ATNI Report 9/2019)
- data fusion method combining monitoring data with supplementary data:
  - chemical transport model,
  - land cover,
  - meteorological data
  - altitude
- linear regression model followed by kriging of the residuals produced from that model (residual kriging)
- Separate rural, urban background and urban traffic map layers are created in 1×1 km² resolution
- map layers are merged into one final map using population density and road data



HIGH RESOLUTION MODELLING

- Done for four largest cities in Austria:
  - Graz
  - Linz
  - Salzburg
  - Vienna
- GRAL model was used
- Resolution: 10 m (central area of Vienna: 4 m)
- Buffer of 10 m around buildings
- Concentration decreases with height
- Buildings data-base: Population per building and number of floors available

- Assumptions
  - Even distribution of people in a building across the floors
  - Exposure equals concentration outside building
- Tricky
  - Different shape files for buildings in general GIS database and in model results
- Decisive
  - Quality of input data (activity data, emission factors)

DECREASE OF CONCENTRATIONS WITH HEIGHT

- Assumption: same concentration above 4th floor (above 15 m)

2 APPROACHES

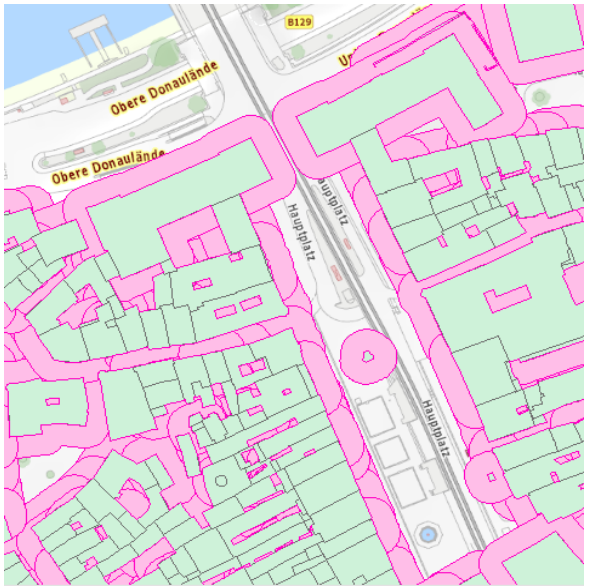
- Linear decrease to the urban background concentration in 17 m above ground, example Graz (UB = 19 µg/m³)
  - $NO_{2(z)} = \quad NO_{2(3)} + (\frac{19 - NO_{2(3)}}{17}) * (z - 3)$
  - $NO_{2(3)}$: modelled concentration at 3 m above ground

- Power function (applicable for Vienna)
  - $NO_{2_H} = \left(1{,}4382 \times NO_{2_{3m}} - 7{,}9753\right) \times H^{-0{,}254 \times \ln NO_{2_{3m}} + 0{,}7308}$

EXPOSURE BY HIGH RESOLUTION MODELLING

- ArcGIS calculation
- Alternatively average or maximum concentration of grid cell in 10 m buffer around building
- Calculated for 3 m, 7 m, 11 m, 15 m above ground level
- Concentration classes in 5 µg/m³ steps
- Population weighted exposure in specific classes assigned to average of class (e.g. class 20 to 25 µg/m³ ➔ concentration: 22.5 µg/m³)

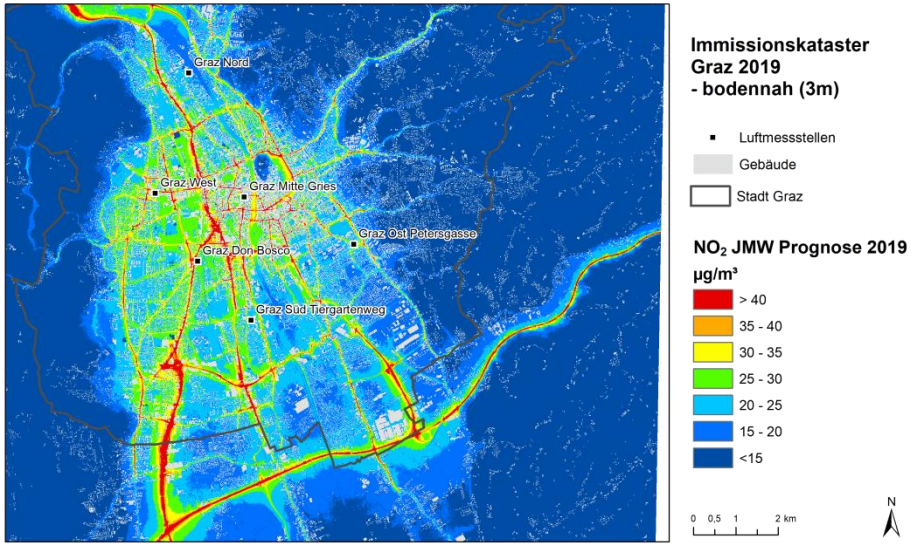
10 m buffer around buildings



Source: Umweltbundesamt

RESULTS GRAZ (2019)

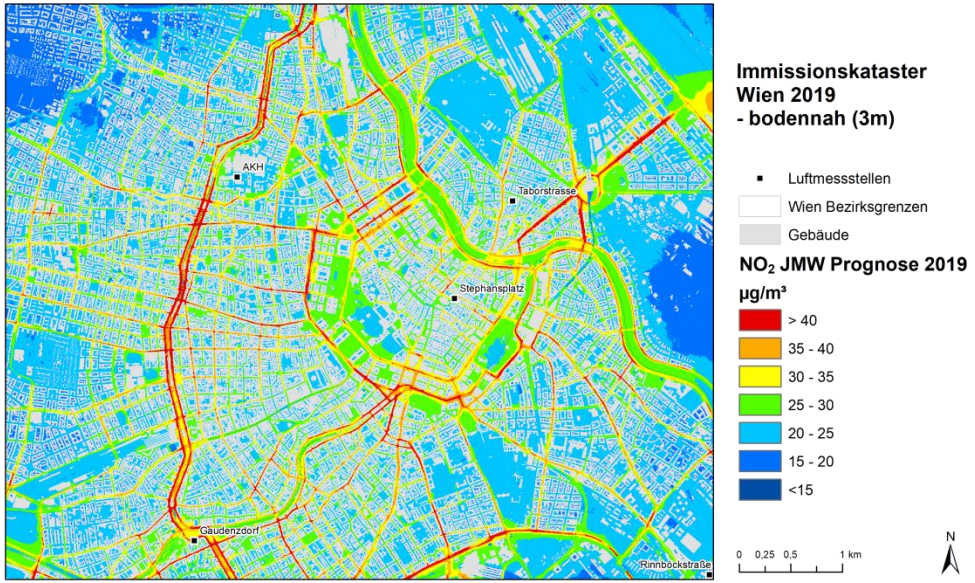
Decrease with height	Average (µg/m³)	Maximum (µg/m³)
None (same concentration as ground level)	25.1	27.8
Linear decrease	22.4	24.1
Exposure via representative area	23.3	



Source: Umweltbundesamt, Federal Province of Styria

RESULTS VIENNA – CENTRAL AREA (2019)

Decrease with height	Average (µg/m³)	Maximum (µg/m³)
None (same concentration as ground level)	24.1	28.9
Linear decrease	19.3	23.1
Power function	22.4	25.9
Exposure via representative area	21.7 (whole city)	



Source: Umweltbundesamt, City of Vienna

POPULATION IN EXCEEDANCE AREA

	Average model conc.	Maximum model conc.	Population in model area
Graz	6,500 (2.0 %)	17,200 (5.4 %)	317,470
Linz	3,000 (1.2 %)	8,000 (3.2 %)	251,659
Salzburg	300 (0.2 %)	2,000 (1.4 %)	140,523
Vienna, central area (linear)	1,900 (0.2 %)	24,700 (2.5 %)	1,000,842
Vienna, central area (power function)	1,800 (0.2 %)	22,000 (2.2 %)	

SUMMARY & CONCLUSION

- Population weighted NO_2 exposure based on representative areas of monitoring stations can be calculated when dense monitoring network is available (passive sampling might help, if not available)
- Time series can be easily calculated; however, clear underestimation compared to EEA approach and modelling of individual cities
- Modelling obvious choice for estimating exposure in cities
- However: quality of input data (activities, emissions) is decisive
  ➔ harmonised methods, quality criteria necessary
- Merging shape files of different datasets for buildings and modelling sometimes tricky
- However: considerable differences depending on approach, assumptions, resolution of model

➔ need for harmonised approach across Europe

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UNECE Air Convention 3th Expert Panel on Clean Air in Cities (EPCAC)
online ● 29 November 2021