Optical Gas Measurement Technology

DIFFERENT THINKING. BETTER MEASURING.

INSTITUTE OF ENVIRONMENTAL PHYSICS

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

Observation of NO_2 air pollution distribution maps in cities with mobile ICAD bicycle measurements

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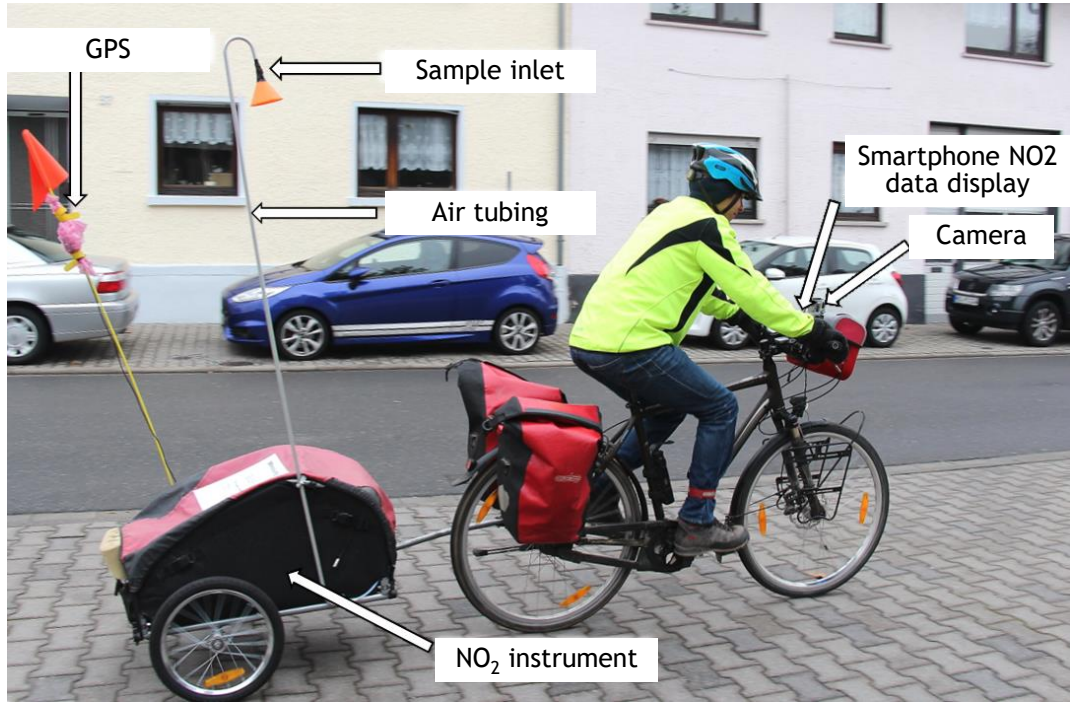


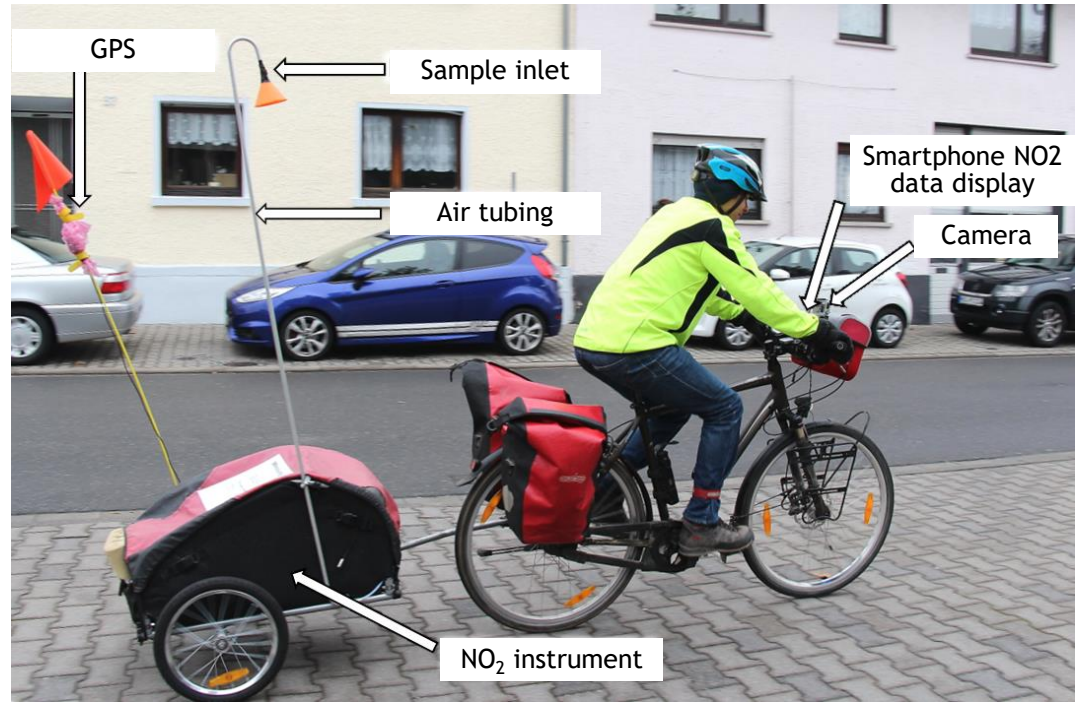
Why observing NO_2 distribution maps?

- NO_2 is one of the most critical air pollutant in urban areas
- Main source is traffic
- Very high spatial NO_2 variability
- NO_2 typical only observed at few local measurement stations
- Smaller cities have often even no measurements at all
- Investigate new locations for long term NO_2 monitoring
- Electrochemical sensors are to inaccurate to provide reliable air pollution levels
- Passive sampler require long observation times and existing knowledge of appropriate locations
- Validation of modelled NO_2 distributions

Mobile bicycle measurements

- Using a bicycle as a mobile measurement station on the footpath
- Sampling point ~1.7m
- NO_2 data point every 2 seconds
- Repeated measurements on a fixed route with varying:
  - Days of the week
  - Time of Day
  - Weather conditions
  - Traffic

  → Cover most typical air pollution situations
- ~ 20 to 40 repetitions over few weeks



NO_2 Instrument

Requirements:

- Mobile, robust to vibration
- High accuracy min. 1ppb/ 2µg/m^3
- Fast response of seconds
- Calibration and zero point drift free
- Low power, 12V operation
- Fast warm-up

Mobile ICAD NO_2 / NO_x analyser:

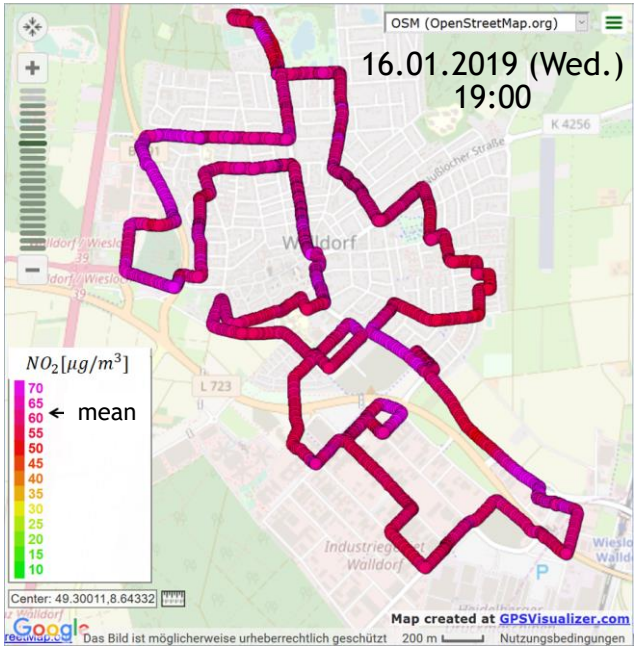
Accuracy	better 0.5 ppb @ 2 sec
Zero-point / calibration drift	<0.1ppb / week
Response time (0-90%)	~2 sec
Calibration	„intrinsic“ DOAS calibration, optical light path determination
Power requirement	< 30 W, 12 V
Operating temp. range	-10 ° C - 40 ° C
Warm-up time	< 1 min.

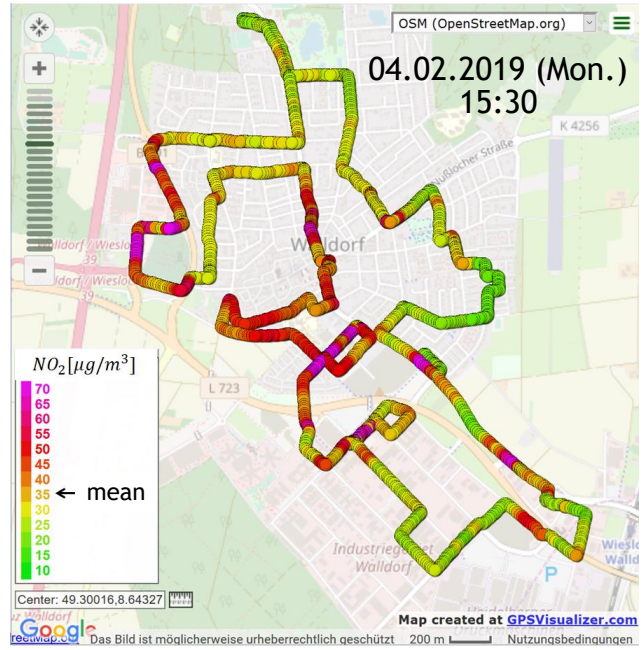
Example study - city Walldorf, Germany (Dec. 2018 - Feb. 2019)

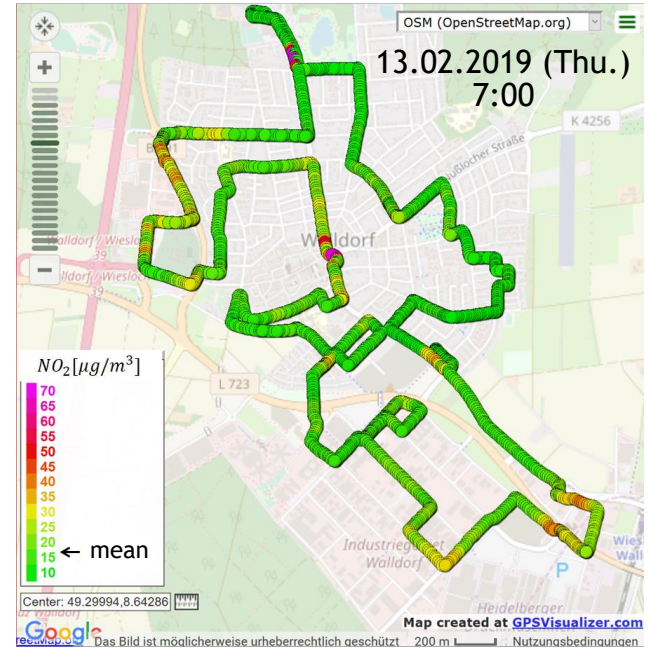
Small city with ~16.000 inhabitants, no NO_2 measurements before

measurement route: 16km repeated measurements: 40 (over 3 months)

→ Show high temporal and spatial variation (like expected)



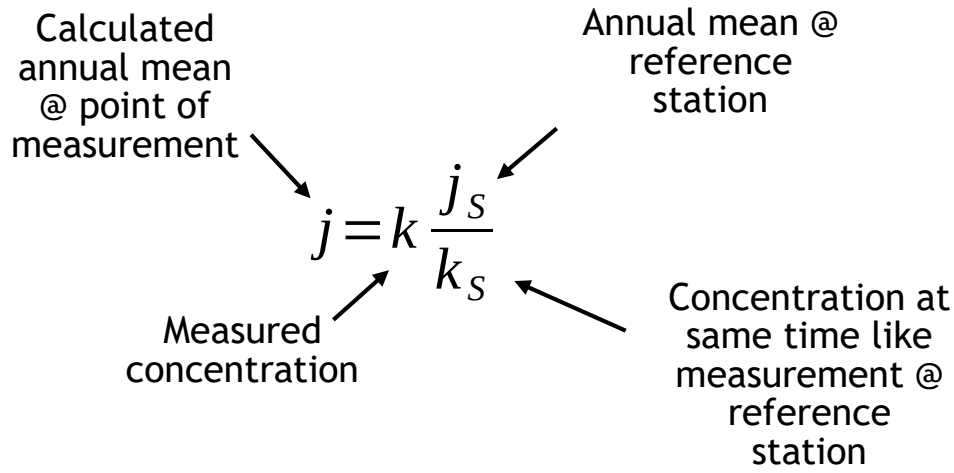




→ Average & derive extrapolated annual mean

Calculate „extrapolated“ annual mean concentration

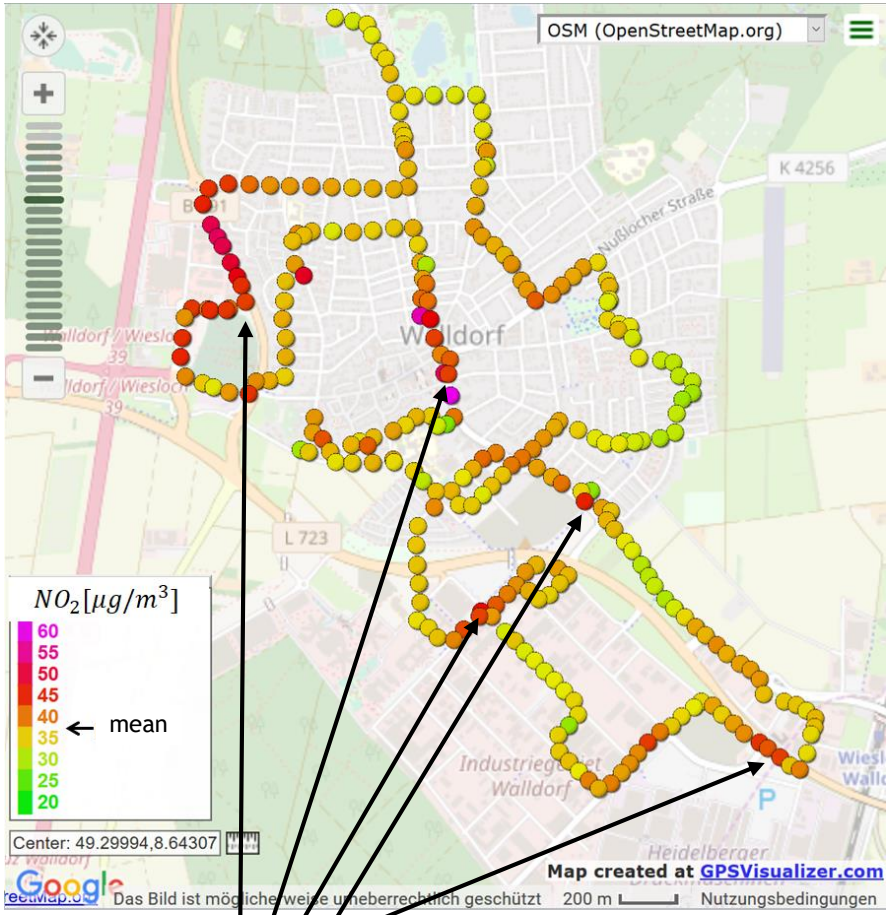
- Each data point (2s) is calculated to an annual mean conc. at this location
- Use NO_2 measurement data of a reference measurement station close by
- Basic idea:
  temporal NO_2 variation are dominated by meteorology and traffic density → these are comparable between reference station and sampling location
  → apply rule of proportion:



- Average extrapolated annual mean values for each location (70x70m²grid)

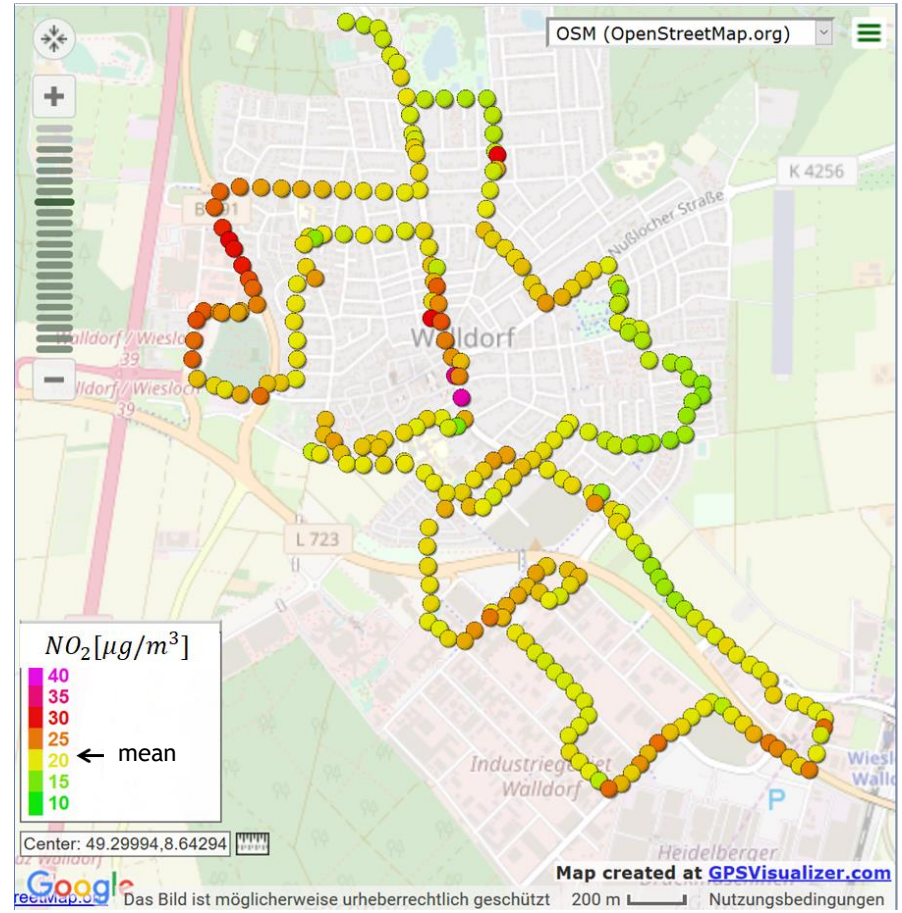
Results

Average of measurements



- Hot-spots identified (exist also in such small cities)
- In general relatively low NO_2 level

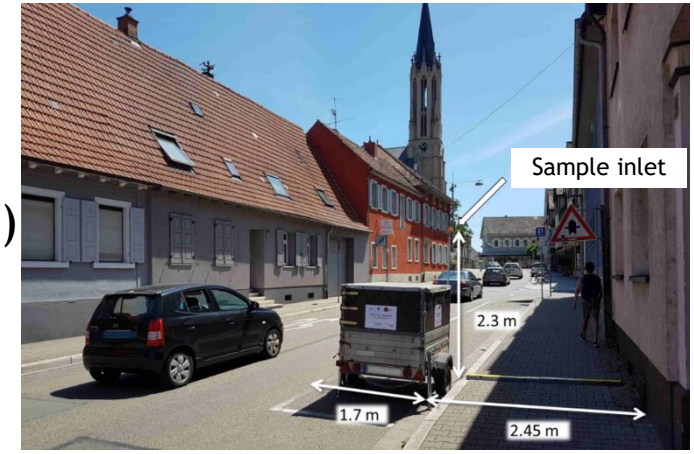
Extrapolated annual mean conc.

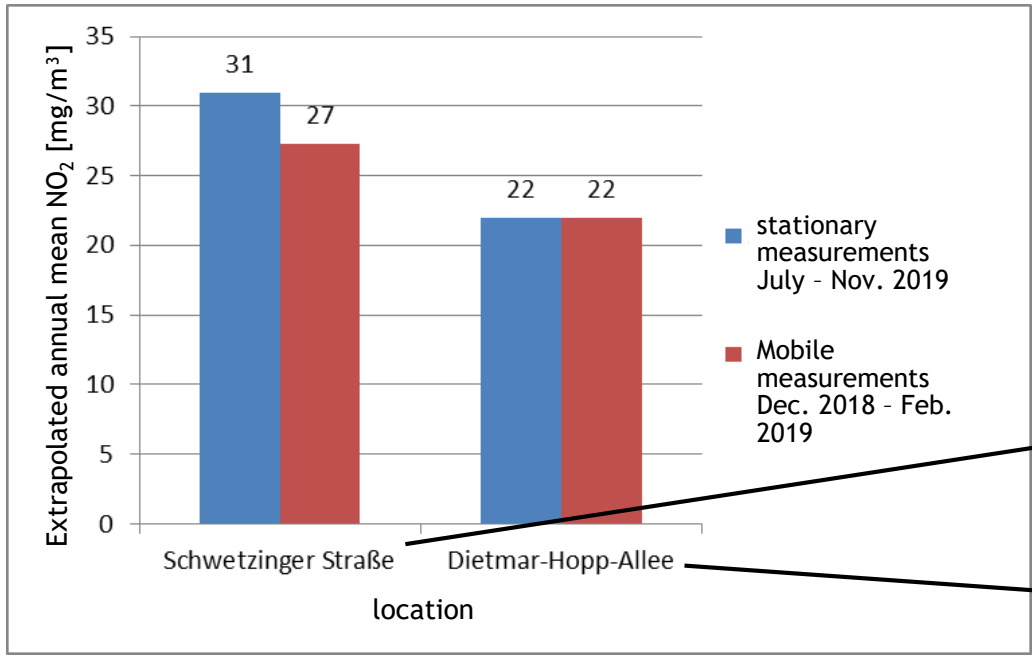


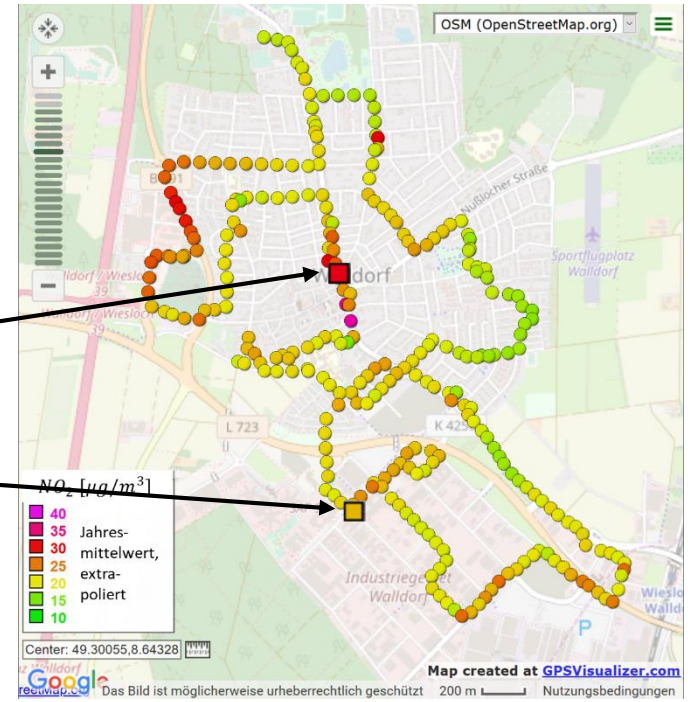
- Extrapolation removes NO_2 overestimation due to winter & mainly daytime measurement period

Validation with stationary measurements

- at two „hot spot“ locations stationary NO_2 measurements with a trailer
- Measurements over few months (with interruptions)
  → extrapolate annual mean





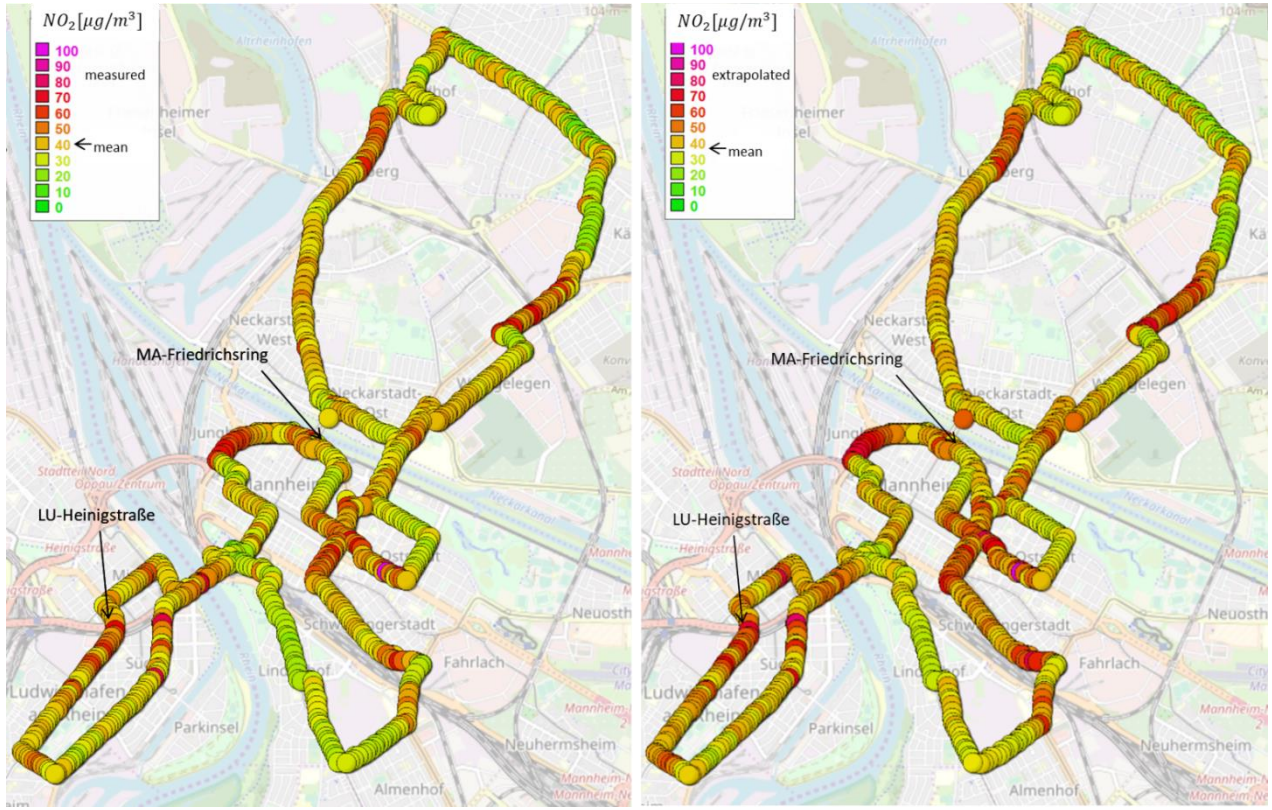


→ Good agreement to mobile meas. results

Example larger city Mannheim + Lufwigshafen, Germany

Average of measurements

Extrapolated annual mean conc.



- Two measurement stations (MA-Friedrichsring and LU-Heiningstraße) are indicated which were passed during the measurement, 30 measurement trips
- Extrapolated annual mean correlate within 15% to measurement station

Conclusion

- ICAD NO_2 analyser allow relative simple mobile measurements with a bike
- NO_2 distribution maps can be derived
- Repeating measurements on a fixed track at different: times of day, meteorological conditions, … → cover different air pollution situations
- Extrapolate to annual mean NO_2 concentration along the track using data from a reference measurement station
- Derived annual mean values were validated with stationary measurements and agree within 10 -15% → sufficient reliable NO_2 distribution maps
- Such studies can fill the gap in observations / air pollution monitoring
- Example result show that also small cities have NO_2 hot-spots
- Larger cities show that measurement stations are often not at the highest polluted streets