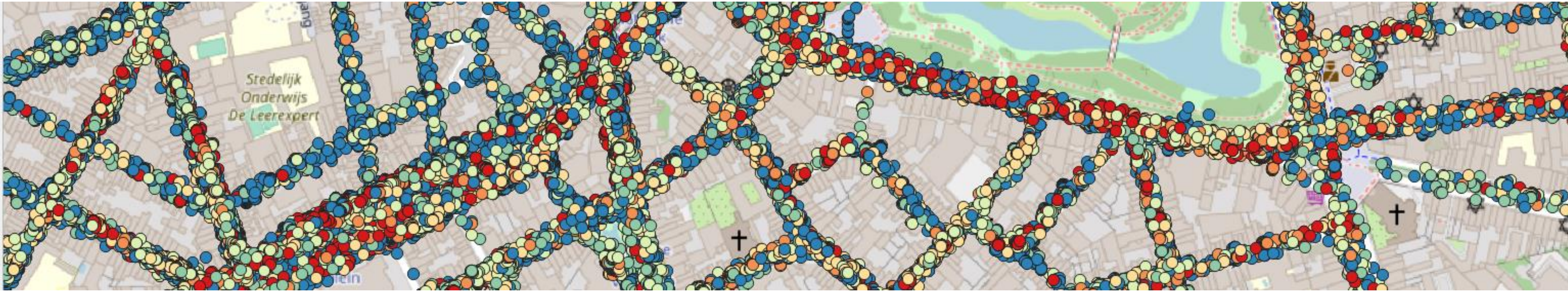
Opportunistic Mobile Air Quality Mapping Using Service Fleet Vehicles:

from point clouds to actionable insights

Air Sensor International Conference 2022



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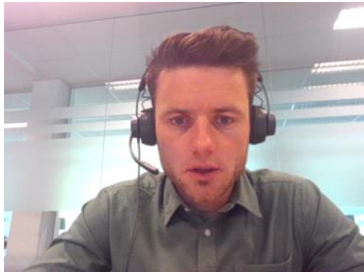

GOAL

- **AIM: “Collection of real-time fine-grained air quality data to gain more insight in urban air pollution exposure”**

- Solution: Kunak Air Mobile (https://www.kunak.es/en/)
  - Alphasense : NO_2, O_3 & PM
  - LTE-M
  - GPS
  - Dedicated housing: Laminar flow/avoid turbulence
- Deployment 20 sensors in Antwerp (Belgium)
  - Postal service: “at every doorstep”
  - 6V power supply via wiring vans
  - Monitoring resolution day (10 sec) + night (5 min)
- Study:
  - Co-location calibration & validation: Jan-Feb, 2021
  - Data collection: March-Sept, 2021
  - https://www.imeccityofthings.be/en/projecten/bel-air

kunak SENSING ANYWHERE

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CALIBRATION & VALIDATION

SENSOR CALIBRATION & VALIDATION

- Device property algorithm
  - Compensation temp/RH
  - Cross-sensitivity NO2-O3
  - mV → ppb or µg/m³ conversion
- Local calibration
  - PM composition/environmental conditions
  - Co-location AQMS
    - Baseline/span calibration NO_2
    - Mass factor (slope) correction PM
- All sensor co-located at AQMS (R817, VMM)
  - 3 in fixed shields
  - 17 in mobile enclosure

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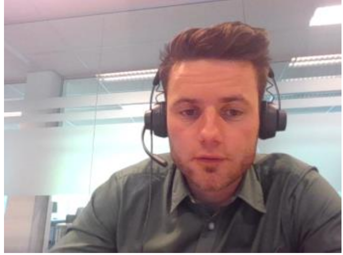
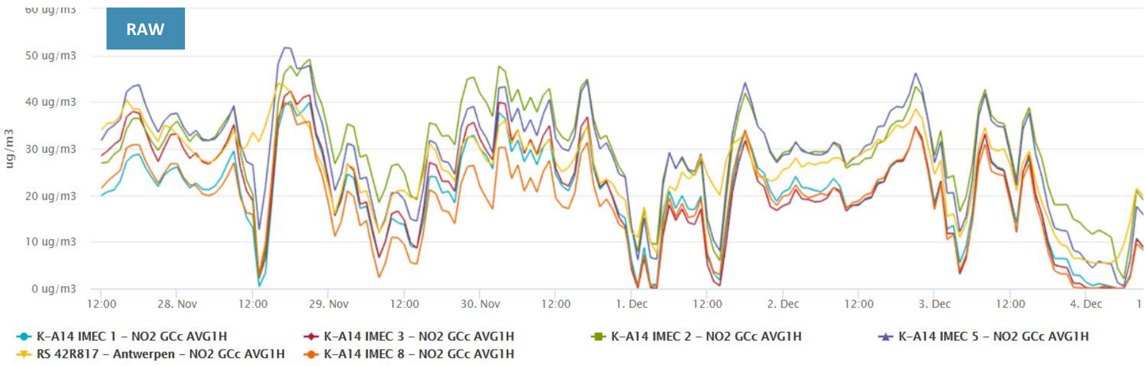
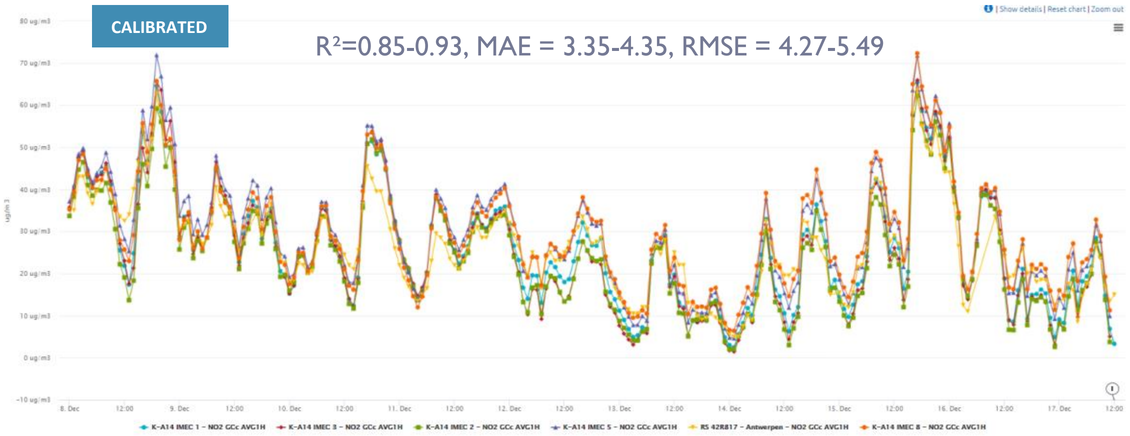
LOCAL CALIBRATION



- Calibration in 4 batches of 5 sensors
  - Within fixed shields
  - 1 week: calibration (training)
  - 1 week validation
- Overall good performance for NO_2
  - Accuracy
  - **Precision**
  - Supplementary/Class 1 (<25%) at hourly level
- Moderate performance PM
  - Supplementary/Class 1 (<50%) at daily level

	Average Peformance				
	NO2	PM1	PM2.5	PM10	
Mean REF	25.88	12.27	13.47	18.41	
Mean sensor	21.11	5.01	11.11	16.33	
R^2	0.88	0.85	0.64	0.57	
MAE	3.62	4.82	5.20	8.82	
RMSE	4.42	6.37	7.16	11.33	
Wcm	24.99	90.09	130.44	175.64	EU Equivalence Tool v3.1
Wcm	14.57	74.63	79.23	-	VMM

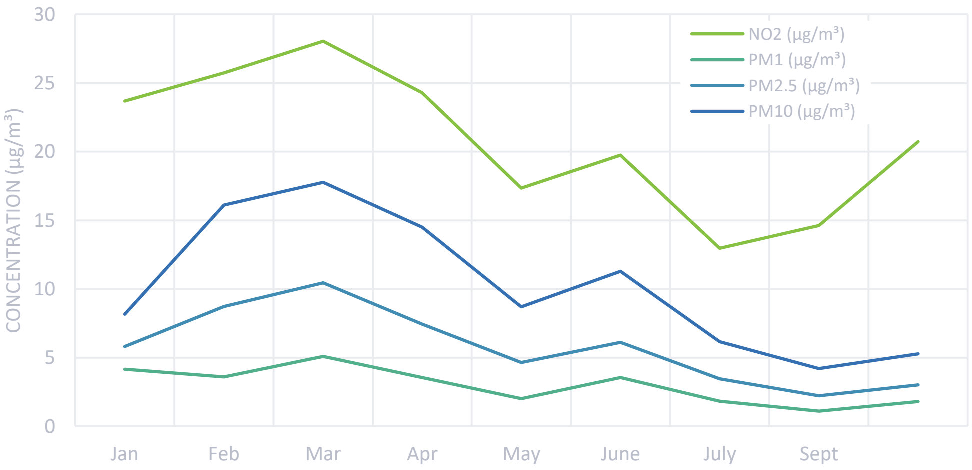


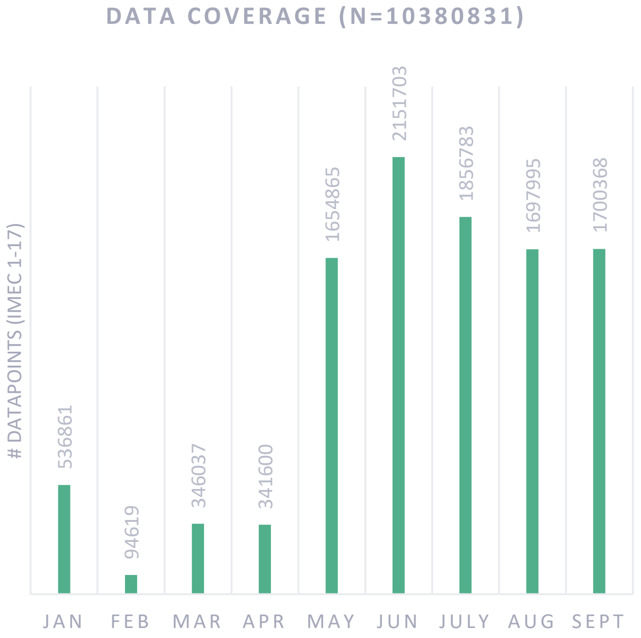


MOBILE DEPLOYMENT

SENSOR DEPLOYMENT

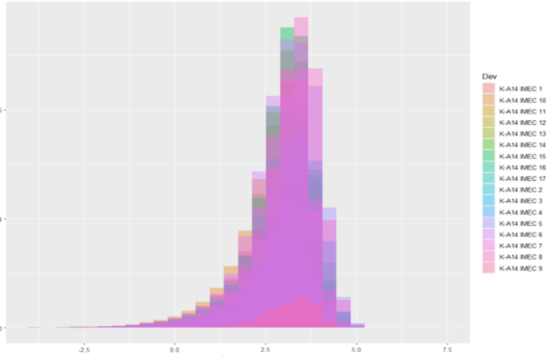
- All sensor batches deployed between Jan and March.
  - 17 deployed on vans
  - 3 remained co-located with R817 (validation)
- Opportunistic data collection: March - Sept 2021
- Temporal monitoring coverage (Jan-Sept)

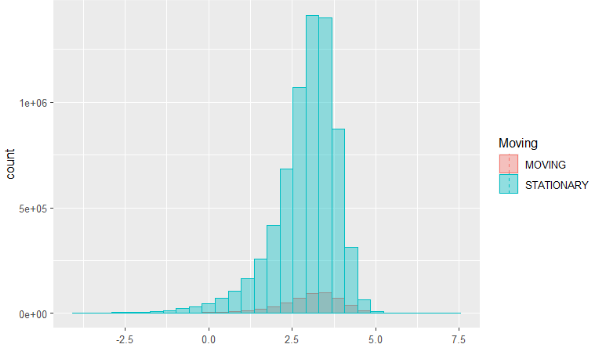


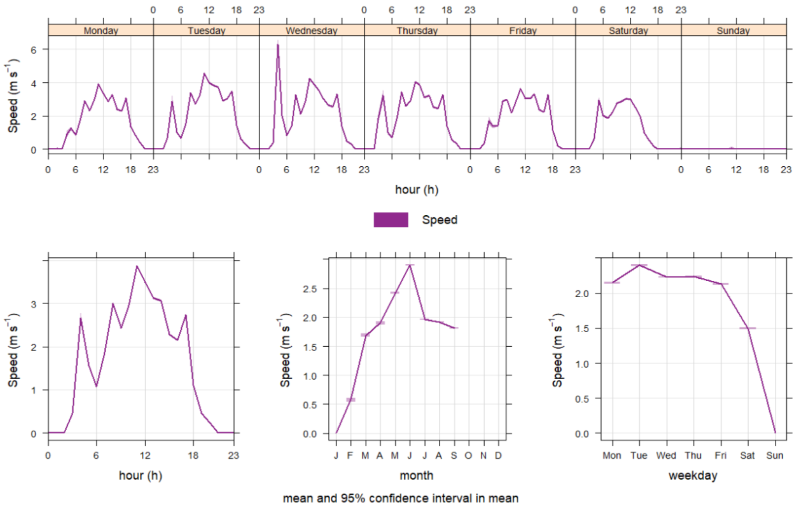


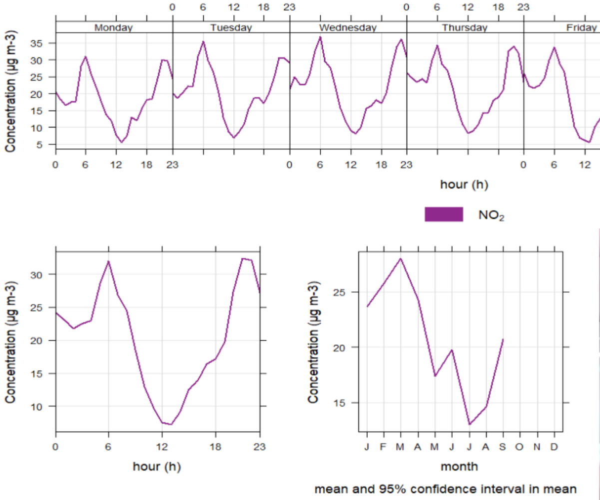
SENSOR DATA

- NO_2 ~ SENSORS
- NO_2 ~ SPEED
- Operation time:
  - 92.7% stationary (speed=0)
  - 7.3% moving (speed > 0)



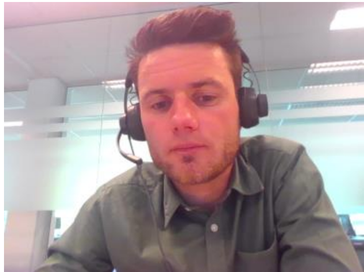




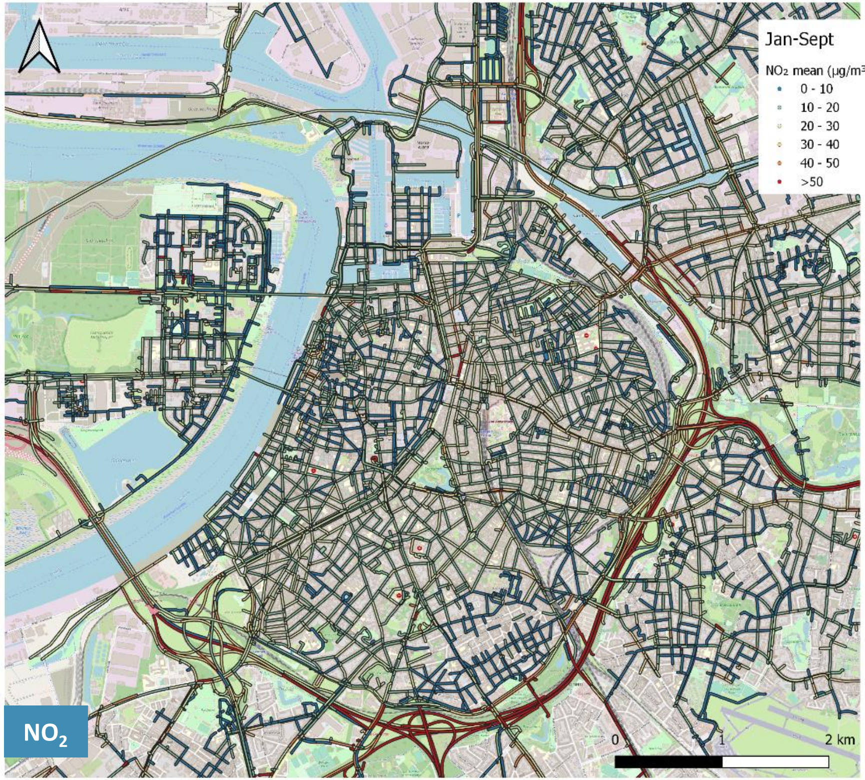


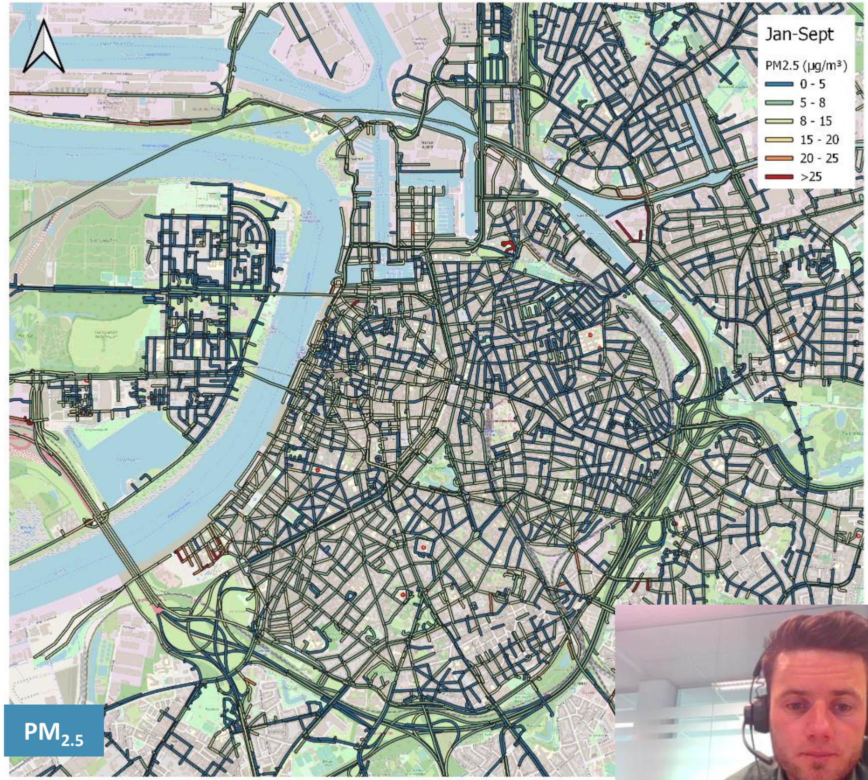
SPATIAL AGGREGATION

- Spatial aggregation datapoints into street segment buffers (10m radius)
  - Count/Min/25%/Mean/Median/75%/Max



POLLUTANTS





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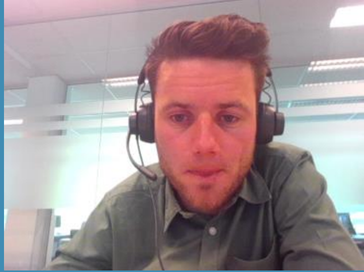
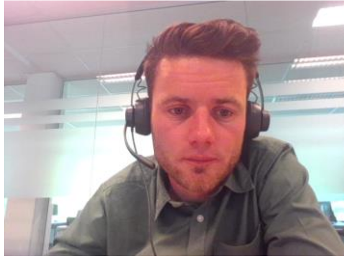


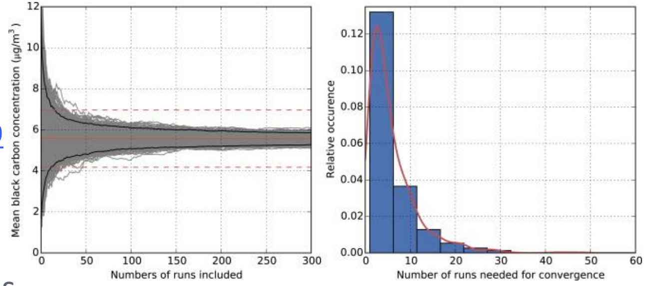
REPRESENTATIVITY

SPATIOTEMPORAL REPRESENTATIVITY



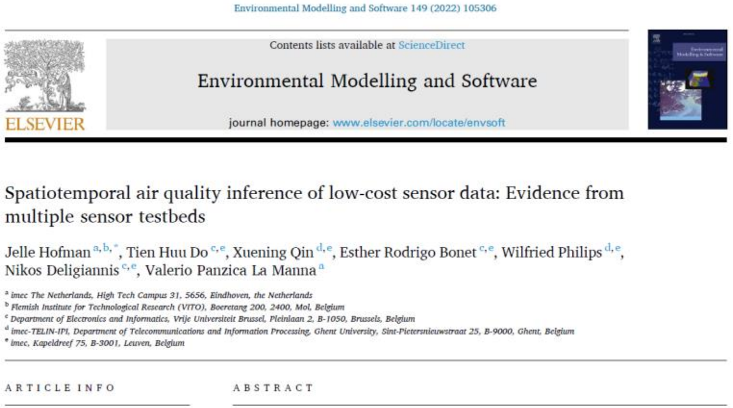
- 10 sec measurements in both space & time: representative?
- Solutions:
  - Subsampling analysis to determine required coverage threshold

    Van den Bossche et al. 2016 https://lib.ugent.be/catalog/rug01:002300079
    Apte et al. 2017 https://pubs.acs.org/doi/10.1021/acs.est.7b00891
    Chen et al. 2022 https://doi.org/10.1016/j.atmosenv.2022.118936



  - Air Quality Inference in space-time based on machine learning models

    Do et al. 2020 https://doi.org/10.1109/JIOT.2020.2999446
    Xuening et al. 2021 https://doi.org/10.1145/3461353.3461370
    Paliwal et al 2021 https://www.youtube.com/watch?v=9yjaScDqlNE
    Hofman et al. 2022 https://doi.org/10.1016/j.envsoft.2022.105306



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Spatiotemporal air quality inference of low-cost sensor data: Evidence from multiple sensor testbeds

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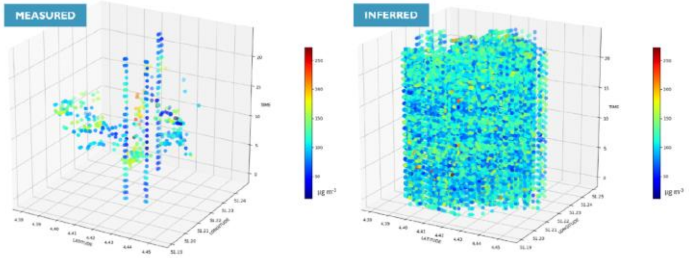
ARTICLE INFO

ABSTRACT



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CONCLUSIONS

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- Mobile AQ sensors are able to generate **actionable results**

- Proper **calibration & validation** is needed to determine their potential & quantify associated uncertainty for each pollutant (interpretation)
  - NO2>PM, impact housing

- **Data Aggregation** Tools: point clouds → AQ maps

- **Comprehensive** AQ maps:
  - Coverage thresholds/subsampling analysis
  - AQ inference models

THANKS!

QUESTIONS?