Low-Cost Air Quality Sensor Network in Munich

Florian Dietrich[1], Jia Chen[1] , Daniel Zollitsch[1], Benno Voggenreiter[1], Luca Setili[1], and Mark Wenig[2]

[1]Technical University of Munich, Environmental Sensing and Modeling, Munich, Germany

[2]Meteorological Institute, Ludwig-Maximilians-Universität München, Munich, Germany

*Correspondence: **Jia Chen** (jia.chen@tum.de)*

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Objectives

- Creating a concentration map of air pollutants
  - Real-time
  - High spatial resolution (every 200 m)
  - High temporal resolution (every minute)
- Finding and quantifying emission sources
- Understanding the interactions between nitrogen oxides and other air pollutants
- Determining the best suited locations for monitoring stations
- Evaluating existing and planned mitigation policies

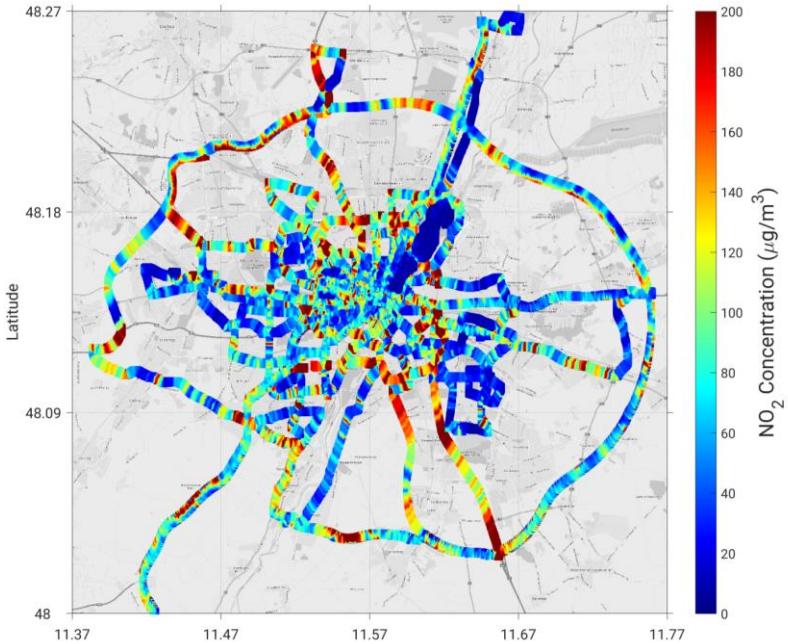
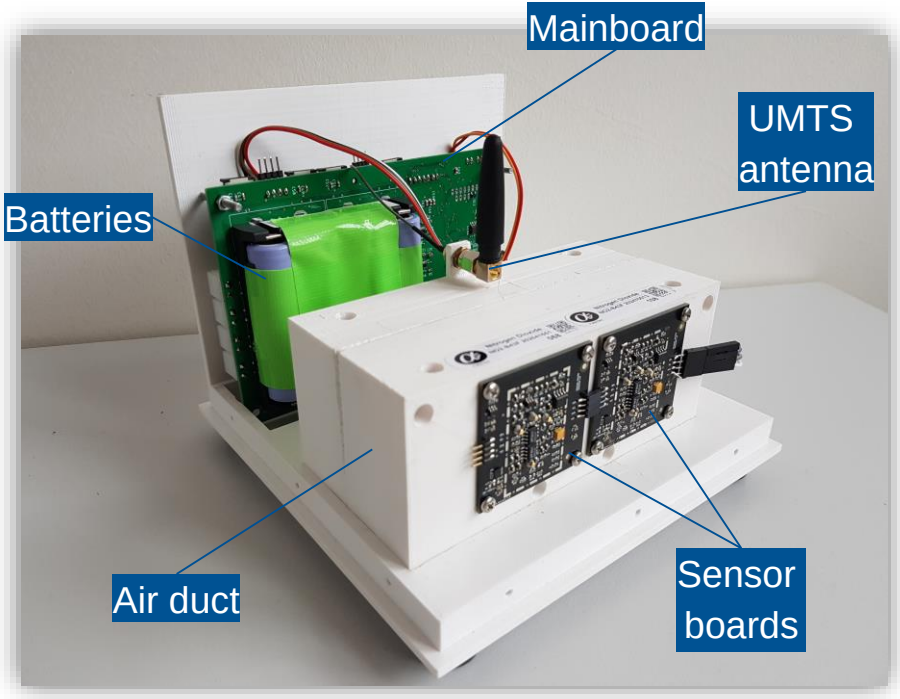


Figure 1: Example of an NO_2 concentration map of Munich measured with a mobile instrument in our 2016 campaign (Zhu et al. 2020)

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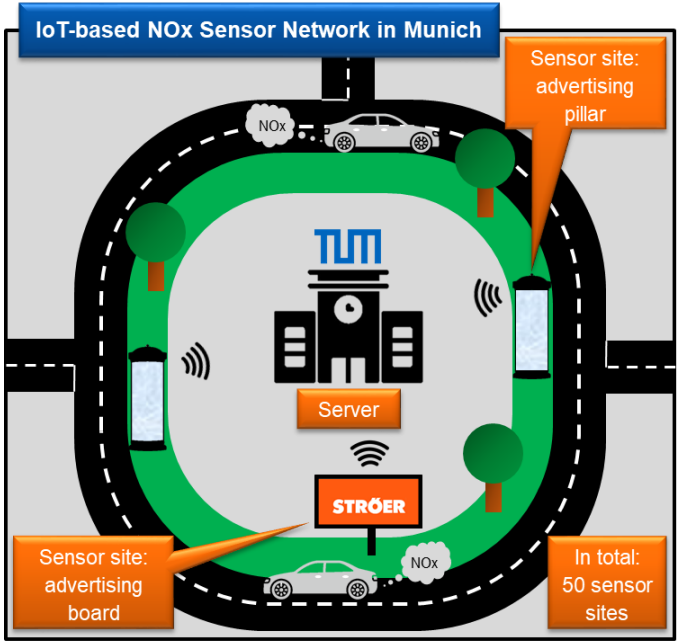
Smart sensor box

- Self-development (mainboard + sensor boards)
- **Stand-alone system**
  - Battery-powered + solar power
  - UMTS connection (more reliable than LoRaWAN)
  - **Automated calibration** based on IoT + AI
- Various gases (4) + particulate matter:
  - NO, NO_2
  - Ozone
  - Carbon monoxide
  - PM10 + PM2.5
- **Special airflow principle** using an air duct



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Worldwide unique NOx & PM monitoring network



- 50 sensor boxes
- Distributed in the inner city of Munich
- Distance between sensor nodes: ≈ 200 m
- Sensor sites:
  - Next to the street (e.g. on advertising boards and pillars)
  - Fulfilling EU regulations
- Each sensor node is connected to the server at our university (TUM) via UMTS
- **Regular calibration** (twice a week) using a mobile, high accuracy calibration unit combined with machine learning algorithms

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Special features of our approach

Sensor box

- **Combination of NO_2 and PM**
  → understanding interactions between them
- **Very low power consumption** in standard mode (< 30 mW): *1 measurements per minute*
- Three additional operation modes:
  - Initial side-by-side calibration
  - On-site calibration *(1 sample per second as long as calibration unit is in the vicinity)*
  - PM mode *(when solar power is available)*

Calibration and modeling

- **Recurring calibration** with mobile reference instruments twice a week to ensure data quality
- **Own calibration algorithm** (no black box as it is the case for commercial products)
- Creating a map using semantic kriging
- Estimating emissions using microscale models

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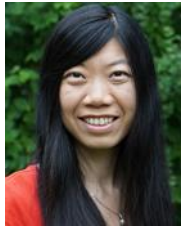
Authors



Florian Dietrich

PhD student at the Professorship of Environmental Sensing and Modeling

Technical University of Munich



Jia Chen

Professor of Environmental Sensing and Modeling

Technical University of Munich

References

Zhu, Y., Chen, J., Bi, X., Kuhlmann, G., Chan, K. L., Dietrich, F., Brunner, D., Ye, S., and Wenig, M.: *Spatial and temporal representativeness of point measurements for nitrogen dioxide pollution levels in cities*, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-1198, in review, 2020

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