Comparison of different dispersion modelling approaches in the surroundings of Legerova street canyon in the city of Prague

Project TURBAN – Turbulent-resolving urban modeling of air quality and thermal comfort (project-turban.eu)

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ATELIER EKOLOGICKÝCH MODELŮ

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Objectives

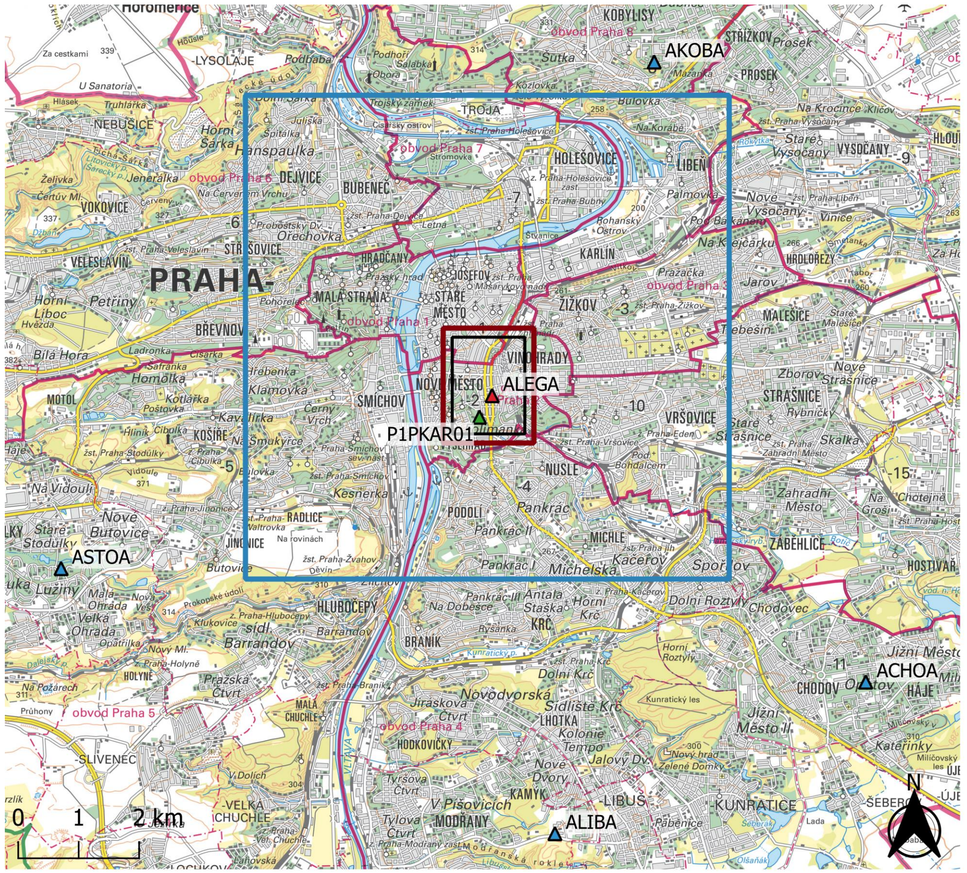
- Compare the models ATEM (Gaussian), GRAL (Lagrangian) and PALM (LES) against air quality measurements of PM10.

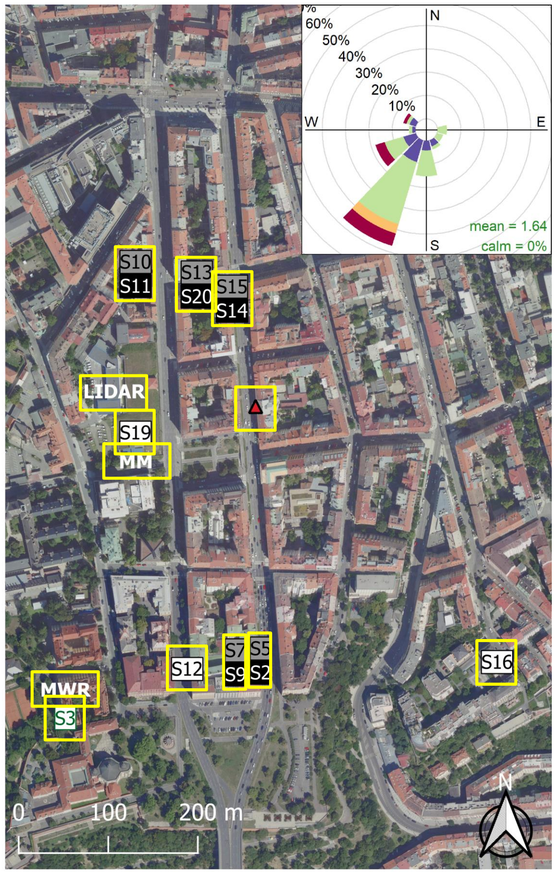
- Analyze the temporal and spatial variability of model outputs (identify the impact of buildings).

- Evaluate the suitability of models for air quality assessment.

Experiment design

Model domain





PALM parent domain
GRAL meso domain
Model domain

Meteorological station
Traffic station
Background stations

Low-cost sensor
Paired sensor: high
Paired sensor: low

Streets with highest traffic pollution load:

- Legerova – AIM, S2, S5, S14, S15
- Rumunská – S13, S20
- Sokolská – S10, S11, S12

‘Background areas’:

- PVK garden – S19
- School Courtyard – S7, S9

Roofs:

- Karlov – S3
- Hotel Le Palais – S16

- Instruments:
MWR, LIDAR, Meteorological mast

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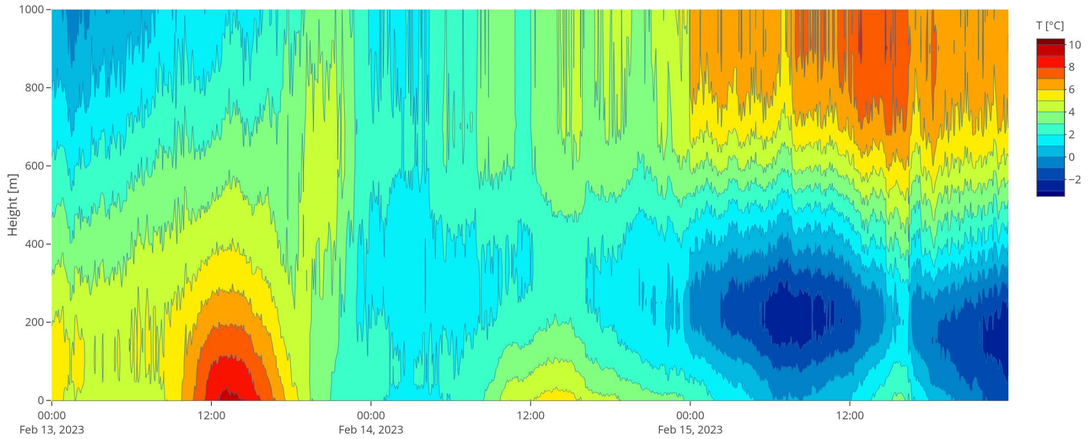
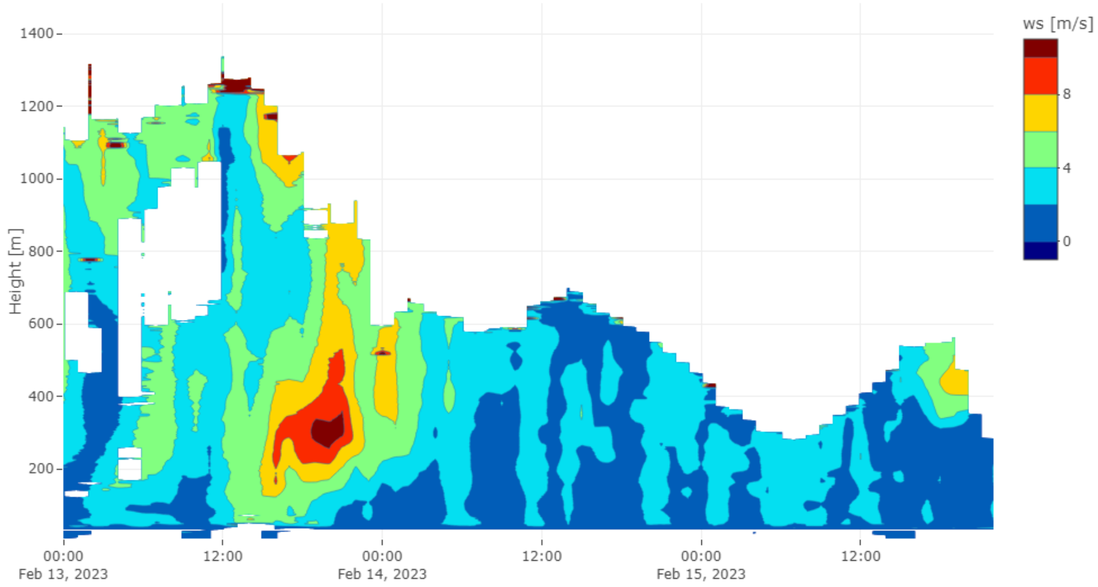
Meteorological input



Temperature profile measured by MWR



Wind speed profile measured by LIDAR

- Wintertime inversion period of 3 days between 13-15 February, 2023.
- Limited computational capacity
- Relevance for elevated pollution

*ATEM/GRAL: input from meteorological station and MWR

*PALM: input from numerical weather prediction model ALADIN

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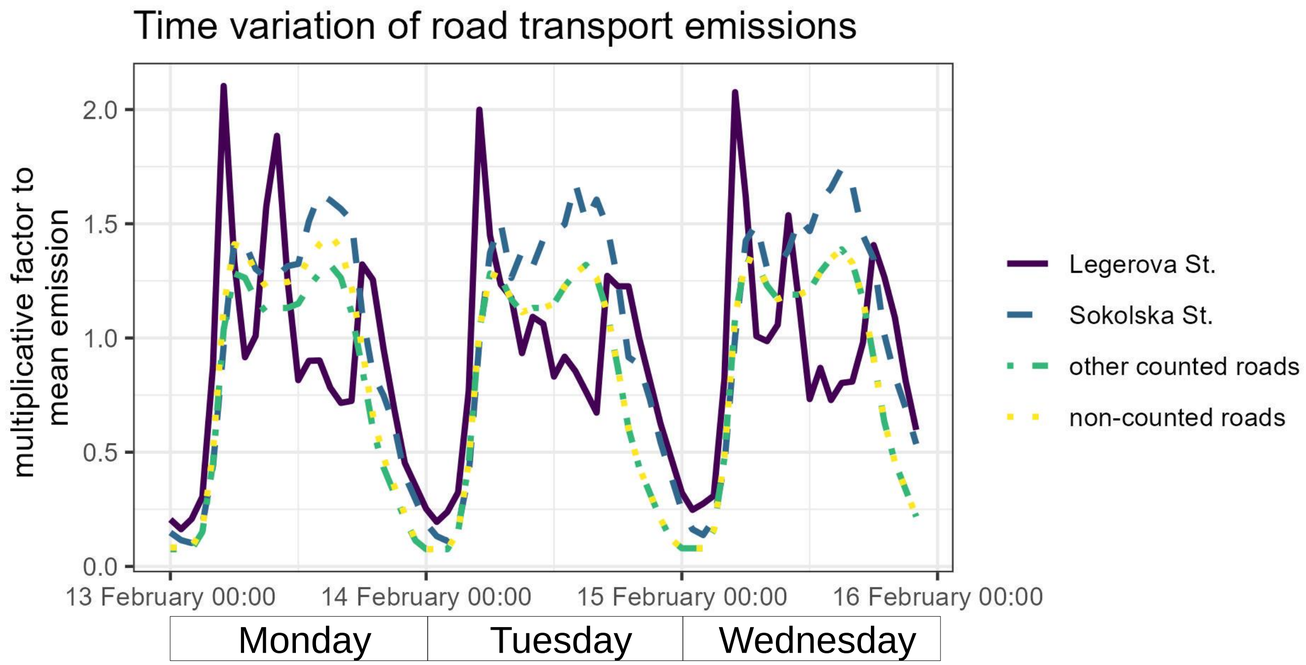
Emissions



- Residential heating
- Mobile sources
  → 90% road sources

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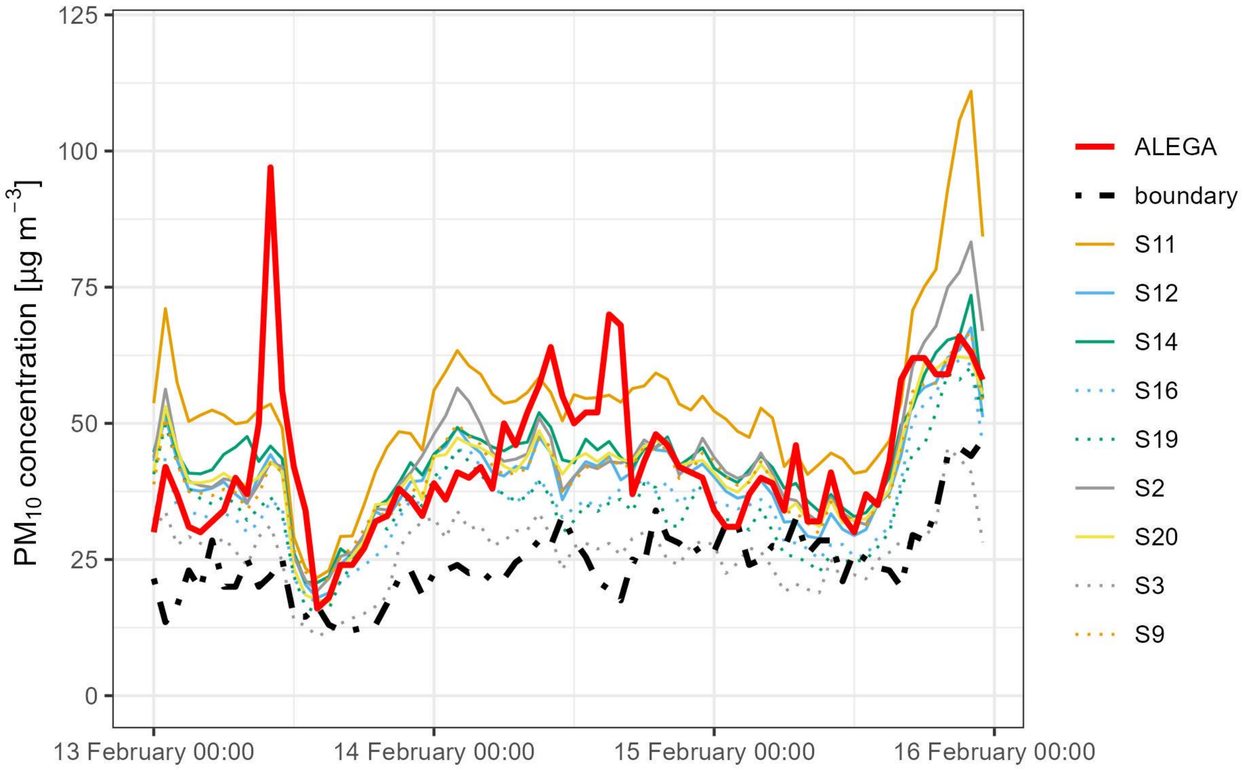
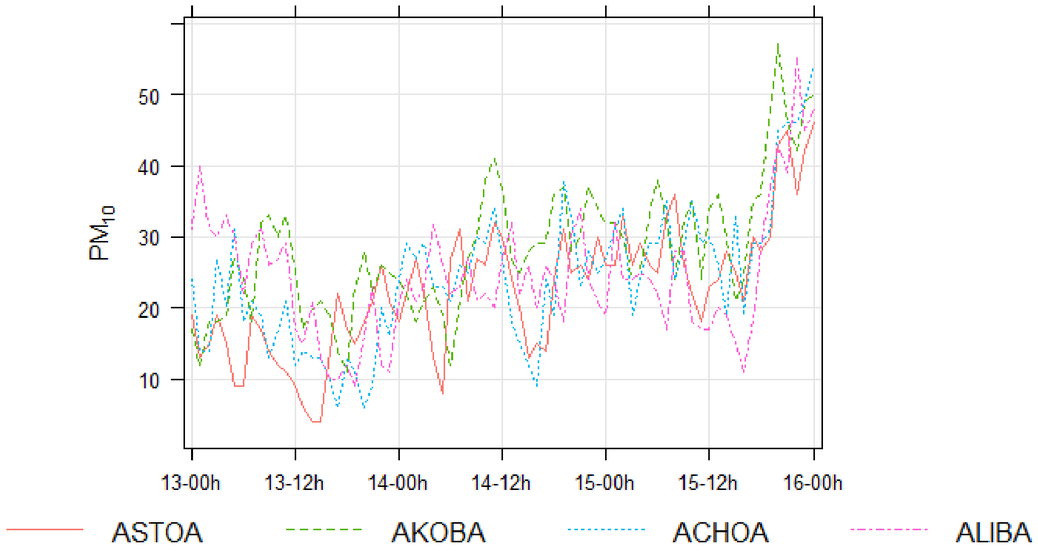
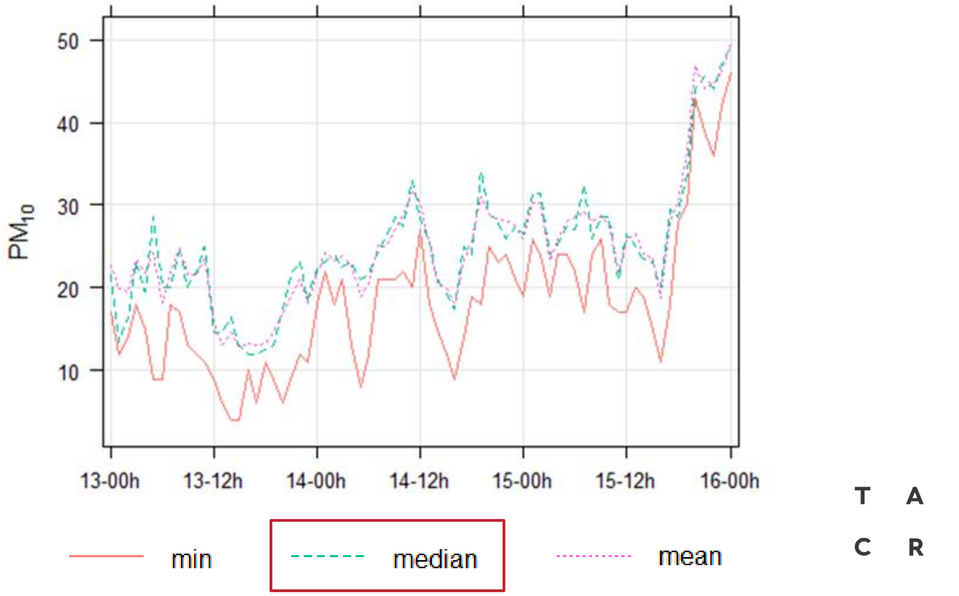
Observations and boundary conditions







PM10 concentrations measured at AIM – ALEGA and LCSs (lower locations).
solid lines – sensors in street canyon.
dotted lines – sensors at a distant location from the roads or background location.

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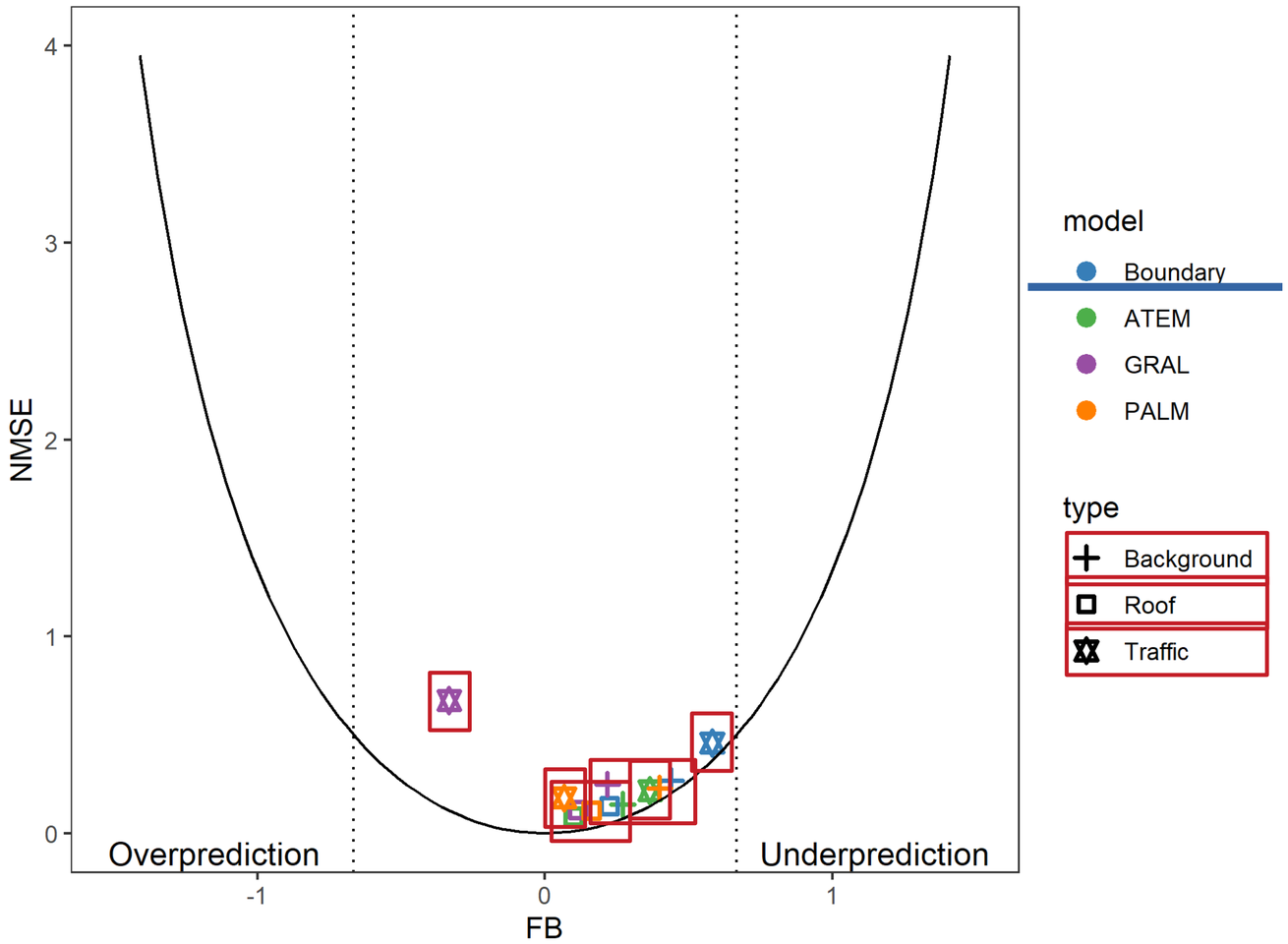
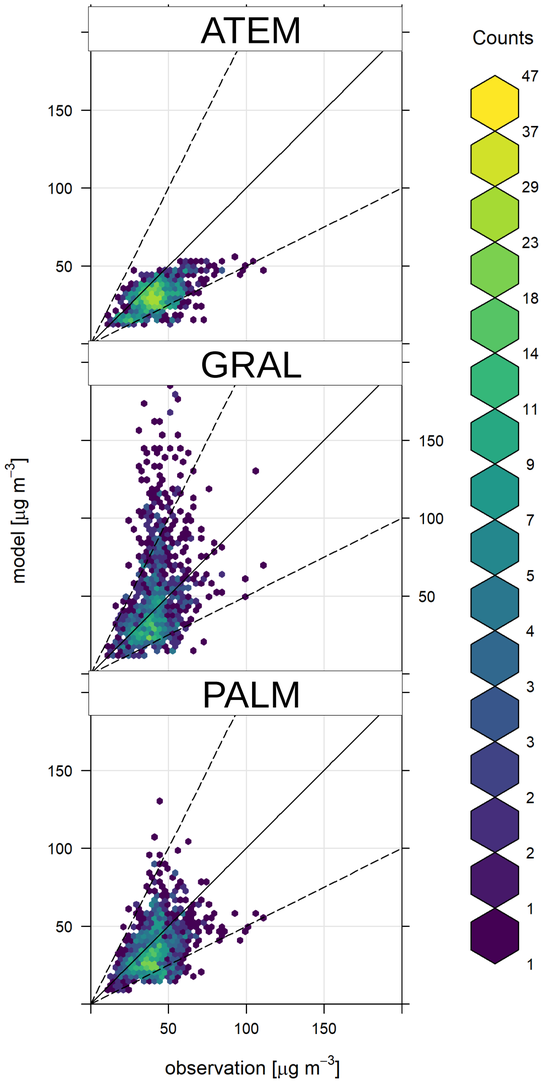
Simulation results

Statistical evaluation



Dashed lines show modelled results within a factor of two of the observations. The parabola indicates the minimum NMSE for a given FB (component due to systematic errors).



Scatter plots using all measurements available.

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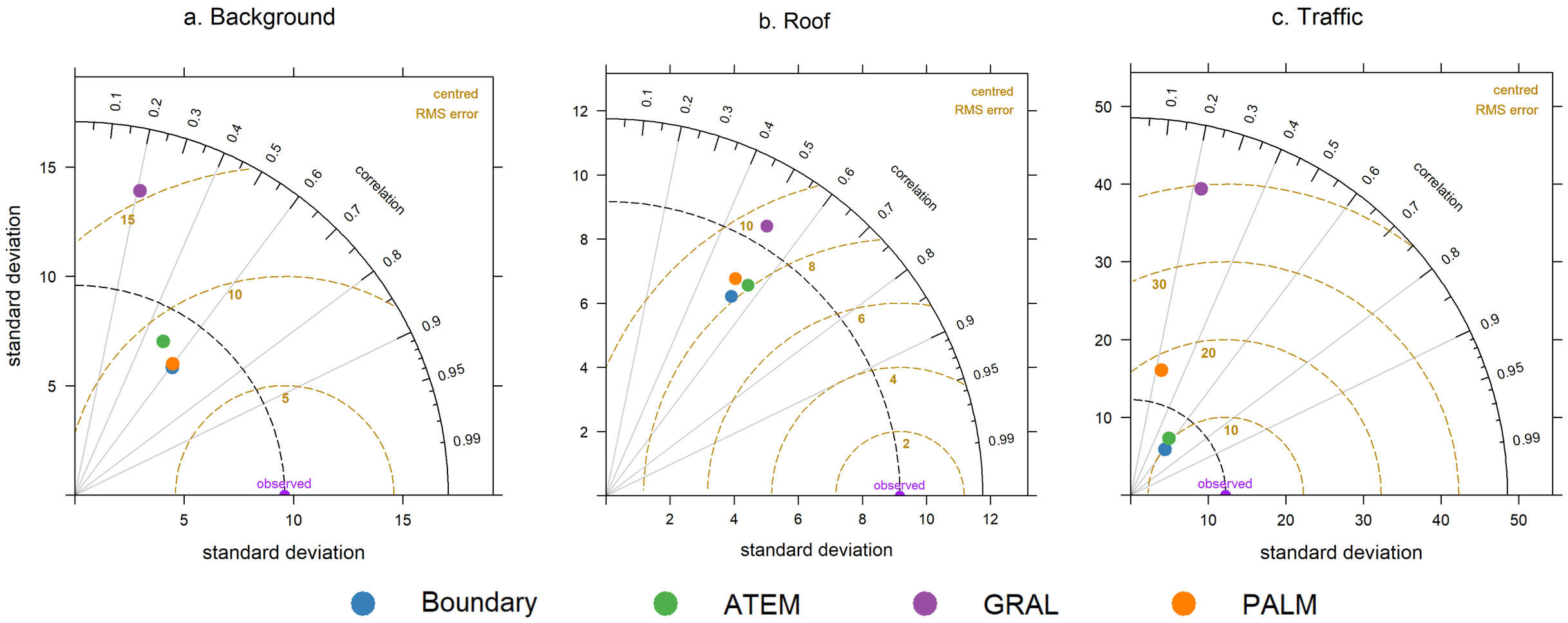

Taylor diagrams split by model and station group.

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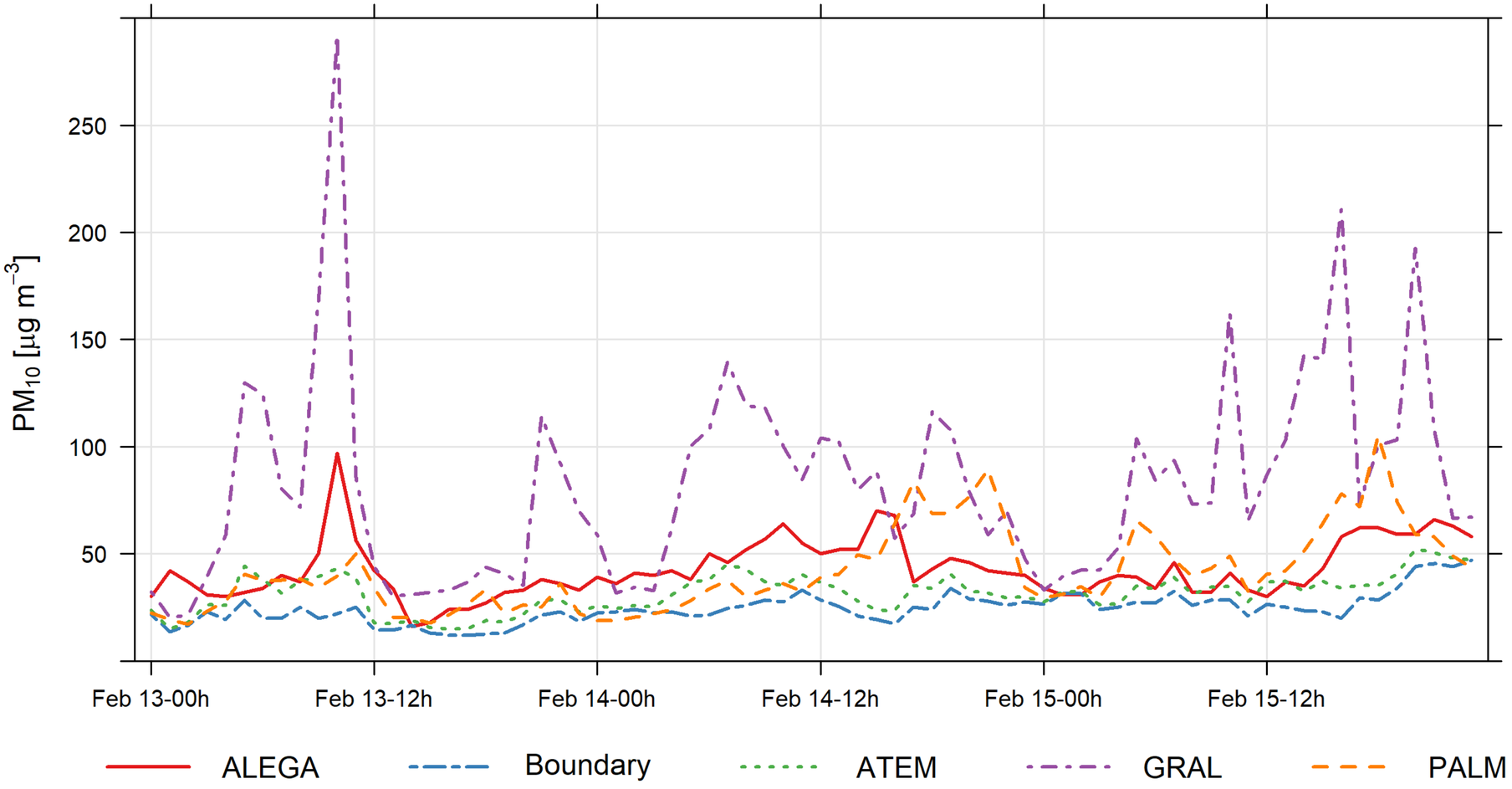
Temporal variability



Time series of PM10 concentrations computed using ATEM, GRAL, and PALM compared against the ALEGA station measurement

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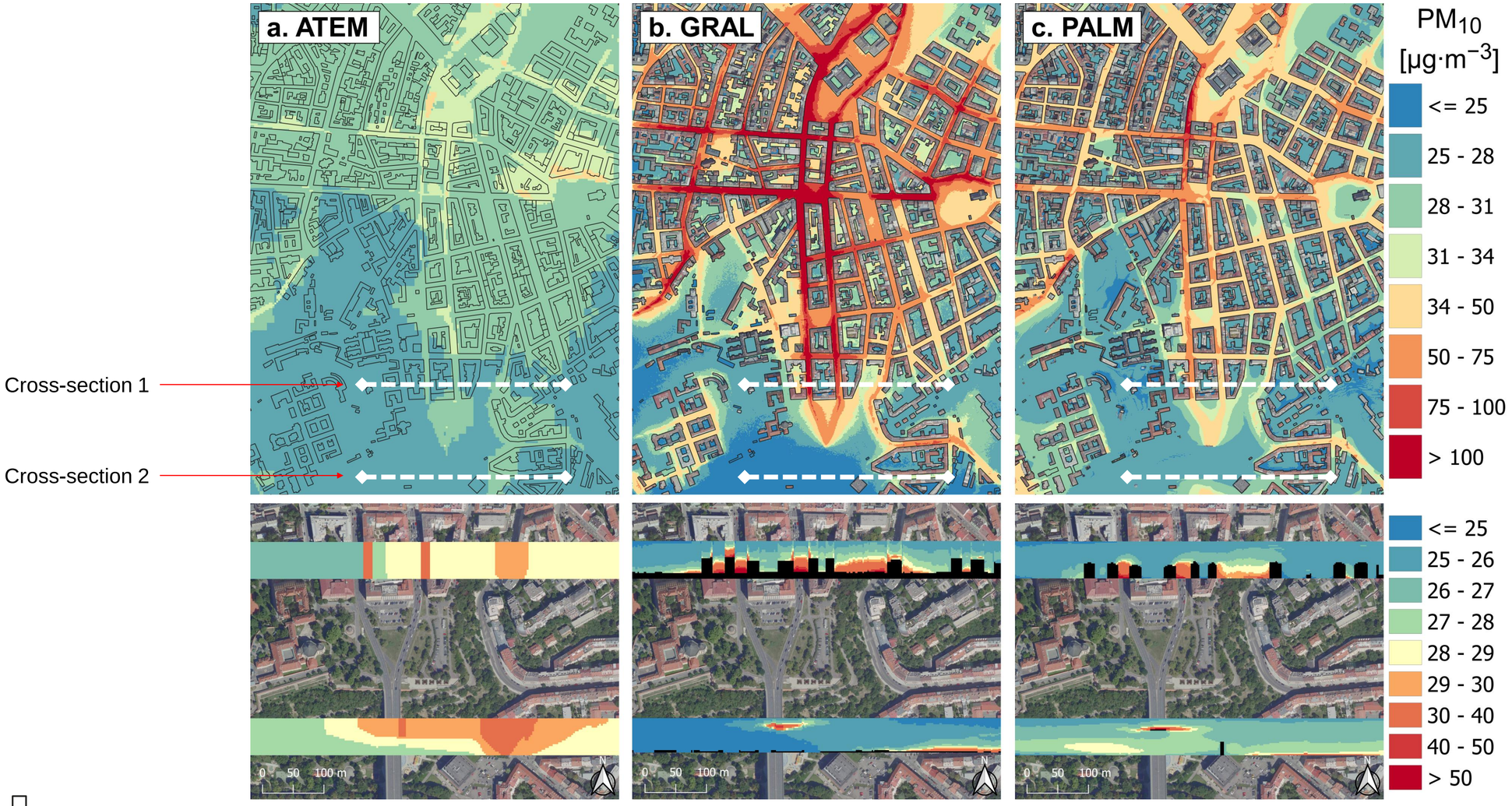
Spatial variability



Mean PM10 concentrations at 3 m AGL (upper) and close up of vertical cross-sections (lower) for the period 13–15 February.

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Conclusions

- Although the Gaussian model ATEM could comply with common statistical performance criteria, the predictions poorly represented the spatial variability of concentrations in the domain.
- GRAL provided a better simulation of formation of vortices inside street canyons, but it tended to overpredict the influence of these phenomena.
- PALM obtained the best accuracy for traffic locations and estimated the distribution of concentrations among different urban areas properly.
- Advanced models demonstrated a behaviour that is more coherent with reality, while still complying satisfactorily with statistical metrics.
- Suitability for urban planning is subject to further considerations, such as time and financial resources, availability of high-resolution input data, user expertise and usefulness of the output provided.

  - assessment of annual air quality statistics.

  - detailed concentration patterns in the street canyons.

  - combined evaluation of air quality and micrometeorological parameters (thermal comfort).

References

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Acknowledgment

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https://www.project-turban.eu/

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