WG4 MICROSCALE MODELING
Status of activity and next steps

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WG4 activities: Context and aims

1. WG4 is focused on microscale modelling but restricted to applications in the context of the air quality directives (AAQD)

2. In this context, results of these models are only useful if they can be aggregated to the temporal and spatial scales of interest for the AAQD

3. An intercomparison exercise is ongoing to compare methodologies for deriving annual statistics (using microscale modelling) to identify best practices.

4. 10 groups:

    ENEA, VITO, NILU, RICARDO, CERC, University of West Macedonia (UOWM), Széchenyi István University (SZE), UPM, AIR-D and CIEMAT.

2020 - 2023 activities

1. CT4 Microscale Modeling was endorsed in FAIRMODE Plenary Meeting, Berlin, Feb 2020.

2. Design and preparation of an Intercomparison Exercise, second half 2020,

3. Modelling simulations during 2021

4. Processing of results mainly during 2022

5. **New contributions and new participants 2023**

6. **New evaluation for other air quality indicators 2023**
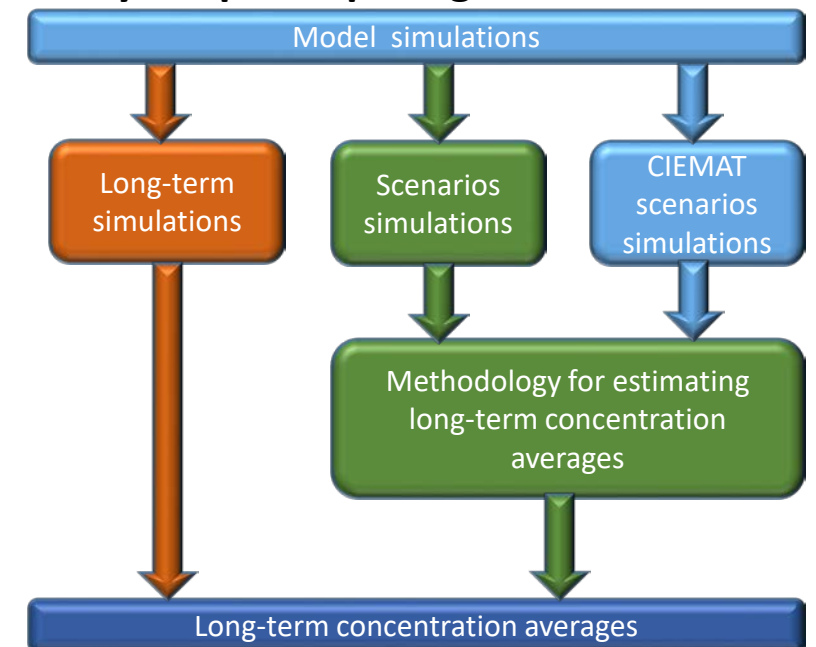
WG4 Intercomparison exercise

Domain and data

- Urban district (800x800 m) of Antwerp (Belgium). NO_2.

- Measurements from two AQ stations and 72 samplers.

- Emission data for traffic.
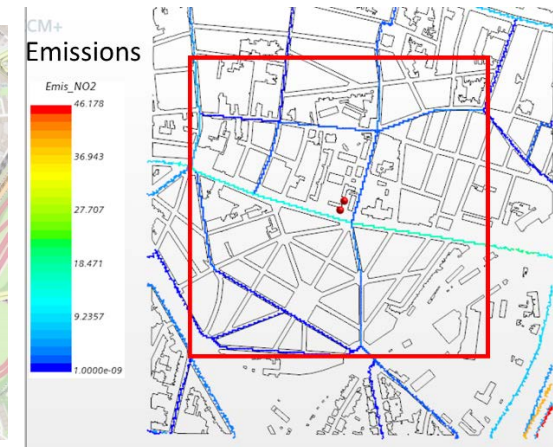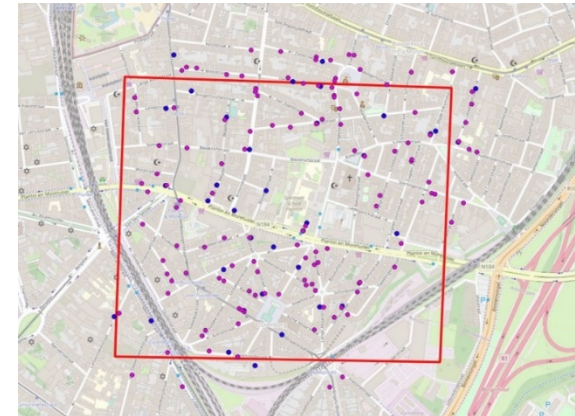
Models and methodologies

- **CFD models (RANS mostly), parametric, Gaussian, Lagrangian, AI.**

- Different methods for computing annual indicators of pollutant concentrations.

  - **Methods based on simulating a set of selected scenarios** (wind scenarios and/or emission scenarios) **and then a postprocessing** (PDF of scenarios, rebuilding a entire year, etc) of model results for retrieving annual indicators.

  - **Simulating the full-year year**, (mostly for No CFD models but some of them run CFD models a complete year).

Ways of participating in the exercise:

Model simulations

Long-term simulations

Scenarios simulations

CIEMAT scenarios simulations

Methodology for estimating long-term concentration averages

Long-term concentration averages

WG4 Intercomparison exercise

Type of evaluations and comparisons

1. *Hourly time series for <u>one day</u> with high pollution.*

   - *May 6th, 2016 selected to simulate.*
   - *The model results compared with <u>two AQ stations data</u>*

2. *Monthly averaged concentration map for the <u>campaign period</u> (April 30 – May 28).*

   - *Comparison with <u>passive samplers' data</u>*
   - *Intercomparison among models results (2D maps).*

3. *Annual concentration map for <u>2016 year</u> .*

   - *Intercomparison of results from every methodology (2D maps).*

4. *To compute LV exceedances and spatial representativeness areas of AQ stations.*

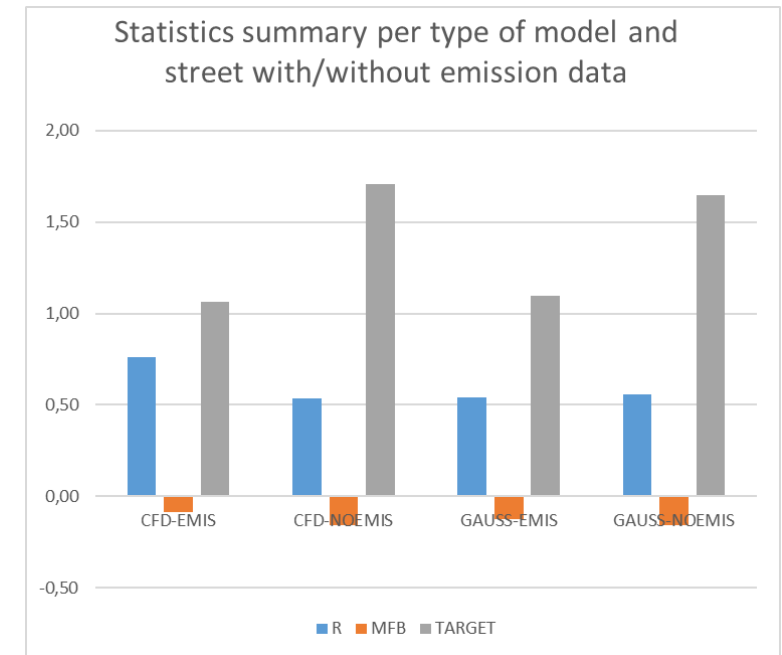   - *Intercomparison of results from every methodology (2D maps).*

What type of models are more suitable?

- Most of the models simulate quite well hourly time evolution, but slightly best statistics for Gaussian models

- Generally NO-Gaussian models seem to predict better monthly concentration and its spatial distribution.
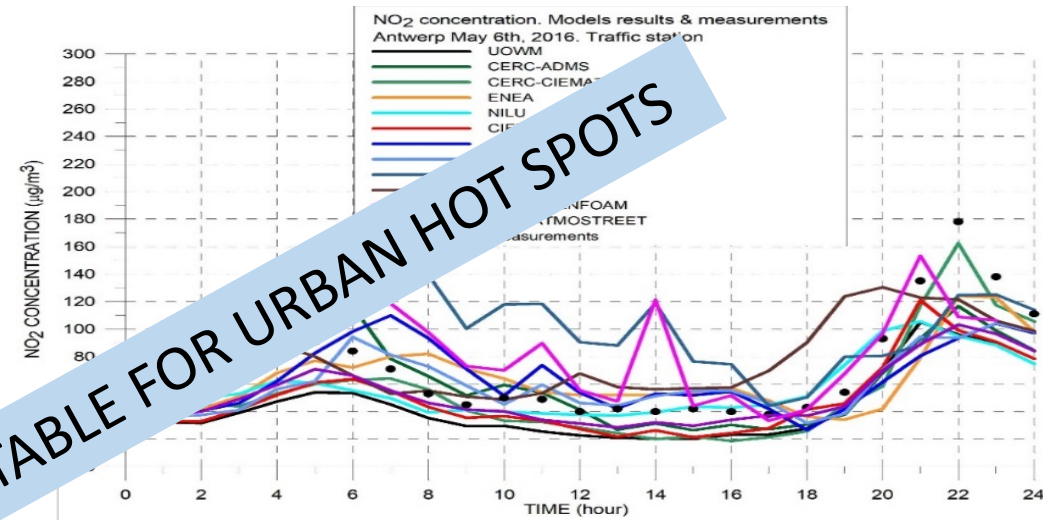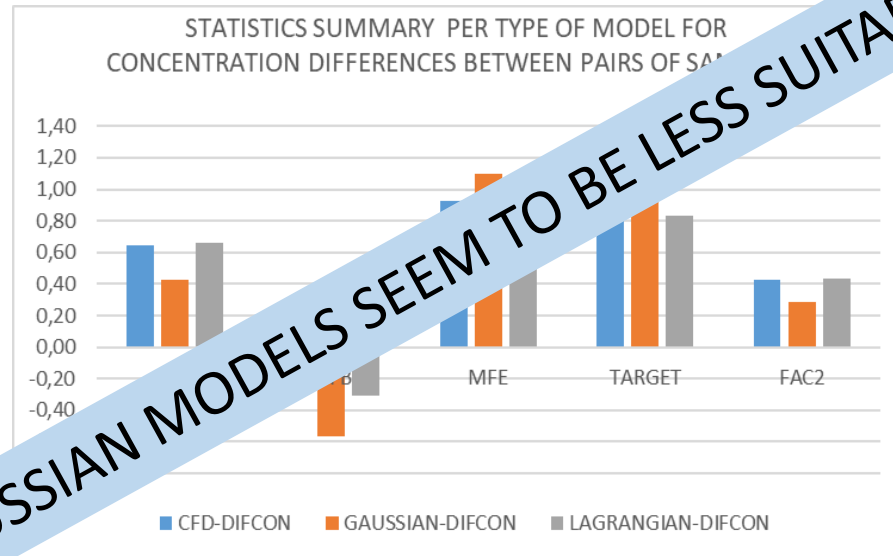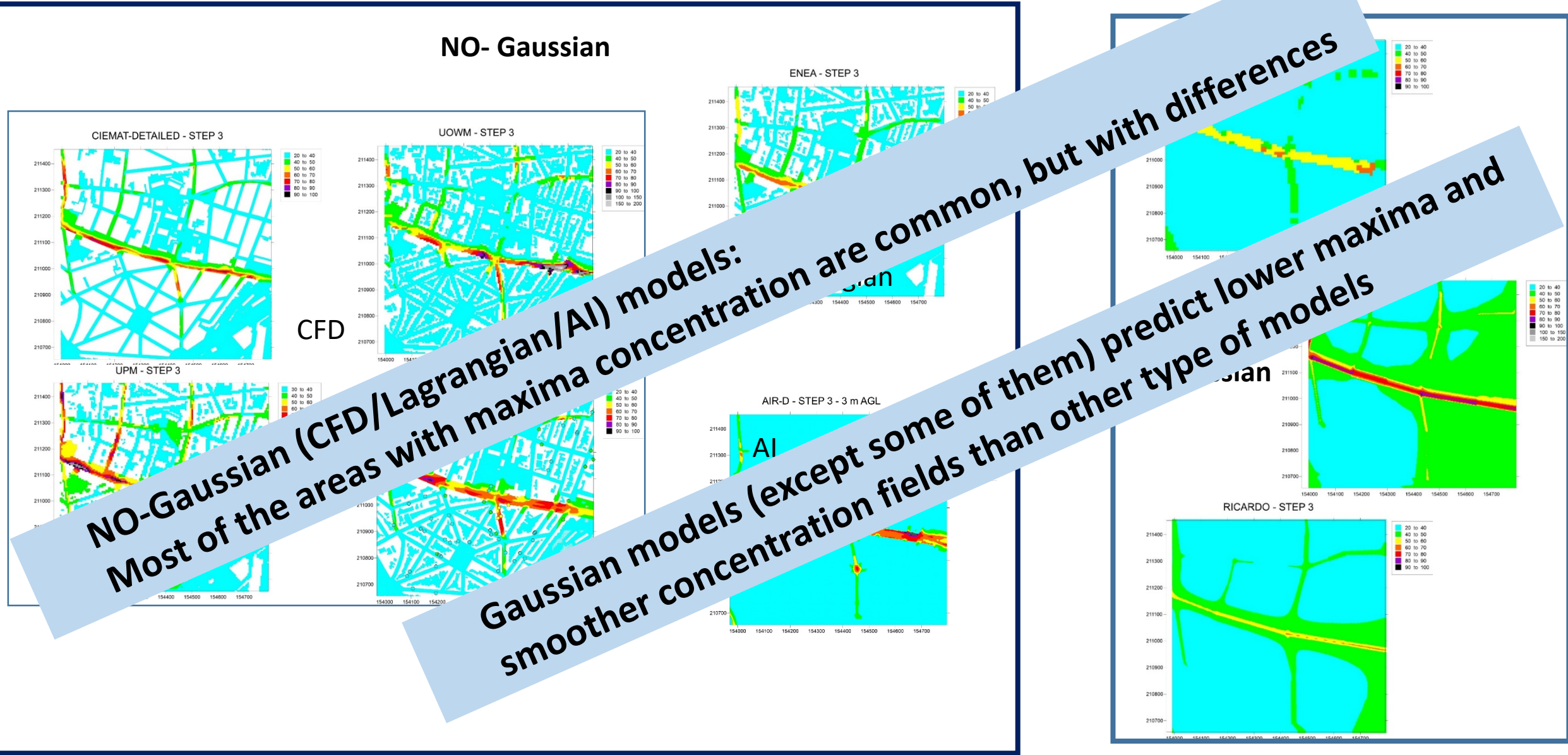
What is the impact of the emissions data?

- Lack of emission data in some streets strongly influences on the NO-Gaussian models performance but not on Gaussian models

NO₂ concentration. Models results & measurements
Antwerp May 6th, 2016. Traffic station

GENERALLY, GAUSSIAN MODELS SEEM TO BE LESS SUITABLE FOR URBAN HOT SPOTS

STATISTICS SUMMARY PER TYPE OF MODEL FOR CONCENTRATION DIFFERENCES BETWEEN PAIRS OF SA...

CFD-DIFCON   GAUSSIAN-DIFCON   LAGRANGIAN-DIFCON

Statistics summary per type of model and street with/without emission data

R   MFB   TARGET

Comparing long-term average concentration maps

NO- Gaussian

CFD

AI

NO-Gaussian (CFD/Lagrangian/AI) models: Most of the areas with maxima concentration are common, but with differences

Gaussian models (except some of them) predict lower maxima and smoother concentration fields than other type of models

How many simulations (scenarios) could be needed to provide good results?
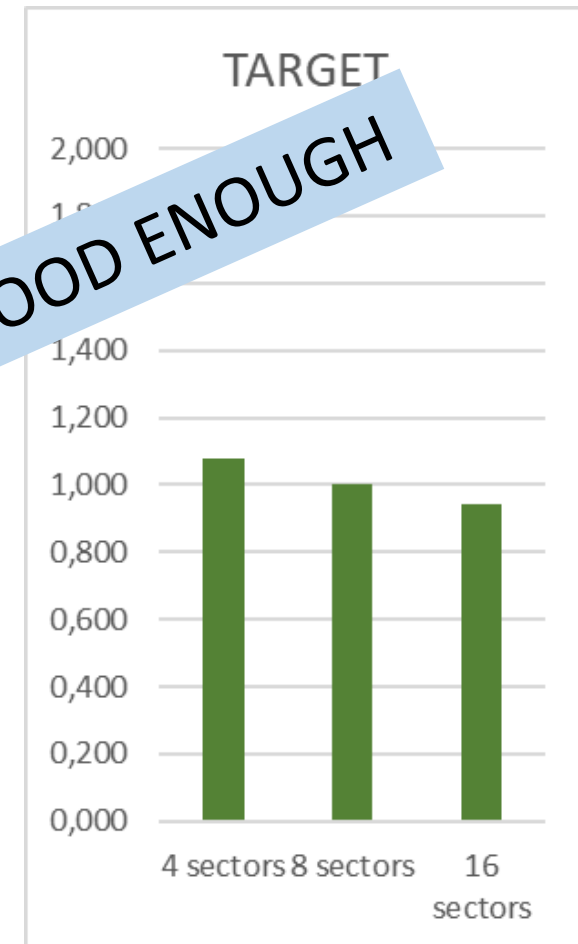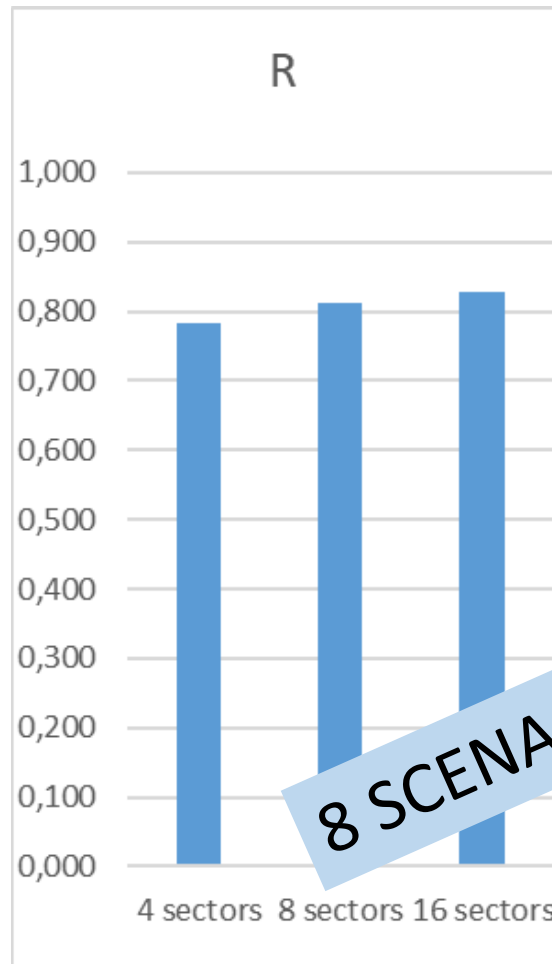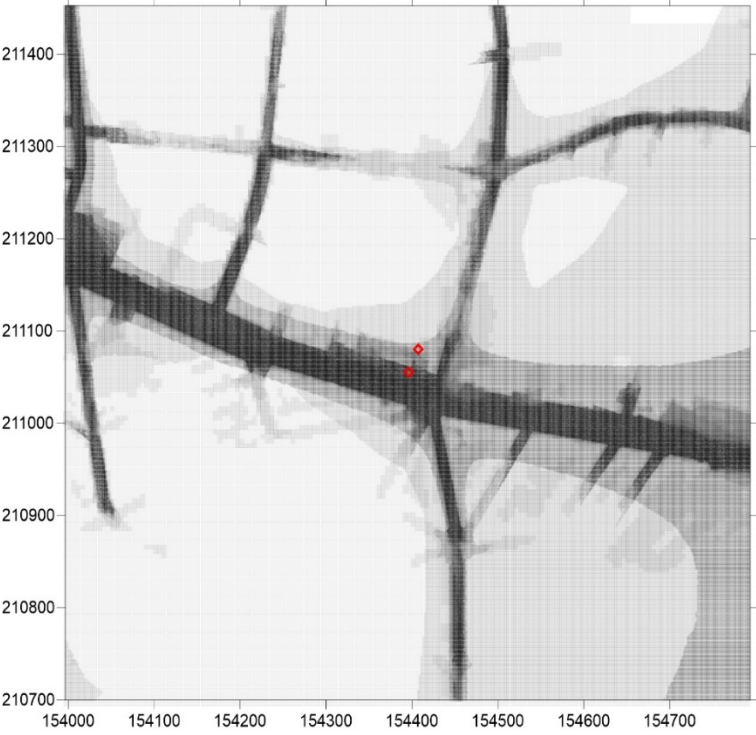

8 SCENARIO SIMULATIONS SEEMS TO BE GOOD ENOUGH

How different are the LV exceedance areas?
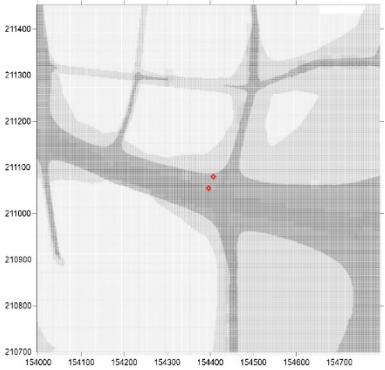
Annual Limit Value for NO₂ (40 μg/m³):
Model ensembles

How different are the spatial representativeness areas?
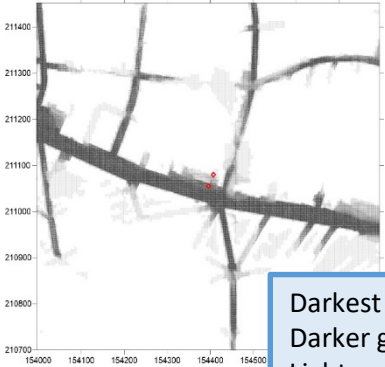
Traffic station (20% tolerance):
Model ensembles

Darkest grey ➔ all models
Darker grey ➔ more models
Lighter grey ➔ less models
White ➔ no models
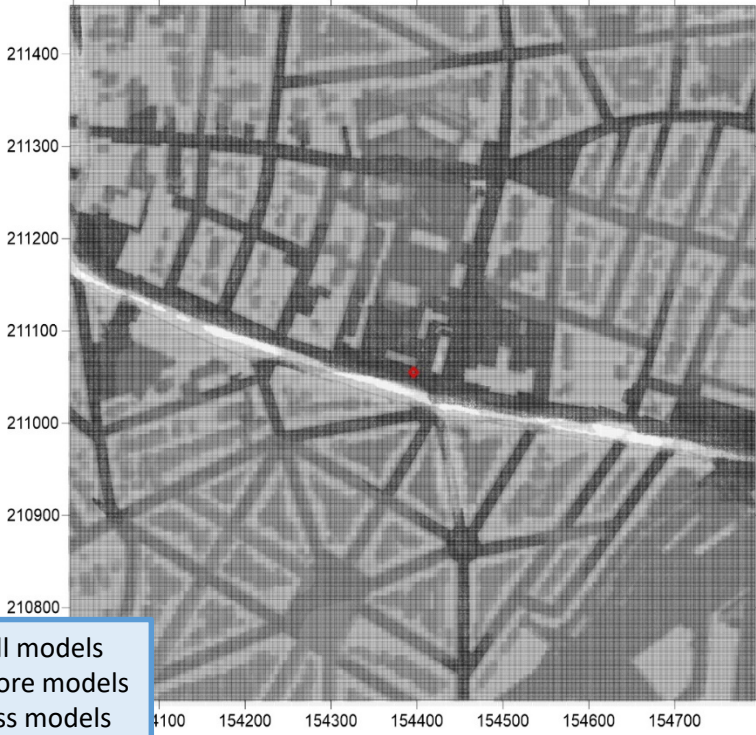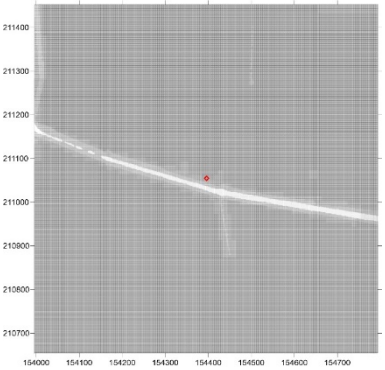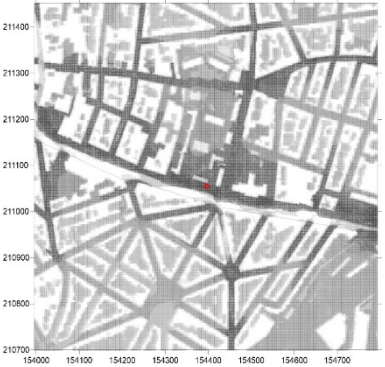
WG4 Conclusions so far…

- Micro-scale models (mainly for NO-Gaussian) are fit for AAQD-purpose

- Spatial patterns (mainly for NO-Gaussian) and time profiles at micro scale can be simulated rather well

- Annual averages can be computed via a wind sector scenarios approach using CFD models or similar:

  - RANS approach seems appropriate for CFD models but need to compare with unsteady long-term simulations

  - 8 wind sectors seems to be a minimum recommended but …

  - Simulation with only one reference wind speed could be sufficient (use the 1/v scaling relation)

  - Annual means derived via the reconstruction of an hourly time series of concentration maps seems to give slightly better results and using PDF distributions of the scenario cases.

  - Other approaches could be explored.

- Good microscale emission data suited for the micro scale are crucial

- Suitable validation data (high resolution in time and space!) is essential for proper model validation

  - Passive samplers are quite good for spatial pattern (dense network needed).

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Future activities and links to AAQD

WG4 Open Questions & Challenges

- Additional testing required to assess the robustness of the yearly aggregation approach
    - Can the minimum number of 8 wind sectors to derive a reliable annual mean be confirmed?
    - Do the needed number of wind sectors or the model/methodology results depend on urban morphology?
    - How to derive other AAQD indicators than the annual average (percentiles related to the limit values)?
- Validation
    - Can we use FAIRMODE MQO for such the evaluation?
    - How many AQ stations do we need for a proper validation at micro scale? Passive samplers? Sensors?
- Further questions/developments
    - How good are microscale models to estimate LV exceedances or spatial representativeness areas?
    - Is inclusion of the NO_X-O_3 chemistry critical? Can it be taken into account?
    - Is an unsteady simulation for a complete year better than the wind sector approaches? Is it worth the (CPU time) effort?
    - Is atmospheric stability important and does it depend on the urban area?

Why WG4 activities are linked to AAQD?

- Focused mainly on urban hot spots. Useful for:
  - Annual AQ assessment:
    - LV exceedances areas,
    - Population exposure
  - Planning for AQ improvement when LV exceedance
  - Forecasting in urban areas
  - Spatial representativeness of urban AQ stations (micrositting of AQ stations)

WG4 2023-2025 roadmap

- **Promote interactions with other FAIRMODE working groups**
- Provide Guidance & Recommendations for micro scale model applications in the context of the AAQD (link with WG8 Spatial representativeness and exceedance indicators)
- Specify requirements for microscale emissions (link with WG7)
- Specify requirements for observation data sets for validation (space & time, link with WG2 & WG6)
- Support planning and design of abatement measures (taking advantage from the annual data, link with WG9)

WG4 2023-2025 roadmap

- **Next steps**
- How good are microscale models to estimate LV exceedances or spatial representativeness areas?
- Test robustness of the wind sector approach for all AAQD indicators (annual avg, percentiles…) and check new approaches
- Understand differences between unsteady full-year simulations vs scenario (wind sector) approach.
- Setup a new intercomparison exercise at a new location (e.g., Gyor)? Or explore more deeply the Antwerp case?
- Preparation of scientific paper for publishing in 2023
- Preparation of a Recommendations/Guidance Document (early 2024)

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THANKS

Open discussion

Questions?