Milestone M33 (M5.5)

Toolbox for AQ models over urban areas

RI-URBANS

Research Infrastructures Services Reinforcing Air Quality Monitoring Capacities in European Urban & Industrial AreaS (GA n. 101036245)

By

KNMI, INERIS, FORTH, FMI, TNO, BSC, MetNO, CSIC & FZJ

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RI-URBANS (www.RIURBANS.eu) is supported by the European Commission under the Horizon 2020 – Research and Innovation Framework Programme, H2020-GD-2020, Grant Agreement number: 101036245

Milestone M33 (M5.5): Toolbox for AQ models over urban areas

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Work package (WP)	WP5: Strategic guidance for upscaling RI-URBANS STs
Milestone	M33 (M5.5)
Lead beneficiary	KNMI
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Reviewed by	WP5 Leaders
Accepted by	Project Coordination Team
Comments	This document summarizes of the main elements of the tools applied for AQ models over urban aeras by showing a number of examples that were shown and discussed in various workshops and project meetings.

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1. About this document

This document summarizes the main elements of the tools applied for Air Quality (AQ) models over urban aeras by showing a number of examples that were shown and discussed in various workshops and project meetings.

This is a public document, available at the RI-URBANS website, https://riurbans.eu/work-package-5/#milestones-wp5, and distributed to all RI-URBANS partners for their use as well as submitted to European Commission as a RI-URBANS milestone M33 (M5.5).

2. Approach

In order to deliver a toolbox for AQ models over urban areas, the following approach has been discussed. Current models, such as the CAMS (Copernicus Atmospheric Monitoring Service) suite generally models on a global scale, and regional scales. Therefore, resolution may, or may not be sufficient to obtain realistic results in urban areas.

At the same time, high-resolution models are under development and under testing on urban scale and in urban areas.

The approach to make a toolbox for AQ models over urban areas that we discussed, relies on the connection of several elements of the RI-URBANS project.

1. WP3 Improving modelling and emission inventories for policy assessment using advanced observation-based methodologies.
2. WP1 Novel metrics and advanced source apportionment Service Tools for PM and nanoparticles, including vertical profiling observations.
3. WP4 Pilot implementations for testing and demonstrating services.

Using these elements, model outputs of various suites of models will be tested against the observations from the pilot studies. In particular the pilots T4.3. and T4.5 that have intensively perused vertical profiling information of atmospheric dynamics and pollution within the urban aeras.

Using these analyses, the validity of the CAMS model suite and the high-resolution models can be assessed.

Moreover, this toolbox shall be useful in formulating recommendations which types of AQ models could be used over urban areas, as well as which types of observations (e.g. from the ACTRIS suite) deployed within the urban area (instead of outside) provide essential information for the assessment of the AQ model output over urban areas.

This toolbox shall also be useful to formulate recommendations for a sustained deployment of (ACTRIS type) of observations in urban areas, in addition to the current AQ monitoring equipment.

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3. Examples

3.1 Example about the different models and their capacities

The goal is to improve urban aerosol particle emission estimations by combining novel measurements and modelling (large-eddy simulation, data assimilation, bottom-up emission models, AQ and dispersion modelling)

3.1.1 SILAM

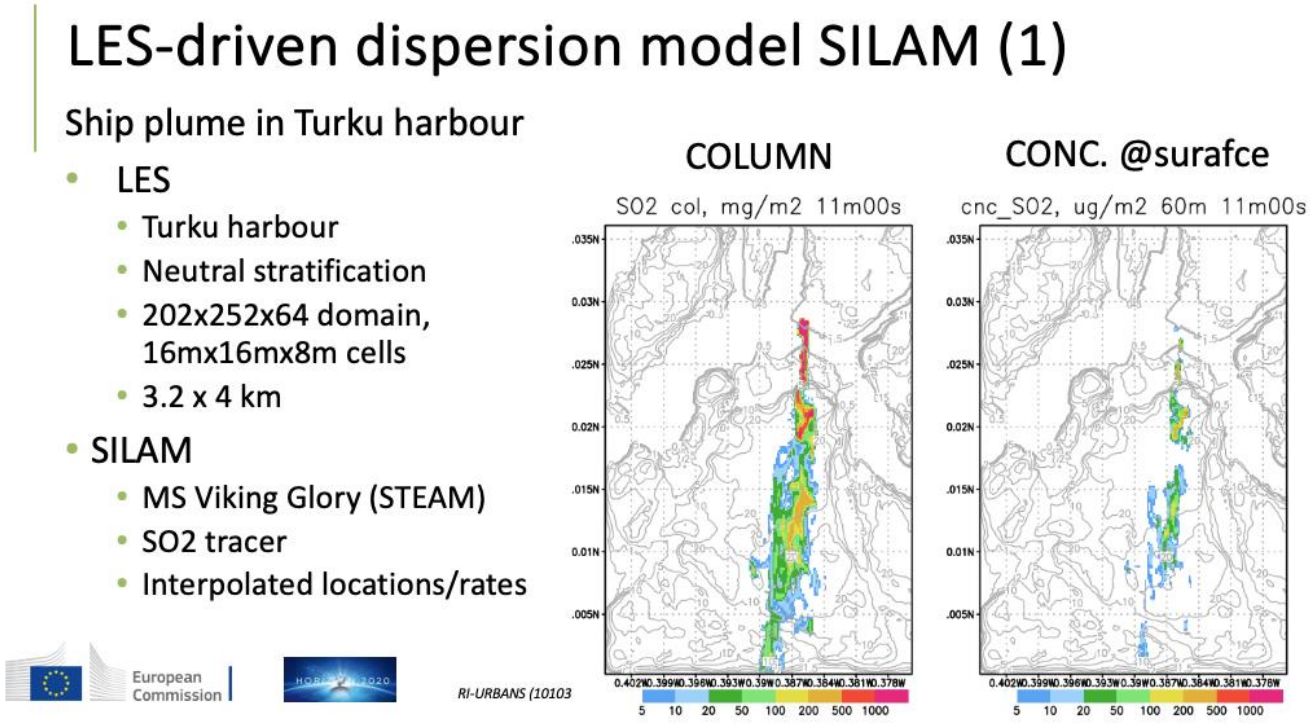

Figure 1. System for Integrated modeLling of Atmospheric coMposition (SILAM))example of a ship plume. Courtesy FMI

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3.1.2 uEMEP

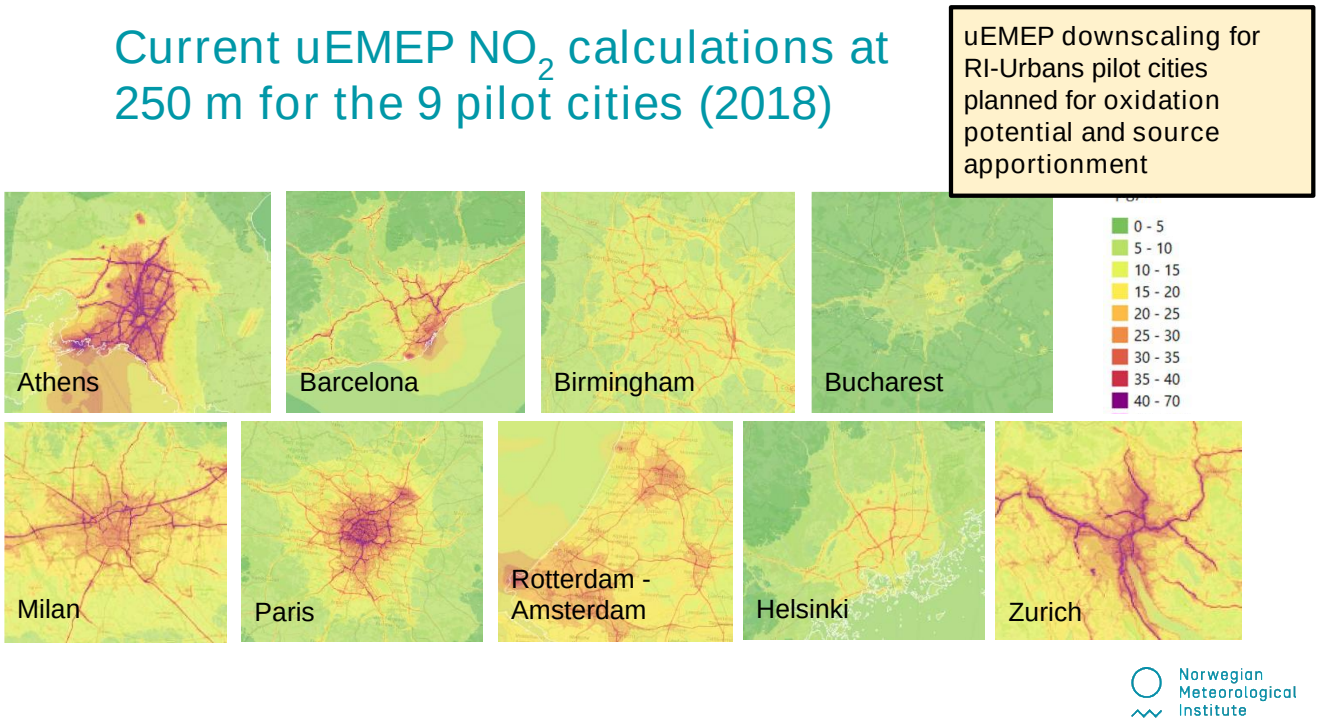

Figure 2. Example courtesy MetNO.

3.1.3. PMCAMx

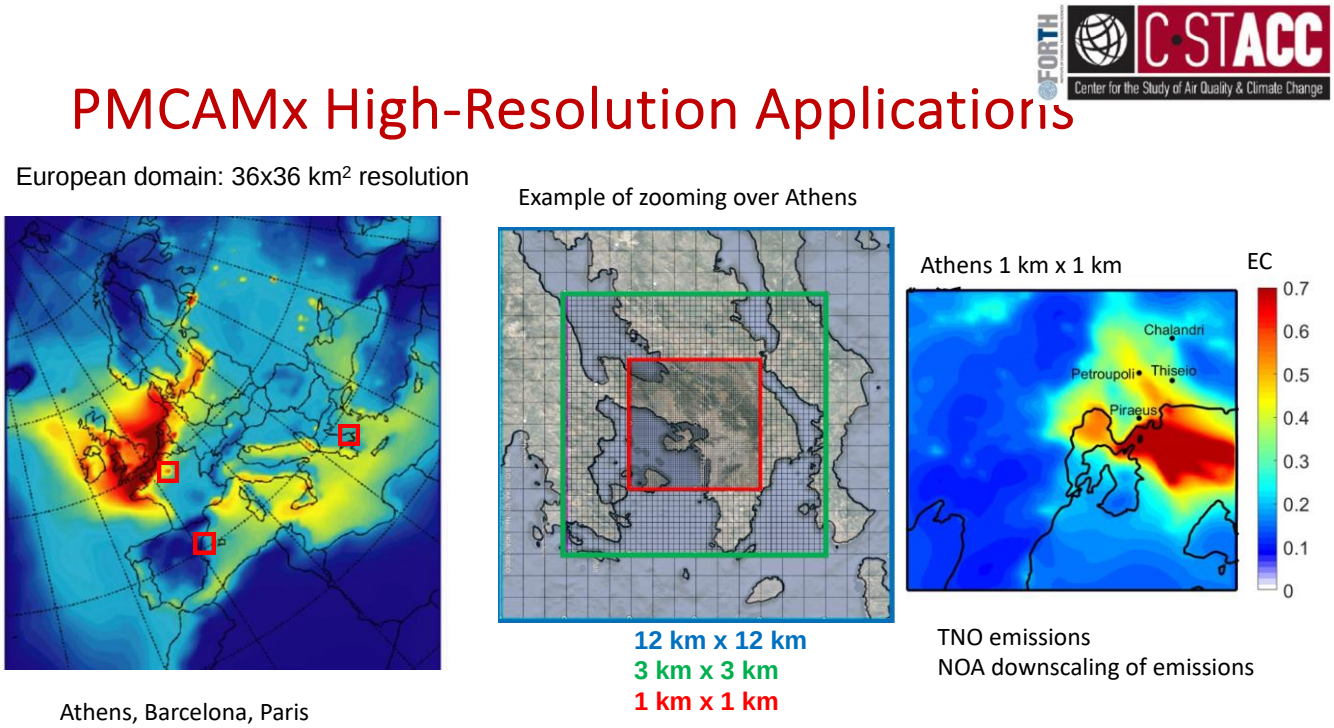

Figure 3. Example courtesy FORTH.

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3.1.4 CALIOPE-Urban

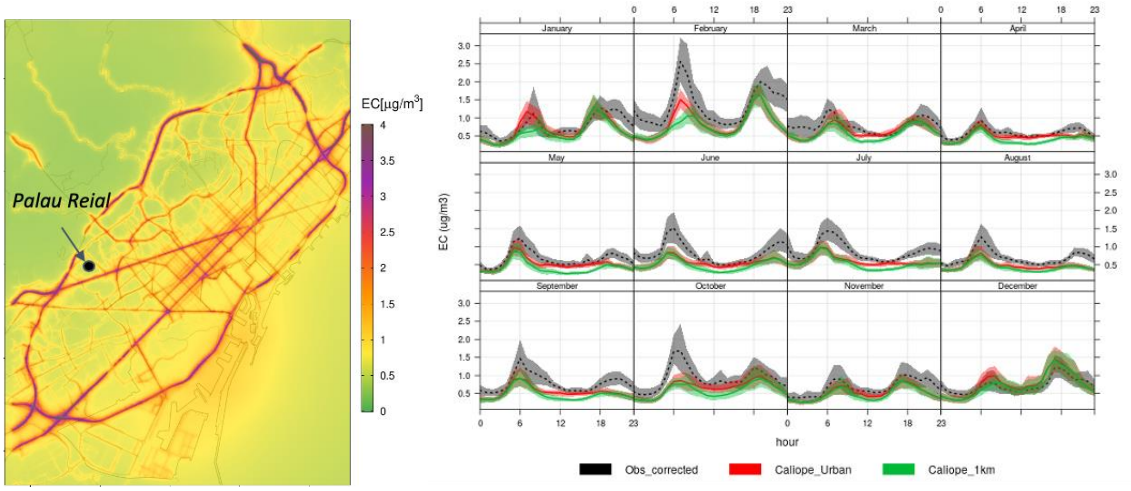

Figure 4. Air quality map of modelled elemental carbon (EC) annual mean concentrations for Barcelona for 2019 at 20m resolution. The concentrations were estimated using the CALIOPE-Urban modelling system (Benavides et al., 2019) and were compared against measurements performed at a urban background station by CSIC.

3.2 Example of new emission inventories

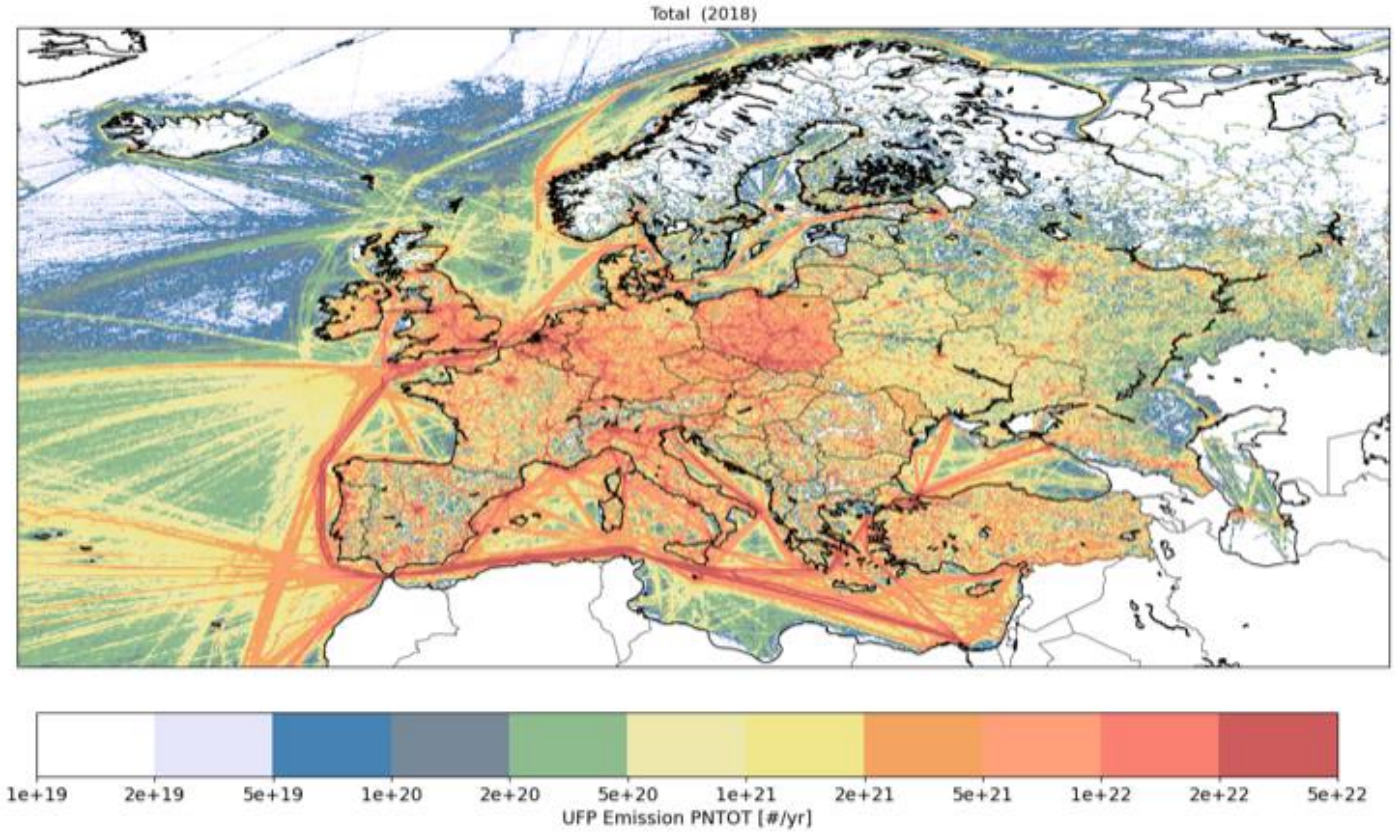

Figure 5. Preliminary results of the RI-URBANS particle number emission inventory for Europe for the year 2018. Courtesy TNO.

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3.3 Example vertical profiling by remote sensing

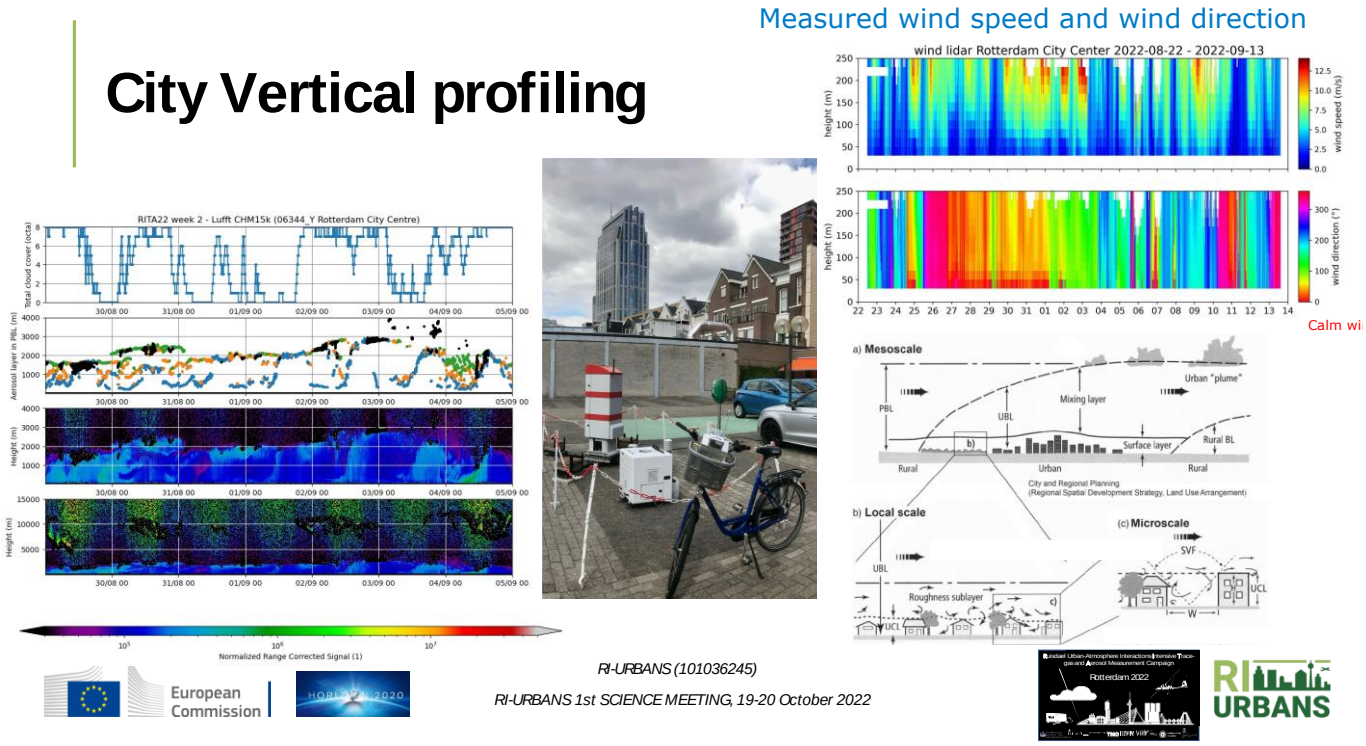

Figure 6. Example of vertical profiling observations with a ceilometer and a Doppller wind lidar within the Rotterdam urban area (courtesy KNMI).

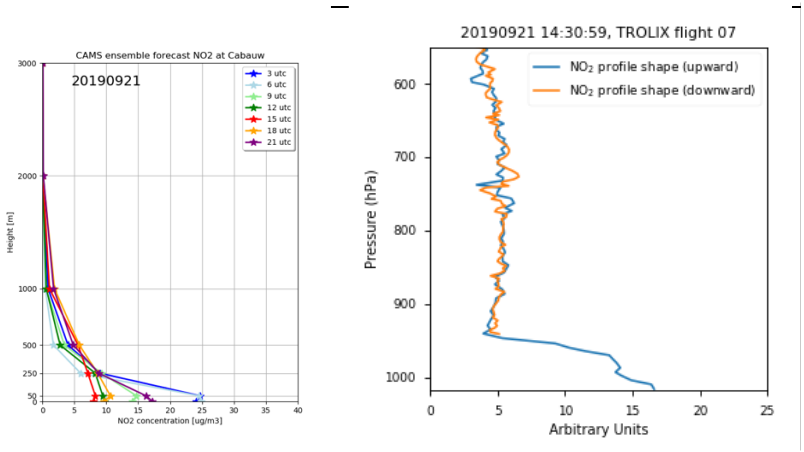

Figure 7. Example of a CAMS ensemble forecast of NO2 profiles over Cabauw (close to Rotterdam) and an NO2 profile observation using a NO2 sonde (courtesy KNMI).

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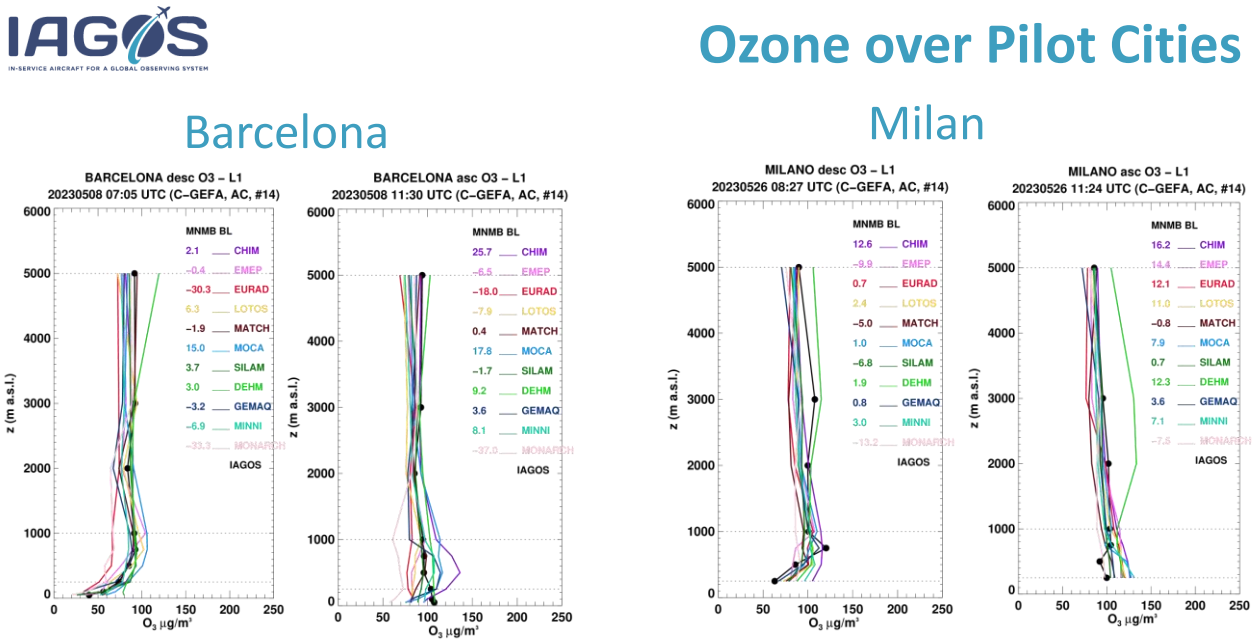
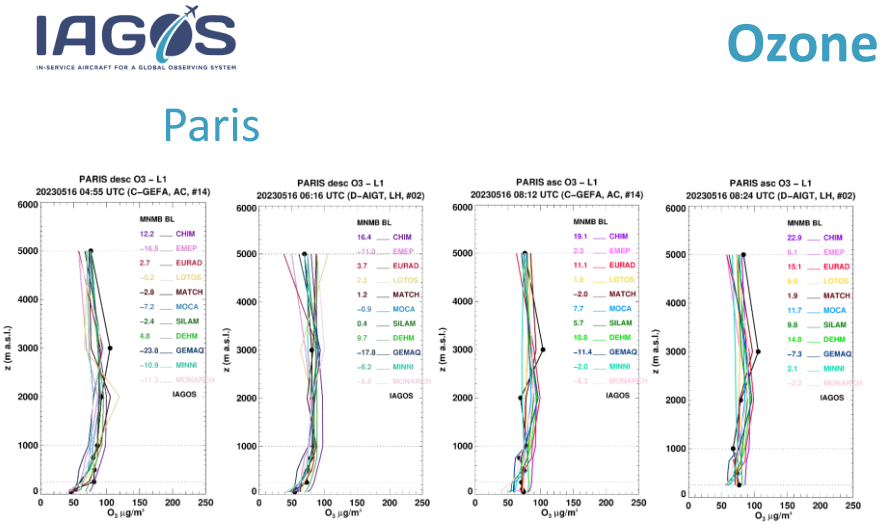
3.4 Example aircraft based vertical profiling observations



increase from 40 to 110µgm^{-3} from 07:05 – 11:30.

increase from 60 to 100µgm^{-3} from 08:27 – 11:24.



Diurnal cycle of ozone: increase from 50 to 70µgm^{-3} from 04:55 – 08:24.

Figure 8. Profiles of ozone measured by IAGOS over the pilot cities Paris, Barcelona and Milan, compared here with the 11 regional European models in the Copernicus Atmosphere Monitoring Service CAMS

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3.5 Example CAMS

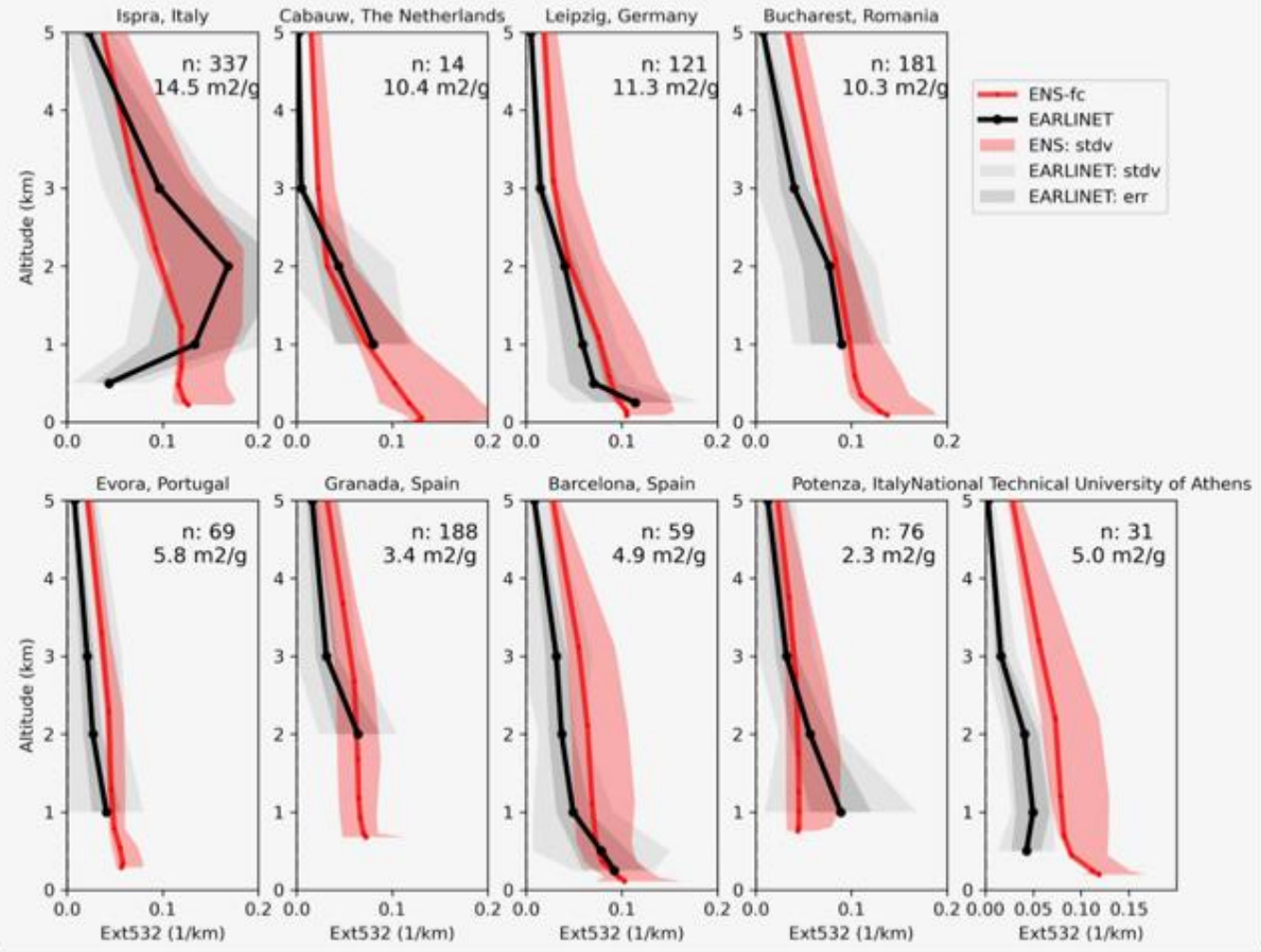

Figure 9. Extinction profiles June - August 2021 derived from the ENSEMBLE forecast mass concentration profiles (red envelope) and from EARLINET (climatology) backscatter profiles (grey envelope: lidar ratio uncertainty, light grey: including sampling error). "n: XX means number of individual EARLINET profiles assembled (June-August 2006-2018). The EMC used for the calculation of the extinction from the concentration profiles is indicated for each station below the number of EARLINET profiles "n" used for the calculation of the climatology.

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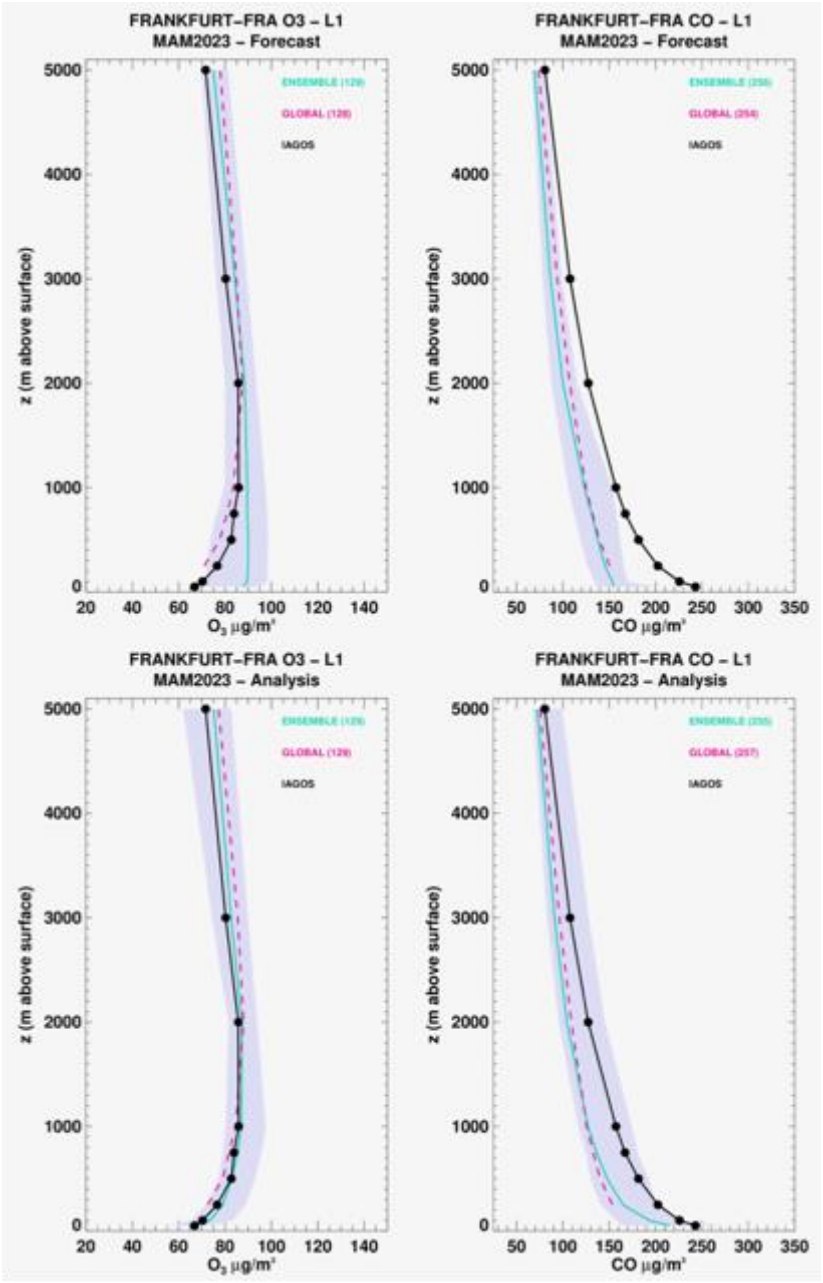

Figure 10. Comparison between forecasts (top) and analyses (bottom) and measured atmospheric ozone (left) and CO (right) concentrations at Frankfurt, averaged for the MAM2023 period. The models are the ENSEMBLE and CAMS-global, while 'IAGOS' (black line) are measurements made by aircraft. The shaded area visualizes the spread among the CAMS regional models (min to max). The numbers in parentheses in the legends indicate the number of takeoffs/landings averaged to produce the profile.

3.5.1 References

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Gauss, M., et al., Quarterly report on the evaluation of the ENSEMBLE NRT productions (daily analyses and forecasts) March 2023 - April 2023 - May 2023; Date: July 27, 2023;

CAMS283 2021SC2 D83.1.4.1-2023Q2 202307 ENSEMBLE EQC Report v1.pdf.

3.6 Example citizen observations

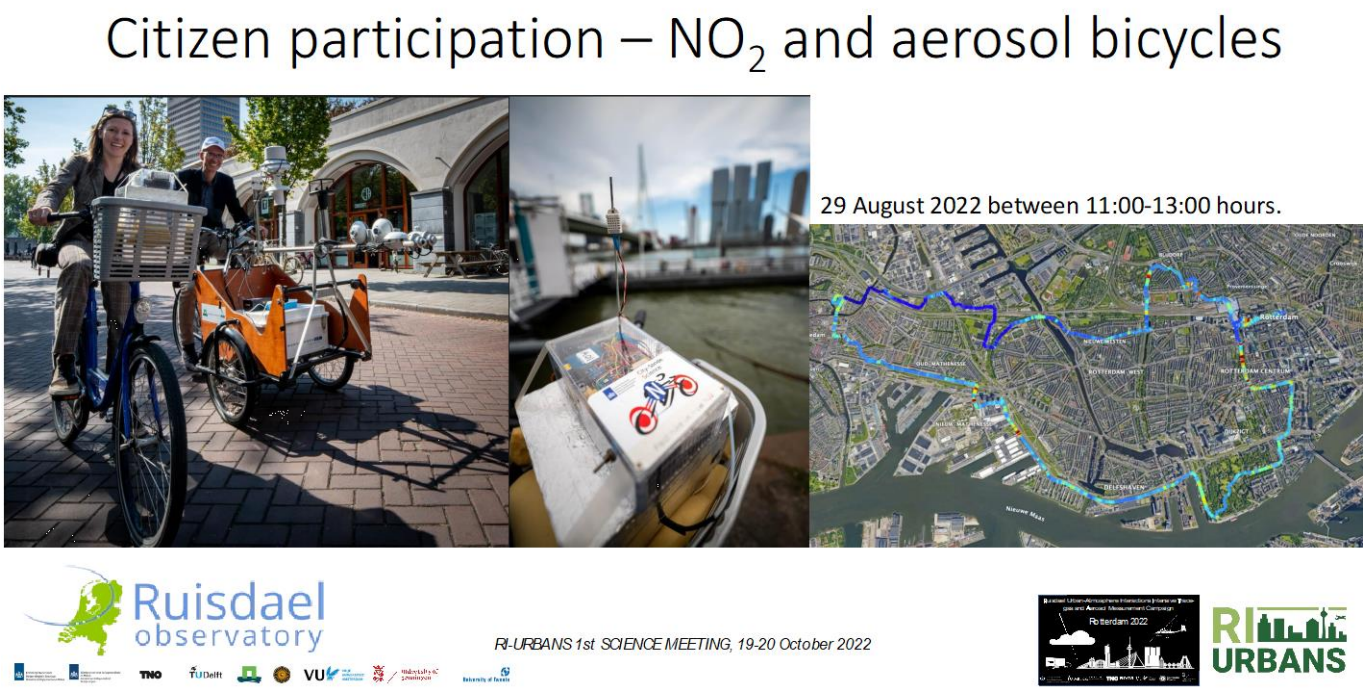

Figure 11. Example of city observations involving citizen participation (courtesy KNMI).

4. Conclusions

Various examples of tools applied for high resolution modelling over urban aeras have been shown, addressing different cities, as well as different species. It was also shown that the methods applied are supported by observations at fixed ground based stations, mobile observations and vertical profiling observations. These ingredients are part of the toolbox that is applied over urban areas.

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