INFLUENCE OF NO_2 - O_3 URBAN BACKGROUND ON NITROGEN DIOXIDE CONCENTRATION NEAR ROADWAY SOURCES IN BARCELONA CITY (SPAIN)

Jaime Benavides, Marc Guevara, Carlos Pérez García-Pando, Albert Soret and Oriol Jorba Earth Sciences Department, Barcelona Supercomputing Center, BSC-CNS, Barcelona, Spain
Michelle Snyder Institute for the Environment, The University of North Carolina, Chapel Hill, NC, USA
Fulvio Amato and Xavier Querol Institute of Environmental Assessment and Water Research, IDAEA-CSIC, Barcelona, Spain

> Introduction

In this work, we introduce the upwind urban background scheme that provides background concentrations using CMAQ depending on the wind speed and direction avoiding double counting emissions and using CMAQ outputs without need to re-run the model. We combine observations and upwind urban background scheme results to analyse NO_2 and O_3 background influence on urban NO_2 in the Barcelona city.

> Methodology

CALIOPE

CALIOPE is a mesoscale air quality modelling system that provides 48 hour air quality forecasts at 12 km horizontal resolution over Europe, 4 km over Spain and 1 km over urban areas (e.g. Barcelona city). It integrates the Weather Research and Forecasting meteorological model (WRF), the High-Elective Resolution Modelling Emission System (HERMES), the Community Multiscale Air Quality Modeling System (CMAQ) and the mineral Dust REgional Atmospheric Model (BSC-DREAM8b).

Upwind urban background scheme

To avoid double counting traffic emissions in CMAQ and R-LINE and to take into account mesoscale meteorological patterns, a new method is under development. The upwind urban background scheme makes a selective choice of CMAQ cells as sketched below. This method is inspired by Berkowicz (2000).

For each hour, a polygon covering air masses retro trajectory (white) is created. Grid cells values are averaged to produce the background estimate.

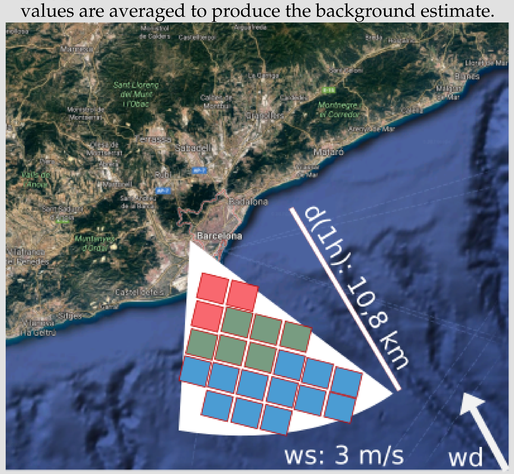


Figure 1: Upwind urban background scheme concept. Squares represent CMAQ cells. White polygon covers air masses retro trajectory. wd is wind direction.

Observations

Ambient street-level pollutant and meteorological measurements collected during a field study in April 2013 within the structured grid of Eixample neighborhood (Amato et al. 2014) are used to explore contributions to urban NO_2 in combination with observations from the official network. This period presents an air quality episode from the 12th to 18th April.

> Results

Influence of background NO_2 - O_3 on urban NO_2 using model and observations

The upwind urban background scheme selects CMAQ cells depending on wind conditions leaving out the cell over the estimated area, to avoid double counting.

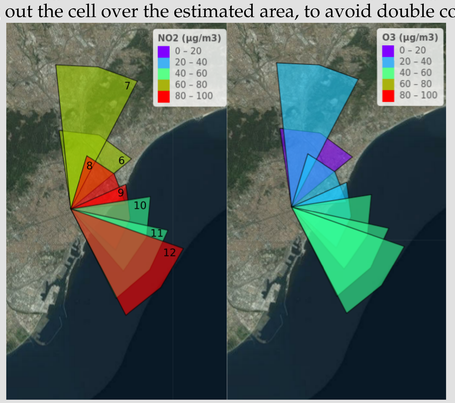
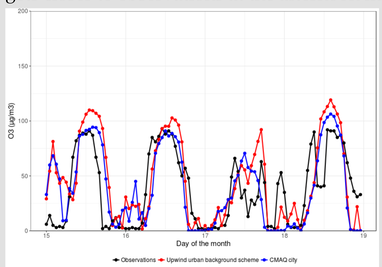


Figure 2: NO_2 and O_3 background for 17/4/2013 from 6 am to 12 pm (UTC). Triangular shapes represent scheme polygons for each hour, colors are background levels and numbers are time of the day. We can see north eastern winds entering from the river basin turning to sea breezes during the afternoon.

The upwind background scheme overestimates O_3 levels at midday as expected. For NO_2 it gets closer to observations at the afternoon minimum compared to CMAQ over the city.



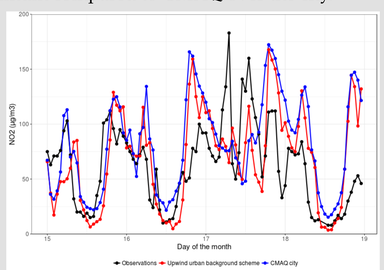


Figure 3 and Figure 4: O_3 and NO_2 background levels at Ciutadella background station (black line), upwind background scheme (red) and CMAQ values over the city (blue), from 15th to 18th April 2013 over Carrer Valencia No. 455, a site of the experimental campaign. This period represents background levels during the air pollution episode.

> References

Amato, F., Karanasiou, A., Cordoba, P., Alastuey, A., Moreno, T., Lucarelli, F., Nava, S., Calzolai, G., and Querol, X., 2014. Effects of Road Dust Suppressants on PM Levels in a Mediterranean Urban Area. Environmental Science and Technology, 77, pp.8069-8077.
Berkowicz, R., 2000. A simple model for urban background pollution. Environmental Monitoring and Assessment, 65, pp.259-267.
Snyder, M.G., Venkatram, A., Heist, D.K., Perry, S.G., Petersen, W.B. and Isakov, V., 2013. RLINE: A line source dispersion model for near-surface releases. Atmospheric environment, 77, pp.748-756.

> Results (con't)

Hourly NO_2 levels produced by R-LINE using GRS chemistry and local meteorology given different options of background concentration input. NO2 background has a marked influence in urban NO_2 results temporal pattern.

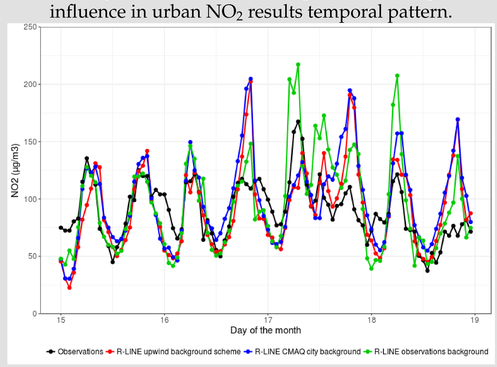


Figure 5: Hourly NO_2 levels given different options of background concentration input: upwind urban background scheme (red), CMAQ over city (blue) and Ciutadella Park background station observations (green). The simulation is run over Carrer Valencia No. 455 site, a highly trafficked street, during the same period (15th to 18th). NO_2 background has a marked influence on model results temporal pattern. For instance, on the 17th at 7h R-LINE using background observations (green) gives a morning peak overestimation directly related to the high peak found at the same time in Ciutadella Park observations in Figure 4. The afternoon minimums are better represented by R-LINE using upwind background scheme and this configuration slightly improves peak results compared to R-LINE using CMAQ city as background.

> Conclusions

A method to estimate background concentrations using CMAQ, the upwind urban background scheme, has been introduced. CMAQ grid cells are chosen depending on wind conditions, tracing air masses retro trajectory. The scheme avoids double counting emissions and provides background concentrations to urban models without re-running CMAQ.
Scheme results show its ability to inject O_3 from outside the city on the afternoon with moderate winds. In addition the scheme provides more precise estimates of afternoon background levels compared to using a CMAQ grid cell falling over the city as background. However, on its current state of development morning and evening peak values are still similar to CMAQ over the city.
The results show that in cities with a high vehicle density with a majority of vehicles being diesel as Barcelona, urban background NO_2 highly influences urban NO_2 concentration levels.

> Acknowledgements

BSC researchers acknowledge the grants CGL2013-46736-R, CGL2016-75725-R and COMRDI15-1-0011-04 of the Spanish Government. Jaime Benavides PhD work is funded with a grant from the FPI Programme by the Spanish Ministry of the Economy and Competitiveness, call 2014, with reference EEBB-I-17-12296.
This methodology is implemented as part of the CALIOPE-URBAN project. Additional results will be presented in CALIOPE-URBAN: COUPLING R-LINE WITH CMAQ FOR URBAN AIR QUALITY FORECASTS OVER BARCELONA by Jaime Benavides at 9:10am on Wednesday 10/25/2017.