THE ROLE OF TRANSBOUNDARY AIR POLLUTION OVER GALICIA AND NORTH PORTUGAL AREA

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ABSTRACT

In summer, high levels of ozone are frequently measured at both Galicia and Northern Portugal air quality monitoring stations, even exceeding the limit values imposed by the European legislation for the protection of human health. The occurrence of these photochemical episodes may be related to the local scale production or the regional scale transport from other polluted regions. Moreover, in remote monitoring sites long-range transport has an important contribution to the measured ozone levels. In this context, this work aims to investigate the origin of the referred ozone concentrations by the application of a chemical transport modelling system over the North-western area of the Iberian Peninsula, covering Galicia and the North of Portugal. For this purpose, the CHIMERE air quality modelling system was selected for a high resolution (3x3 km^2) simulation of selected air pollution episodes occurred simultaneously in Galicia and North Portugal, in order to study both the contribution of local emission sources and the influence of transboundary pollution over the region under study. Emission inputs have been ed7iodrt oseutio thnha ee cthe o th Portqes an GalinRTH

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site) and Galicia (Louseiras site), respectively; whereas the last one, from 10^{th} to 12^{th} August 2007, reaching 233 and 163 g/m^3 (Portugal) and O Saviñao (Galicia), respectively.

2.2 Meteorological input

The WRF-ARW meteorological model v3.2 (Skamarock et al., 2008) provides the meteorology fields required by the CHIMERE chemical transport model. The meteorological model was configured with 29 vertical layers, and 3 one-way nested domains (Figure 1) with horizontal resolutions of 27, 9 and 3 km. Other model settings include the Asymmetric Convective Model (ACM2) boundary layer scheme, the Kain-Fritsch cumulus scheme (outer and medium domain), WSM 3-class microphysics scheme, a RRTM longwave and Dudhia shortwave radiation scheme, and a Pleim-Xiu soil model. The NCEP (National Center for Environmental Prediction) GFS analysis with horizontal resolution of 1^o x 1^o and 3-hour time resolution were used to develop the initial and lateral boundary conditions. Elevation and land cover data were provided by the digital terrain model from the United States Geological Survey (USGS, 2008).

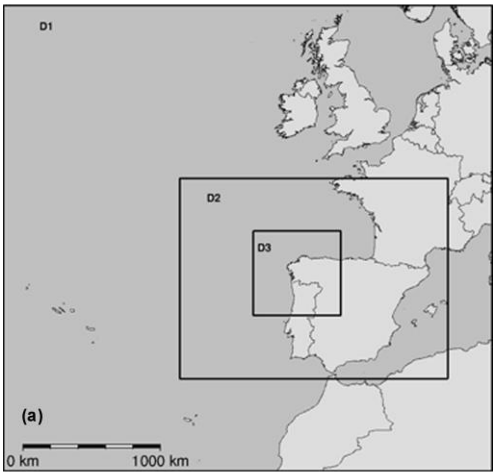

Figure 1. Meteorological and air quality simulation domains. D1, D2, and D3 are the meteorological WRF domains whereas domains D2 and D3 matched up with the CHIMERE domains.

2.3 Emissions input

The emissions input was developed through the combination of both top-down and bottom-up strategies, based on EMEP emission data and other emission data sources (regional PRTR, LRTAP and statistical information). Over D2 domain (outside D2 domain), the 2008 EMEP emission inve

Portugal and Galicia, with 3x3 km^2 grid resolution (see Figure 1). The CHIMERE model was applied over the 1-15th August period, with daily nesting simulations.

3. RESULTS AND DISCUSSION

3.1 Validation of WRF model

For the evaluation of WRF model simulation, hourly surface observations (2-m temperature and 10-m wind speed) available at twenty meteorological sites over the study area have been compared with the simulated results. The model performance has been evaluated applying a statistical analysis based on mean bias (MB), mean absolute gross error (MAGE) and root mean square error (RMSE) for each station. Results of hourly 2-m temperature and 10-m wind speed are shown in table 1.

Table 1. Comparison of benchmarks goals proposed by Emery (2001) and simulation results of mean bias MB, mean absolute gross error MAGE and root mean square error RMSE of hourly 2-m temperature and 10-m wind speed for meteorological simulation of the high-O_3 episode (August 2007, 1st-14th). Hourly data from 20 meteorological surface sites.

1-14 August 2007	MB	MB Goals	MAGE	MAGE Goals	RMSE	RMSE Goals
2-m temperature (K)	-0.759	-0.5 < MB < 0.5	1.768	< 2	2.268	N.P.
10-m wind speed (ms^{-1})	-0.010	-0.5 < MB < 0.5	1.445	< 2	1.861	< 2

N.P.: No goal was proposed by Emery (2001).

To bring the preceding statistics into perspective, the benchmarks proposed by Emery (2001) were used: MB, MAGE and RMSE wind statistics fall within the benchmarks goals, and also MAGE goal for temperature. However, temperature MB goal is not accomplished, as temperature is sometimes underestimated by the model. This deviation in MB for temperature is mainly due to the underestimation of the daily minimum temperatures: the model cannot accurately simulate the temperatures at night, especially the existence of thermal elevations. However, this problem affects more the lowest values of ozone than the ozone maxima, so this deviation does not invalidate the meteorological simulation as input to this air quality simulation.

3.2 Analysis of CHIMERE model results

The simulation of one of the relevant episodes identified previously   4th August 2007   confirms the occurrence of high O_3 concentrations over the Porto Litoral area, with values superior to 80 ppb (Figure 2).

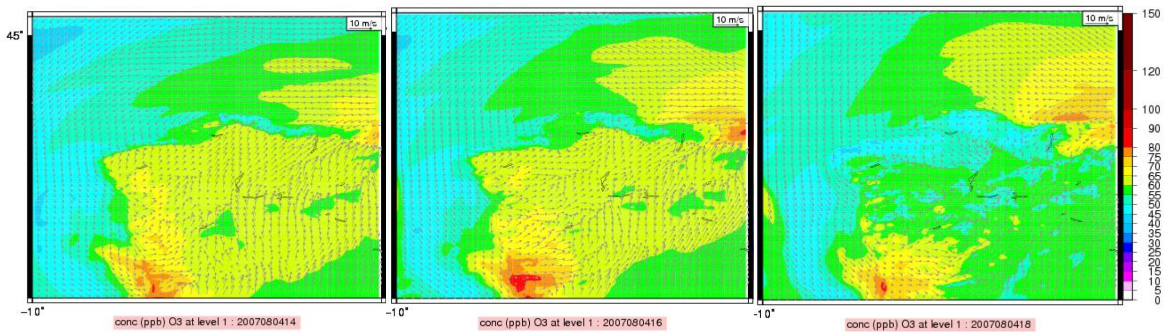

Figure 2. Wind (m.s^{-1}) and O_3 concentration (ppb) surface fields simulated for D3, at 14, 16 and 18 UTC in August 4th, 2007.

The joint analysis of both wind circulation and O_3 concentration indicates that transport of this pollutant from the Portuguese north coast area to Galicia region occurred. This transport starts at 12 UTC due to the prevailing south-southwest wind synoptic pattern and is forced to the northwest during the afternoon. These results help to understand that the O_3 episode has its origin on the urban and industrialized north coastal area of Portugal and the transport of this secondary pollutant to the north   northwest is the main responsible for the concentrations above 60 ppb observed in Galicia air quality stations.

4. CONCLUSIONS

This work aims to investigate the source of O_3 episodes that occurred simultaneously in North of Portugal and Galicia region. Air quality time series data from monitoring sites located in both regions were analysed in order to select potential case studies episodes. One of the most relevant episodes was simulated using the WRF-CHIMERE modelling system with high-resolution and adjoining both national/regional emission inventories. Modelling results evidence the role of the transboundary transport over the two neighbour regions/countries, indicating that the episode has its origin over the urban and industrialized area of North coast of Portugal and due to the south-southwest synoptic pattern transported over Galicia region, where lower concentrations, but still high, were observed.

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6. REFERENCES

Bessagnet, B., Hodzic, A., Vautard, R., Beekmann, M., Cheinet, S., Honoré, C., Liousse; C., Rouil, L. 2004. Aerosol modeling with CHIMERE - preliminary evaluation at the continental scale, Atmospheric Environment, 38, 2803-2817.

Borrego, C., Miranda, A.I., Coutinho, M., Ferreira, J., Carvalho, A.C., 2002. Air quality management in Portugal: example of needs and available tools. Environmental Pollution 120, 115-123.

Carvalho A., Monteiro A., Ribeiro I., Tchepel O., Miranda A.I, Borrego C., Saavedra S. , Souto J.A. , Casares J.J. 2010. High ozone levels in the Northeast of Portugal: analysis and characterization. Atmospheric Environment. 44, 8, 1020-1031.

CEIP EMEP Centre on Emission Inventories and Projections. Officially reported emission data 2008. http://www.ceip.at/ (last accessed 18/Dec/2011)

EEA European Environment Agency 2009. Chapter 7: Spatial Emissions mapping. EMEP/EEA air pollutant emission inventory guidebook - 2009. Technical report No 9/2009.

Emery, C.A. 2001. Enhanced meteorological modeling and performance evaluation for two Texas ozone episodes. Prepared for the Texas Natural Resource Conservation Commission, by ENVIRON International Corporation.

Flocas, H., Kelessis, A., Helmis, C., Petrakakis, M., Zoumakis, M., Pappas, K. 2009. Synoptic and local scale atmospheric circulation associated with air pollution episodes in an urban Mediterranean area. Theoretical and Applied Climatology 95, 265-277. doi:10.1007/s00704-008-0005-9.

Monteiro, A., Vautard, R., Borrego, C., Miranda, A.I., 2005. Long-term simulations of photo oxidant pollution over Portugal using the CHIMERE model. Atmospheric Environment 39, 3089-3101.

Saavedra, S., Rodríguez, A., Souto, J.A., Casares, J.J., Bermúdez, J.L., Soto, B. 2012. Trends of Rural Tropospheric Ozone at the Northwest of the Iberian Peninsula. The Scientific World Journal (in press).

Schmidt, H., Derognat, C., Vautard, R., Beekmann, M. 2001. A comparison of simulated and observed ozone mixing ratios for the summer of 1998 in western Europe. Atmospheric Environment 35, 2449-2461.

Shi, C., Fernando, H.J.S., Jie Yang, J. 2009. Contributors to ozone episodes in three U.S./Mexico border twin-cities. Science of the Total Environment 407, 5128 5138.

Skamarock, W.C., Klemp, J.B. 2008. A time-split non-hydrostatic atmospheric model for weather research and forecasting applications. J. Comput. Phys. 227, 3465-3485.

USGS, 2008. U.S. Geological Survey, Technical report U.S. Geological Survey. http://www.usgs.gov (November 2008).