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A modelling case study to evaluate control strategies for ozone reduction in Southwestern Spain

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Ozone is a strong oxidant and when certain concentrations are reached it has adverse effects on health, vegetation and materials. With the aim of protecting human health and ecosystems, European Directive 2008/50/EC establishes target values for ozone concentrations, to be achieved from 2010 onwards.

In our study area, located in southwestern Spain, ozone levels regularly exceed the human health protection threshold defined in the European Directive. Indeed, this threshold was exceeded on 92 days in 2007, despite the fact that the Directive stipulates that it should not be exceeded on more than 25 days per calendar year averaged over three years. It is urgent, therefore, to reduce the current ozone levels, but because ozone is a secondary pollutant, this reduction must necessarily involve limiting the emission of its precursors, primarily nitrogen oxides (NOx) and volatile organic compounds (VOC).

During the central months of the year, southwestern Spain is under strong insolation and weak synoptic forcing, promoting the development of sea breezes and mountain-induced winds and creating re-circulations of pollutants. The complex topography of the area induces the formation of vertical layers, into which the pollutants are injected and subjected to long distance transport and compensatory subsidence. The characteristics of these highly complex flows have important effects on the pollutant dispersion. In this study two ozone pollution episodes have been selected to assess the ozone response to reductions in NOx and VOC emissions from industry and traffic. The first corresponds to a typical summer episode, with the development of breezes in an anticyclonic situation with low gradient pressure and high temperatures, while the second episode presents a configuration characteristic of spring or early summer, with a smooth westerly flow and more moderate temperatures.

Air pollution studies in complex terrain require the use of high-resolution models to resolve the complex structures of the local flows and their impact on emissions; nevertheless, these mesoscale systems are developed within the scope of a synoptic circulation, which also affects both the breeze development and the pollutant transport. In order to take the relationship between the different atmospheric scales into account, we used the CAMx photochemical model coupled with the MM5 meteorological model, both configured with a system of nested grids. The study domain covers an area of $28224\ km^2$, with $2\ km$ horizontal resolution and 18 vertical layers up to a height of $5\ km$ with high resolution in the levels close to the ground.

This paper assesses the impact over the hourly and 8-hourly maximum daily ozone concentrations of four reduction strategies in an area with complex terrain: (i) 25% reduction in VOC and NOx from industry and traffic, (ii) 50% reduction in NOx and VOC from the industry, (iii) 50% reduction in NOx and VOC from traffic, and (iv) 100% reduction in NOx and VOC from the petrochemical plant and the refinery. The study area has large industrial sources, such as a petroleum refinery, a petrochemical plant, several chemical complexes and co-generation power plants, among others. The study area includes the cities of Huelva (148,000 inhabitants), Seville (699,760 inhabitants) and Cadiz (127,200 inhabitants). The analyses presented in this work provide an assessment of the effectiveness of several strategies to reduce ozone pollution in different meteorological scenarios.