Atmospheric Environment 43 (2009) 4194–4204

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Simulation and evaluation of 2010 emission control scenarios in a Mediterranean area

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A R T I C L E I N F O

Article history:
Received 13 February 2009
Received in revised form
18 May 2009
Accepted 19 May 2009

Keywords:
Emission scenario
Model
ESCOMPTE
Ozone
Environmental policy
Mediterranean area

A B S T R A C T

At the onset of the 2010 statutory deadline for the respect of the European National Emission Ceiling directive, two questions arise. Will the engaged regulations for the respect of ozone air quality thresholds be fully efficient on the most polluted regions? How can we design the continuation of ozone control in those areas? This study is based on refined 3D modelling studies over a French Mediterranean region. It compares 2001 and 2003 situations with several prospective 2010 emission scenarios with, for the first time, the evaluation of local action plans. The degree of compliance with air quality regulation is investigated and the impact of emission control on the local potential for ozone formation is discussed. The results show that current efforts on emissions, although substantial and efficient, are not sufficient yet to abrogate all the ozone threshold exceedances. They also highlight the gap between regulatory and effective emission control, as well as the need for regional regulations to complete national efforts. Finally, the simulations indicate that large-scale emission control significantly helps reducing rural ozone (−20 ppbv) but affects much fewer (−2 to −10 ppbv) the highest peaks. The continuation and the strengthening of ozone policies under their current form in such regions are considered.

1. Introduction

On the eve of 2010, photochemical pollution remains of great concern in Europe, as the population is frequently exposed to ozone concentrations exceeding the prescribed thresholds (Baldasano et al., 2003; Ribas and Penuelas, 2004). In summer 2006, ground-level ozone levels showed widespread exceedances of the 90 ppbv information threshold, values between 150 and 185 ppbv being attained with one of the highest frequencies since the existence of a dense monitoring network (EEA, 2007a). It is estimated that from 1996 onwards, 13–60% of the urban population in Europe is exposed to ambient O_3 concentrations exceeding the EU target value set for the protection of human health (EEA, 2007b).

From 1990 on, several common action plans have been elaborated to reduce the frequency of ozone episodes above the European continent. The most recent one, elaborated in 1997 by the European Commission, proposed air quality targets for ozone to be attained by 2010. To achieve these environmental objectives, emission control measures were identified from cost-effectiveness analyses and transcribed into National Emission Ceilings (NEC) to be imposed on all Member States (Amann and Lutz, 2000; EU, 1999), with the possibility for local authorities to reinforce national measures via local Plans for the Protection of the Atmosphere (PPA).

Several studies – among which the City-Delta project (Cuvelier et al., 2007) – investigated the potential of those policies for air quality improvement in various European cities. The results indicate that a reduction in the frequency of ozone exceeding threshold was expected from implemented regulations, yet with some regional differences (Thunis et al., 2007; Vautard et al., 2005). But although numerous studies recognized that the substantial reductions in primary pollutant emissions succeeded in reducing ozone hourly peak levels in Europe during the last fifteen years (Derwent et al., 2003, 2007b; Havasi and Zlatev, 2002; Jonson et al., 2001; Kimmel et al., 2002; Kuebler et al., 2001; Szopa et al., 2006), measurements indicate that the ozone baseline level and the daily 8-h maximum still tend to increase with the help of increasing global emissions (EEA, 2007b). Furthermore, a large number of locations in Central and Southern Europe still show some distance to cover before complying with the target ozone values (EEA, 2008). Among them, the case of Mediterranean areas deserve particular attention, as they are submitted to high insulation, elevated temperatures, intense biogenic emissions of volatile organic compounds (VOCs) and sea breeze circulations aggravating local pollution (Gangoiti

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1352-2310/$ – see front matter
doi:10.1016/j.atmosenv.2009.05.034

et al., 2001; Millan et al., 1996; Thunis and Cuvelier, 2000). And it is in those Southern regions that the effective reduction rates in total nitrogen oxide (NO*x*) emissions show up as the smallest in Europe (EEA, 2007c). Eulerian modelling studies (Moussiopoulos et al., 2000; Palacios et al., 2002) investigated the ozone sensitivity to local and large-scale NO*x* and VOC emissions in these areas. However, local specificities (regional plans, evolution of anthropogenic activities) were not investigated, as the works mainly focused on inventories reflecting the strict application of the European directives or a theoretical control of precursor emissions. The reason is principally the difficulty of obtaining realistic and highly resolved 2010 inventories at this scale.

The work presented here focuses on critical Mediterranean areas. It proposes to go further in the evaluation of prospective emission scenarios in Southern Europe. Through the example of a French Mediterranean region, it analyses several possible emission situations for year 2010, including i) the exact NECD transcription ii) realistic projections based on current emission trends, and iii) local specificities such as the respect of prefectorial decrees, which may have significant impacts on emissions. All scenarios are compared with a 2010 socio-economic situation with no engaged regulation. After a presentation of our domain and of the modelling system (Section 2), the 2010 scenarios will be presented (Section 3). Their impact on local ozone formation will be discussed in Section 4. Finally, the conclusions will bring elements to the discussion on the achievement of ozone control after 2010 in polluted areas of Southern Europe.

2. Model description

2.1. Domain of study

The Berre–Marseille region is a coastal Mediterranean site located in the South of France (Fig. 1). It is characterized by intense anthropogenic activities roughly grouped into 2 coastal poles: (i) the Marseille-Aix agglomeration including 1.3 million inhabitants, where road traffic is the most important NO*x* emitter, and (ii) the Fos-Berre industrial area, which is the first pole for chemical industry in Southern Europe and emits a wide variety of VOCs. The inland part of the domain is composed of forested areas associated with high biogenic VOC emissions, which play a key role in the local photochemistry (Lasry, 2006). Finally, the increasingly high mountains toward the North-East limit the dilution of pollutants in the air masses transported inland by the sea breeze.

This region has been the host of the ESCOMPTE field campaign in summer 2001 (http://medias.obs-mip.fr/escompte), that aimed at constituting a database for the evaluation of Chemistry-Transport Models (CTMs): in addition to standard ground-based observations of ozone and NO*x*, supplementary experiments provided information on air mass circulation and on their chemical composition at ground-level, along vertical profiles and in altitude (Cros et al., 2004). It allowed the documentation of 4 Intensive Observation Periods (IOPs), representing 14 days of pollution in June and July 2001. The following research works revealed fast ozone production (Coll et al., 2005) and a strong dependence of ozone upon local urban, industrial and biogenic emitters (Lasry, 2006). They also enlightened the complex air mass circulation resulting from the alternation of the land/sea breeze as a worsening factor of ozone events on this domain (Drobinski et al., 2007; Lasry et al., 2005). Such a combination of parameters makes this area 2–3 times more affected by photochemical pollution than other French regions, with 45–80 days per year exceeding the ozone information threshold (http://www.atmopaca.org).

2.2. Model configuration

Simulations of photochemical episodes have been conducted with the 3D chemistry-transport model CHIMERE (http://euler.lmd.polytechnique.fr/chimere). This model is dedicated to the interpretation of regional-scale measurement campaigns, but also real-

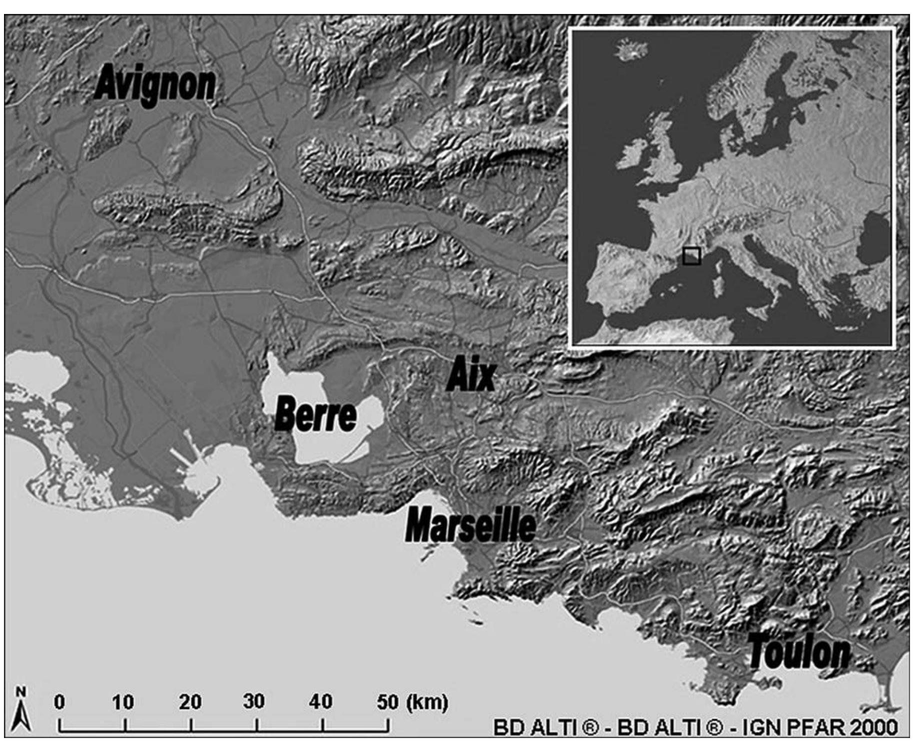

Fig. 1. Domain of the study. The domain is 140 km wide.