Air Pollution VIII, C.A. Brebbia, H. Power & J.W.S Longhurst (Editors)
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Pre-modelling for ESCOMPTE in the Marseille-Fos-Berre area

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Abstract

The ESCOMPTE project (2000-2001) in the Marseille Fos/Berre domain is designed for the development of a consistent data base in this heavily polluted area, with the aim of testing and validating air quality models. This zone displays intense various pollution emission sources due to urban activities in Marseille, heavy industrial activities around the Etang de Berre with the presence of petrochemical and steel factories, together with intense car traffic in the whole region and typical Mediterranean vegetation. In preparation of the main field experiment in 2001, a pre-modelling exercise has been realized to document the dynamic interactions between sea and land breezes with orographic flows over this complex topographical area. This study is carried out using a nesting procedure at local and regional scales using the MESO-NH model (developed by Laboratoire d'Aérologie and MétéoFrance at Toulouse). Tracers emitted at various locations in the Marseille and Etang de Berre areas are followed. Results of such preliminary simulations from July 27 to 30, 1997 and June 24 to 25, 1999 at 15 km, 3km and 1km horizontal resolutions exemplify some typical regional effects. First, the complex topography constrains the circulation of these tracers, secondly the development of coastal winds (breezes) has a significant impact on the pollution plumes propagation in case of weak synoptic winds. Moreover, reduced development of the boundary layer over the sea generates there strong tracer concentrations which, combined with the local circulations previously quoted, can lead to significant concentrations of pollutants at ground level (e.g. between Marseille and Toulon). Various situations have been simulated, related to different synoptic settings at the origin of heavy pollution episodes. These preliminary results make it possible to better understand the dynamics of these pollution episodes over the Marseille area. Chemical simulations will be carried out with the MESO-NH CHEMISTRY model (MESO-NHC).

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1 Pre-modelling tracer studies

1.1 Interests and goals

The purpose of dynamical modelling coupled with tracer emissions is to follow the concentration's evolution of pollutants from their emission sources, considering such tracers as chemically passive pollutants. They thus allow to realize a preliminary study of the Marseille area dynamics, and to display plume circulations in given weather situations favourable for the appearance of heavy pollution episodes. Interpretation of extent of the local phenomena (orographical effects, breezes ...) on the plume development is proposed. From these results, it is possible to optimize the aircraft flight patterns and the geographical distribution of ground measuring stations in order to correctly follow the horizontal and vertical plume evolutions.

1.2 Selected episodes

A few typical periods were selected for 1997 and 1999 for these pre-modelling exercises. This choice was made after analyses of pollution peaks over the Marseille area, the most intense episodes being retained to perform these simulations with tracers. Thus, two periods have been selected for 1997 and three ones for 1999, during the months of June, July and August, the more favourable to ozone threshold exceedences.

1.3 The model and modelling conditions

Simulations during these episodes are realized with the Meso-NH model (Lafore et al.,1998). This model was jointly developed by Centre National de Recherche météorologiques (CNRM/Météo France) and Laboratoire d'Aérologie (LA/CNRS). The Meso-NH model is a non-hydrostatic numerical model applicable to atmospheric motions at the mesoscale. This model relies on a comprehensive physical parametrization package, a set of initialization facilities, either idealized or interpolated from real meteorological analyses. Some of the main characteristics of Meso-NH are its updated description of the surface process with the ISBA scheme (Interaction between Soil Biosphere Atmosphere). It allows for the transport and diffusion of passive scalars (Tulet et al.,1999). The radiative scheme comprises two parts: solar visible radiation after the ECMWF scheme, while the Madronich's scheme is used for UV. Moreover, a deep convection scheme based on the parametrisation of Kain and Fritsch (1990) is also implemented in the model .

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2 Presentation of the simulations

The simulation domain (figure 1) extends over a 240 km x 180 km centered over Marseille. The resolution here is 3km by 3km. The stretched vertical resolution extends over 62 levels up to 14000m. This results in fine resolution of the boundary layer (about 40 m in the first levels). Simulations have been carried out on a larger domain (800 km by 800 km with a resolution of 15 by 15 km) centered over Marseille too, the boundary conditions and initializations being provided by dynamic field issued from the French meteorological operational model Arpege . These simulations results are used to force simulations at smaller scales.

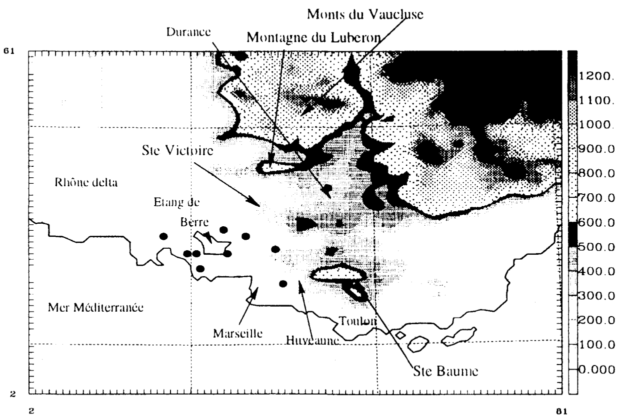

Figure 1: Marseille area (orography in grey shades with values on the right)

2.1 Emissions

Tracers are emitted in the domain at various strongly industrialized zones. Five sources of emissions are thus used for the 1997 simulations (Fos, Martigues, Vitrolles, Marseille and Toulon), a sixth emission zone being added at Aix en Provence for the 1999 simulations. Intensity of these emissions is constant and the same at any emission point.

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2.2 The meteorological situations

2.2.1 The 27-30 July 1997 episode

The weather situation during this episode is initially dominated by a Mistral end period. Then, for July 28 and 29, an anticyclonic situation is established over France and on the Marseille area on July 30. The dynamical model behaviour was validated over this period using observations provided by Météo-France.

2.2.2 The 24-25 June 1999 episode

Weather during these two days is under the influence of an anticyclone centered over North Africa with high sunshine on the Marseille area, particularly during June 24.

3 Simulation results

Interpretation of the simulated fields obtained after simulation is carried out using horizontal sections for visualizing the geographical distribution of the tracers, in fact the concentration data 20 meters above the ground. In order to display dispersion of the tracers in the boundary layer, various vertical sections have been drawn.

3.1 Importance of the orographical constraints

The very hilly topography over the Marseille area has quite a significant incidence on plume development in the presence of weak winds, such as in the case of coastal breezes. Orography imposes strong channeling on plumes, the flow of the pollutants mainly taking place in the valleys. During the simulations such a phenomenon was frequently met.

3.2 Coastal effects

With morning winds from the north before development of the sea breeze circulation, as in the after-mistral event of June 24,1999, plume development initially occurs towards the sea. Then, under the influence of the breeze cell, the tracer flows back to the coast where it is channeled towards Toulon (figure 2). Sea breezes enhancement enables the tracer to flow over the coastal topography.

3.3 Local meteorological effects

One main local effect in this area is due to the cycle of breezes which plays a significant role on the geographical distribution of the pollutants, especially since the industrial and urban areas are located essentially at the coastline. Winds resulting from combination of the synoptic wind and the sea breeze determine the inland plume penetration. Thus, for the two periods presented here, the

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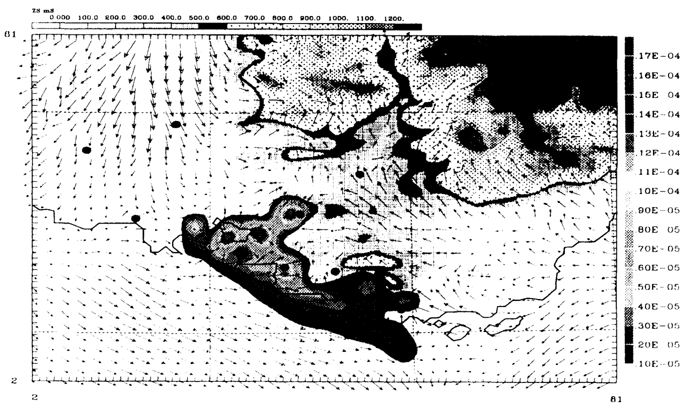

Figure 2 :Tracer penetration in the Durance valley on 24 June 1999, at 15 UTC

situations displayed both similar wind fields directions, however the evolution of the breeze front is less significant in one case than in the other, leading to different plume speed propagations and characteristics. Wind convergence between the mistral end period and development of sea breeze determines the propagation of the tracer plumes. For example, the plume from Marseille will develop towards north and frequently penetrates the Durance valley (figure 3).
On the other hand if the breeze front has a slow progression over land, it constrains the plume to be transfered quickly to the east, along the Huveaune valley towards Fréjus.
Another wind convergence occurs between the sea breeze cell and a lake breeze cell induced over the Etang de Berre. Superposition of these two wind fields involves a breeze front with strong vertical development above l'Estaque, a very industrialized site, with strong pollutant emissions.

3.4 Boundary layer effects

Different evolutions of land and marine boundary layers involve large tracer concentration gradients. It appears on horizontal simulated tracer fields that higher pollutant concentrations are found over marine surfaces before the passage of the front of breeze, these phenomena being mainly observed over the Etang de Berre, west of Marseille.

3.5 Plume evolution according to its source location

The emission representation allows to follow the tracer evolutions from their

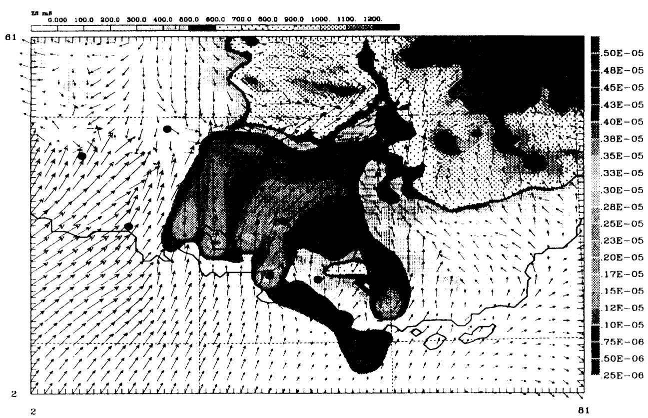

Figure 3 : Tracer penetration in the Durance valley on 24 June 1999, at 15 UTC

source. In spite of reduced distances, between these sources, different distinct plumes are observed (figure 4). For example, concentrations close to the Rhone delta are the weakest due to the influence of strongest northern winds (figure 3). High concentrations are simulated in areas far from emissions sites. Due to wind channeling, several plumes can contribute after convergence to local high concentrations (figure 5).

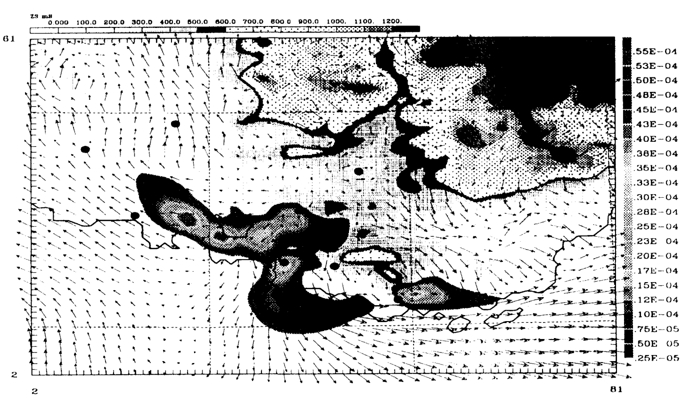

Figure 4:Tracer on 25 June 1999, at 00 UTC

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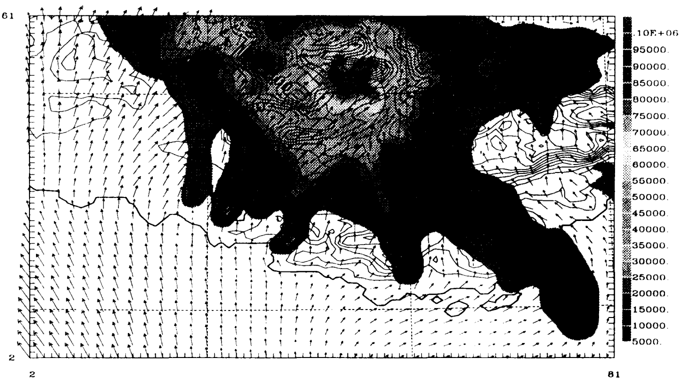

Figure 5 :Tracer vertically integrated on 24 June 1999, at 14 UTC

4 Conclusions

For the Escompte pre-modelling exercise, a few typical high pollution episodes have been selected for 1997 and 1999. We have developed here one of such situations (for June 24-25,1999) which has shown, using wind field computation together with tracer simulations, the complexity of topographic forcing due to combination of sea breezes and orographic channeling. Such simulations have helped to design aircraft flight patterns and implementation of surface stations.

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