Escompte 2001 : multi-scale modelling and experimental validation

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Abstract

ESCOMPTE is a European pollution campaign which took place in the Marseille-Fos/Berre area in summer 2001.This Mediterranean area, with its frequent pollution peaks, is characterized by a complex topography subject to sea breeze regimes together with intense localized urban, industrial and biogenic emission sources. Four IOP have been identified, the most significant being IOP 2a/b, a 6-day complex pollution episode extensively documented with surface networks, aircraft, lidar and radar measurements, constant-level balloon flights, for dynamics, radiation, gas phase and aerosols. A 2-way nested version of the MESO-NH-C meso-scale model (down to 3 km resolution) has been run for IOP 2, forced by meteorological and chemical fields issued from the global MOCAGE model (9 km local resolution near Marseille). Detailed simulations bearing upon dynamical and chemical fields favorably compare to the collected extensive data base.

1 Introduction

Escompte in a European programme designed for the establishment of an exhaustive database for the development and validation of numerical air pollution models (Cros et al, 2003). The region of Marseille / Fos / Berre l'Etang has been selected for this field experiment due to frequent summer photochemical pollution episodes. This pollution, associated with nitrogen oxides and organic compounds emitted by anthropogenic activities and biogenic sources, is caracterized by high ozone level. Four intensives observation periods (IOP) have been documented from June to July 2001, particularly IOP2 from

June 21 to 26, 2001. Days 24 and 25 June have been selected during IOP2, characterized by a south-southwesterly synoptic wind and deep inland penetration of sea breeze.
The Meso-NH-C model has been used, with the chemical scheme ReLACS (Crassier et al, 2000, Tulet et al, 2002) derived from RACM (Stockwell et al, 1997). As a first step, dynamical validation of these days will be presented, using surface stations and aircraft measurements. Then, chemical validation will be done using surface, aircraft and lidar measurements

2 Dynamical study of days 24 and 25 June, 2001

These days are characterized by a south-westerly synoptic flux deeply penetrating inland and driving the industrial and urban pollutant plumes respectively issued from Berre and Marseille, within the Durance valley (fig. 1).

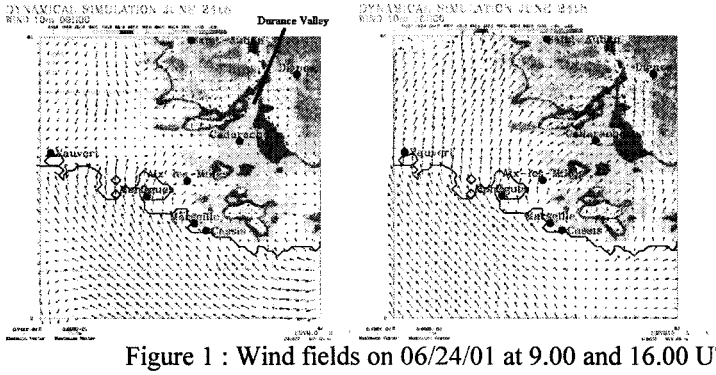

Figure 1 : Wind fields on 06/24/01 at 9.00 and 16.00 UTC

2.1 Comparison with surface measurements.

On June 24, the see breeze begins at 9.00 UTC on the coast (fig. 2) before rapidly extending over the western part of the domain (fig. 3) and then afterwards, over the whole domain. Inland, wind are from the south-west, driving pollution plumes within the Durance valley (fig. 4).

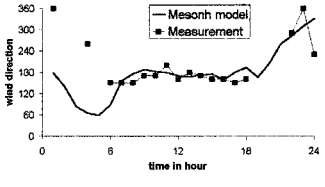

Figure 2: Wind direction at Cassis (06/24/01)

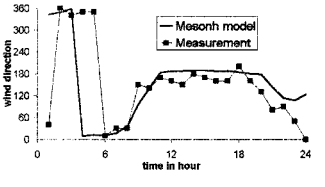

Figure 3: Wind direction at Vauvert (06/24/01)

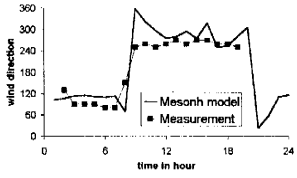

Figure 4 : Wind direction at Saint Auban (06/24/01)

On June 25, the wind field is about the same. In the early morning, weak winds from the north are predominant by inland. At 7.00 UTC, coastal winds are from the south (fig. 5), while at 12.00 UTC, the sea breeze has progressed inland over the whole domain. The flux is from the south before turning to the North in the evening (fig. 6).

To be noticed, the agreement between the measurements and simulations, particularly as regards the sea breeze regime. The same holds for temperatures during these two days, with inland values of 30 to 35° against 20° at the coast.

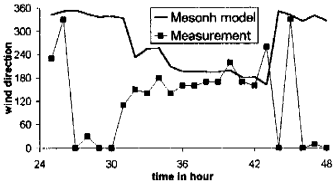

Figure 5: Wind direction at Cassis (06/25/01)

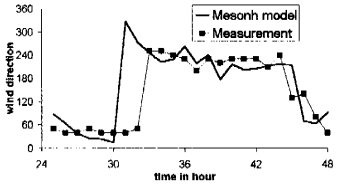

Figure 6: Wind direction at Dignes (06/25/01)

2.2 Aircraft measurements

Several flights have been displayed during these days over the Escompte domain. This is the case for the Merlin flight 17, from 10.25 to 12.55 UTC. Along the flight level run at 878hPa, observed winds are from the west whereas surface ones are from the south-east (fig. 7 and 8). These wind direction changes are well captured by the model, together with the potential temperature evolution. However, higher up, the modelled temperatures are underestimated by 3° to 4° (fig. 9). Good agreement between measurements and Meso-NH-C simulations is found again for the other flights and the same for June 25.

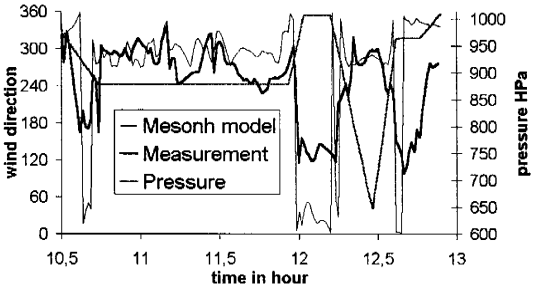

Figure 7 : Wind direction Merlin flight 17

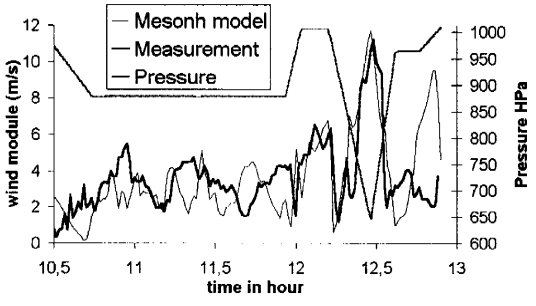

Figure 8 : Wind module Merlin flight 17

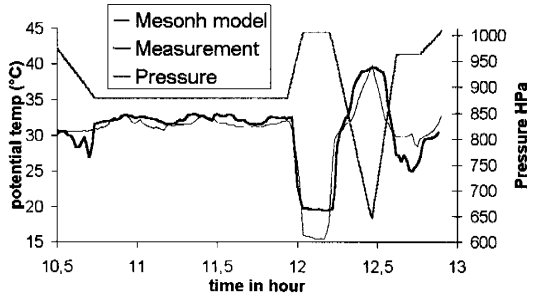

Figure 9 : Potential temperature, Merlin flight 17

3 Chemical validation for days 24 and 25 June, 2001

During these days, high temperatures and strong emissions promote the formation of ozone plumes (Sillman et al, 1995) with the winds driving inland the plumes within the Durance valley.

3.1 Surface stations

During the morning of June 24, ozone concentrations observed are about 50ppb east of the domain. At noon, ozone production begins west of the domain near Aix. An ozone underestimation of 15-20ppb between the model and measurements is then observed around the Berre pond (fig. 11). Ozone concentrations are much more closer in urban zones, in particular in Marseille (fig. 12).
These differences can mainly be attributed to the emission inventory used : the present Genemis inventory (Wickert et al, 1998) displays erroneous NOx emission source fields, particularly in industrial areas such as near Berre (fig. 10), thus leading to reduced ozone production rates (Sillman et al, 1990).

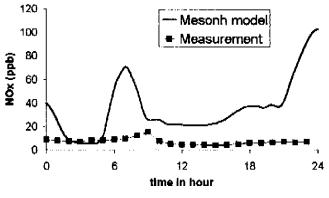

Figure 10 : NOx evolution at Martigues (06/24/01)

This is then reflected in the resulting plume affecting the Durance valley. For instance, at Cadarache, the simulated ozone level agrees with the observed peak, nevertheless rapidly decreasing thereafter (fig. 13). This is also true for June 25, with futher accumulation of NOx in the simulation. Nevertheless, good timing is observed as for the arrival of the pollution plume at Cadarache, together with a correct simulation of ozone evolution.

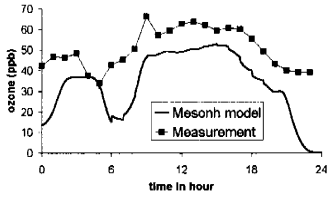

Figure 11: Ozone at Martigues (06/24/01)

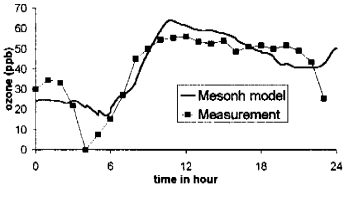

Figure 12: Ozone at Marseille (06/24/01)

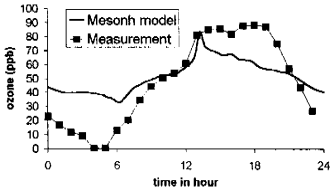

Figure 13 : Ozone at Cadarache (06/24/01)

3.2 Aircraft measurements

The Merlin flight 17 shows ozone values of about 60ppb at middle levels, quite consistent with simulated ones. Higher up, the model generally underestimates the observed ozone levels, both for June 24 and 25 (fig. 14).

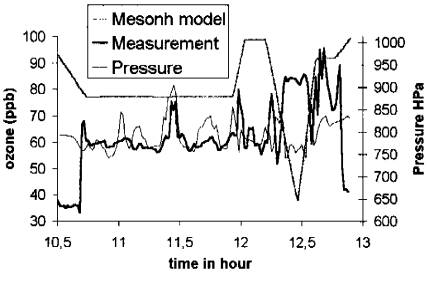

Figure 14 : Ozone along Merlin flight 17 (06/24/01)

3.3 Lidar Alto data

Lidar measurements have been made at Aix-les-Milles, in clear agreement with the previous results. This is particularly true for June 25. At the surface, the observed ozone concentrations are well simulated with correct timing for high ozone values reaching the ground. Nevertheless, there is some general underestimation of these concentrations, the station of Aix-les-Milles being within the plume trajectory issued from the industrial zone near Berre and subject to errors in the emission inventory. Higher up, the ozone levels are less correctly simulated (fig. 15 et 16).

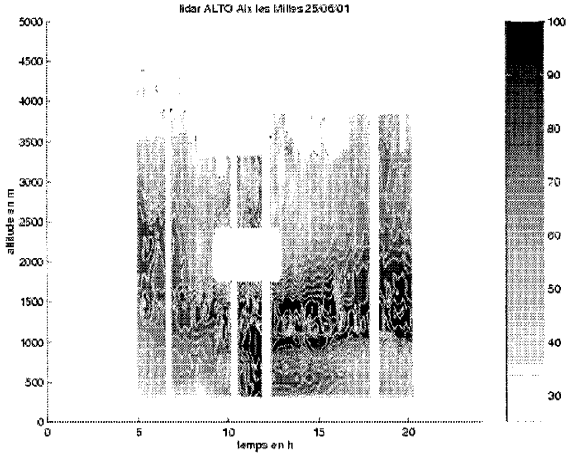

Figure 15: Alto ozone measurements (06/25/01)

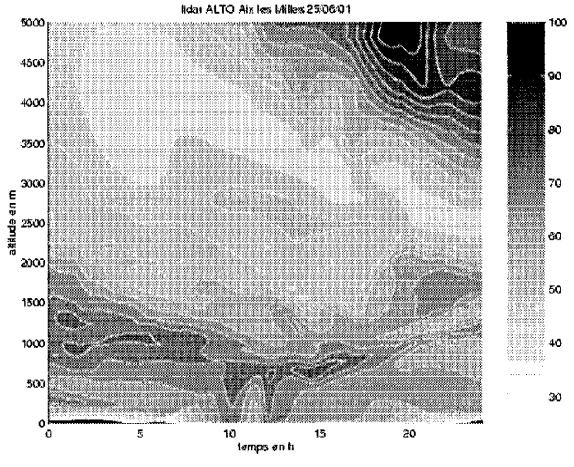

Figure 16: Simulated ozone (06/25/01)

4 Conclusion

Good agreement was found between observed and simulated dynamical fields, both for June 24 and 25. The southerly flow on the coast deeply penetrates inland while veering to a south-westerly direction, driving the pollution plumes issued from Berre and Marseille within the Durance valley. As for the chemical simulations, they display 20 to 30ppb ozone biaises, mainly due to an erroneous emission inventory near the industrial sites of Berre. New simulations with an improved inventory are being run. These simulations will further incorporate a sectional aerosol module describing the heterogeneous chemistry within the plumes.

Reference

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