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ANALYSIS OF IOP2B LAND-SEA BREEZE CASE DURING THE ESCOMPTE EXPERIMENT

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1*. INTRODUCTION

Fos-Berre Marseille region (south french coast) is exposed to severe pollution episodes caused by production and accumulation of high concentrated pollutants (Ozone, particles...). This pollution was documented in the framework of the ESCOMPTE program (http://medias.obs-mip.fr/escompte). The aim of this program is to produce an appropriate high quality 3-D data base from emissions, transport and air composition measurements during urban photochemical pollution episodes at the meso-scale. The complex local conditions of this region (proximity of the Mediterranean, coastline shape, presence of the Berre pond, mountainous surroundings...) increase the importance of dynamics in the development of pollution events. The interaction between dynamics and chemistry is great and it is necessary to take into account the local dynamic processes to improve the forecast and the understanding of the evolution of the urban plume.

The propitious conditions to provoke pollution episode are observed when the synoptic forcing wind is weak, which favours the development of a land-sea breeze circulation. Flows in the breeze cell have a pronounced diurnal cycle and velocities within the low layers of atmosphere can be 7 or 8 m/s. The impact of this circulation on the pollutants transport is of high importance, since the landward and the seaward extent of the sea breeze can reach 150 km from the coast line. So, the local pollution accumulated at the end of the day may be displaced offshore by the land circulation (circulation in place during the night) and it may be removed in the urban zone with the re-establishment of the sea breeze. One of the objective is to study the sea breeze phenomenon, disturbed by the urban area and by topography.

An important instrumental device has been unfold in a range of about 200 km around Marseille, using lidars, radars, a GPS network, rawinsondes stations... In particular, a ground-based Doppler lidar and the French-German airborne Doppler lidar WIND (Werner et al. 2001), developed by CNRS, CNES and DLR and first validated during the MAP experiment (Reitebuch et al. 2001), have been used to investigate the sea breeze along the South French coast at Marseille. This instrumentation allows to make the retrieval of the three-dimensional wind field as a function of time. The combination of these instruments provide complementary data which are essential to determine the different parameters (return flow height, land-sea breeze penetration distance,...), which characterize the sea breeze phenomenon.

In this paper, the analysis focuses on the IOP2b that took place between 24 and 26 June 2001. First results are given that show the landward penetration of the breeze, the vertical extent and the flow splitting between the Rhone valley and the Durance valley (see Fig. 1).

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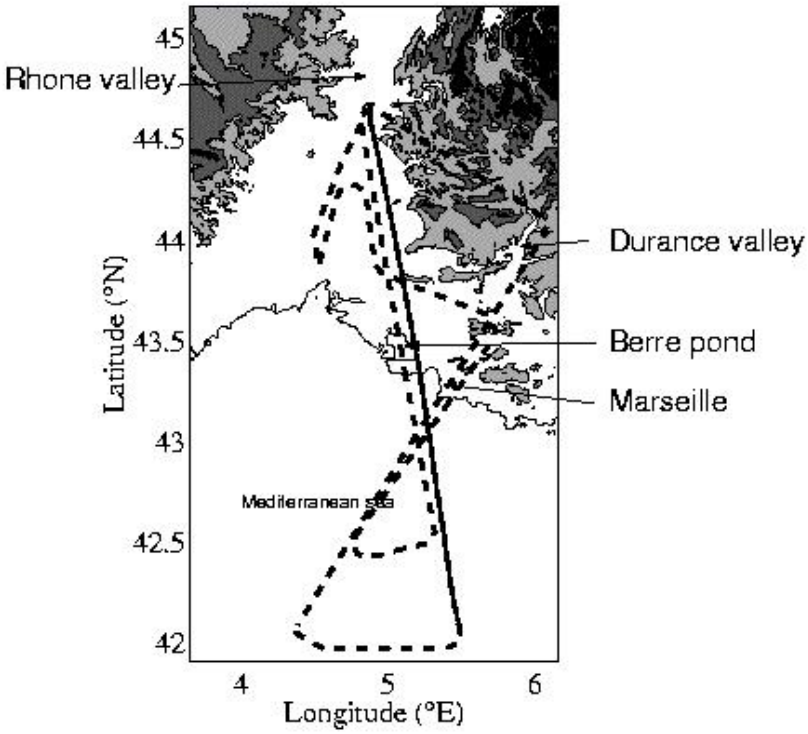

Figure 1: Topography of the ESCOMPTE target area. The isocontour increment is 500 m from the surface to 1500 m above sea level (ASL). The contour line in the white area is the coast line. Marseille (43.30°N, 5.36°E) and the Berre pond (43.47°N, 5.17°E) are located on the figure. Dashed lines follow the aircraft trajectory made 25 June 2001 from 1506 to 1712 UTC. The leg in solid line is studied in detail in this paper.

2. SYNOPTIC SCALE CONDITIONS

At the beginning of this period (24 June 2001), a ridge extends from Marocco to Norway at 500 hPa level. It generates a north-westerly synoptic wind all over the south of France. In addition, the pressure field is high at the
surface. The ridge becomes stronger hour after hours, inducing anticyclonic conditions with a dry and very hot air mass at all levels on 25 June 2001. The north-westerly wind keeps on blowing in altitude. On 26 June 2001, the ridge stays above France but high values at the surface go eastward and the strength of the wind clearly decrease. Temperatures are canicular and the atmosphere is very sultry which generates local thunders at the end of the afternoon. Based on the above observations, a pollution episode has been predicted to occur during IOP2b.

3. DESCRIPTION OF IOP2B

The aircraft, in which the airborne french-german Doppler lidar WIND has been emplaned, flew over the region to be documented on 24 June from 0841 to 1053 UTC, on 25 June from 1506 to 1712 UTC and on 26 June from 1102 to 1257 UTC. The distance covered on 25 June is represented in Fig. 1. The aircraft has investigated a part of the Rhone valley, the Durance valley and the Berre pond. The wind has been measured with an horizontal resolution of 4 km and a vertical one of 250 m.

Figure 2 displays the wind field measured along the flight track represented in solid line on the figure 1. This trajectory has been effected on 25 June from 18h44 local time (UTC+2) to 19h12. Arrows indicate the horizontal wind direction as a function of height. Arrows are scaled to fit within the wind strength. Observations clearly show the existence of a north-westerly (coast-parallel) synoptic forcing wind on 25 June in altitude but only the lower-level of the atmosphere has been represented here (up to 1500 m ASL). Well-developed sea breeze case is observed since the low-level wind differs from the synoptic flow. In this case, the limits of the breeze cell correspond to the change of direction of the wind. The sea breeze cell extends from 42°N to 44.3°N near the sea level but its inland penetration depends on the altitude. Below 500 m, the breeze enters the Rhone valley.

The maximum value of the vertical extent is about 1 km ASL and data from the ground-based Doppler lidar TWL, located near the coast line, in the north of Marseille, corroborate these results : the sea breeze is established this day and the vertical extent is about 1 km.

The sea breeze velocity seems to be maximum at the junction between the sea and the land One can note the acceleration induced by the presence of the Berre pond since arrows are longer just above it.

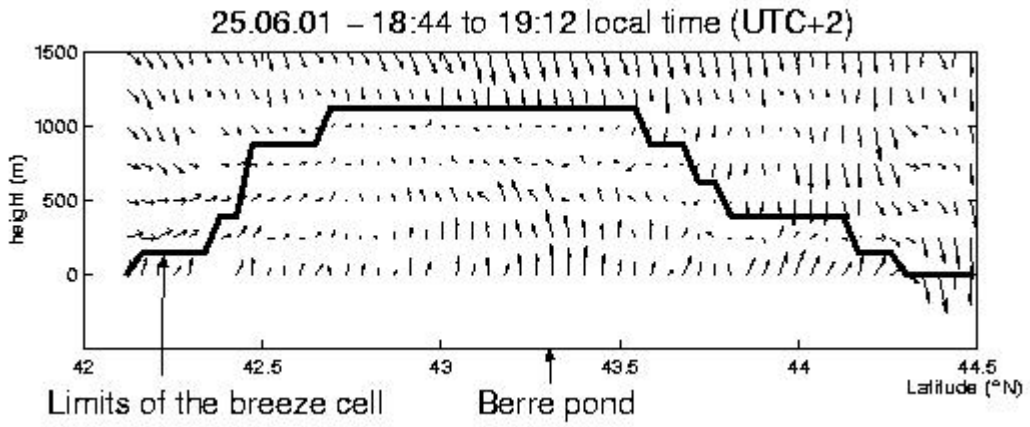

Figure 2: Wind field measured along the trajectory represented in solid line in Fig. 1 and covered between 18h44 and 19h12 local time (UTC +2) with a zoom for the lower level of the atmosphere. Arrows represent the horizontal wind direction. The Berre pond position is shown and the limits of the breeze cell are indicated.

Figure 3 displays the horizontal wind integrated between 500m and 750m ASL. It is a zoom of the target area. The left part of the figure corresponds to the end of the Rhone valley and the Durance valley is located at the right top of the figure. One can recognize the Berre pond below of the figure. Arrows indicate the horizontal wind direction and they are scaled to fit within the wind strength. At the left top of the figure, a reference arrow is shown.
An interesting point that is worth being emphasized is the existence of flow splitting between the Rhone valley and the Durance one. This local particularity is of great importance since coastal flow regimes take a prominent part in the pollution transport. Air quality is directly affected by this phenomenon. Figure 3 clearly shows the division of the flow between these two valleys when it encounters the mountain ridge. The flow splits in two parts and each part is influenced by either the Rhone or the Durance valley. One can see that the horizontal wind in the Rhone valley and in the Durance one are in the opposite direction. This heterogeneity can be explained by the existence of the north-westerly synoptic wind during this day. The Rhone valley is quite large to allow the synoptic wind to be channelled in it. And the existence of this north wind prevents the sea breeze (weak south wind) from going far away in the Rhone valley. On the contrary, the Durance valley is too narrow to allow the forcing wind to be channelled and the sea breeze can penetrate this valley. Since the breeze is channelled, the wind strength increases in the valley. So, the horizontal extent of the breeze is disturbed by the complex local conditions.

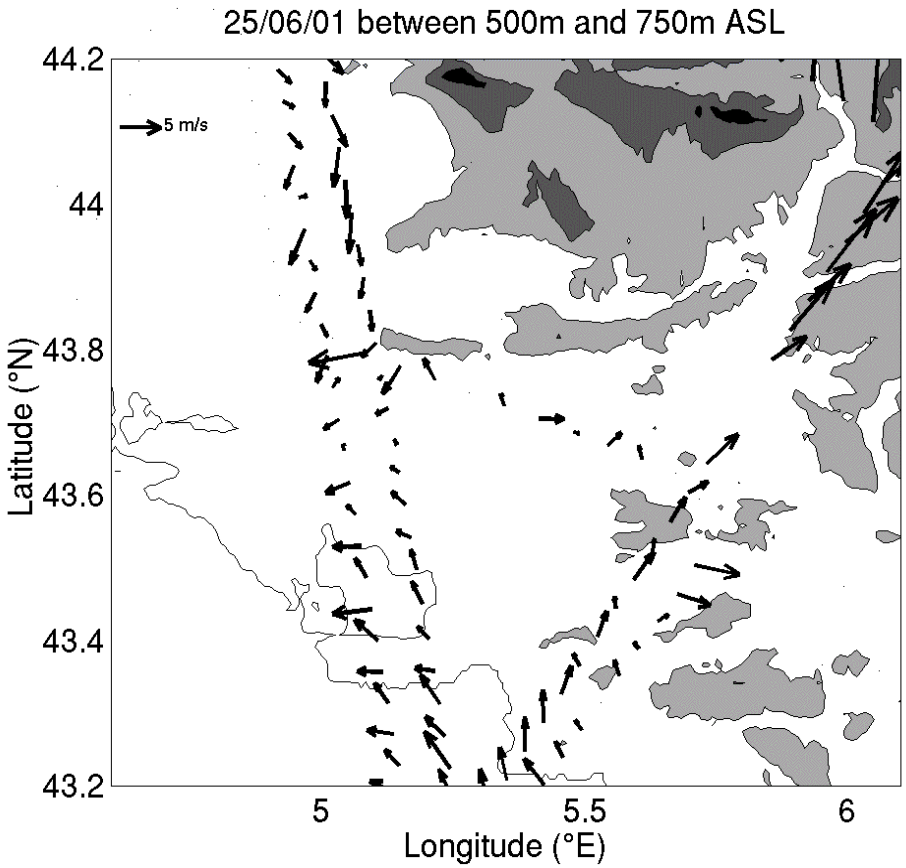

Figure 3: Horizontal wind field between 500m and 750m ASL . Arrows indicate the wind direction.

4. CONCLUSION AND FUTURE PROSPECTS

The structure of the sea breeze circulation will be explored in detail trough the use of high-resolution aircraft data and of an important network of local data. Thanks to a statistical study, possible relations between different parameters will be established (or checked). Is the linear theory (e.g. Rotunno 1983) successfull to describe the structure of the breeze (horizontal and vertical extent, position of the breeze front...)? Orography, the synoptic forcing wind, the presence of a urban center are so many parameters that will be taken into consideration. Lots of questions need to be answered : can the vertical extent of the breeze be determined intrinsically from the local forcing? What is the impact of topography?

This work aims at determining the synoptic situations that lead to develop a sea breeze circulation. Even if Mistral is blowing in altitude, a sea breeze regime can establish in the lower level of atmosphere and, in this case, pollutants are driven far away into the land, channeled by the local valleys instead of being transported towards the Mediterranean by Mistral. Consequence is an accumulation of pollutants far away from the urban area.

5. REFERENCES

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