ANALIZING THE BASIC FEATURES OF DIFFERENT COMPLEX TERRAIN FLOWS BY MEANS A DOPPLER SODAR AND A NUMERICAL MODEL: SOME IMPLICATIONS TO AIR POLLUTION PROBLEMS

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*** INTRODUCTION**
(Pointing out the main purposes of this study)

*** THE EXPERIMENT**
Area description
Experimental set-up
Mesoscale model

*** THE COMPARISON BETWEEN THE WIND FLOWS MEASURED WITH A SODAR DOPPLER AND SIMULATED WITH A MESOSCALE MODEL**

*** CONCLUSIONS**

INTRODUCTION

Air Quality Planning

Governing flow field
Thermic conditions
Complex areas
Not far from industrial zones

Complex area in NE of Barcelona "La Plana" presents Spring and Summer high values of Ozone and during winter high values of SO_2 concentration

The main cause of this pollution is the sea breeze
Advecting

Barcelona's area

Pollutants
Ozone and its precursors

La Plana

Besides the sea breeze flow, (very important) other flows and thermic situations are considered.
Special attention is dedicated to:
valley drainage flows ,cold air accumulation,
and channelling flows

SITE DESCRIPTION

• It's a flat area surrounded by mountains, which is almost isolated since it has two exits. One of them is on the south direction and the other one in the east, following a river.

• With this south exit, which is a narrow pass, La Plana communicates with an important industrial area, and also the sea breeze from the Mediterranean sea reaches la Plana transporting polluted air from this industrial zone.

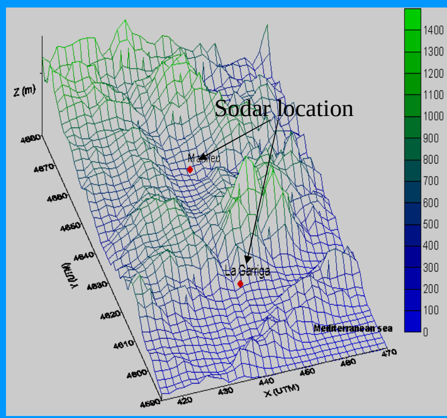


Figure 1.- 3-D orographic map of the area in study,indicating where the Sodar has been placed.

EXPERIMENTAL SET UP

•The Doppler Sodar used is a SCINTEC FAS 64, deployed in the lower part of La Plana, from April 2000 to September 2001

•The Sodar works in a cyclical form. Each cycle is defined by different pulse sequences which are sent up to Vertical / East / North / West/South main directions (29º) and the mirrored ones (-22º).
Pulses always alternate between the main and the mirrored directions.

• In addition to Sodar measurements, data from a network of meteorological ground stations are used and a mesoscale model is executed.

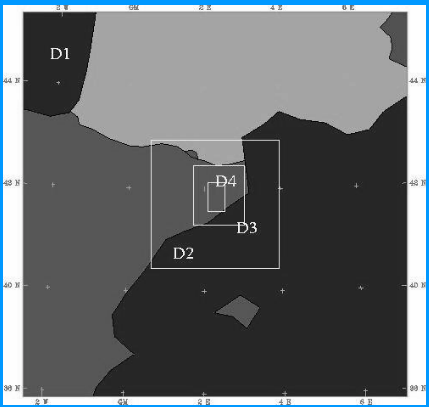
MESOSCALE MODEL

Four domains two ways nested are defined using the following resolution: 27, 9, 3 and 1 km.

In order to simulate the sea breeze, the dimensions of each domain are 31x31 for the two outer domains, and 37x43 and 37x61 grid points for the two inner domains, respectively. The biggest domain is centred at (41.70N, 2.27E) and the smallest domain covers an area from 41.6N to 42.1N.

In order to simulate the drainage winds, the dimensions of each domain are 31x40 and 37x61 for the two outer domains, and 37x43 and 37x61 grid points for the two inner domains, respectively. The biggest domain is centred at (41.99N, 2.27E) and the smallest domain covers an area from 41.91N to 42.46N.

MESOSCALE MODEL DOMAINS



MESOSCALE MODEL

The initial and boundary conditions are updated every six hours with information obtained from the ECMWF model with a 0.5ºx0.5º resolution.

For the two inner domains, we have used a topography and land-use with 30" resolution. For the two outer domains the horizontal resolution has been 1'.

14 levels are considered in the ABL, with higher resolution on the low levels.The boundary layer schemes are calculated using MRF scheme based on Troen and Mahrt (1986)

MAIN WIND CIRCULATIONS

In this section we will consider the main wind circulations observed in this area:
SEA BREEZE, DRAINAGE FLOWS and CHANELLING WINDS

SEA BREEZE

- Comes into “ La Plana” from its southern entrance.
- It takes place from Spring to Autumn with a variable duration, between 9 and 4 hours.
- Its maximum speed is between 10 and 5 m/s at a height of approximately 150 m over the measured place.
- The sea breeze return is mainly located at a height of 1200 m according to the results found by the MM5 model.

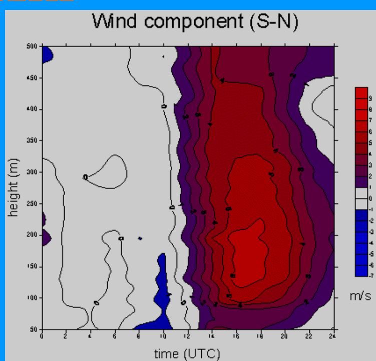
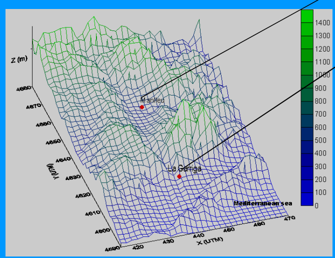


Figure 2. Time height cross section of S-N wind component measured by Sodar corresponding to a sea breeze situation

To prove the assumption that the entrance of sea breeze takes place via the south direction, we have executed the mesoscale model MM5 with a resolution of 1 km. Next figures show an example.

Just to remember the location of measurements points.



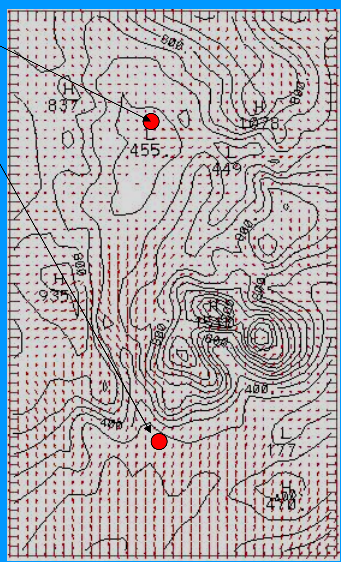
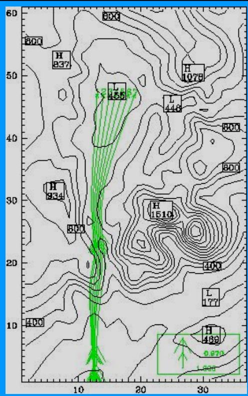
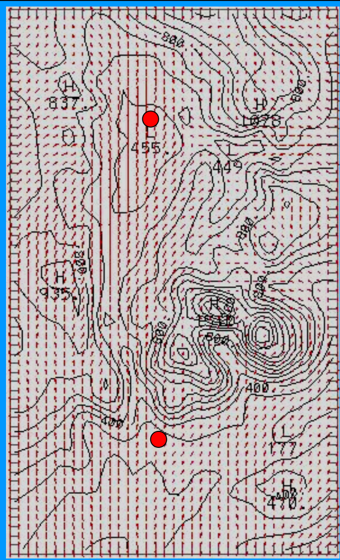


Figure 3 shows surface wind field simulated by MM5 for the smallest domain. We can see the sea breeze entrance, at 11 UTC , which has reached the Congost area. This simulation corresponds to 21-06-2001.

(b)

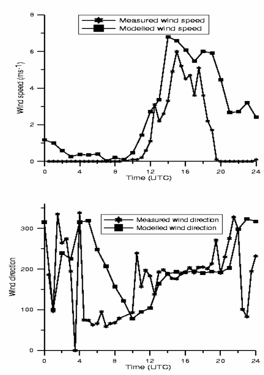


(a)



In figure 4a also you can see the surface wind field. At 14 UTC the sea breeze has reached the prepyreenean zone.
Figure 4b) shows backtrajectories calculated by MM5 at different levels from 0800 to 1600 UTC, indicating also the sea breeze entrance.

COMPARISON BETWEEN GROUND STATIONS MEASUREMENTS AND MM5 MODEL



As an example figure 5 shows the strong increment presented by the ozone concentration related to the sea breeze entrance to La Plana

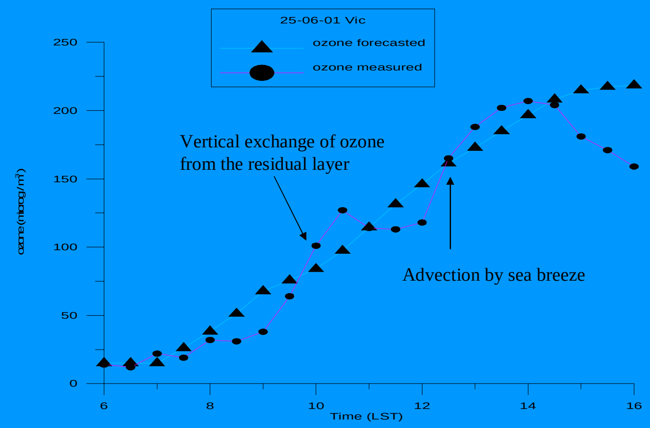


Figure 5. Time evolution of measured ozone concentration

MAIN VALLEY DRAINAGE FLOWS

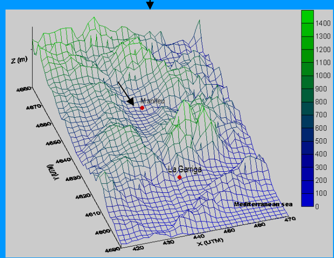
Are a frequent phenomena, take place anticyclonic situations, calm winds and cloudless sky

→ The drainage flow comes to La Plana from the North and North-West direction

Basically two types of regimes can be considered:

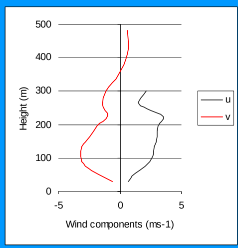
1.- Wind profile with a maximum near 100m

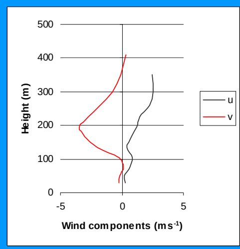
2.- Wind profile indicating near calm until ~100 m and a maximum near 200 m



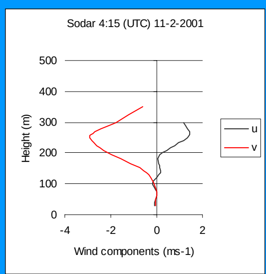
EXAMPLES OF DRAINAGE WINDS

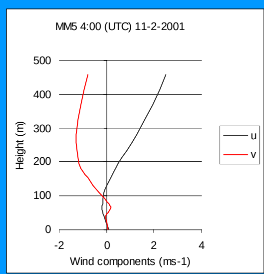
Figure 6. Vertical wind profiles showing maximum intensity at 100 m and 200 m respectively





In order to compare numerical values, next figure, as an example, presents measured (Sodar) and simulated (MM5)wind profiles at the corresponding grid. Night 10 -11 at 0400 UTC.





We can see that although MM5 simulates a maximum near 200 m it is lower and smoother than that measured by Sodar. The reason could be that the Sodar system is a measure over the vertical, and MM5 results represents an average over a grid.

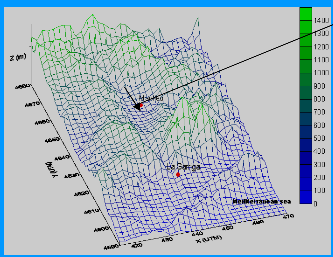
In addition backtrajectories are calculated over different points from 0100 to 0400 UTC at different heights.

below 100 m

100 an 200 m

200 and 300 m

Figure 8a: Backtrajectories calculated over the Sodar point measurement .



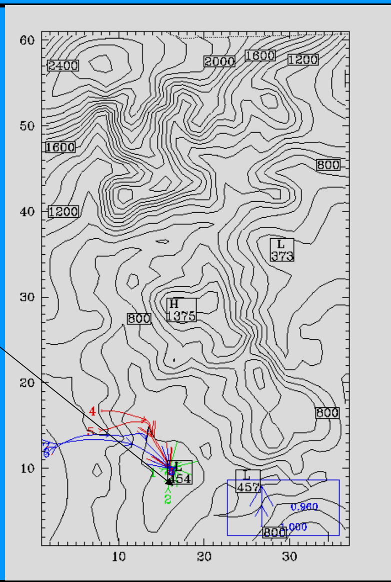


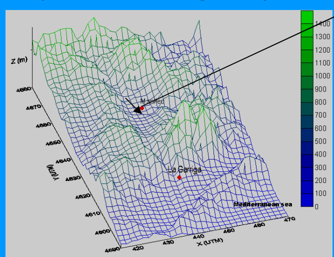
Figure 8b: Backtrajectories calculated over a point located in the North part of La Plana.

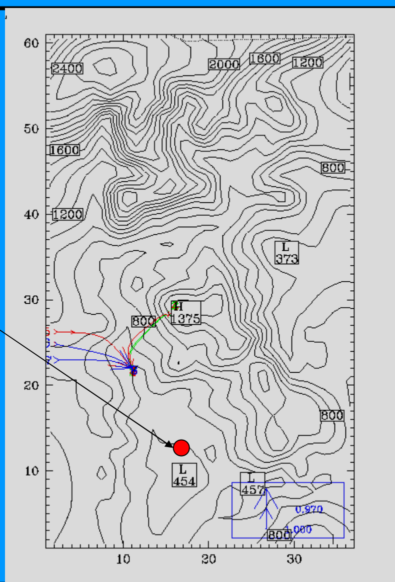
below 100 m

100 an 200 m

200 and 300 m

Drainage flow in the lower layer and in the higher layers

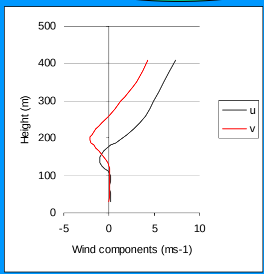




STAGNATION SITUATION AND A DECOUPLING BETWEEN AIR MASSES

Phenomenon related to the second wind profile, which occurs usually in winter is the

The development of a cold layer which remains stagnant in La Plana and a decoupling between the air mass inside the valley and the one that comes from the higher layers

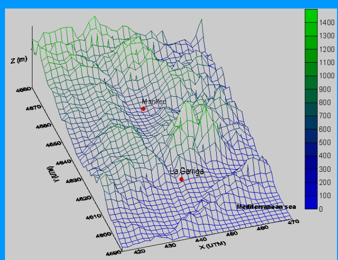


In figure 10. Wind profile measured by Sodar showing calm until 100 m and a maximum higher up.

CHANNELLING WINDS

The Congost orography forces the development of strong drainage winds

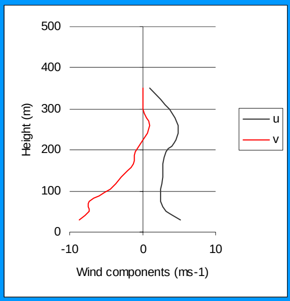
(Smooth slope) Could generate channelling winds flowing from La Plana to La Garriga, via the narrow pass.



Strong drainage flows through the Congost area

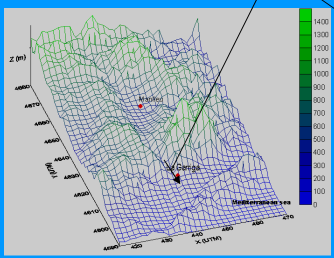
EXAMPLE

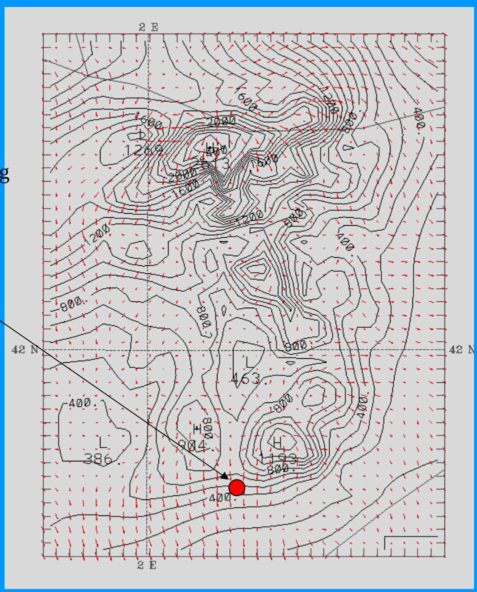
In figure11. Wind profiles observed by Sodar located in La Garriga showing channelling winds with a maximum in the first layer (40 m) decreasing slowly until 200 m.

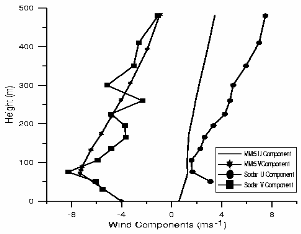


MM5

Figure 12. Surface wind vectors at 0800 UTC modelled by MM5 showing also **CHANNELLING WINDS LEAVING LAGARRIGA**







CONCLUSIONS

• The model has been reproduced with excellent timing the sea breeze arrival and direction, although their intensity is slightly overestimated

• When the model simulates the drainage flow, its intensity is lower than that measured by the Doppler Sodar, the reason could be the horizontal diffusion scheme used by the model. However, we think that much more work should be done in this topic.

• In the second case when drainage winds are higher because they are forced to flow through the mountain pass, the results have improved and it seems to be much more realistic.

•The comparison between the measurements given by the Sodar and the results provided by MM5 model point out a good agreement between both systems, although the first one is a measure over the vertical of the measurement point, and the second one provides an average over a grid.