SPECIAL PROJECT INTERIM REPORT

Interim Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	**2010**
Project Title:	**STUDY OF THE STABLY STRATIFIED ATMOSPHERIC BOUNDARY LAYER THROUGH LARGE-EDDY SIMULATIONS AND HIGH RESOLUTION MESOSCALE MODELLING**
Computer Project Account:	SPESTURB
Principal Investigator(s):	JOAN CUXART RODAMILANS
Affiliation:	UNIVERSITAT DE LES ILLES BALEARS
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	2002
Expected end date:	computed sources booked up to 2011

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	96000	96000	96000	**9**
Data storage capacity	(Gbytes)	200	200	200	200

Summary of project objectives

(10 lines max)

The representation of the stably stratified atmospheric boundary layer (SBL) in the numerical models of the atmosphere is far from optimal. When the stability of stratification is weak (presence of moderate wind and/or clouds) the turbulence is more or less continuous; but for moderate to strong stability (usually in weak pressure gradient conditions and clear skies), the turbulence is weak, sporadic or intermittent, many times of elevated origin, and highly dependent on the physiographical characteristics of every particular location. Most of the parameterisation schemes fail to properly represent these features. This project is doublefold. Its first aspect is to perform Large-Eddy simulations of the SBL, of increasing complexity. Secondly, to explore the real SBL, over complex terrain since the inhomogeneities of the terrain are among the main factors producing coherent structures in stably stratified conditions. Simulations of real cases at the basin scale are performed.

Summary of problems encountered (if any)

(20 lines max)

Summary of results of the current year (from July of previous year to June of current year)

A summary is given here and the updated scientific report is attached.

Although the project is twofold (Large-Eddy Simulations and mesoscale simulations), during the last year the attention has focussed in studying the real nocturnal boundary layer over complex topography. High resolution runs, to properly capture the fine scale the details of the SBL circulations are made using the MesoNH model.

Since the starting of this special project, simulations of clear-sky and weak synoptic pressure gradients have been made for several problem areas of different scales and conditions: the Majorca island (scale 100 km, 40 N 2E), the Duero basin (scale 400 km, 42 N 5W), Iceland (scale 600 km, 55 N 21W), the Hudson River Valley (scale 400 km, 42 N 74 W) and the Ebro River basin (scale 500 km, 42 N 0E). The simulations are made with nested domains and horizontal resolutions of 5 and 1 km respectively or with 1 domain at 2 km resolution. The vertical mesh is very fine in the lower half km of the atmosphere.

During the last year of the project, the Ebro and Duero river basins have been further studied and since November 2010 a new domain that covers the Garonne river basin and the Pyrenees in the south of France is also considered. Inspection of the topographically generated flows is in progress, as well as the development of verification tools in these difficult conditions. The runs in the Ebro river basin are now verified using data from a WindRASS profiler, a surface energy station and an Unmanned Aerial Vehicle (UAV), apart from surface observations and data from satellite images.

Recently, the night time cooling in the **Duero basin** is being further studied. Martínez et al. (2010) showed that the complex topography generates different coolings in the elevated plateau and in the lower areas, cooler than the areas with moderate or gentle slopes or near the river. During 2010 the same run was performed but with two domains, the inner one at 400 m resolution and centered in the elevated plateau. Also, the numerical diffusion was not applied as Belusic and Guttler (2010) suggested to better represent the mesoscale motions. That run was computationally very expensive since the time steps used were very low (0.5 s). It was found that the plateau was better described and the effect of not using the numerical diffusion results on more mixing close to the surface and higher jets. However, the mean patterns over the plateau obtained from the 2 km run were very close to those obtained from the 400 m run. That meant that 2 km of horizontal resolution is enough to properly represent the dynamics over the plateau but higher resolutions are needed (close to those used in Large-Eddy Simulations) to capture the finer scale motions. More results are explained in Jiménez and Cuxart (2011).

Mesoscale simulations over the **Ebro river basin** complement the climatological study (Martinez et al., 2008) using a period of seven years data from several automatic weather stations in an area close to the city of Lleida (150 km inland from Barcelona). Two cases of the most frequent situations are further studied with mesoscale outputs in order to describe the organization of the flow in the basin during clear-sky nights. This work is still in progress and during the last year the attention is focused in fog conditions, since they are also very common in this area. A 60 hour time interval (from 9th to 13th December 2009) is taken where there were a windRASS profiler and a surface energy budget station in this area measuring properly, apart from a densely network of automatic weather stations. Data from satellite images is also used for verification purposes. The results, further explained in Cuxart et al. (2011), show that the model is able to generate fog in the Ebro river valley in agreement with satellite observations and the windRASS profiler. After the establishment of a high pressure system in the area, fog appeared at the end of the first night and it dissipated the day after but it formed again during the second night up to the atmospheric conditions changes at the end of the period. The fog depth, it was between 200-300m above ground level (a.g.l.) during the first day and when the fog episode finished it was around 500m (a.g.l.). Regarding the horizontal extension, firstly the fog appeared in the lowest areas of the basin and when the fog was maximum it extended to almost all the places up to 700 m above sea level (a.s.l.).

Recently the attention is focussed in the **Garonne river basin**, a domain that covers the south of France and the Pyrenees mountain range. There is a densely instrumented location at Lannemezan, in the foothill of the Pyrenees, at the end of a narrow valley and in a plateau. In June-July 2011 there is a campaign and since November 2010 this area has been studied using observations and a high resolution simulation. Two nested domains are taken, the inner one at 500 m resolution centered in Lannemezan, to better represent the upslope and downslope winds and their transition. Two models are considered (WRF which is run by the University of Bergen under a supercomputer there and MesoNH that is run at the ECMWF) to determine the parameters that produce results closer to the observations. It is found that an easterly jet is formed during night time parallel to the Pyrenees at about 800 m (a.g.l.) and with speeds of 7 m/s. Under this situation, the wind is channelled between the Massif Central and the Pyrenees and it is favoured the formation of this jet. On the other hand, at lower levels, katabatic and anabatic winds are developed during night and day, respectively, with the direction of the slope (from N during day and from S during night). These are lower jets (located bellow 100m a.g.l.) and they are also less intense. Both models obtain the same patterns and with the WRF model some sensitivity tests are performed. It is found that a proper representation of the soil water is needed to obtain results close to those observed and that the vertical resolution close to the surface is important to better capture these jets. This work is still in progress and some results are found in Jonassen et al. (2011) and in Jiménez et al. (2011).

List of publications/reports from the project with complete references

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Summary of plans for the continuation of the project

(10 lines max)

LES: continue along four lines

i) interaction of turbulence and radiation in the stable boundary layer;
ii) the representation of the surface layer and the proper description of the energy budget;
iii) intermittent turbulence depending on the surface boundary conditions;
iv) mixing across inversions (top of convective boundary layer, surface radiative inversion).

Mesoscale: two domains will be considered in the near future:

i) the Ebre River, where strong interactions with topography takes place;
ii) the Garonne river basin in the south of France, where mountain-plain flows and valley circulaions in the Pyrenees are to be studied.