

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 2007

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 2010

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)	66500	66500	96000	38296
Data storage capacity	(Gbytes)	120	120	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 geographical 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)

We had some problems in the code when the radiation scheme was activated in the LES. The surface radiative temperature (T_{rad}) was a fixed value when the ISBA soil scheme was not activated. Since in our LES ISBA is not activated by default (we use an energy budget equation instead) the obtained T_{rad} was wrong. Now the bug is fixed.

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

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

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

Large-Eddy Simulations (LES) of the Stable Boundary Layer (SBL) are computationally very costly, especially in strongly stratified conditions. This is due to the small size of the vertical energetic eddies, and to their relatively large horizontal size, anisotropy induced by the stratification acting only in the vertical. This feature compels to use very high resolutions (about 2 m) combined with domains large enough to capture the relevant horizontal structures (about 1 km). Such very costly simulations can only be made within powerful computers as in ECMWF. The activities since the start of the project consist on LES of standard surface shear driven SBL -which includes the participation in the GABLS project- and of several coherent structures present on the flow such as nocturnal Low-Level Jets or temperature inversions. The comparison to available observations from recent campaigns is made systematically and, in fact, the LES are inspired by observed features.

During the last year, the LES works have been focused on the study of the surface layer. A steady-state low-level jet (LLJ) observed in the SABLES-98 experimental campaign is simulated using an LES to study the basic processes taking place in this regime and the structure of the associated turbulence (further details in Cuxart and Jiménez, 2007).

The model distinguishes between two separated layers, one above the maximum of the wind, with weak stable stratification and strong shear and the other below, with stronger stratification and shear. Both layers have significant turbulence, of similar intensity, with the upper part extending as high as 3 times the height of the maximum of the wind. An inversion is formed at the wind maximum (slightly stronger than the observed one) that decouples both layers.

The temperature gradient in the lower layer is somewhat too large. However, the differences in the modelled surface layer might be due to the imposed surface boundary conditions, other forcings that might be ignored, the dynamic forcing used, or a too coarse grid resolution near the ground that might rely more than advisable on the subgrid-scale scheme.

In order to improve the surface gradient of temperature, different sensitivity tests on the surface conditions have been performed. For instance, the observed values are imposed at the first model level instead of using an energy budget equation (standard run), among other tests further explained in the extended report. All of the cases present a maximum of the wind at the inversion height as well as the maximum of turbulence above the jet. However, the surface layer results depend on each surface condition considered. It is found that when the imposed observed surface values are taken, a strong surface cooling is avoided (as in other cases) and the temperature profile manages to stay parallel to the observed one. Besides, under this surface condition, the model experiences mixing episodes with certain regularity as the one observed during the same night (but prior to the simulated period). This does not imply that the generating mechanism is the same but probably that the response to a forcing of the same intensity is well captured by the model. This is a work still in progress.

The **mesoscale simulations** are made using the same tool, the french-community model Meso-NH. In this case, the aim is to reproduce at very fine scale the details of the SBL circulations considering the watershed basin as the natural unit of organisation. 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), the Duero basin (scale 400 km, 42 N), Iceland (scale 600 km, 55 N), the Hudson River Valley (scale 400 km, 42 N, 74 W) and the Ebre River basin (scale 500 km, 42 N). The simulations are made with nested domains and horizontal resolutions of 5 and 1 km respectively. The vertical mesh is very fine in the lower half km of the atmosphere.

As night advances the air near the ground cools down, especially in the valleys. The flow near the ground also follows the topography. In Majorca and in Iceland, air flows out of the islands, mostly through the centres of the basins, generating wind maxima near the coast. A description of the setup and results for the Majorca Island (6/01/99) is found in Cuxart et al. (2007), for Iceland in Agustsson et al. (2007) and for the Duero River in Cuxart et al. (2008). A further description of the verification techniques used in the group is found in Jiménez et al. (2008).

Inspection of the orographically generated flows is in progress, as well as the development of verification tools in these difficult conditions. Besides in-situ observations, radiative temperatures out from satellite images are used to perform object-oriented verification analyses. The comparison of these data to the model outputs is made through the inspection of: horizontal cross-sections at a single instant; comparison of modelled radiative temperature against the one obtained from the NOAA image and comparison of time series at a single location. A further description of the verification techniques used in the group is found in Jiménez et al. (2008). The PDFs have been also used to further study the simulations and also the organizations of the basin and local scales.

The runs are also used to develop a methodology to study katabatic winds along slopes. The study of the katabatic winds developed along two slopes in the Majorca Island (Martínez and Cuxart, 2008) and the Duero basin (Martínez et al., 2007) is a work still in progress. The hydraulic theory has been applied in order to study the dynamics.

To check how the parameterizations are able to reproduce the nocturnal observed events, two models (MM5 and Meso-NH) are run under the same conditions in the Duero basin (Bravo et al., 2008).

List of publications/reports from the project with complete references

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Martínez, D., and Cuxart, J., 2007: A gravity current study within the Palma de Mallorca basin. *Física de la Tierra*, **19**, 21-36.

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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) intermittent turbulence depending on the surface boundary conditions: iii) second LES GABLS intercomparison exercise (a morning transition): iv) Mixing across inversions (top of convective boundary layer, surface radiative inversion).

Mesoscale: four areas will be considered in the near future: i) The Duero Basin and the island of Majorca, already under verification: ii) the HVAMS in the Hudson Valley (New York), where topographic channelling and the interaction with mountain outflow above it make a new and interesting problem to study, iii) The Ebre Valley, where strong interactions with topography take place