Characterization of evening atmospheric boundary layer transitions from a sonic anemometer and an array of microbarometers during the BLLAST field campaign

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1. INTRODUCTION

- The BLLAST (Boundary Layer Late Afternoon and Sunset Turbulence) field campaign took place between 14th June and 8th July 2011 in Lannemezan (43.12 N, 0.36 E), France.
- One of the objectives of this international campaign was the study of the turbulence decay which happens around sunset in the boundary layer of the atmosphere. For this purpose, many and diverse meteorological resources were employed.
- The experimental site is not far away from the Pyrenees, so that the influence of complex terrain in the evening transition can be explored, as in previous studies [1].
- Here we analyze how different time scales are involved in the phenomena that occur during the evening transition, underlining differences among days and finding out some wave-like events.
- The temporal interval studied is mainly –but not only– 17:00-23:00 UTC, regarding sunset happened at 19:39-19:42 UTC during the days of the field campaign.

2. DATA AND METHODOLOGY

2.1 Data

Among all the instrumentation used during the field campaign, here we focus on data from:

- A sonic anemometer (u, v, w, T) at 2.4 m a.g.l., sampling at 20 Hz.
- Three high resolution Paroscientific microbarometers (p) at 1 m a.g.l. (2 Hz). For some calculations, a 45-minutes filter is applied to these data to remove longer period perturbations.
- A meteorological 60m tower (T at 2, 15, 30, 45 and 60 m).

2.2 Wavelet analysis

Microbarometers were nearly equally spaced, forming a triangular array of around 150 m. In this way, wave-likely events can be characterized and its parameters (wavelength, phase speed, direction) calculated by using wavelet methods and small time differences in registering the perturbations [2], [3].

2.3 MultiResolution Flux Decomposition (MRFD)

A multiscale analysis [4] is applied to the covariance fluxes calculated from the sonic components, to obtain which timescales have more relative importance.

3. RESULTS

- The synoptic situation and the temperature evolution for three selected transitions are plot in Fig. 1. A surface based inversion starts to develop after sunset (orange line), at about 18:30 UTC, except for 29th June, when it is not formed along the time period shown.
- In Figs. 2, 3 and 4 several variables evolution can be seen, respectively for the three selected days.
- MRFD shows, for friction velocity (U_*) and vertical heat flux ($w'T'$), differences in scale contributions linked to the stablishment of a surface based inversion.
- TKE reaches a wide range of values (notice different scales for the three days) and shows an intermitent behaviour.
- The wind speed is the main agent controlling turbulence for days 24th (IOP4) and 25th (IOP5): both variables suffer a similar qualitative evolution.
- Wave events are found from pressure fluctuations for two of the days: on 24th (around 23:55 UTC) and on 29th (around 18:43 UTC). The first one has about 12 minutes as period, a waveleght of 19 km and moving at 25-30 m s^{-1} from NW to SE. Oscillations in temperature can also be seen some hours before this wave appears, but not a coherent structure is found then. The second one has a period of 13 minutes, goes from NE to SW with a phase velocity of 7 m s^{-1} and its wavelenght is not so large, just 5.6 km.
- On 25th June it is not found a clear coherent structure. Pressure series do not seem to have a wavy behaviour as in the other two days.

Figure 1: Synoptic situation (A) and temperature evolution (B) at different levels for three evening transitions

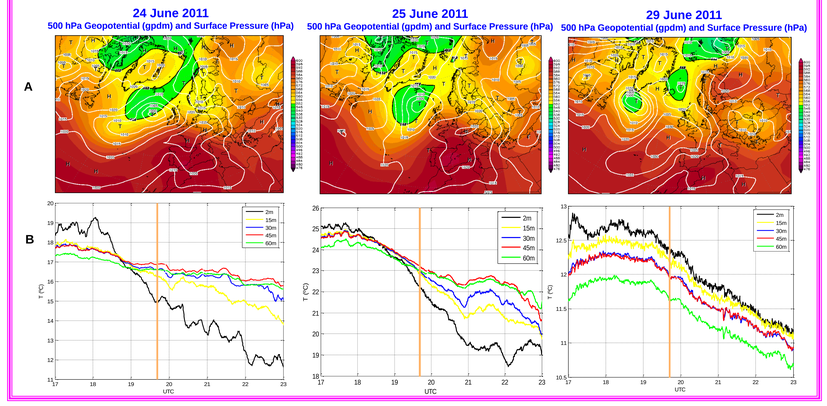


Figure 2: Plots for day 24th June 2011

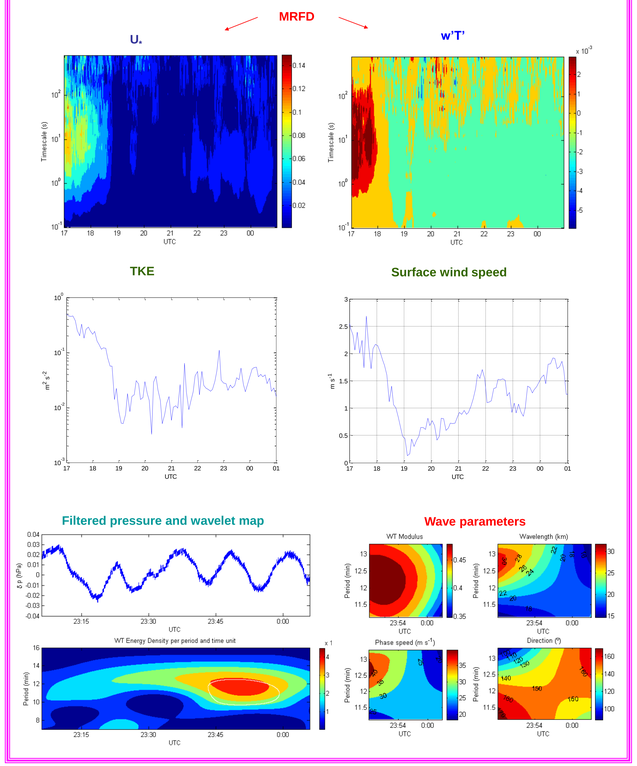


Figure 3: Plots for day 25th June 2011

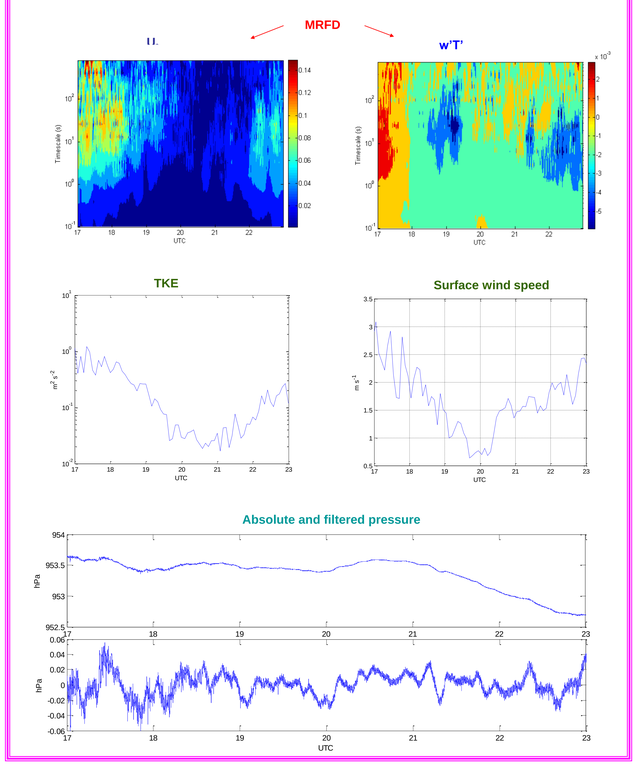
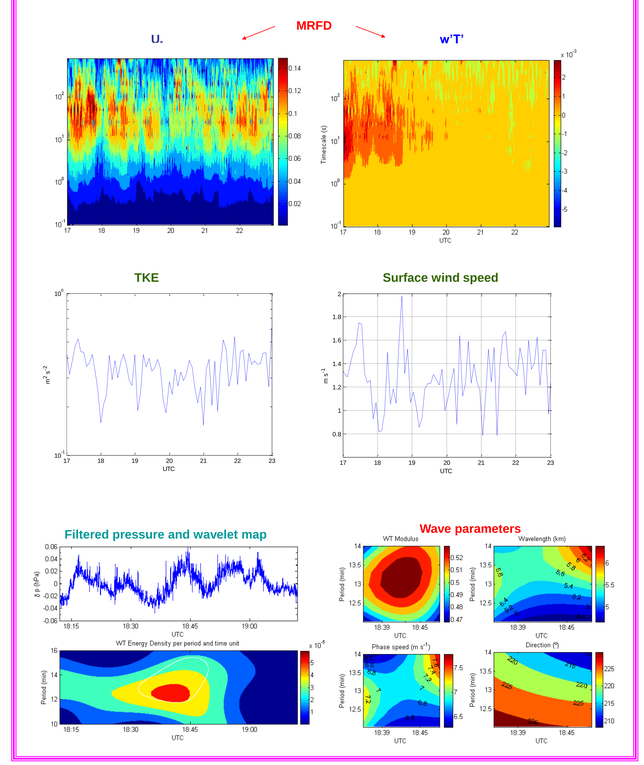


Figure 4: Plots for day 29th June 2011



4. SUMMARY AND CONCLUSIONS

- ❖ Some evening transitions during BLLAST campaign, with diverse characteristics, have been explored.
- ❖ Wave-like events can be detected during the evening transition, both when there is a surface based inversion due to stability and when the instability does not let the inversion to form. However, they have quite different wave parameters, probably because they have different origin.
- ❖ Contributions from different time scales to vertical movements are found depending on the formation or not of a surface based inversion.
- ❖ MRFD and Wavelet methods can be used as complementary techniques to investigate phenomena in the atmospheric boundary layer.

5. REFERENCES

[1] Fernando, H. J. S., Princevac, M., Pardyjak, E. R., and Dato, A. (2004): The decay of convective turbulence during evening transition period. Paper 10.3, 11th Conf. on Mountain Meteorology and MAP Meeting, Bartlett, NH, Amer. Meteor. Soc., 4 pp.

[2] Terradellas, E., Morales, G., Cuxart, J., and Yagüe, C. (2001): Wavelet methods: application to the study of the stable atmospheric boundary layer under non stationary conditions, *Dyn. Atmos. Oceans,* **34,** 225–244.

[3] Viana, S., Yagüe, C. and Maqueda, G. (2009): Propagation and effects of a mesoscale gravity wave over a weakly stratified nocturnal boundary layer during the SABLES2006 field campaign. *Bound.-Layer Meteorol.,* **133,** 165–188.

[4] Howell J. F. and Mahrt, L. (1997): Multiresolution flux decomposition. *Bound.-Lay. Meteorol.*, **83**, 117-137.

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APPENDIX: TURBULENT PARAMETERS

➢ **Turbulent kinetic energy**

$$TKE = \frac{1}{2}(\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$$

➢ **Friction velocity**

$$U_* = \left[(\overline{u'w'})^2 + (\overline{v'w'})^2\right]^{1/4}$$