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THE PRESSURE-CORRELATION TERM IN THE TKE BUDGET ESTIMATED BY THE WAVELET TRANSFORM USING CASES-99 DATA

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1 INTRODUCTION

In the studies of turbulence using higher-order turbulence schemes, several terms need to be parameterised. Among those, the pressure-correlation terms have historically been difficult to represent due to several reasons. The most important one has been the lack of measurements of the pressure in the precission of the ABL phenomena (below 10 Pa) at a enough fast sampling rate and minimizing the measuring problems- dynamic pressure fluctuations and temperature drift-. During the CASES-99 field campaign, three microbarometers using the change of the oscillation frequency of a quartz cristal were sampled at 2 Hz, as a compromise between resolution and sampling rate. Using the continuous wavelet transform, estimations of the pressure fluxes and other terms in the TKE budget equation have been computed. Several classical assumptions made in the parameterisation of the turbulence pressure terms are reviewed.

2 MEASURING THE PRESSURE

The high precision required in the ABL pressure measurements is difficult to attain. Under nocturnal conditions, fluctuations related to Internal waves are not larger than 10 Pa, whereas turbulent fluctuations are about 1 Pa. The main factors against a proper pressure measurement are the extreme sensitivity of the microbarograph to temperature variations and the dynamic pressure fluctuations, since the static pressure is the variable to be studied. During the CASES-99 field campaign, three devices measuring absolute pressure were set up at different heights (1.5, 30 and 50 m above ground level) together with sonic anemometers on the main tower. The measuring principle is the change of the oscillation frequency of a quartz crystal with pressure induced stress, with the variations due to temperature changes compensated in origin. The resolution is a function of the sampling rate: the lower this rate is, the higher the resolution can be. A rate of 2 s^{-1} was chosen, with a resolution of about 0.2 Pa. To reduce the undesired effects of dynamic pressure fluctuations, three static pressure ports were used. Data are analised only for periods above 0.1 Hz.

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3 TURBULENT MOMENTS

In this paper the Morlet wavelet is used as the mother wavelet. It is a plane wave modulated by a Gaussian

$$\psi_0(t) = \pi^{-\frac{1}{4}} e^{-\frac{t^2}{2}} e^{i\,t\,\omega_0} \quad (1)$$

where ω_0 is usually known as the base frequency, although it is a non-dimensional quantity. An energy density and an I-density per time and period (T) unit of the time series $f(t)$ and $g(t)$ can be defined (Cuxart et al, 2002) -F,G: wavelet transform-

$$e_f(T,t) = \frac{8\pi}{C_\psi(\omega_0 + \sqrt{2+\omega_0^2})} \frac{|F_{T\,t}|^2}{T^2} \quad (2)$$

$$i_{fg}(T,t) = \frac{8\pi}{C_\psi(\omega_0 + \sqrt{2+\omega_0^2})} \frac{F_{T\,t}\,G^*_{T\,t}}{T^2} \quad (3)$$

The energy density allows to compute the kinetic energy (KE) or any other variance of a meteorological variable, whereas the I-density is useful to determine any correlation of two variables within a flow.

The turbulence kinetic energy is defined setting a period T_c as the upper limit of the wind oscillations contributing to turbulence.

$$TKE = \frac{1}{2}\int_0^{T_c} (e_u(T,t_0) + e_v(T,t_0) + e_w(T,t_0))dT \quad (4)$$

When the TKE is computed using the averaging method, such limit is implicitly introduced when the averaging period is set. In the wavelet method, the choice of a limit is not an a-priori requirement.

4 IOP6: TKE BUDGET

Turbulence momenta have been computed using the WT with data from level at 1.5, 30 and 50 m AGL, obtaining two budgets, one between 1.5 and 30 m, located inside the surface radiative cooling inversion, the other between 30 and 50 m, outside it. In fig 1, the spectral intensity for the pressure has been integrated for the periods 0-10 min., 10-20 min. and 20-60 min. Most of it belongs to the large periods, contrarily to what happens for the TKE, where it is maximum below 10 minutes.

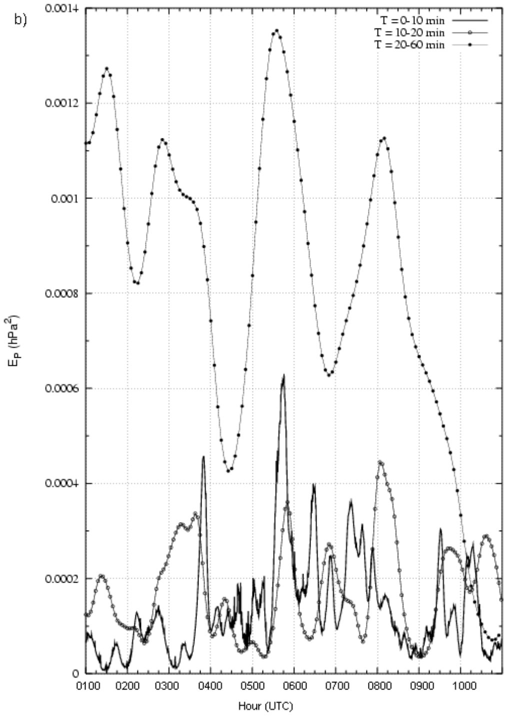

Figure 1: Wavelet transform of the pressure

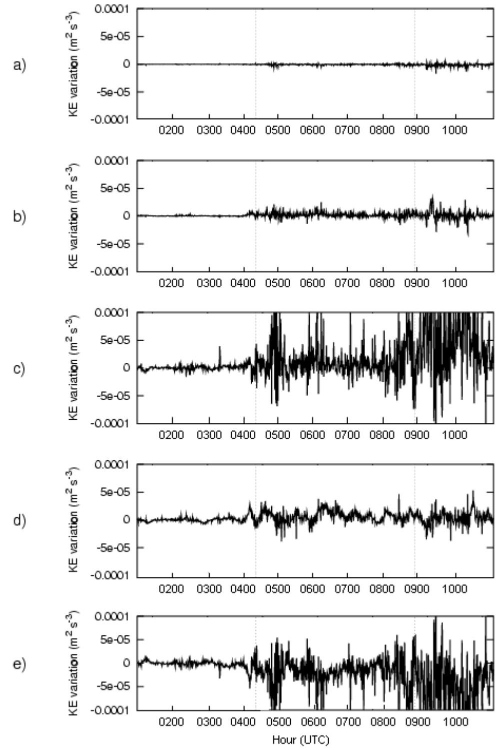

Figure 2: TKE budget: (a) buoyancy, (b) shear, (c) turbulent transport, (d) pressure term, (e) residual

In figure 2, the TKE budget is shown for the upper layer. Plots suggest that the night can be divided into three distinct intervals (approximately 1-4, 4-8 and 8-12 UTC), with different dynamic conditions. The first interval had very little small scale turbulence and it was dominated by structures with time scale of about 20 minutes. The main processes at these scales are the pressure and the turbulence transport (TT) terms (not shown). For the smaller scales all the terms are very small, with production by the wind shear and destruction through dissipation. The buoyancy destruction is negligible. TT and the pressure terms are very small and not well correlated.

The second interval has a pulsating structure of 4.5-minute period and small scale turbulence, also separated by an energy gap. The large scales do not contribute significantly to the budget. The terms are larger than in the first interval, indicating more turbulent activity. The pressure transport is not correlated with the turbulence transport term, both mostly positive. The buoyancy contribution is negligible. The residual has frequent occurrences of positive values, not acting as a dissipation and might indicate that the terms neglected in the approximations are important.

The third interval is characterized by strong small-scale turbulence and the absence of well-defined coherent structures. The buoyancy flux is still very small, with frequent occurrences of positive values. At the lower level, the turbulence transport is the largest term, whereas the pressure term is mainly negative, smaller and not correlated with the turbulent transport. In the upper level, the turbulent transport is clearly the largest term, the pressure term is smaller but seems to follow the same pattern than the turbulence transport term, more in the sense of the classical parametrizations. The residual is large, again with frequent positive values.

5 SUMMARY

A simplified turbulence kinetic energy equation computed by the wavelet transform has been used to study the contribution to the energy budget of the different terms. The buoyancy is always negative but not very significant. The wind shear is the major production term and the turbulence transport and the presso-correlation terms are significant, of the same order of magnitude and not always well correlated. The pressure and the turbulence transport terms are the only ones significant for scales above 10 minutes. The remainder of the budget includes the horizontal terms and the dissipation. This term is not always negative indicating the importance of the horizontal motions.

REFERENCES

Cuxart, J. et al.,2002: 'Study of coherent structures and estimation of the pressure transport terms for the SBL', *Boundary-Layer Meteorol.*, , In Press.