Towards a spectral definition of the atmospheric stability

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Wavelet-based methods have proved to be useful in the analysis of the different scales of motion that are present in the atmospheric boundary layer (ABL). In the range of small-scale turbulence, these methods provide much better estimations of the turbulent moments than the traditional method based on the Reynolds decomposition of variables into a mean value and a perturbation. The reason is that, with a suitable selection of the mother wavelet, the wavelet transform presents a much better performance than the Reynolds decomposition in filtering out low frequencies. Wavelet methods are especially advantageous in the stable ABL, where the common absence of a spectral gap between the turbulent scale and the low-frequency perturbations makes very problematic the use of the Reynolds decomposition in the estimation of turbulent kinetic energy or fluxes. Since the wavelet methods yield a time-frequency representation of the turbulent moments, they also allow analysing the time evolution of the contribution of different scales, in opposition to the Reynolds method, where this spectral analysis is only possible for selected time periods.

Going further, the authors try to introduce a new approach in the definition of the atmospheric stability. Turbulent fluxes of heat or momentum are present in the definition of some stability parameters, such as the Obukhov length. Using a wavelet method to estimate the total flux during a certain time period may provide a better estimation of the stability, but does not change the approach to the problem. On the other hand, an estimation of the stability parameters can be done for different scales or different spectral ranges, providing a complete new vision of these values that would become a function of the scale, the period or the frequency.

The technique is applied to several events analyzed with data recorded at a tower located close to Valladolid, in Central Spain, and in Kansas, during the CASES-99 field campaign, both under stable and unstable ABL. In the analysis of the results, special emphasis is put in the assessment of the information supplied by the new method.