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Studying the height of atmospheric stable boundary layer from turbulence moments at different heights

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SABLES98 data constitutes a quite comprehensive description of atmospheric stable boundary layer. Measurements taken at three different heights (5.8, 13.5 and 32 m a.g.l.) with sonic anemometers and mean wind and temperature at many heights up to 100 m cover a period from 10 to 28 September 1998. In this work we have used data form 7 consecutive nights forming the so called S-period characterised by weak to strong stability.

MultiResolution Flux Decomposition (MRFD), which a multiscale technique, has been applied to sonic data to evaluate the heat and momentum fluxes as well as temperature and velocity variances. MRFD allows to know what timescales contribute more to the covariance/variance of the temporal series and it has been used to locate the gap between turbulence and larges scales, avoiding the 'contamination' from higher scale motions on the evaluation of turbulent fluxes or variances evaluated from eddy correlation technique with a fixed time window.

The analysis presented here focuses on boundary layers that are expected to be directly influenced by surface fluxes: namely, cases characterised by a decrease of turbulence second order moments with height. (In detail, we took into consideration vertical fluxes of momentum and sensible heat, and variances of vertical velocity and temperature fluctuations.)

The vertical profiles of momentum and heat fluxes proposed by Nieuwstadt (1984) and Zilitinkevich and Esau (2007) suggest possible dependences of the fluxes on the height. Both theories give also expressions for the stable boundary layer height. The functional forms have been fitted on the data, giving best-fit estimates of the surface fluxes (which are expected to be larger that those measured at the lowest level available in the tower) and of the boundary layer height, h_{uw} and h_{wt} (the first one if the fit is made on momentum flux measurements, the second one if heat flux is considered). Also, Zilitinkevich and Esau (2007) formulas have been directly applied to the measured fluxes at the lowest level, giving another estimate of the height, h_{ZE}.

h_{uw} and h_{wt} are different each other, and are different if Zilitinkevich and Esau (2007) Gaussian shape or Nieuwstadt (1984) power law shape are chosen. However, the values are broadly consistent. Remarkably, these values appear to be not strongly affected by the values of the surface fluxes, in the ranges covered by the data set.

h_{ZE} is by its definition mainly a function of the surface fluxes (especially in conditions of strong stability), although its representative value is not too far from that derived by the fitting procedure.

If the fit is assumed to give an estimate of the stable boundary layer height, the main result of this study is that this height cannot be expressed as a function of the surface fluxes only, at variance with the theoretical formulations discussed here.