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Shear Capacity as Prognostic of Nocturnal Boundary Layer Regimes

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After sunset the surface temperature can drop rapidly in some nights and may lead to ground frost. This sudden drop is closely related to the occurrence of fundamentally different behaviour of turbulence in the nocturnal boundary layer. Recent theoretical findings predict the appearance of two different regimes: the continuously turbulent (weakly stable) boundary layer and the relatively 'quiet' (very stable) boundary layer. Field observations from a large number of nights (approx. 4500 in total) are analysed using an ensemble averaging technique. The observations support the existence of these two fundamentally different regimes: weakly stable (turbulent) nights rapidly reach a steady state (within 2-3 hours). In contrast, very stable nights reach a steady state much later after a transition period (2-6 hours). During this period turbulence is weak and non-stationary. To characterise the regime a new parameter is introduced: the Shear Capacity. This parameter compares the actual shear after sunset with the minimum shear needed to sustain continuous turbulence. In turn, the minimum shear is dictated by the heat flux demand at the surface (net radiative cooling), so that the Shear Capacity combines flow information with knowledge on the boundary condition. It is shown that the Shear Capacity enables prediction of the flow regimes. The prognostic strength of this non-dimensional parameter appears to outperform the traditional ones like z/L and R_i as regime indicator.