Geophysical Research Abstracts
Vol. 15, EGU2013-1245, 2013
EGU General Assembly 2013

The onset of the very stable boundary layer

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Here, the mechanism behind the collapse of turbulence in the evening is investigated as a precursor to the onset of the very stable boundary layer. A cooled, pressure-driven flow is investigated by means of a local similarity model. Simulations reveal a temporary collapse of turbulence whenever the surface heat extraction, expressed in its non-dimensional form h/L, exceeds a critical value. As any temporary reduction of turbulent friction is followed by flow acceleration, the long-term state is unconditionally turbulent. In contrast, the temporary cessation of turbulence, which may actually last for several hours in the nocturnal boundary layer, can be understood from the fact that the time scale for boundary layer diffusion is much smaller than the time-scale for flow acceleration. This limits the available momentum that can be used for downward heat transport. In case the surface heat extraction exceeds the so-called maximum sustainable heat flux (MSHF), the near-surface inversion rapidly increases. Turbulent activity is largely suppressed by the intense density stratification which supports the emergence of a different, calmer boundary layer regime. Finally, results are translated into a practical model to predict the minimum wind speed for sustained turbulence in the atmosphere. It is shown that under clear sky conditions 5 m/s is the typical geostrophic wind limit for Cabauw, below which continuous turbulence cannot be sustained. Below this threshold therefore the emergence of the very stable nocturnal boundary regime is foreseen.