Geophysical Research Abstracts
Vol. 13, EGU2011-7485, 2011
EGU General Assembly 2011

Structure of turbulence in 'the eddy surface layer'

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In a study of the kinematic structure of the near neutral atmospheric surface layer, Högström, Hunt and Smedman, 2002 (HHS), it was demonstrated that a model with detached eddies from above the surface layer impinging on to the surface (Hunt and Morison, 2000) could explain some of the observed features in the neutral atmospheric boundary layer. This is a fundamentally different approach compared to the generally accepted model for neutral boundary layers in typical laboratory conditions (see e.g. Lee, Kim and Moin, 1990, Adrian et al., 2000), which has small eddies being formed right at the surface, growing in size continually with height. In HHS it was argued that the detached eddy model is applicable for high enough turbulent Reynolds number, which is the case in the atmospheric surface layer, but not for typical laboratory conditions and in Direct Numerical Simulations (DNS) of turbulent boundary layers. Thus, the detached eddy model proved successful in explaining the dynamic structure of the near neutral atmospheric surface layer, especially the shape of the longitudinal and vertical wind components. No attempt was made in HHS to test the ability of this model to explain the total 3-dimensional structure including the lateral wind component.

Here we make the hypothesis that the detached-eddy model can be used to explain also the experimental results related to the 3-dimensional turbulence structure. Measurements were taken both over land and sea in the eddy surface layer. However, the lateral wind component shows a possible bifurcation of the large scale eddy structure towards a state in which there are quasi-steady longitudinal rolls and on a smaller scale unsteady detached eddies. In a LES simulation a similar co-existence of large and small scale eddies can be seen.

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