Similarity Theory and Linear Approximations of Turbulent Moments within the Convective Surface Layer of the Atmosphere

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Abstract:

Two limiting cases are provided by the Monin-Obukhov similarity theory for the convective surface layer of the atmosphere. The first one, so called a dynamic limit of the convective surface layer, defines a flow with zero buoyancy flux at the underlying surface and a logarithmic profile of wind within the layer. The second one, which is free-convection limit of the surface layer, defines a flow with positive buoyancy flux at the underlying surface and zero velocity of the wind.

The higher order turbulent moments can be defined by the generalize Monin-Obukhov theory for these limiting cases.

The paper is based on the assumption that a convective surface layer is divided into two sublayers: a dynamic sublayer, which is adjacent to the underlying surface, and a forced convective sublayer located higher. The turbulent moments of these sublayers can be defined independently.

This allows proposing linear approximations for the turbulent moments of the vertical velocity and the potential temperature variance within a forced convection sublayer. The free-convection limit of the Monin-Obukhov theory under no wind conditions is described by the first-order expansion terms of these approximations. The second-order expansion terms correspond to the profiles of the turbulent moments under conditions with low wind. The comparison between the proposed approximations and field data shows the correctness of the linear approximation within the forced convection sublayer.