Boundary Layer Modeling of the Atmosphere Processes above Plain Surface

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The most part of the meteorological processes are taken place in the atmospheric boundary layer (ABL) – lowest part of the atmosphere with the height of 1.5-2 km. Therefore the mathematical models describing the state of this layer are very important for weather forecast, pollution modelling etc. The problem formulation for such models usually includes motion, temperature, moisture, turbulent kinetic energy equations as well as equations of continuity and state. Such system is very hard to solve analytically or numerically due to non-linearity.

In this paper the approach for the plain surface modelling is developed which is based on splitting the whole ABL in two parts – the surface layer with the height of 030 m (depending on surface vegetation) and the rest of the boundary layer. Then the governing equations are simplified using characteristics inherent for each part. In the surface layer the largest gradients of the meteorological parameters (wind speed, moisture, and temperature potential) are observed. On the other hand, the height of turbulence flows here is relatively steady. The structure of the surface layer is determined based on the height of the vegetation canopy (e.g. forest or pasture). The influence of the vegetation type on the unknown parameters is also taken into account by adding the source term to the basis equations of the system [1]. The final simplified model for the surface layer has the constant coefficient of the turbulent kinetic energy. For the model of the rest of the ABL the velocity, temperature, humidity and the coefficient of the turbulent kinetic energy are assumed to be constant for the short period of time. Also, the system is considered to be horizontally homogenous, as this part of the atmospheric boundary layer does not contain any vegetation.

The obtained mathematical model is solved using the finite difference method. First, the equations for the upper layer were solved, after that the obtained values for the wind speed, moisture, temperature potential were used as the boundary conditions for the surface layer. The obtained numerical results are in good agreement with the known experimental data.

References

1. Goldberg V., Bernhofer Ch. Quantifying the coupling degree between land surface and the atmospheric boundary layer with the coupled vegetation-atmosphere model HIRVAC // Annales Geophysicae (2001) 19, p. 581–587.