Improved atmospheric boundary layer model for operational short-range forecasting

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The basic conception of the Hydrometeorological Research Center (HMRC) of Russia system for operational short-range forecasting is the reconstruction of both synoptic-scale and mesoscale weather patterns from the output product of a large-scale prediction scheme by atmospheric boundary layer (ABL) model and parameterization procedures (1,2). The results of the reconstruction of the ABL internal structure from objective analysis ad forecast data demonstrate the possibility of using the ABL model in operational prediction of meteorological fields and weather phenomena for a limited area encompassing Russia, Eastern Europe. Simultaneously these results showed the necessity of the improvement of the quantitative description of ABL turbulence structure. Let's remind that the mentioned above results were obtained by using the simplified turbulence closure scheme. It's supposed that the deficiencies are related on the simplification of the turbulence closure scheme. The two-equations closure scheme is used but the equations of turbulent kinetic energy and dissipation rate are written in time-dependant one-dimensional form. The missing terms seem to be represented the physical processes which have to be incorporated in the model realization.

The improvement of ABL model concerns the transport of the turbulent kinetic energy and dissipation rate, the production due to horizontal turbulent exchange. These effects are included in the closure scheme. The horizontal turbulent terms in the equations of the motion are described by the deformations of velocity. The capture of the missing terms in the equations of the turbulent kinetic energy and dissipation rate demands to rewrite the numerical algorithm. The finite-difference form of these equations in one-dimensional version is written in such way that the unknown functions of turbulent kinetic energy and dissipation rate have to be positive. Now it's done with taking into account the transport terms.

The comparison of the results obtained with unimproved and improved schemes shows that the improvements considered give essentially differences of turbulent characteristics and velocities of the organized motions. It means that the terms of the turbulent kinetic energy and dissipation rate transport are important for description the ABL turbulence structure.

The results of the improved model calculations show the better agreement with the measured data of meteorological fields. But these results are obtained only for small number of cases. The verification of the improved model is in progress.

Now we consider the ways to take into account the results of (3,4) for including the pressure correlation mechanism in the formation of the ABL turbulence structure. We use the parameterization scheme of the pressure-correlation which includes the turbulence-turbulence and mean fields-turbulence interactions. The two-equation turbulence closure scheme allows to calculate the both parts of the pressure-correlation term by using the Kolmogorov-Prandtl and Smagorinsky relationships and eddy-viscosity approximation. The use

of the algebraic expressions of Reynolds stresses obtained from simplified third moments equations is in the discussion. The dynamical interaction between underlying surface and atmospheric transfer with two characteristics of the relief (the heights and the slopes of the obstacles), with introduction of the effective roughness and urban effects will be also captured.

The ABL model improvements will be connected with further developments of the other modules of the Dynamical Weather Forecasting System operated in HMRC. The modeling algorithms will describe the humidity prediction through the implementation a land surface hydrology circle, the impact of atmospheric fronts upon the evolution of the meteorological variables in the boundary layer and free atmosphere.

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