Modeling of mesoscale processes and pollution distribution for the atmospheric boundary layer

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Pollution of the environment with anthropogenic emission has a negative effect on living organisms, soil, buildings, architectural monuments, and constructions. It causes metal corrosion and decreases atmospheric transparency. Under the effect of gravity, pollutants deposit onto the surface (soil, water bodies) from the atmosphere. Surface run-off causes secondary pollution of water bodies (partial washout of pollutants from soil) This is why estimation of pollutant flow from the atmosphere to the surface is of great importance. One of the means of such estimation is mathematical simulation that permits one to find the optimal variant from the viewpoint of minimizing anthropogenic load by simulating possible situations on a computer.

We consider the statement and the method of solution of non-stationary three-dimensional nonlinear problem for mesoscale processes arising over thermal and orographic nonhomogeneities of the underlying surface on a background of time – and space – variable large-scale meteorological fields. The model is constructed without the hypothesis on quasistatics and without the simplifications of the free convection theory.

We take into consideration all components of Coriolis force and the atmosphere compressibility.

The system of differential equations of nonstationary 3D non-linear model includes: the equation of motion, the equation of continuity, the equation of heat influx, the equation of humidity (salinity) transfer, the general form of the equation of state.

The boundary conditions along the horizontal direction are set as fluxes of momentum, heat, humidity, and mass. At the upper and lower boundaries, conditions of the first kind are set.

Since necessary information about hydrometeorological fields is absent, the initial conditions are replaced by solving the corresponding stationary problems.

The equations of the model are integrated in the Cartesian coordinate system by the method of fictitious domains. Introduction of such domains permits one to perform calculations with an arbitrary function describing the terrain and basin's bottoms.

The velocities and turbulence characteristics, which are obtained using the hydrothermodynamic model, are used in calculating gas and aerosol pollutant transfer (the equation of transport and turbulent diffusion of pollutants).

In any case, solution of transport and turbulent diffusion of pollutants gives, as a rule, estimates of the absolute pollutant concentration for an individual realization of the behavior of the medium. However, for many practical problems of interest are the zones of dangerous concentrations of the compounds from the viewpoint of not only their excess over the norms established for them, but also of their long-term effect on the natural medium. Just the long-term effect of pollutants creates real threat to the most vulnerable objects and contributes to the origin of cumulative effect, which can lead to delayed negative consequences and irreversible deviations from the natural equilibrium. Therefore of definite interest are the authors' mathematical models capable to detect the zones of hazardous effects on the natural medium with consideration for all climatic peculiarities of the examined region.

Consideration of climatic peculiarities of the region for the mathematical models allows one to detect more stable zones of enhanced level pf pollution, which must attract particular attention of the experts in different fields to make optimal decisions.

The diagnostic and prognostic versions of the calculations for anthropogenous sources of pollution are presented.