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Modeling of the Electric Field near the Surface Layer under Strong Turbulent Mixing

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The problem of the electrode effect under strong turbulent mixing with taking into account the molecular diffusion layer was discovered by J.C. Willet (1978) for the first time. The equations were solved in this layer and then were coupled with the solution in the area where the turbulent diffusion takes place. Comparison of the results shows that such detail specification of the problem does not lead to any significant differences of the solution. Thus, it can be considered the quite sufficient solution of the problem within the turbulent diffusion action area with the introduction of the parameter z0. Solution of the problem (J.C. Willet, 1978) is required when the roughness parameter becomes significant (about 0.1 - 1 m). The problem was considered by J.C.Willet (1983).

The problem of surface layer electrical state under strong turbulent mixing and analytical solution were observed by Kupovykh, Morozov, Schwartz (1998). Theoretical assessment indicated that if the dimensionless parameter ξ1,2 $<<$ 1 (when the surface layer wind speed is 4-5 m/s) then the distribution of the small ions is determined only by the turbulent diffusion. In this case the electrodynamic equations of the surface layer under strong turbulent mixing is the following:

$$\frac{\partial n_{1,2}}{\partial t} - \frac{\partial}{\partial z}\left(D_T(z)\frac{\partial n_{1,2}}{\partial z}\right) = q - \alpha n_1 n_2,$$
$$\frac{\partial E}{\partial t} - D_T(z)\frac{\partial^2 E}{\partial z^2} + \frac{1}{\varepsilon_0}\lambda(z)E = \frac{1}{\varepsilon_0}j_0,$$

where n1,2 – is space concentration of the small ions, E – is the electric field, DT(z,t) = χ(z,t) = D1$\times$z – are the coefficients of turbulent mixing of small and heavy ions accordingly, q(z,t) – is the ion formation rate, α – is the small ions recombination coefficient.

The equations were solved with appropriate initial and boundary conditions using up-to-date numerical methods. Analysis of received results indicates that if the turbulent mixing is increased the electrode effect value is decreased by 5%. Moreover its value increases by 10% if the height increases from 0,5 m to 2 m but this process becomes slower. Increasing of the height from 0,5 m to 2 m the values of n1(z)/n1(∞) increase by more than 25 %, n2(z)/n2(∞) by more than 40 %. Electrode layer thickness is 90 m that is 3-4 times more than for the results received under weak turbulent mixing.

Thus, in the case of strong turbulent mixing in the atmosphere the distribution of electrical parameters is determined only by the turbulent diffusion. Character thickness of the electrode layer is determined by Lm parameter.