Geophysical Research Abstracts,
Vol. 11, EGU2009-8249, 2009
EGU General Assembly 2009

Air dynamics near the ground surface and convective aerosol emission

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Field measurements conducted in a Caspian desert and estimates obtained for fluid dynamic parameters in the viscous thermal boundary layer near the ground surface are used to derive asymptotes for the mass concentration of fine aerosols. The external parameters in the problem are the friction velocity and the temperature drop across the thermal boundary layer. A porous soil layer model with air dynamics governed by the Darcy equation is used as a possible mechanism of aerosol emission. The critical parameters are estimated at which the thermal rolling of sand particles takes place in soil pores.

The underlying hypothesis in this work is that fine aerosol emission from the soil is proportional to the horizontal air velocity u_T at the height of the thermal boundary layer. In addition to the obvious simplicity of this hypothesis, another supporting argument is that it implies Bagnold's law u_*^3 for relatively high friction velocities: an increase in u_T leads to emission of not only fine aerosols but also larger soil particles that satisfy this law. However, it should be noted that this empirical law holds when u_* is much higher than the threshold values $\sim$ 0.4-0.5 m/s. The thermal factors then become not very significant, and sand and aerosol are carried away by strong turbulent velocity fluctuations ensuring the rolling and saltation of numerous particles at the ground surface. In this work, primary attention was given to the thermal factors at relatively low friction velocities associated with the mean wind shear. A fine aerosol fraction was separated in the soil, which was treated as a porous medium.

For low and moderate friction velocities u_*, formulas show that, as δTgrows, u_T increases with an exponent a ranging from 1/2 to 2/3. For large u_* as δTgrows, u_T falls off like $\delta T^{-1/2}$, which is fairly similar to the measured dependencies for the aerosol concentration. Based on the permeable medium model, we estimate the threshold values of δTat which sand particles in the ground begin to move. The corresponding formulas show that the convective emission of fine aerosols in no wind or light wind can be more effective than in moderate wind.

The investigation was fulfilled under the support of RFBR grant No. 08-05-00942.