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THE NUMERICAL MODEL OF CLOUDS BY TAKING INTO ACCOUNT OF MICROPHYSICS ELEMENTS

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In meteorology a string of such problem as microphysics of clouds, an active influence on them, biological prognosis, radio- and satellite communications have a significant meaning. Let's remark, that a clouds electricity, 'taking down' electrical energy from them is still in a so-called infantile age [1-4].

A special interest is a cloud electrical field, an electrical interaction between big and small drops. There are a lot of ineplicable, unintelligible phenomenons. The study of these questions has not only theoretical, but and a big practical interest: scientists more and more incline to that is not possible a successful artificial influence on clouds by no sooner than a process thermodynamics and condensation centres sowing without a careful research of a cloud electrical field. Today we have not got a certain, clear replay, answered on even first sight very easy elementary question: why an electrical lightning and a heavy shower coincide with each other in time. It is existence three hypothetical supposition: a) a lightning causes a heavy shower - elecrically charged drops are holding on by existencing cloud electrical field. At discharging this field is destroyed and because drops downfall; b) a heavy shower causes a lightning; c) it is existence a third some unknown factor causing both these processes.

Let's remark that during experimental works they often resort to methods of a simple analogy, that is results of laboratory research are directly transfering on native, natural phenomenons without observance of a similarity criterion, which are not clearly determining yet. For example, today it is already exactly finding out that because of different character scales (laboratoral and natural) it is not possible researching of two rather badly studied phenomenon: an unelectrode discharge-lightning and a spherical lightning. That is all secret lies in that itself process qualitatively changes because of its increasing to gigantic sizes. It is possible analogy in case of a electrical field of cloud and its microphysics.

Let's also take notice, that a directly, experimental research of clouds, especially in storm conditions, is a very dangerous affair for an aviation.

Therefore a role of a theoretical, in particularly, a numerical simulation of clouds and taking place processes in it becames all more and more actual. By the way at such kind of study we are also insuring from errors of experimental researches caused by the principle of Heisenberg - that is an impossibility of a simultaneous measuring of certain physical values.

At present it is existence a lot of suppositions about a rainformation mechanism. But among them it is more current, popular one is that in this process one of main role belongs to electrical interaction between small and big drops. As a rule the formers have a positive charge and the letters - a negative one. Let's remark at present stage we don't interest a prehistory, that is drop forming, rising, charging and so on.

We use as a basis the developed by our group during string of years the numerical models of mesoscale boundary layer of atmosphere (MBLA), clouds, fogs and aerosol turbulence diffusion in them in order to investigation of this problem. Presently we want to research small and big drops spreading in stratus and convective clouds. A numerical simulation scenario will be such: on a background of atmosphere thermohydrodynamics is forming a cloud. In some moment of time a certain concentration small (positive) and big (negative) drops is artificial given in it. They differ from the other in velocities of precipitation (naturally, big drops have more weight and, accordingly, more velocity than small drops). That is we will have positive and negative charged drops and by numerical simulation will be able to determine their a space-time distribution on an underground of an atmosphere termohydrodynamics, a circulation, a trajectory, cycles of a drops lift and come down, formation separate drops layers and so on. We must once more remark that on this stage don't consider neither coagulation growth, nor splash, nor electrical interaction between drops.

The basic system of MBLA equations by taking into account of a cloudformation and spreading of big (negative charge) and small (positive charge) drops in it has such view [5-8]:

$$\begin{aligned}
&\frac{\mathrm{du}}{\mathrm{dt}} = -\frac{\partial\pi}{\partial \mathrm{x}} + \Delta'\mathrm{u},\\
&\frac{\partial\pi}{\partial \mathrm{z}} = \lambda\theta,\\
&\frac{\partial \mathrm{u}}{\partial \mathrm{x}} + \frac{\partial \mathrm{w}}{\partial \mathrm{z}} = 0,\\
&\frac{\mathrm{d}\theta}{\mathrm{dt}} + \mathrm{Sw} = \frac{\mathrm{L}}{\mathrm{c_p}} + \Delta'\theta,\\
&\frac{\mathrm{dq}}{\mathrm{dt}} + \gamma_{\mathrm{q}}\mathrm{w} = - + \Delta'\mathrm{q},\\
&\frac{\mathrm{dv}}{\mathrm{dt}} = \ + \Delta'\mathrm{v},\\
&\frac{\mathrm{dN}}{\mathrm{dt}} - \mathrm{w_N}\frac{\partial \mathrm{N}}{\partial \mathrm{z}} = \Delta'\mathrm{N},\\
&\frac{\mathrm{dn}}{\mathrm{dt}} - \mathrm{w_n}\frac{\partial \mathrm{n}}{\partial \mathrm{z}} = \Delta'\mathrm{n},\\
&\frac{\mathrm{d}}{\mathrm{dt}} = \frac{\partial}{\partial \mathrm{t}} + \mathrm{u}\frac{\partial}{\partial \mathrm{x}} + \mathrm{w}\frac{\partial}{\partial \mathrm{z}}, \quad \Delta' = \mu\frac{\partial^2}{\partial \mathrm{x}^2} + \nu\frac{\partial^2}{\partial \mathrm{z}^2},
\end{aligned} \tag{1}$$

where u, w are horisontal and vertical components of an air velocity, respectively, π, θ, q - deviations of pressure analog, potential temperature and water-vapor mixing ratio, from their undisturbed fields, respectively, v - liquid-water mixing ratio, n, N - concetrations of small and big drops, respectively, w_n, w_N - precipitation velocities of small and big drops, respectively, λ, S - parameters of atmospheric flotation and stratification, respectively, γ_q - vertical gradient of undisturbed water-vapor mixing ratio, - rate of water-vapor condensation, L -latent heat of condensation, c_p -specific heat of dry air at constant pressure, μ, ν - horisontal and vertical coefficients of turbulence, respectively.

Boundary and initial conditions may be written as

$$\begin{aligned}
&\text{at } \ \mathrm{z}=0 \ \ \mathrm{u}=0, \ \ \mathrm{w}=0, \ \ \theta=\mathrm{F1(x,t)}, \ \ \mathrm{q}=0, \ \ \mathrm{v}=0, \ \ \mathrm{n}=\mathrm{N}=0,\\
&\text{at } \ \mathrm{z}=\mathrm{Z} \ \ \mathrm{u}=0, \ \ \pi=0, \ \ \theta=0, \ \ \frac{\partial \mathrm{q}}{\partial \mathrm{z}}=0, \ \ \frac{\partial \mathrm{n}}{\partial \mathrm{z}}=\frac{\partial \mathrm{N}}{\partial \mathrm{z}}=0, \ \ \frac{\partial \mathrm{v}}{\partial \mathrm{z}}=0,\\
&\text{at } \ \mathrm{x}=0,\mathrm{X} \ \ \frac{\partial \mathrm{u}}{\partial \mathrm{x}}=0, \ \ \frac{\partial \theta}{\partial \mathrm{x}}=0, \ \ \frac{\partial \mathrm{q}}{\partial \mathrm{x}}=0, \ \ \frac{\partial \mathrm{v}}{\partial \mathrm{x}}=0, \ \ \frac{\partial \mathrm{n}}{\partial \mathrm{x}}=\frac{\partial \mathrm{N}}{\partial \mathrm{x}}=0, \qquad (2)\\
&\text{at } \ \mathrm{t}=0 \ \ \mathrm{u}=0, \ \ \theta=0, \ \ \mathrm{q}=0, \ \ \mathrm{v}=0, \ \mathrm{n}=0, \ \ \mathrm{N}=0,\\
&\text{at } \ \mathrm{t}=\mathrm{t_0} \ \ \ \mathrm{n}=\mathrm{M_n}\ \delta(\mathrm{x}-\mathrm{x_0},\mathrm{z}-\mathrm{z_0}), \ \mathrm{N}=\mathrm{M_N}\ \delta(\mathrm{x}-\mathrm{x_0},\mathrm{z}-\mathrm{z_0}),
\end{aligned}$$

where X, Z are horizonthal and vertical boundaries of MBLA, F1(x,t) - the temperature of an underlying surface given function from meteorological experiments, M_n, M_N - powers of small and big drops sources, respectively, (x_0, z_0) -coordinates of sources, t_0 - a moment of drops spreading, δ -the Dirac function.

The problem (1), (2) is at a stage of numerical realisation. In order to its solve it was applied obvious finite-difference scheme first order accuracy in time and second accuracy in coordinate except equations of drops transfer [7, 8]. In relation to letters they was solved by a monotonous numerical scheme (a drop concentration can't be negative) with direction differences. It has first order accuracy both in time and in coordinate. Later on we must perfection it by applied of conservative (concerning of drops quantity) and more high occurate schemes.

The constants and parameters, which didn't change in numerical experiments, are such, as in [7, 8].

As an illustration are giving the simplified variant of problem solution: we have a cloud in MBLA and in it weighty drops spread from a instaneous point source, that is we limite oneself only one kind of drops.

In Fig. 1 they are given liquid water ratio isolines of the simulated cloud, which drops was spreaded in. In Fig. 2 - concenrtation isolines of drops without a precipitation velocity ($\mathrm{w_n} = 0$ - this is a control variant) and in Fig. 3 - concentration isolines of weighty drops ($\mathrm{w_n} = 0.2$ m/sec). They are given levels of maximal drops concentration by shade lines.

In Fig. 2, 3 one can clearly see that maximal concentration levels of weighty drops marcedly fall in comparision of the control case. Evidently we will have by analogy in case of different drops (that is, small and big drops case) spreading.

First numerical experiments satisfactorily describe the concider process. Further ones will give us possibility to research the present problem more in detail.

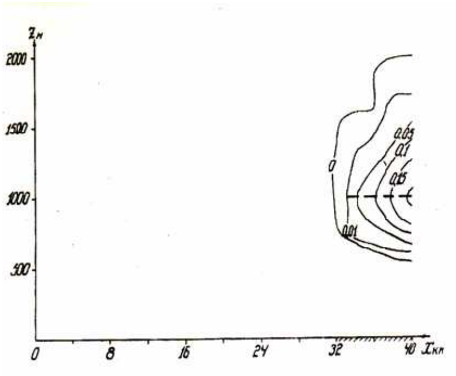

Fig. 1

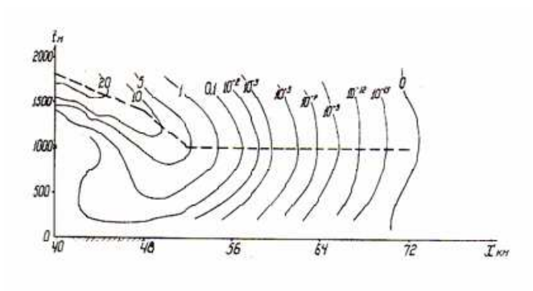

Fig. 2

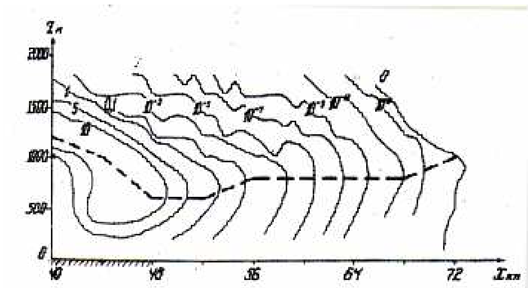

Fig. 3

R E F E R E N C E S

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