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One-dimensional non-stationary convection model

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One-dimensional convection model is widely used in large-scale atmospheric models for the description of the convective clouds and calculating precipitation. Such models are stationary and can not describe the dynamics of the convection. There are widely used the non-stationary version of the one-dimensional models that are remaining within the framework of the simple versions. Evaluation of the convection processes in these models differs from the stationary version. If we consider the results of the stationary version as an initial condition for the non-stationary model, then in the process of solving the non-stationary task it will be the development of convection and establishing of the convective.

In the present paper the equation processes for the vertical velocity are considered. That contains the time derivative. It is solved by the finite-difference scheme for a variety of levels k. The number of the levels k is determined by the spline approximation of the input data. As a result we have a quadratic equation for the vertical velocity w, taking into account the effects of entrainment, detrainment and release of condensation heat. If the vertical velocity in the calculation is positive, we assume the formation of the cloud elements.

Based on the equations for the specific humidity q, water content δ and the statistical stability s, and introduce to them the time derivatives we obtain the equations system for the one-dimensional non-stationary cloud model, that take into account the processes occurring inside the cloud and in the surrounding area. Also here is presented an approach for the calculation of the precipitation.

Many experiments using the model were performed to optimize the input parameters, empirical coefficients and calculated algorithm.

The calculations showed that all model parameters are changing over time and finally the development process is stabilized. This is due to the surrounding state of the atmosphere that does not changed in these calculations. Value of the time steps for the integration in the cloud and the time steps of changing the environment parameters must be conformed: the period of convection is less than the step of change in the external environment. In our case we choose a step in non-stationary cloud model up to 10 seconds.

The model is convenient to use because minimum of the input data is required: the geopotential, pressure, temperature and humidity. At the output the model can provide quick calculations and fairly realistic values of the vertical velocity, precipitation, and the various parameters of the clouds. The presented algorithm can be adapted to large-scale hydrodynamical models of the atmosphere.