On the cloud amount parameterization.

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Today state of the cloud amount parameterization in the hydrodynamical models of the atmosphere is based upon the relative humidity threshold values that regulate the cloud formation starting, so called relative humidity critical value, f_{cr}. Smagorinsky (1960) used many experimental data to draw the curves for the cloud amount dependence upon the relative humidity for different atmospheric layers. He showed that f_{cr} is depends upon height, - the larger height, the smaller f_{cr} value.

The great experience existed in Russia from the regular aircraft observed data supports this conclusion. The analyses of the aircraft data were carried out by Gogoleva (1956), Reshetov (1962), Abramovich (1964). They used the dew point deficit, Δ, as the best characteristic of the moist air proximity to the saturation state. They found that Δ values within the cloud are in limits of 1° ÷ 5° in dependence of height. Aircraft information and curves presented by Smagorinsky are the objective results for the real atmospheric situations.

The wide spread cloud parameterization methods used in hydrodynamical atmospheric models are based upon the prescribed f_{cr} values. The another approach to cloud amount parameterization doesn't exist now. This problem isn't correct because it is necessary to describe the cloud amount distribution inside the model grid cell knowing the humidity characteristics in the center of the cell only. To solve this problem some hypothesis are needed.

All cloud amount parameterizations used today have very different vertical distribution of f_{cr} as a model tuning parameter. Comparison of different cloud amount parameterization methods was carried out by Kurbatkin et al. (1988) under the same initial data. The discrepancy of cloud amount in different models was very great in limits of 0.2 ÷ 0.8. It is evident that every parameterization is tuning radiation fluxes at top of the model atmosphere. So the cloud parameterization methods are model depended and aren't objective.

Sundqvist (1978) proposed the new hypothesis of humidity characteristics distribution inside of model grid cell in dependence of cloud amount. This idea was applied to dew point deficit as the Humidity transformation model developed in Hydrometeorological center of Russia includes the transfer equation for this characteristic (Dmitrieva-Arrago et al., 1985, 1996,1998). We proposed that in every grid point:

$$\Delta = \Delta_{cr}(1-C) + C\Delta_{cl}, \qquad (1)$$

where C is a cloud amount, Δ_{cr} is Δ critical value for the cloud formation starting and Δ_{cl} is Δ in cloudy part of the cell.

The scheme of this parameterization is presented on Fig.1. We assume that after the cloud formation beginning the value of Δ_{cr} is remained in cloudless part of the cell. The expression for cloud amount follows from (1) for every model level:

$$C = \frac{\Delta_{cr} - \Delta}{\Delta_{cr} - \Delta_{cl}} \qquad (2)$$

Formula (2) may be applied to model predicted Δ value or to observation data to check the proposed method of cloud amount parameterization. We have used the set of radiosonde data of relative humidity and temperature vertical distribution for the European region of Russia for September and October 2000 (638 cases). The radiosonde data were accompanied by synoptic observation of the general cloud amount.

The vertical distribution of Δ was calculated using the radiosonde data. Needed Δ_{cr} values for (1) were calculated using the prescribed f_{cr} vertical distribution (Table 1) taken in accordance with analyses of aircraft data and Smagorinsky results. Than the general cloud amount was computed and compared with observed synoptic data using the method developed by Veselova (1988). The results of comparison are presented in Table 2 and 3. Here in Tables: $\tilde{\delta}$ is mean systematic (arithmetic) error, $\bar{\delta}$ is mean absolute error, σ is standard deviation, $P = N_i/N$, N_i is a number of results in the prescribed interval of mean absolute error, N is general number of cases. The mean absolute error intervals were taken as $\bar{\delta} \le 0.1, \le 0.2, \le 0.3, \le 0.4$.

The results of calculation of skill criteria values are in limits of 0.3÷0.4 for this set of data.

The Tables 2 and 3 and received skill criteria values show that the proposed parameterization for the general cloud amount may be evaluated as satisfactory method in limits of error of 0.2.

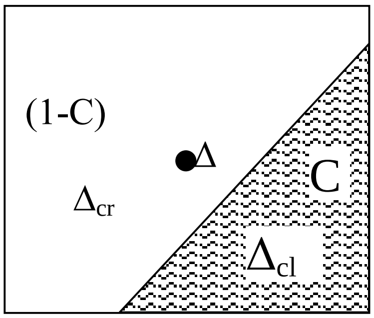

Fig.1

Table1

Vertical distribution of f_{cr}

P,gPa	925	850	700	500	400	300
f_{cr}	0,7	0,7	0,6	0,5	0,4	0,3

Table 2

Mean values of general cloud amount

Month	Number of cases	Observed values	Calculated values
September	318	0.67	0.80
October	320	0.78	0.85

Table 3

Cloud amount calculation errors

Month	$\bar{\delta}$	σ	$\tilde{\delta}$	P, %			
				≤0.1	≤0.2	≤0.3	≤0.4
September	0.22	0.35	0.13	43	68	75	78
October	0.19	0.32	0.07	48	73	80	84

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