THE METHOD OF THE CLOUD – RADIATION INTERACTION DESCRIPTION FOR THE ATMOSPHERIC HYDRODYNAMICAL MODEL

Dmitrieva – Arrago L.R., Shatunova M.V.

Hydrometeorological Research Center of Russia, Russia

dmitrieva@mecom.ru

The delta – Eddington approximation to the radiation transfer equation solution is used for the solar radiation fluxes calculations. The developed algorithm is presented in (*Dmitirieva-Arrago, Shatunova, 2001*). The main problem of the radiation fluxes calculation is the influence of the cloudiness, its spreading and microphysical properties. Microphysical properties define the cloud optical characteristics – the albedo and transmission and the fluxes at the surface. To receive the microphysical characteristics the humidity transformation model that include the cloud water content transfer equation is used (*Dmitrieva-Arrago, 2004 a,b*). As a result of model integration space distribution of cloud water content and mean cloud particle radius are obtained. The clouds optical properties are defined by the value of the cloud absorption (σ_{abs}) and extinction (σ_{ext}) coefficients.

Mentioned coefficients are calculated by the following formulas (*van de Hulst, 1957*):

$$\sigma_{ext} = \pi \int_0^\infty r^2 Q_{ext} n(r) dr, \tag{1}$$

$$\sigma_{abs} = \pi \int_0^\infty r^2 Q_{abs} n(r) dr, \tag{2}$$

where

$$Q_{ext} = 2 - 4e^{-\rho tg\beta} \frac{\cos\beta}{\rho} \sin(\rho - \beta) - 4e^{-\rho tg\beta} \left(\frac{\cos\beta}{\rho}\right)^2 \cos(\rho - 2\beta) + 4\left(\frac{\cos\beta}{\rho}\right)^2 \cos 2\beta, \tag{3}$$

$$Q_{abs} = 1 - \exp(-4\chi k) \tag{4}$$

are the expressions of effectiveness factor of the extinction and absorption of the solar radiation by the clouds (*van de Hulst, 1957; Shifrin 1955*), correspondently. ***n*(*r*)** is cloud particle distribution function, $\rho = 2\chi(m-1)$, $\chi = 2\pi r/\lambda$, $tg\beta = k/(n-1)$, ***r*** is particles radius, λ is wavelength, ***m*** is media refraction index, $m = n - ik$, ***n*** is the real part of the refraction index, ***k*** is the image part of the refraction index .

Two parameters gamma – distribution function is prescribed:

$$n(r) = \frac{N_0}{\Gamma(\alpha+1)\beta^{\alpha+1}} r^\alpha \exp\left(-\frac{r}{\beta}\right) \tag{5}$$

α is assigned as constant, β is variable value that calculated during the humidity model integration.

Using (1) - (5) values of the absorption and extinction coefficients could be calculated.

The cloud optical characteristics were calculated in the dependence of the cloud liquid water content, mean particles radius and the asymmetry parameter of the phase function that is depend upon the effective particles radius according Slingo (*1989*).

The results of calculation of the liquid cloud albedo and transmission are presented on Fig. 1. and Fig. 2.

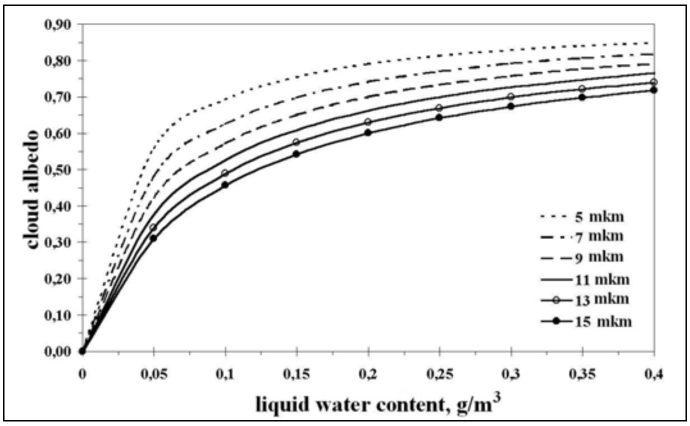

Fig. 1. Cloud albedo in dependence of liquid water content and mean particles radius

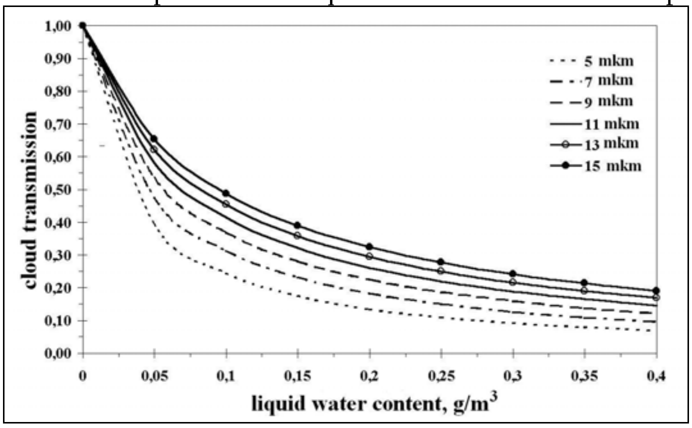

Fig. 2. Cloud transmission in dependence of liquid water content and mean particles radius

As follows from the Fig. 1 cloud albedo is depends at the first upon the liquid water content. The maximum difference in albedo is near 30-40% under the mean radius variation within the limits of 5-15 mkm and liquid water content variation from 0,05 to 0,1 g/m^3. The variation of the transmission (Fig. 2) with in the same interval of liquid water content may be two times more. The more the mean particles radius, the greater the transmission value.

The presented algorithm may be used in the hydrodynamical model of the atmosphere that includes the cloud water content transfer equations.

References:

Dmitirieva-Arrago L.R, Shatunova M.V., 2001: Investigation of the dependence of solar radiation characteristics of the atmosphere on atmosphere, cloud and underlying surface properties. SPIE Proceedings "Atmospheric and ocean optics. Atmospheric physics", 4678

Dmitrieva-Arrago L.R., 2004a: The methods of short-term forecast of the nonconvective clouds and precipitation on the basis of the humidity transformation model with microphysics parameterization. Part 1. Humidity transformation model in the atmosphere and forecast of the noncovective cloudiness.

Dmitrieva-Arrago L.R., 2004b: The methods of short-term forecast of the nonconvective clouds and precipitation on the basis of the humidity transformation model with microphysics parameterization Part 2. The method of the precipitation forecast based on the calculated fields of the liquid water content and parameterization of the microphysical processes in noncovective clouds.

van de Hulst, 1957: Light scattering by small particle. New York, J.Wiley & Sons, Inc.

Shifrin K.S., 1955: To the cloud radiative properties calculation. MGO proceeding, 46(108)

Slingo, A., 1989: A GCM parameterization for the shortwave radiative properties of the water clouds. J.Atmos.Sci., 46