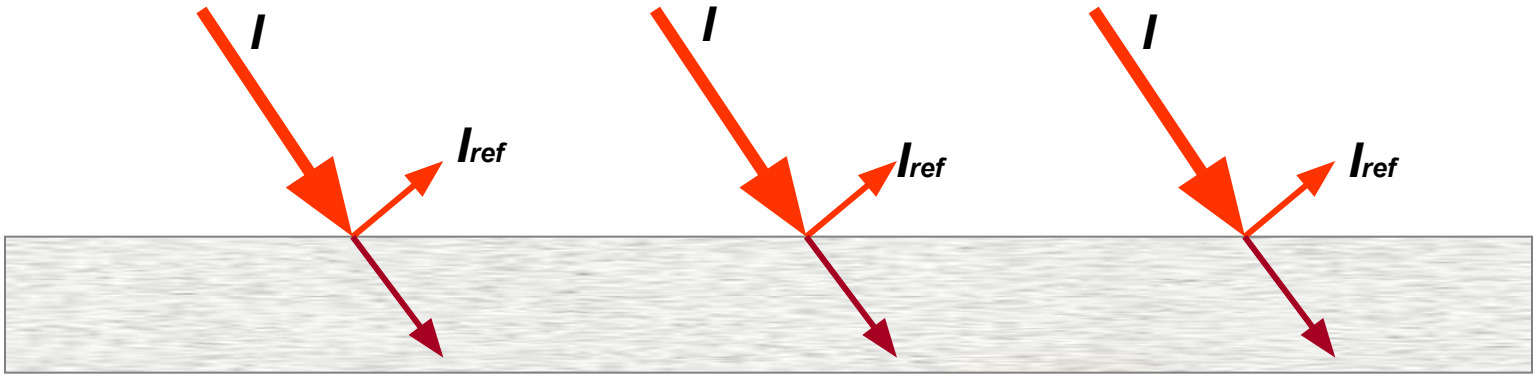
Albedo

The ratio of back-scattered from a surface radiation to the incident radiation is known as *reflectability* or *albedo of the surface.* This ratio is usually expressed in % or in decimal fractions.

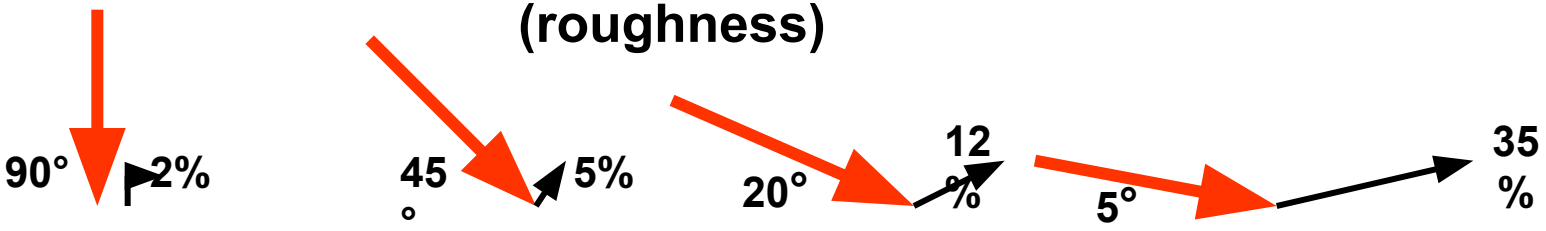


$$I = I_d + i$$

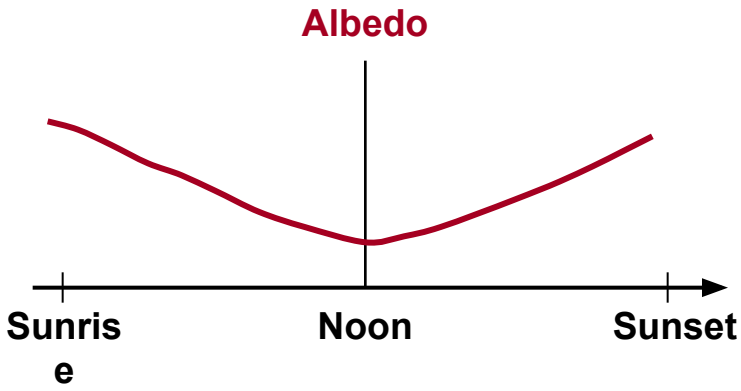
Albedo of water surfaces

Albedo depends on the Sun altitude especially over water surface

(roughness)



Dependence on the Sun altitude causes well-defined diurnal and annual variations of albedo



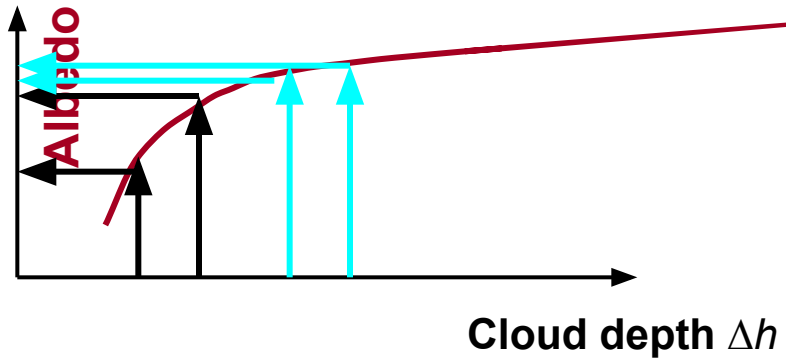
Annual variation of albedo

Minimal albedo – summer

Maximal albedo -- winter

Albedo of clouds

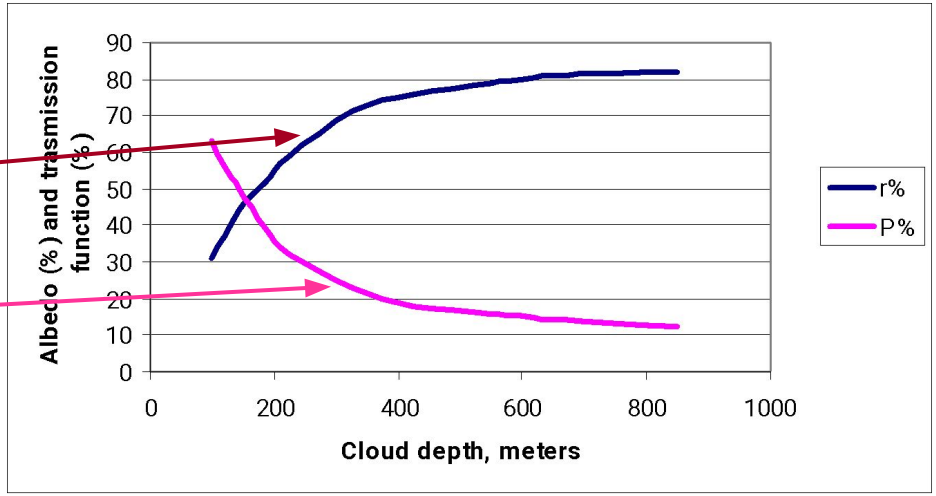
Albedo depends on cloud depth



Threshold

Albedo also depends on cloud form. The largest albedo is at *Ac* and *Sc* clouds. *Ac – 73%; Sc – 64%; Cu – 52%*

Cloud depth (Δh), albedo (r), and transmission function (P).



Altocumulus (Ac)

http://www.clouds-online.c

- Description:
- Grey cloud bundles, sheds or rollers, compound like rough fleecy cloud, which are often arranged in banks.

- Origin:

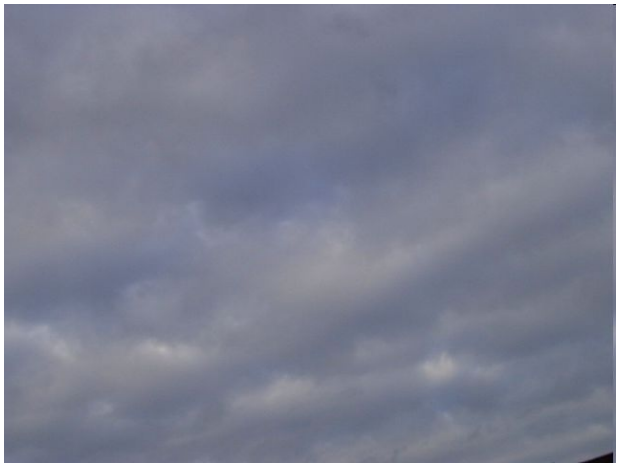
- By rise of an expanded air layer at the border of a rising zone.

- By convection or turbulence within an unstable layer of the middle cloud level.

- By transformation from Altostratus und Nimbostratus at lability or Cumulus and Cumulonimbus at stability.

Stratocumulus (Sc)

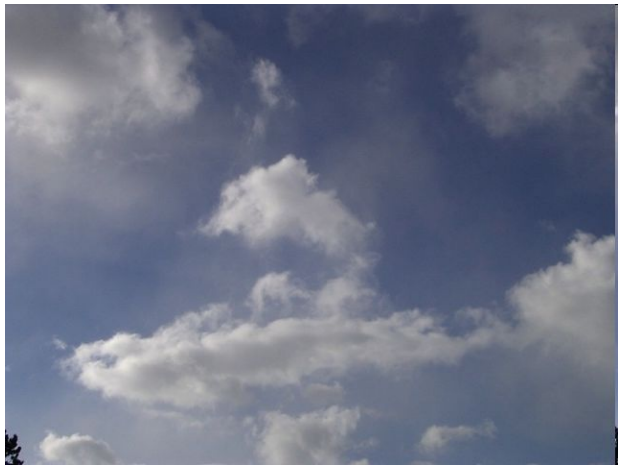
- Description:
- Cloud plaices, rollers or banks compound dark gray layer cloud.
- Origin:
- By turbulence.
- By convection in unstable air layers, which are limited by a strong inversion upward.
- By undulation in very damp air layers and usually at inversions.
- From other clouds (Nimbostratus, Cumulus, Stratus)



Cumulus (Cu)

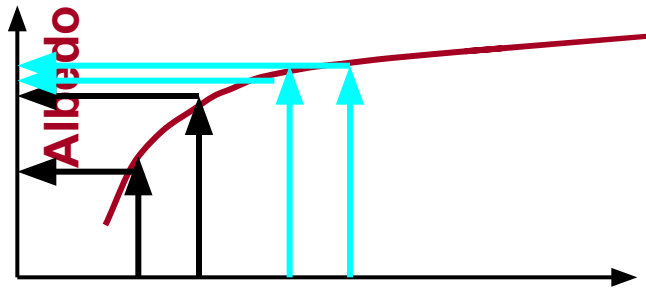
- Description:
- Heap cloud with flat basis in the middle or lower level, whose vertical development reminds of the form of towers, cauliflower or cotton.

- Origin:
- The Cumulus always indicates an instability to the layering of air with appropriate convection or turbulence.



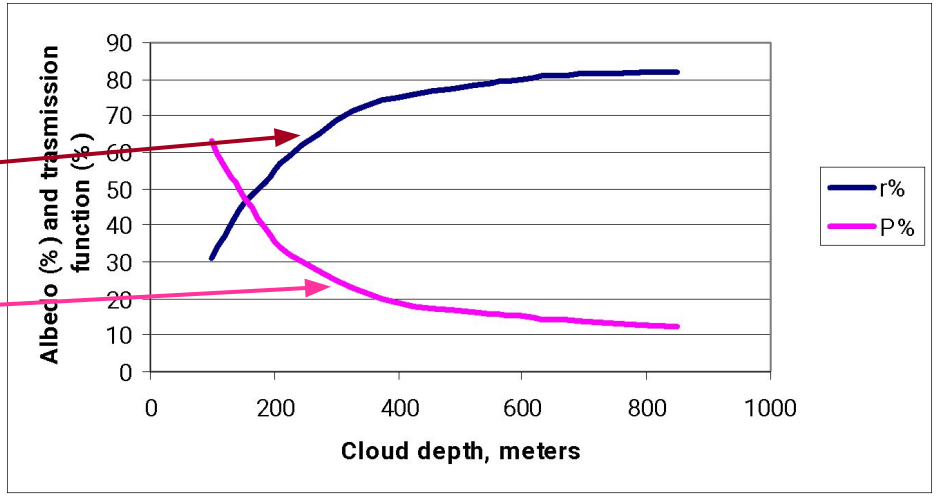
Albedo of clouds

Albedo depends on cloud depth

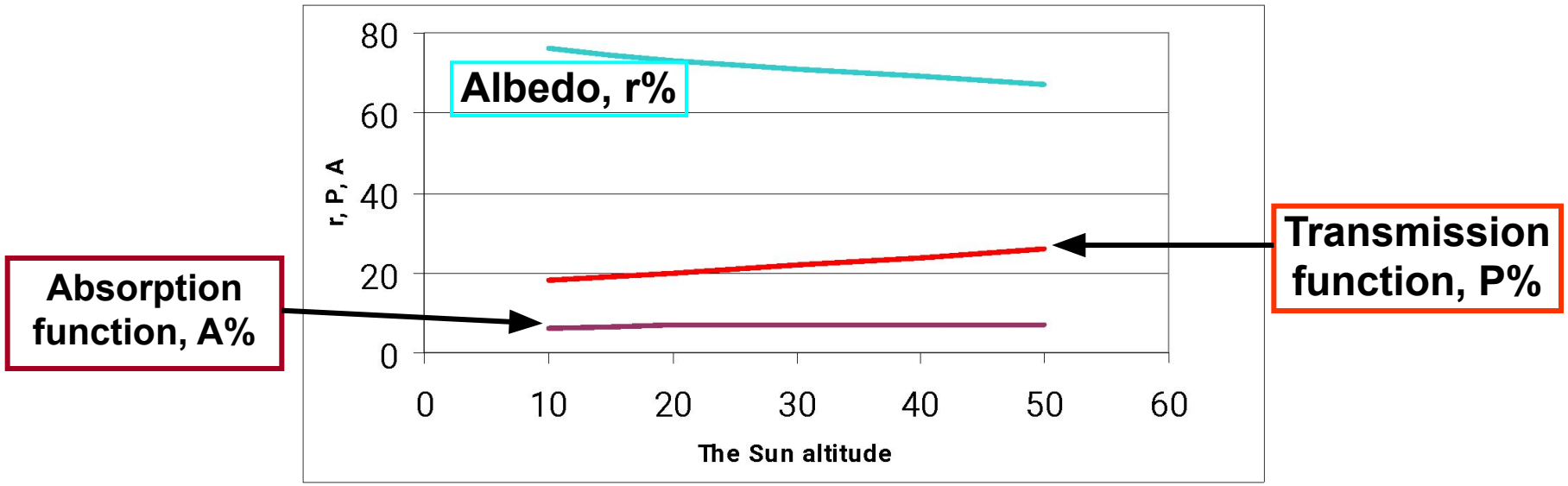


Albedo also depends on cloud form. The largest albedo is at *Ac* and *Sc* clouds. *Ac – 73%; Sc – 64%; Cu – 52%*

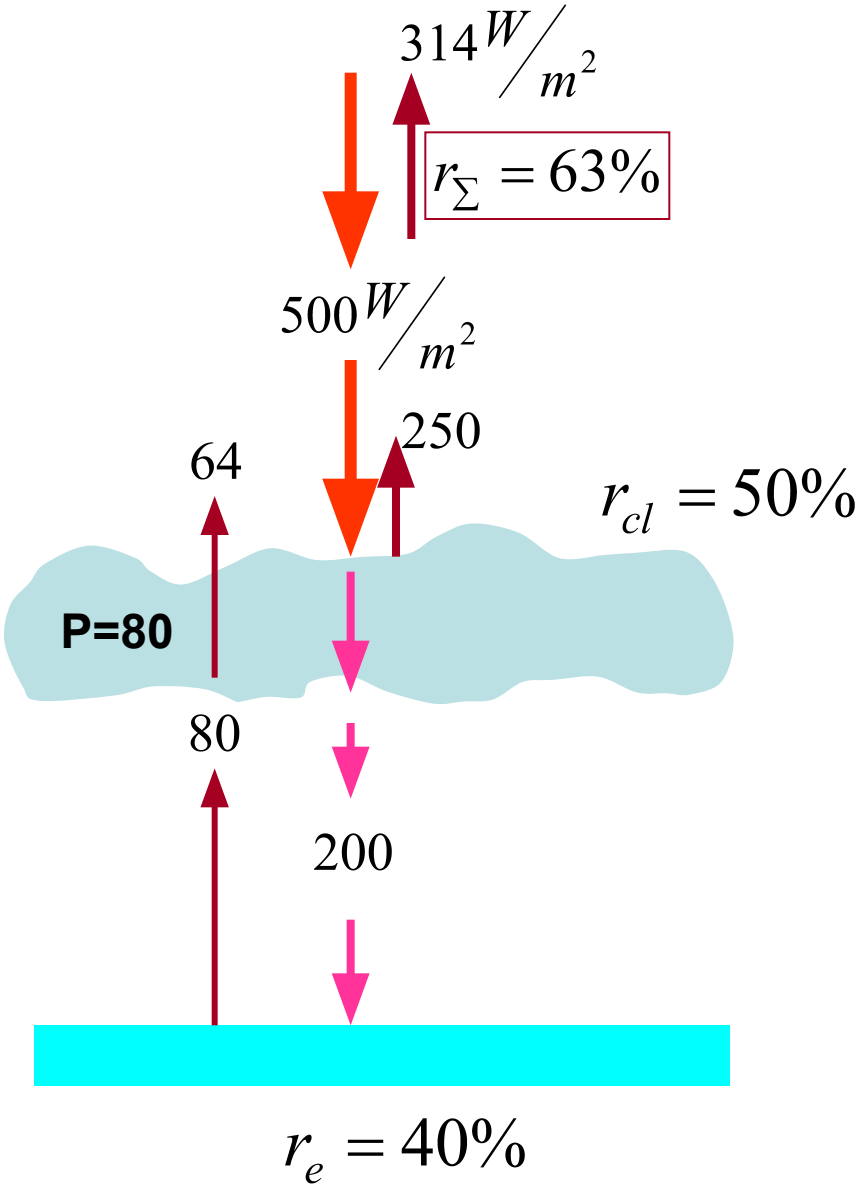
Cloud depth (Δh), albedo (r), and transmission function (P).

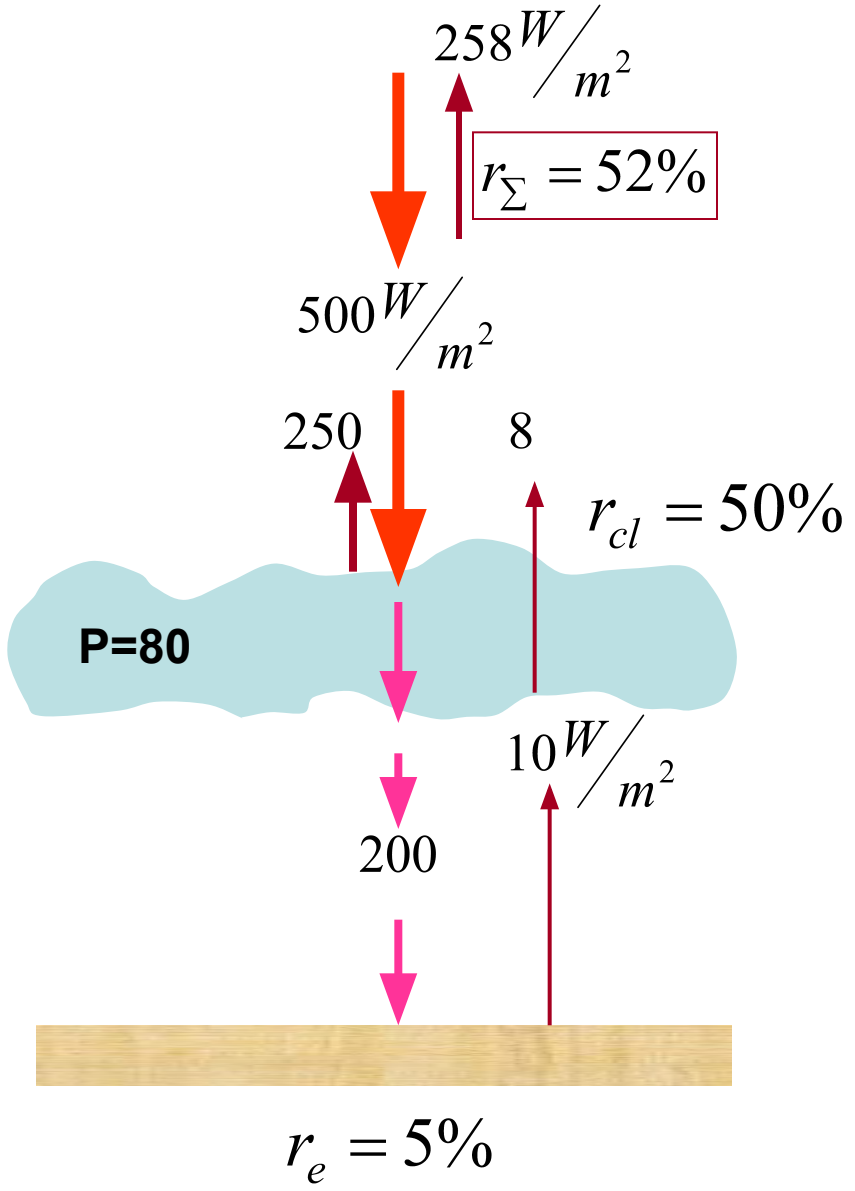


Dependence of albedo (r), transmission (P), and absorption (A) functions on the Sun altitude.



Albedo of clouds also depends on Earth's surface albedo (r_e). The stronger the r_e value, the larger the cloud albedo


314 W/m²
r∑ = 63%
500 W/m²
250
64
rcl = 50%
P=80
80
200
re = 40%


258 W/m²
r∑ = 52%
500 W/m²
250
8
rcl = 50%
P=80
10 W/m²
200
re = 5%

Addition to albedo of clouds

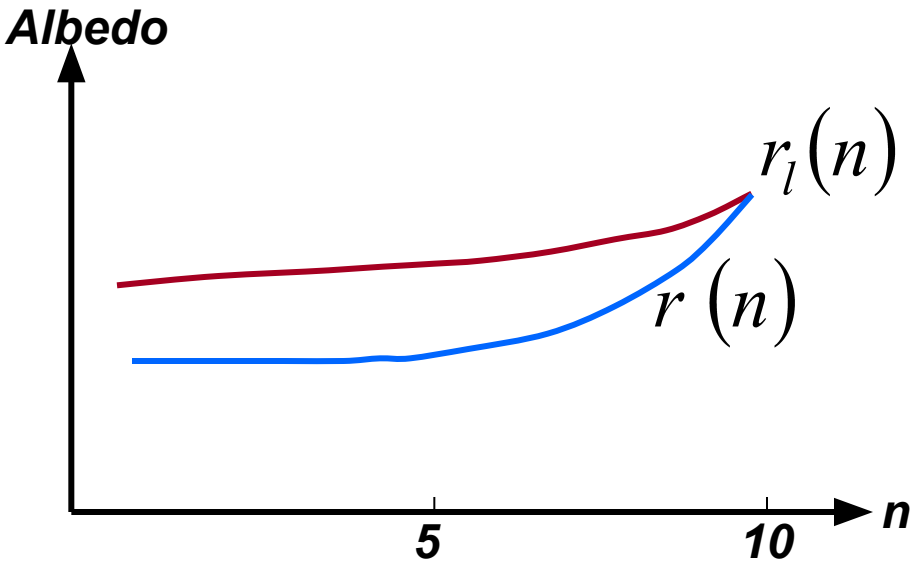
Difference between albedo of a separate cloud *r* and albedo of a cloud layer r_l.

$$r_l = r_l(0)(1-n) + r \times n$$

"*n*" is cloud amount in decimal fractions, $r_l(0)$ is albedo of cloud free atmosphere at the level of the possible cloud top. From the experimental data the following formula has been obtained.

$$r_l(n) - r_l(0) = \frac{n}{0{,}826 - 0{,}06n}$$

Here, r_l%, and *n* in points.



The rate of separate cloud albedo, *r(n),* can be explained by the fact that, at small cloud cover (*n<6 point)*, the distance between clouds is rather big, and separated clouds act in each cloud own way (not interacting with each other).

As amount of clouds increasing, the clouds start interacting. Radiation scattered by a cloud side reaches some other clouds, resulting in increasing of reflection.

Experimental data analysis has shown that albedo of cloud layer depends only slightly on cloud depth. At *n=4…6 points*, correlation coefficient is as low as *0,19±0,1*. This fact can be explained in the same way as it was done in previous discussion.

The albedo of clouds can vary significantly as the initial depth is rather small (the cloudiness is thin).

Cloud depth, m	***100***	***400***	***700***	***1000***
Albedo %	***40***	***72***	***82***	***84***