Homework Problem (see website for the other problem).

Reproduce the figure on the next slide using the simple model with absorption for the values of $\omega \neq 1$. Calculate the cloud albedo as a function of effective radius and liquid water path for single scattering albedo equal to 0.999, 0.98, and 0.95. For each case, assume that the absorption is caused by black carbon aerosol embedded in the cloud. Calculate the absorption coefficient necessary to give each value of the single scattering albedo as a function of the liquid water path.Comment on the likelihood of observing these absorption coefficients. Finally, comment on how aerosol light absorption impacts the aerosol indirect effect (i.e. the increased cloud albedo because of smaller more numerous droplets).

Note: the mean free path of photons between scattering events is = 1 / β_{sca}.

T_{dir} = exp(- $\beta_{ext} h$)= exp(-$\underline{\tau}$) = probability that photons pass through the general medium without interaction with the scatterers and absorbers. (Ballistic, unscattered photons useful for imaging in scattering medium with fast lasers that can gate out scattered photons that arrive later due to their larger path length).

Cloud Liquid Water Path, Effective Radius, And Cloud Albedo

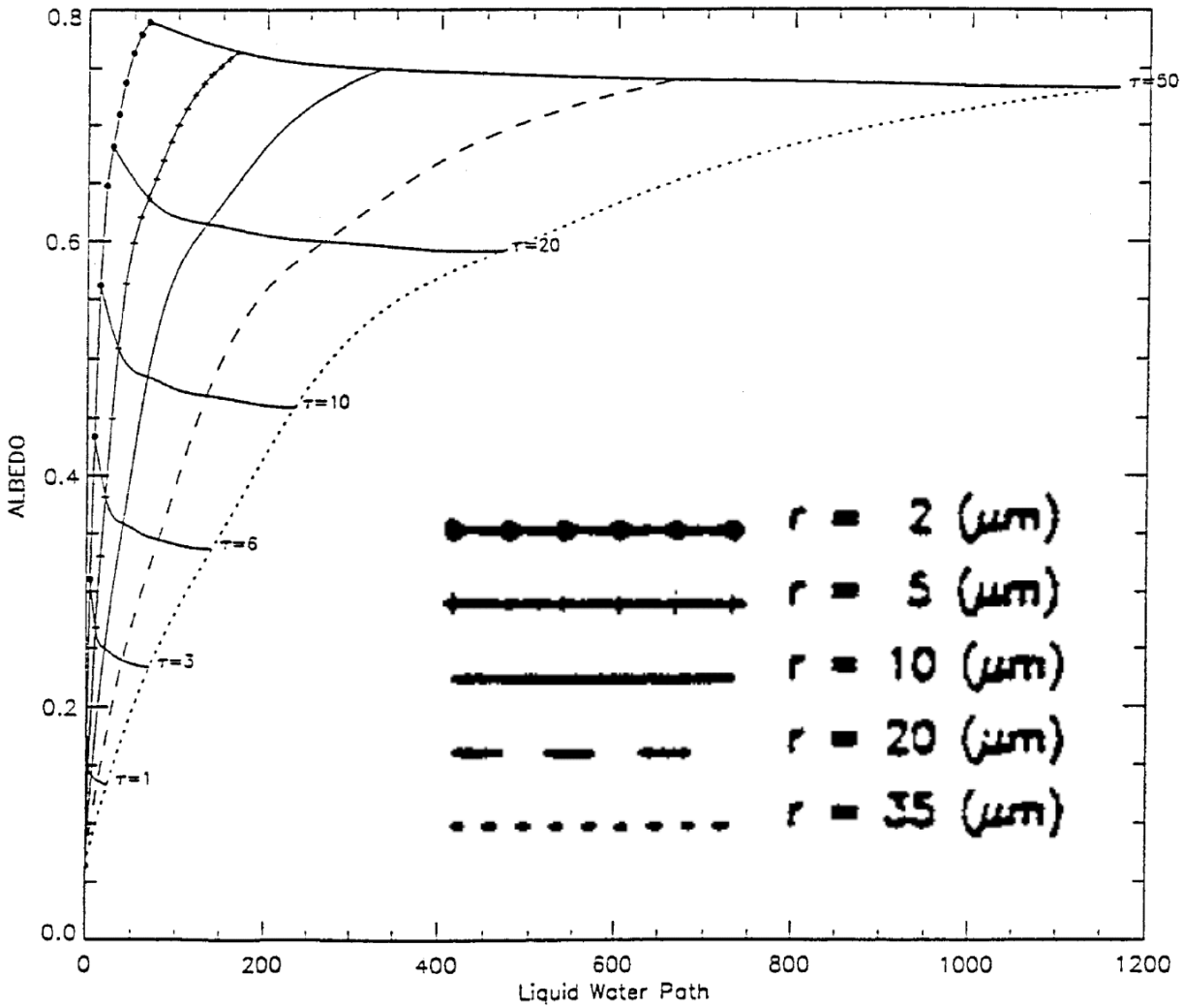

FIG. 1. Model results of cloud albedo as functions of r_e and LWP.

grams / m^2

Does this make sense? Why?

How do things change when the single scattering albedo is not equal to 1, and absorption happens?

Global Survey of the Relationships of Cloud Albedo and Liquid Water Path with Droplet Size Using ISCCP.Preview By: Qingyuan Han; Rossow, William B.; Chou, Joyce; Welch, Ronald M.. Journal of Climate, 7/1/98, Vol. 11 Issue 7, p1516.