Atmospheric Sciences 6150

Autoconversion

The parcel model treats the cloud liquid water and the rain water as two mutually exclusive categories so it is necessary to parameterize a conversion from cloud water to rain water. We can do this using the physically intuitive idea that once the mean cloud drop size exceeds a certain threshold some of the cloud water is converted to rain water by collision and coalescence. This conversion is controlled by a parameterization that follows Kessler (1969) such that the rate at which cloud water is converted to rain water is given by

$$\left(\frac{\partial q_r}{\partial t}\right)_{\text{auto}} = A(q_c - q_0)$$

where q_c is the cloud liquid water mixing ratio and $A = 10^{-3}$ s^{-1} represents the rate at which the conversion takes place when $q_c > q_0$. For some time it was thought that collision and coalescence could not proceed until the radius of droplets exceeded 19 μm (Hocking 1959). Later calculations suggest that the collection efficiency of droplets smaller than 19 μm is non-zero, although the collision rate among such small droplets is very low. Therefore, it is thought that a few droplets with radius greater than about 20 μm must form in a cloud in order to initiate significant growth due to collisions among cloud droplets.

Abel and Shipway (2006) specified the threshold cloud liquid water mixing ratio q_0 by assuming that the threshold *mean* droplet radius for autoconversion to occur, r_0, is 10 μm. They also assumed that the cloud droplet number concentration, n_c, is constant so that

$$q_0 = \frac{\rho_l}{\rho}\frac{4}{3}\pi\, n_c\, r_0^3$$

where ρ and ρ_l are the densities of air and liquid water, respectively.