Condensational growth

$$\frac{dr}{dt} = \frac{(S-1) - \frac{A}{r} - \frac{B}{r^3}}{F_D + F_K}$$

$$where \quad F_D = \frac{R_v T \rho_l}{D e_s(T)}, \qquad F_K = \frac{L_v \rho_l}{KT}\left(\frac{L_v}{R_v T} - 1\right)$$

$$D = 2.11\left(\frac{T}{T_0}\right)^{1.94}\left(\frac{p_0}{p}\right) \cdot 10^{-5}\,[m^2/s],\ T_0 = 273.15K, p_0 = 1013hPa$$

$$K = (4.378 + 0.0711 \cdot T) \cdot 10^{-3}\,[\frac{J}{msK}]$$

When drops are large they fall with an appreciable velocity. The assumption that the vapour field surrounding each drop is spherically symmetrical becomes invalid. The water vapour field around the drop is distorted and the heat and mass transfer increase, analogous to the way the wind enhances evaporation from the land/sea surface. These effects are incorporated into the theory of diffusional growth by multiplying the diffusion and conductivity coefficient by an appropriate ventilation coefficient (f_v) that is described empirically as a function of Reynolds number ($Re = 2ru_\infty(r)/\nu$, where u_∞ describes the terminal drop velocity and ν is kinematic viscosity). The ventilation factors need not be the same for vapour (diffusivity) and heat (conductivity) transfer, however they are often assumed to be so as a convenient approximation so that $D'/D = K'/K = f_v > 1$:

$$f_v = 1.00 + 0.09\,Re \qquad 0 \le Re \le 2.5$$

$$f_v = 0.78 + 0.28 Re^{1/2} \qquad Re \ge 2.5.$$

Evaluating f_v for typical conditions shows that the ventilation factor is negligible for droplets smaller than $10\mu m$ in radius, $f_v \approx 1.06$ for $r = 20\mu m$ and increasing to $f_v = 1.25$ for $r = 40\mu m$. The growth by condensation of drops this large is usually negligible compared with the mass transfer through collision-coalescence . Hence the ventilation effect is negligible for condensational growth, but becomes very significant in the evaporation of raindrops.

1. Plot F_D and F_K in a function of T. Compare with values given in Table 7.1 in *A Short Course in Cloud Physics* by R. R. Rogers and M. K. Yau.

2. Plot $r(t)$ for $T = 0, 10, 20^oC$.

3. Plot $r(t)$ as in 2. but applying a correction with the ventilation factor.