Cloud Physics Lab

LAB 7: Droplet Growth by Diffusion II

Introduction:

In the previous lab you have investigated the process of cloud droplet growth by diffusion through analyzing the growth rate at different supersaturations and different temperatures for two types of solutes. In this lab student will further explore more details about the growth process of cloud droplet by diffusion.

Objective:

a) Plot and study growth rate for different initial radii of cloud droplets and long it will take these drops to grow to larger size.

Theory:

Recall the droplet growth equation from previous Lab

$$r\frac{dr}{dt} = \frac{\left((S-1) - \frac{a}{r} + \frac{b}{r^3}\right)}{F_k + F_d} \tag{1}$$

For radii greater than a few microns, the solute and curvature effects become negligible. In this case the growth equation becomes:

$$\frac{dr}{dt} = \frac{1}{r}\frac{S-1}{F_k + F_d} = \frac{\xi}{r} \tag{2}$$

Integrating this equation will give the radius as a function of time:

$$r(t) = \sqrt{r_o^2 + 2t\xi} \tag{3}$$

- ξ depends on temperature and pressure. The larger T, the lower p, the higher ξ.
- The parabolic form of equation (3) leads to a narrowing of the drop-size distribution as growth proceeds.
- Consider two cloud droplets with initial radii of r_{1o} and r_{2o} with $r_{2o} > r_{1o}$. From equation (3) it follows:

$$r_2 - r_1 = \frac{r_{2o} - r_{1o}}{r_{2o} + r_{1o}} \tag{4}$$

Because the difference between the squares of the initial radii remains constant, at any time t, the difference in radii becomes smaller.

Materials and Procedures:

1. Run the Matlab script **Lab7a.m** to plot the droplet growth rate for different initial radii of cloud droplet.
2. Run the Matlab script **Lab7b.m** again to plot the droplet growth rate for different droplet temperatures.
3. Run the Matlab script **Lab7c.m** again to plot the droplet growth rate for different super saturation.

Analysis and Conclusions:

1. Use figure 1 to explain how the droplet initials radius can affect the growth rate of droplet.
2. Use figure 2 to explain the effect of increasing the temperature of cloud droplet on the growth process.
3. Use figure 3 to explain how supersaturation can affect the growth rate of cloud droplet.

Questions:

1. What did you further learn about cloud droplet growth by diffusion by completing the activity?
2. In fig.1 the first three curves of initial radii of cloud droplet coincides together. Explain?
3. Find the time required for the cloud droplet to grow to 50 μm at T=0 ^{o}C (use fig. 2) and SS=1.02. Compare your results to find which case requires longer time and why?
4. Fig 1. Shows that it would take around 900 min (15 hours) to grow the droplets to the size of a typical cloud droplet (50 μm) and around 3000 min (about 2 days) to grow to a precipitation size (100 μm). Do you think diffusional growth can produce precipitation? Why?
5. Derive equation (4).