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Calculating the Temperature where Rain Droplets in a Cloud become Ice Particles

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Abstract

On June 4, 2012, Jennings (2012) [1] published his theory of how a polystyrene solution superheats and nucleates. From Jennings (2012) [1] came Jennings (2024) [2] where the formula for raindrop formation in a cloud is presented. Then was published Jennings (2026) [3] where the following equation for the rain dew point was derived.

$$To–T = (3\ k\ To^2/\sigma_o\ a_o)\ (P^*_{H2O}/P_{air})$$

For Jennings (2025) [4] there is the formula for snow formation in a cloud related to ice formation in a supercooled bath.

$$T = D\ (7.14 \times 10^7) / (k\ n_s\ a\ \Delta T^{0.69})$$

Now ΔT = To-T, where To = melting temperature Kelvin of ice and T = temperature Kelvin of the bath or supercooling limit in the cloud. In this paper, we eliminate To-T between these two equations to get this result.

$$T = D\ (7.14 \times 10^7) / (k\ n_s\ a\ ((3\ k\ To^2/\sigma_o\ a_o)(P^*_{H2O}/P_{air}))^{0.69})$$

In the text of the paper, the author will calculate T, where the rain droplet has cooled enough to become an ice particle. Another aspect of this paper is to point out that cloud seeding should be done in the Rocky Mountains that feed the Colorado river. The clouds in the mountains could be seeded with NaCl, AgI, dry ice or even possibly CH3-O-Na+. Jennings (2022) [5] NOMENCLATURE will be included.

Keywords: Dew Point, Cloud Nucleation, Cloud Seeding, Supercooling, Colorado River

Introduction

We need to put in the values for the variables in the third equation in ABSTRACT.

$$T= D\ (7.14 \times 10^7) / (k\ n_s\ a\ ((3\ k\ To^2/\sigma_o\ a_o)(P^*_{H2O}/P_{air}))^{0.69}) \tag{1}$$

From Price, *et al* (1999) [6] we have for D, above 242K.

$$D = (4.00 \times 10^{-8}\ m^2\ s^{-1})\ \exp(-\ 371\ K^{-1}/(T-169.7)K) \tag{2}$$

k = 1.3805×10^{-16} erg/K (Boltzmann constant); To = 273.15 K, freezing point of water The surface tension of supercooled water is from Hacker (1951) [7] for σ_o.

$$\sigma_o = 75.6\ dynes/cm + ((79.2-75.6)\ dynes/cm)/(-20°C))xT°C \tag{3}$$

$a_o = 46.6 \times 10^{-16}\ cm^2$ (separate calculation and densityof supercooled water is close to 1 g/cc).
$n_s = 3.0656 \times 10^{22}$ molecules/cm^3 (number density of ice) at 0°C and a = 2.767×10^{-10} m at 0°C (atomic spacing of ice). According to Barnes (1929) [8] there is no change in the structure of ice between 0°C and -183°C. $P^*_{H2O} = 0.00605$ atm, equilibrium vapor pressure of H_2O at 0°C. (Reference 9) For Pair, we have the following:

h	Pair
0m	1atm
2000m	0.8atm
7000m	0.4atm
12,000m	0.2atm

So, the equation relating h and Pair is. Air pressure above sea level can be calculated as:

$$Pair = 101325\ (1 - 2.25577\times10^{-5}\ h)x5.25588 \qquad (4)$$

Where 101325 = normal temperature and pressure at sea level (Pa), Pair = air pressure (Pa), h = altitude above sea level (m) [10].

The calculation has to be done by computer because T occurs a number of times in Equation (1).

Results

It must me mentioned here that cloud seeding needs to be done in the Rocky Mountains that feed the Colorado River. NaCl, AgI, dry ice or even possibly CH3-O- Na+ could be used with monitoring of the rainfall. The distribution of clouds and snow cover exert a major influence on the proportion of light reflected back into space and energy balance. Shell (2018) This means that the forests must be preserved.

Conclusion

The author has an interest in cloud chemistry and is trained in physical chemistry research. This paper is another effort to explore rain and snow and their effect on the environment.

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