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A New Formula for the Rain Dew Point II

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Abstract
In the first version of this document there were errors, which will be addressed in ERRATUM. The formula proved was the following for the rain dew point [1].

$$To-T=(3kTo^2/\sigma_o a_o)(P^*_{H2O}/Pair)$$

A table will be devised to show the use of this equation in atmospheric chemistry. All of the variables here can be obtained and T is the undercooling below to the freezing point of water. Pure water can be supercooled to about – 40 °C. The best place to intervene with cloud seeding is in mountains to feed the rivers for the crops [2].

Keywords: Cloud Seeding, Dew Point, Equilibrium Vapor Pressure of Water, Surface Tension

Erratum

In the first version of this paper [1] there was an error in MW_{water}. It should be 18.015 gram/mole. Also, for P^*_{H2O}, equilibrium water vapor pressure, it should be 0.00605 atm at 0°C [3]. It is necessary to present the calculation for δ again. Taking the values in the first paper, we have.

$$\delta=2\sigma_o((MW_{water})/(N_A kT))/((\rho_{liquid})(r)) \tag{1}$$

Also, for r, a better value is 0.1 cm as the radius of a beginning rain droplet in a cloud [4]. 0.1 cm is for the rain droplet, which increases in size. The values for the terms in (1) are all for 0°C, the same as before except for r [1]. $\delta=1.2x10^{-6}$. Then we have $\delta=(P_{H2O}-P^*_{H2O})/P^*_{H2O}$, so that means $P_{H2O}=0.00605$ atm and $P_{H2O=}P^*_{H2O}$. There is no NOMENCLATURE.

Introduction

In the first paper, this equation was proved using the Ostwald-Freundlich [5] equation as derived from Lord Kelvin's formula for increase of pressure due to curvature of the surface [6]. We note that (2) is quadratic in To but it is not needed to solve for to.

$$To-T=(3kTo^2/\sigma_o a_o)(P^*_{H2O}/Pair) \tag{2}$$

To is taken to be 0°C and a_o is calculated as the surface area of a water molecule. σ_o and P^*_{H2O} are at 0°C for water. It is instructive to get T, the undercooling temperature Kelvin, while varying Pair [7]. This calculation is for the beginning rain droplet in the cloud, r=0.1 cm.

Results

A table is written as follows, with To=273.15 Kelvin and we take for P^*_{H2O} the value 0.00605 atm, as above. We calculate from (2). $\sigma_{o,}$ a_o and P^*_{H2O} are taken to be at 0°C and 1 atm initially and also for higher elevations for P_{air} (an approximation). $\sigma_o=75.6$ erg/cm^2, $a_o=46.6x10^{-16}$ cm^2 and $P^*_{H2O=}0.00605$ atm. We assume P^*_{H2O} does not depend on the height of the storm cloud. We take the cloud starting at $P_{air}=1$ atm and increase the height h. Also, we assume the surface tension of the supercooled water in the cloud can be calculated from the data of Hacker [8].

T(calculated)	Pair	h (storm cloud)	ΔT=To-T
272.6 Kelvin	1 atm	0 m	0.5308 Kelvin
272.5 Kelvin	0.8 atm	2000 m	0.6636 Kelvin
271.8 Kelvin	0.4 atm	7000 m	1.327 Kelvin
270.5 Kelvin	0.2 atm	12,000 m	2.654 Kelvin

Air pressure above sea level can be calculated as:

$$P_{air} = 101325\ (1 - 2.25577\times10^{-5}\ h)x5.25588 \qquad (3)$$

Where 101325 = normal temperature and pressure at sea level (Pa), P_{air} = air pressure (Pa), h = altitude above sea level (m) [7].

Since the density of air falls off with altitude, according to the ideal gas law P_{air} falls with temperature. So this obtains [9].

$$P = \rho RT \text{ where } \rho=n/V \qquad (4)$$

Thus temperature in the storm cloud drops as h increases. The effect from lowered density and pressure is considerable as the temperature drop with rising h is temperature decreasing by roughly 6.5°C per 1000 m altitude rise.

Discussion

As can be readily seen, the change due to Eq. (2) is minor as the ideal gas law produces more change in temperature for the storm cloud than the effect due to water vapor. Higher elevations in the earth's atmosphere are colder because the pressure falls off [10].

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