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Humidity Equations

The following symbols appear in the equations below:

- **e** = Vapor pressure, *millibar*
- **e_i** = Vapor pressure with respect to ice, *millibar*
- **e_w** = Vapor pressure with respect to water, *millibar*
- **e_{is}, e_{ws}** = Saturation vapor pressure, *millibar*
- **P** = Total pressure, *millibar*

- **T** = Temperature, *°C*
- **T_a** = Ambient temperature, *°C*
- **T_d** = Dew Point temperature, *°C*
- **T_f** = Frost Point temperature, *°C*

Vapor Pressure

Saturation vapor pressure with respect to water is a function of temperature only and is given by the following:

$$e_{ws}(T) = \left(1.0007 + 3.46 \cdot 10^{-6} \cdot P\right) \cdot 6.1121 \cdot \exp^{\frac{17.502 \cdot T}{240.9+T}}$$ (exp : exponential function) ❶

Saturation vapor pressure with respect to ice requires a minor adjustment of the constants as given by the followings

$$e_{is}(T) = \left(1.0003 + 4.18 \cdot 10^{-6} \cdot P\right) \cdot 6.1115 \cdot \exp^{\frac{22.452 \cdot T}{272.55+T}}$$ ❷

In addition to yielding saturation vapor pressure as a function of ambient temperature, the above equations also yield ambient vapor pressure as a function of dew/frost point.

The total pressure of a gas mixture is equal to the sum of the partial pressures each constituent gas would exert, were it to occupy the same total volume, according to Dalton's Law. The first term (in parentheses) in Equation ❶ and ❷ is the enhancement factor, and corrects for the slight difference between ideal behavior of pure water and the behavior of water vapor as a constituent of air.

Humidity

Relative Humidity is defined as the ratio of the water vapor pressure (e) to the saturation vapor pressure (e_s) at the prevailing ambient or dry bulb temperature T_a:

$$\%RH = 100 \cdot \frac{e}{e_s} = 100 \cdot \frac{e_w(T)}{e_{ws}(T_a)}$$ ❸

Absolute humidity is expressed as water vapor density: water vapor mass per unit volume of dry air, according to the following:

$$g/m^3 = \frac{216.7 \cdot e(T_d)}{T + 273.16}$$ ❹

Water vapor content expressed as parts per million by volume is given by the following:

$$ppm_v = \frac{10^6 \cdot e(T_d)}{P - e(T_d)}$$ ❺

Expressing water vapor content as parts per million by weight (or mixing ratio) requires multiplication of the above by the ratio of the molecular weight of water to that of air as given by the following:

$$ppm_w = 0.622 \cdot \frac{10^6 \cdot e(T_d)}{P - e(T_d)}$$ ❻

The above information comes from :

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