Education and Outreach

Education and outreach provided by the Planetary Atmospheres Node

Encyclopedia of Standard Planetary Information, Formulae, and Constants

- Summary of Constants
- Tables of Atmospheric Parameters for the Planets
- Adiabatic Lapse Rate, Dry
- Autoconvective Lapse Rate
- Amagats
- Beer's Law
- Beta Plane Approximation
- Brunt Vaisala or Buoyancy Frequency
- Cloud Clearing
- Cloud Properties
- Dobson Units
- Double Linear Interpolation
- Earth: Molecular Abundances
- Earth: Molecular Spectral Regions
- Earth: Oceans
- Earth: Orbit
- Equations of Motion
- FFT and Cosine Transform
- Gas Constant
- Geopotential
- Geostrophic Approximation
- Gravity
- Heat Balance
- Humidity
- Hurricanes
- Hydrostatic Equilibrium
- Ideal Gas Law
- IR Filter Bandpasses
- Latitude: planeto-graphic and planeto-centric
- Longitude Systems and Conversion
- Orbital Equation of Motion
- Planck Function
- Planetary Missions Summary
- Potential Temperature
- Potential Vorticity
- Radiative Time Constant
- Radiative Transfer Equation (IR)
- Rayleigh Scattering: Optical Depth
- Rayleigh Scattering: Phase Function
- Richardson Number
- Rossby Number
- Saturation Vapor Pressure
- Scale Height
- Thermal Wind Equation
- Velocity of Sound
- Vorticity
- Weighting Functions
- Wind Measurement

Broker/Forum listing
Welcome to the Planets
Planetary Photojournal
PDS Education

Saturation Vapor Pressure

Given T in Kelvin these equations will give e_s in milliBar.

from Fleagle and Businger, Vol.5, pg. 62 (QC880.F59)

The first law can be written as

$L = T \cdot (S_2 - S_1) = U_2 - U_1 + P_s \cdot (\alpha_2 - \alpha_1)$

where $\alpha_1 \equiv 1/\rho_1$ and index 1 refers to the liquid phase and index 2 refers to the gas phase.

For an isothermal change of phase, the Clausius-Clapeyron equation has the form

$d P_s / d T = L / [T \cdot (\alpha_2 - \alpha_1)]$

Water vapor behaves like an ideal gas and $\alpha_2 \gg \alpha_1$ for a change in state.

$L \approx 2.5 \cdot 10^3$ Joules/gm

$L \approx 2.824 \cdot 10^3$ Joules/gm over ice

$R_w = R_* / \langle mw \rangle_w = 8.3143/18.016 = 0.4615$ Joules/gm/K

$P_s = \rho_2 \cdot R_w T$

$d P_s / d T = L / [T \cdot (\alpha_2 - \alpha_1)] \simeq (L \cdot \rho_2)/T = (L \cdot P_s) / (R_w \cdot T^2)$

$d \log(e_s) = d P_s / P_s = (L/R_w) \cdot (dT/T^2)$

$\log_e(e_s) = \int (L/R_w) \cdot (dT/T^2) = -(L/R_w)|T \to T_0 + C = -L/(R_w \cdot T_0) + L/(R_w \cdot T) + C$

at triple point all 3 phases can exist in equilibrium, 0.0098° C and $P_s = 6.11$ mB

$e_s(T=T_0) = 6.11$

$L/R_w = 5417.12$

$L/(R_w T_0) = 19.8313$

$6.11 \cdot \exp[L/(R_w T_0)] = 2.504 \cdot 10^9$

$e_s(T) = 6.11 \cdot \exp[5417(1/T_0 - 1/T)] = 2.504 \cdot 10^9 \cdot \exp[5417/T]$

Undocumented fit is used in the program watsat.F (over liquid)

$e_s = 2.229 \cdot 10^9 \cdot \exp[-5385/T]$

Note this is the same equation as above, except that it assumes $L = 2485.2$ Joules/gm and $T_0 =$ 273.15 ° K

Another undocumented fit is given (but not used) in the program watsat.F

$e_s = 0.001 \cdot \exp[a/T + b + c \log(T) + d \cdot T + e \cdot T^2]$

coef	over ice	over water
a	-5631.1206	-2313.0338
b	-8.363602	-164.03307
c	8.2312	38.053682
d	$-3.861449 \cdot 10^{-2}$	$-1.3844344 \cdot 10^{-1}$
e	$2.77494 \cdot 10^{-5}$	$7.4465367 \cdot 10^{-5}$

From Rogers and Yau, pg. 16

$e_s = 6.112 \cdot \exp[a \cdot (T-273.16)/(T-b)]$

coef	Rogers & Yau over water
a	17.67
b	29.66

Murray, F.W. 1966. ``On the computation of Saturation Vapor Pressure'' *J. Appl. Meteor.* **6** p.204

$e_s = 6.1078 \cdot \exp[a \cdot (T-273.16)/ (T-b)]$

coef	Murray over ice	Murray over water
a	21.8745584	17.2693882
b	7.66	35.86

Saucier, W.J. 1883. ``Principles of Meteorological Analysis'' *Dover* pg. 9 who uses values of Tetens (1930). Note, he used $10^{[(a'T)/(T-b')]}$ with T in Centigrade so to convert into the form above $a = \log 10 \cdot a'$ and $b = 273.16 - b'$.

coef	over ice	over water
a	21.875	17.27
b	7.66	35.86