Air humidity calculation

http://www.cactus2000.de

Constants:

N_L	$6.0221415 \cdot 10^{23}$	mol^{-1}	Avogadro constant	NIST
R	8.31447215	$J\ mol^{-1}\ K^{-1}$	Universal gas constant	NIST
M_{H2O}	18.01534	$g\ mol^{-1}$	molar mass of water	
M_{dry}	28.9644	$g\ mol^{-1}$	molar mass of dry air	

Variables:

c_{H2O}	$g\ m^{-3}$	mass concentration of water
$[H_2O]$	cm^{-3}	molecular concentration of water
e	hPa	vapor pressure of water
P	hPa	pressure
P_{H2O}	hPa	partial pressure of water
q	$kg\ kg^{-1}$	specific humidity (mass mixing ratio in wet air)[1]
mmv	$kg\ kg^{-1}$	mass mixing ratio in dry air[2]
n_{air}	$mol\ m^{-3}$	air density
RH	%	relative humidity
T	C	temperature
T_D	C	dew point temperature
x_{H2O}	-	mole fraction, volume mixing ratio of water [3]

Vapor pressure of water:

$$e = a_0 + T \cdot (a_1 + T \cdot (a_2 + T \cdot (a_3 + T \cdot (a_4 + T \cdot (a_5 + T \cdot a_6)))))$$

from Lowe, P.R. and J.M. Ficke, 1974: The computation of saturation vapor pressure. Tech. Paper No. 4-74, Environmental Prediction Research Facility, Naval Postgraduate School, Monterey, CA, 27 pp.

	water	ice
a_0	6.107799961	6.109177956
a_1	$4.436518521 \cdot 10^{-1}$	$5.034698970 \cdot 10^{-1}$
a_2	$1.428945805 \cdot 10^{-2}$	$1.886013408 \cdot 10^{-2}$
a_3	$2.650648471 \cdot 10^{-4}$	$4.176223716 \cdot 10^{-4}$
a_4	$3.031240396 \cdot 10^{-6}$	$5.824720280 \cdot 10^{-6}$
a_5	$2.034080948 \cdot 10^{-8}$	$4.838803174 \cdot 10^{-8}$
a_6	$6.136820929 \cdot 10^{-11}$	$1.838826904 \cdot 10^{-10}$

$e = \min(e_{water}, e_{ice})$, $-50\ C \le T \le 100\ C$

1 multiply by 1000 to get 'g kg^{-1}'
2 multiply by 1000 to get 'g kg^{-1}'
3 multiply by 1000 to get 'per mille'

Other equations:

Air density: $n_{air} = \frac{P \cdot 100}{R \cdot (T + 273.15)}$

Relative humidity: $RH = \frac{e(T_D)}{e(T)} \cdot 100 = \frac{P_{H2O}}{e(T)} \cdot 100$

Volume mixing ratio: $x_{H2O} = \frac{P_{H2O}}{P}$

Specific humidity: $q = \frac{x_{H2O} \cdot M_{H2O}}{x_{H2O} \cdot M_{H2O} + (1 - x_{H2O}) \cdot M_{dry}}$, $q = \frac{mmv}{1 + mmv}$

Mass mixing ratio: $mmv = \frac{q}{1 - q}$

Mass concentration: $c_{H2O} = x_{H2O} \cdot n_{air} \cdot M_{H2O}$

Molecular concentration: $[H_2O] = x_{H2O} \cdot n_{air} \cdot N_A \cdot 10^{-6}$

Cactus2000:

The equations on this sheet are used in the Cactus2000 'Air humidity converter':

http://www.cactus2000.de/uk/unit/masshum.shtml (in English)

http://www.cactus2000.de/de/unit/masshum.shtml (auf deutsch)

http://www.cactus2000.de/fr/unit/masshum.shtml (en français)