SENSIRION

Humidity at a glance

Abstract

This summary provides an overview on the most used humidity related formulas. The sample code is optimized for microprocessors (e.g. the common logarithm "log10" is used rather than the natural logarithm "ln"). For an in-depth explanation of the equations please refer to our complementary information note "Introduction to Humidity".

1 Relative humidity

The following formula relates two states (temperature and relative humidity) of a system. It is only valid at constant absolute humidity (e.g. closed system).

$$RH_2 = RH_1 \exp\left(m\, T_n\, \frac{T_1 - T_2}{(T_n + T_1)(T_n + T_2)}\right)$$

RH_1	Relative humidity at state 1
RH_2	Relative humidity at state 2
T_1	Temperature [°C] at state 1
T_2	Temperature [°C] at state 2
m	17.62
T_n	243.21°C

Sample code:

```
RH2 = RH1*exp(4283.78*(T1-T2)/(243.12+T1)/(243.12+T2));
```

2 Dew point

The dew point is the temperature at which air must be cooled (at constant barometric pressure) so that water vapor starts condensing into liquid water.

$$T_d(T, RH) = T_n \frac{\ln\left(\frac{RH}{100}\right) + \frac{m\, T}{T_n + T}}{m - \left(\ln\left(\frac{RH}{100}\right) + \frac{m\, T}{T_n + T}\right)}$$

T_d	Dew point temperature [°C]
T	Actual temperature [°C]
RH	Actual relative humidity [%]
m	17.62
T_n	243.21°C

Sample code:

```
h = (log10(RH)-2.0)/0.4343+(17.62*T)/(243.12+T);
Td = 243.12*h/(17.62-h);
```

3 Absolute humidity

The absolute humidity is the mass of water vapor in a particular volume of dry air. The unit is [g/m³].

$$\rho_V(T, RH) = 216.7 \left(\frac{\frac{RH}{100}\, A \exp\left(\frac{m\, T}{T_n + T}\right)}{273.15 + T}\right)$$

ρ_V	Absolute humidity [g/m³]
T	Actual temperature [°C]
RH	Actual relative humidity [%]
m	17.62
T_n	243.21°C
A	6.112 hPa

Sample code:
```
rho_v = 216.7*(RH/100.0*6.112*exp(17.62*T/(243.12+T))/(273.15+T));
```

4 Mixing ratio

The mixing ratio is the mass of water vapor in a particular mass of dry air. The unit is [g/kg].

$$r\,(T, RH) = \frac{622\,\frac{RH}{100}\,A\exp\left(\frac{m\,T}{T_n + T}\right)}{p - \frac{RH}{100}\,A\exp\left(\frac{m\,T}{T_n + T}\right)}$$

r	Absolute humidity [g/m³]
T	Actual temperature [°C]
RH	Actual relative humidity [%]
p	Barometric air pressure [hPa]
m	17.62
T_n	243.21°C
A	6.112 hPa

Sample code:
```
e = RH/100.0*6.112*exp(17.62*T/(243.12+T));
r = 622.0*e/(p-e);
```

5 Heat index

The heat index expresses the “felt” air temperature based on actual air temperature and relative humidity. It is determined according to the National Weather Service and Weather Forecast Office of the National Oceanic and Atmospheric Administration (NOAA).

$$HI = c_1 + c_2\,T + c_3\,RH + c_4\,T\,RH + c_5\,T^2 + c_6\,R^2 + c_7\,T^2RH + c_8\,T\,RH^2 + c_9\,T^2\,RH^2$$

$$\text{adj}_1 = \frac{5}{9}\left(\frac{RH - 13}{4}\sqrt{\frac{17 - |1.8\,T - 63|}{17}} - 32\right)$$

$$\text{adj}_2 = \frac{5}{9}\left(\frac{(RH - 85)(55 - 1.8\,T)}{50} - 32\right)$$

HI	Heat index [°C]
T	Actual temperature [°C]
RH	Actual relative humidity [%]
c_1	- 8.78469475556
c_2	1.61139411
c_3	2.33854883889
c_4	- 0.14611605
c_5	- 0.012308094
c_6	- 0.0164248277778
c_7	0.002211732
c_8	0.00072546
c_9	- 0.000003582

If RH < 13% and 26.7°C < T < 44.4°C, then one should correct HI with the first adjustment term:

$$HI \leftarrow HI + \text{adj}_1$$

If RH > 85% and 26.7°C < T < 30.6°C, then one should correct HI with the second adjustment term:

$$HI \leftarrow HI + \text{adj}_2$$

In practice, one should first compute the simple formula for HI given below and average its result with the actual temperature. If the averaged value is 26.7°C or higher, the full regression equation with possible adjustments as described above is applied – else the result of the simple formula can be kept.

$$HI = \frac{5}{9}\,(\,1.98\,T - 7.1 + 0.047\,RH\,)$$

HI	Heat index [°C]
T	Actual temperature [°C]
RH	Actual relative humidity [%]

Sample code:

```
HI = 1.1*T + 5*(0.047*RH - 7.1)/9;
If (HI+T)/2 >= 26.7 Then {
    HI = - 8.78469475556
         + 1.61139411*T
         + 2.33854883889*RH
         - 0.14611605*T*RH
         - 0.012308094*T*T
         - 0.0164248277778*RH*RH
         + 0.002211732*T*T*RH
         + 0.00072546*T*RH*RH
         - 0.000003582*T*T*RH*RH;
    If RH<13 && T>26.7 && T<44.4 Then
        HI = HI + (5/36)*(RH-13)*sqrt((17-abs(1.8*T-63))/17)
                - 160/9;
    If RH>85 && T>26.7 && T<30.6 Then
        HI = HI + 5*(RH-85)*(55-1.8*T)/450 - 160/9;
}
```

Version history

Date	Revision	Changes
Aug. 2008	1.0	Initial version
Jun. 2021	2.0	Corrected heat index definition, updated design

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