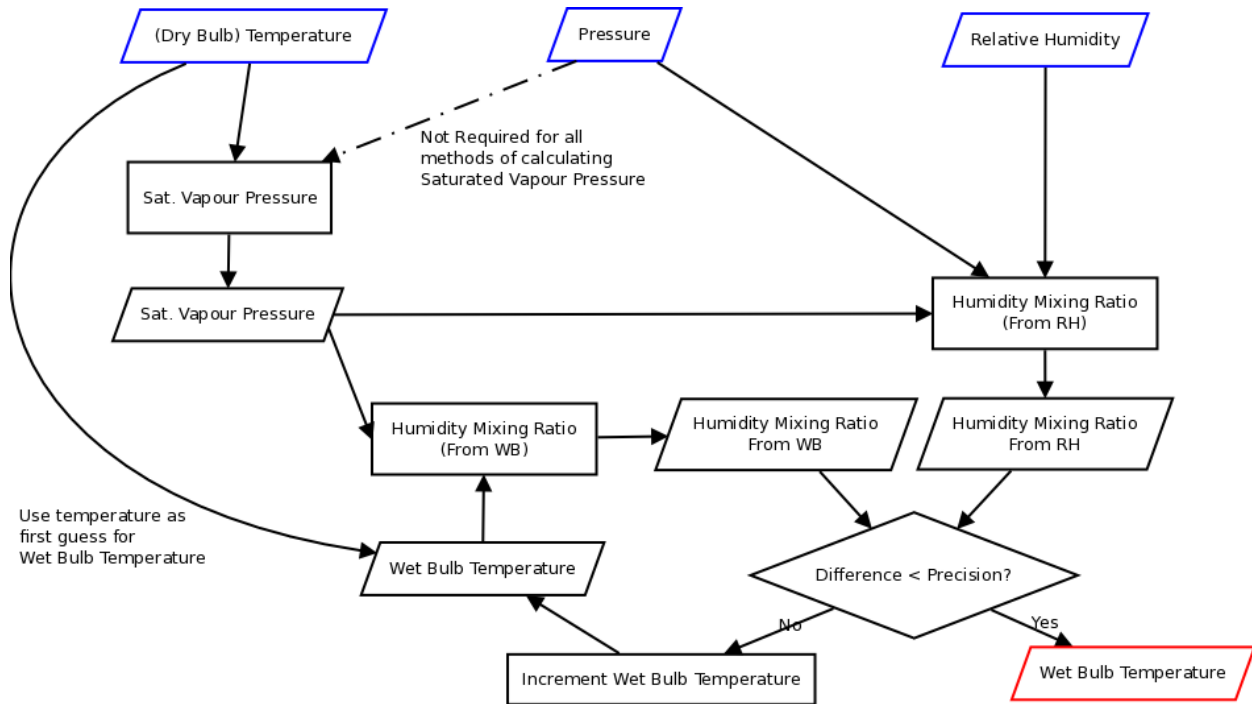


## Review of Methodology

### 1. Overall Structure



Methods as written in code:

1. Saturated Vapour Pressure
  - a. Using ASHRAE Equation
  - b. Using Goff Gratch Equation
  - c. Using Simple Equation
2. Humidity Mixing Ratio From Wet Bulb
3. Humidity Mixing Ratio from Relative Humidity
4. Relative Humidity Calculation

### 2. Saturated Vapour Pressure Methods

A number of Saturated vapour pressure calculations were considered and three were coded. Further experimentation may prove worthwhile in determining which of these should be used, although at the moment Goff-Gratch is used for consistency with the UM.

- Goff Gratch<sup>1</sup>: Method adopted by the WMO, valid for a range of temperatures between 173 and 373 K. This is the method used to generate the lookup table used in the UM. This method is corrected for pressure<sup>2</sup>.

<sup>1</sup> Numerical data and functional relationships in science and technology.

- Simple Formula<sup>3</sup>: Has a relative error of <1% for the range 173 – 373 K. This becomes significant at larger temperatures.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers Formula<sup>4</sup>

Additionally a number of other formulae were touched on:

- The Magnus formula<sup>5</sup>: Was not coded because it is only described as valid between – 60C and 70 C rather than the larger ranges of the above formulae.
- A formula valid in the range  $-40\text{ C} < T < 40\text{ C}$  is given in Gill<sup>6</sup>. This is clearly fine for many everyday applications but is well inside the range of possible meteorological temperatures.
- A number of other formulae also exist such as the Arden Buck Equation<sup>7</sup>, although many of these have small useful ranges.
- Look up tables – Although the Goff-Gratch formula is used to generate them the UM method uses a look up table. Gill<sup>8</sup> also refers to the Smithsonian Meteorological tables as a method for finding Saturation Vapour Pressure.

Brief experiments were carried out showing that the three methods coded started to diverge in result above around +10 C. It may be useful to carry out further investigation into how the results differ for each formula.

A comparison of a number of different methods can be found at

[https://www.eas.ualberta.ca/jdwilson/EAS372\\_13/Vomel\\_CIRES\\_satvpformulae.html](https://www.eas.ualberta.ca/jdwilson/EAS372_13/Vomel_CIRES_satvpformulae.html)

Although it should be noted that these use the Goff-Gratch formula rather than measurements as a datum.

### 3. Humidity Mixing Ratio

Relatively simple formulae taken from ASHRAE Handbook<sup>9</sup>.

### 4. Wet Bulb Temperature

New series. Group V. Volume 4. Meteorology. Subvolume b. Physical and chemical properties of the air, P35.

<sup>2</sup> Gill, Atmosphere-Ocean Dynamics, Appendix 4 Equation A4.7

<sup>3</sup> Numerical data and functional relationships in science and technology.

New series. Group V. Volume 4. Meteorology. Subvolume b. Physical and chemical properties of the air, P36

<sup>4</sup> ASHRAE Fundamentals handbook (2005) p 6.2, equation 5 and 6 -

[http://www.ce.utexas.edu/prof/Novoselac/classes/ARE383/Handouts/F01\\_06SI.pdf](http://www.ce.utexas.edu/prof/Novoselac/classes/ARE383/Handouts/F01_06SI.pdf) (31/08/2017)

<sup>5</sup> Numerical data and functional relationships in science and technology.

New series. Group V. Volume 4. Meteorology. Subvolume b. Physical and chemical properties of the air, P36

<sup>6</sup> Gill, Atmosphere-Ocean Dynamics, Appendix 4 Equation A4.5

<sup>7</sup> [https://en.wikipedia.org/wiki/Arden\\_Buck\\_equation](https://en.wikipedia.org/wiki/Arden_Buck_equation)

<sup>8</sup> Gill, Atmosphere-Ocean Dynamics, Appendix 4

<sup>9</sup> ASHRAE Fundamentals handbook (2005) Equation 22, 24, p6.8

Uses Newton-Raphson iteration. Initially calculates the Humidity ratio from relative humidity and using the wet bulb formula, assuming that WB temperature = temperature. If the difference between the Humidity ratios is greater than the precision then the estimate of the wetbulb temperature is changed incrementally and the humidity ratio is recalculated.