The following are typical equations and conversions for calculating flux densities of sensible, latent and carbon dioxide from eddy covariances presented by Kevin Tu, St. Louis (10/97). The properties of air used are from List (1951).

Sensible Heat

$$\mathbf{H = (M_a C_p / V) * (\mathit{w't'} - [3.210^{-4} * T_K * \mathit{w'q'}])}$$

If a correction for crosswind effects on the temperature measurement (typically derived from the vertical wind velocity component) is required (not required for ATI, Campbell or Gill R3's), the above equation should be modified as follows (Kaimal and Gaynor 1991)

$$\mathbf{H = (M_a C_p / V) * (\mathit{w't'} - [3.210^{-4} * T_K * \mathit{w'q'}] + 2\hat{u}\mathit{u'w'}/403)}$$

- M_a is the moleculair weight of dry air (0.0289644 kg/mol)
- C_p is the specific heat of dry air (1004.84 J/(K.kg))
- V is the molar volume of air (m^3/mol)
  $V = R * T_K / P$
  - R is the universal gas constant (0.082 L.atm/K.mol)
  - T_K is the air temperature (K) [see below]
  - P is the atmospheric pressure (1.01325 atm at sea level)
- T_K is the air temperature (K) estimated from the sonic temperature, T_S (Kaimal and Gaynor 1991):
  $T_K = T_S / (1 + 3.210^{-4} * q)$
  - q is the water vapor mole fraction (mmol/mol)
  - T_S is the sonic temperature (K) which can be derived from the speed of sound (Kaimal and Gaynor 1991):
    $T_S = c^2 / \{403 * (1 + 0.32 * q / P)\}$
    - c is the speed of sound (m/s)
    - q is the water vapor mole fraction (mmol/mol)
    - P is the atmospheric pressure (1.01325 atm at sea level)
    - $403 = R * C_{p'}/C_{v'}$
      - R is the universal gas constant (287.04 J/(K.mol))
      - $C_{p'}/C_{v'}$ is the ratio of the specific heats of moist air at constant pressure and constant volume. This ratio is very close to the ratio of the specific heats for dry air $C_p / C_v = \sim 1.4$.

- $w't'$ is the covariance between w', the vertical wind velocity (m/s) and t', temperature (K), and has units of m/s*K
- $w'q'$ is the covariance between w', the vertical wind velocity (m/s) and q', the water vapor mole fraction (mmol/mol), and has units of m/s * mmol/mol
- $\hat{u}$ is the mean lateral wind velocity (m/s)
- $u'w'$ is the covariance between w', the vertical wind velocity (m/s) and u', the lateral wind velocity (m/s), and has units of m^2/s^2

Latent Heat

$$\mathbf{LE = L\ (M_w / V)}\ \boldsymbol{w'q'}$$

- L is the latent heat of vaporization of water (J/g) (List 1951)
  $L = 2500.8 - 2.3668 * T_C$
    - T_C is the air temperature (^oC)
- M_w is the molecular weight of water (18 g/mol)
- V is the molar volume of air (m^3/mol) (see above)
- *w'q'* is the covariance between *w'*, the vertical wind velocity (m/s) and *q'*, the water vapor mole fraction (mmol/mol), and has units of m/s * mmol/mol

CO_2 Flux

$$\boldsymbol{F}\mathbf{CO_2} = \boldsymbol{w'c'}\ \mathbf{V^{-1}}$$

- *w'c'* is the covariance between *w'*, the vertical wind velocity (m/s) and *c'*, the CO_2 mixing ratio (umol/mol), and has units of m/s * umol/mol
- V is the molar volume of air (m^3/mol)

References

Kaimal, J.C. and Gaynor, J.E., 1991. Another look at sonic thermometry. *Boundary Layer Meteorology*, 56: 401-410.

List, R.J., 1951. *Smithsonian Meteorological Tables*, Smithsonian Miscellaneous Collections, v.114, publ.4104.