The relationship of snow water equivalent to snow depth and density
Mary J. Brodzik (brodzik@nsidc.org)

Snow water equivalent is the water content obtained from melting a sample of snow. Density is defined as the ratio of mass per unit volume. Since the mass of the sample is the same whether it is snow or water, the relationship can be expressed using the respective densities and volumes.

Let V_{snow} = the volume of the snow in the sample
ρ_{snow} = the density of the snow in the sample
V_{water} = the volume of the water when the sample is melted
ρ_{water} = the density of water

And given that ρ = mass/V, so mass = ρ V, then

$$\rho_{snow} \, V_{snow} \;=\; \text{mass of sample (water or snow)} \;=\; \rho_{water} \, V_{water}$$

Rearranging and substituting the known density of water (1000 kg m^{-3}), this can be written

$$V_{water} \;=\; V_{snow} \, \frac{\rho_{snow} \, (\text{kg m}^{-3})}{1000 \text{ kg m}^{-3}} \tag{1}$$

This is where it gets tricky, because everyone assumes it and then forgets it. Define the dimensions of the volume of the snow sample as some base area times the depth of the snow. Now, keep the base area the same but melt the snow.

Let z = height of the snow (more often called snow depth)
SWE = height of the water
A = base area of your measurement volume

Then you can substitute V_{water} = (A) (SWE) and V_{snow} = A z into (1):

$$(A)\,(SWE) \;=\; A\,z \, \frac{\rho_{snow} \, (\text{kg m}^{-3})}{1000 \text{ kg m}^{-3}}$$

and cancel the area A from both sides, to get:

$$SWE = z \frac{\rho_{snow}\,(kg\ m^{-3})}{1000\ kg\ m^{-3}}$$

As long as the units for SWE and z are the same, this relationship holds. However, depth is usually measured in cm but SWE is customarily expressed in mm. So you will have to use a conversion factor to express SWE in mm as a function of z in cm, thus:

$$SWE(mm) = z\,(cm)\ \frac{10\ mm}{1\ cm}\ \frac{\rho_{snow}\,(kg\ m^{-3})}{1000\ kg\ m^{-3}}$$

Finally:

$$SWE(mm) = z\,(cm)\ \frac{\rho_{snow}\,(kg\ m^{-3})}{100}$$

Example: A 10 cm depth of snow with density 300 kg m^{-3} has a snow water equivalent SWE(mm) = 10 cm (300 kg m^{-3})/100 = 30 mm.

N.B. Sometimes water content is expressed as a percentage, which assumes that the units of SWE and z are the same, and refers to the ratio:

$$water\ content\ (\%) = \frac{SWE}{z}\ 100$$

5/4/2004