Appendix B
Units

B.1 Units

A unit is a particular physical quantity, defined and adopted by convention, to which other quantities of the same kind are compared to determine their relative value. The use of a common system of units aids in communication of quantities, qualities, and rules of thumb between people and programs. A recommended system of units for snow, weather, and avalanche observations is listed in section B.2. It follows the International System of Units (SI) (section B.3) with a few exceptions.

B.2 Units for Snow, Weather and Avalanche Observations

In the United States, personnel of avalanche operations and users of their products may not be familiar with all SI units. For this reason individual programs should choose a unit system that suits their particular application. Data records generated for regional and national databases should use the international units listed below (or clearly list units used in accompanying metadata files). Deviations from the international units should use the common U.S. units listed below. Conversions between the two systems are listed in section B.4.

Table B.1 Recommended Units for Snow, Weather, and Avalanche Observations

Quantity	International Unit		Common U.S. Unit	
	Unit	**Symbol**	**Unit**	**Symbol**
temperature — air	degree Celsius	°C	degree Fahrenheit	°F
temperature — snow	degree Celsius	°C	degree Celsius	°C
wind speed	meter/second	m/s	mile/hour	mi/hr
aspect and wind direction	compass degree	°	compass direction	N,NE,E,SE, S,SW,W,NW
relative humidity	percent water	%	percent water	%
barometric pressure	millibar	mb (1 mb = 1 hPa)	inches of mercury	inHg
new snow depth	centimeter	cm	inch	in
total snow depth	centimeter or meter	cm or m	inch	in
water equivalent of precipitation or snowpack	millimeter	mm	inch	in
density	kilogram/cubic meter	kg/m^3	percent water	%
snow grain size	millimeter	mm	millimeter	mm
length	meter	m	foot	ft

Note: Most topographic maps in North America use feet as the unit for elevation. Thus it is more practical to use feet for the common elevation unit. Field observations can use feet to record elevations, however metadata for weather and snow study plots should list the elevation in meters.

B.3 SI Units

The Système International d´Unités (SI), or International System of Units, has been accepted by most of the nations of the world as a common language for science and industry. It defines a set of base units from which other quantities are derived. Details of the International System of Units can be found at http://physics.nist.gov/cuu/Units/. Common conversion factors are listed in section B.4.

Some derived SI units have been given special names to make them easier to use.

For large or small quantities, a set of prefixes and associated decimal multiples can be used with SI units. These prefixes can be used with any base or derived SI unit with the exception of kilogram. Since the base unit kilogram already contains the prefix kilo, the set of prefixes are used with the unit name gram.

Example of prefix use:

1 m x 10^3 = 1 kilometer
1 m x 1000 = 1 kilometer
1 kilometer = 1000 m

Table B.2 SI Base Units

Quantity	Unit Name	Unit Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
amount of substance	mole	mol
electric current	ampere	A
luminous intensity	candela	cd

Table B.3 Common Derived SI Units

Quantity	Unit Name	Unit Symbol
area	square meter	m^2
volume	cubic meter	m^3
speed	meter per second	m/s
acceleration	meter per second squared	m/s^2
density	kilogram per cubic meter	kg/m^3

Table B.4 Derived SI Units with Special Names

Quantity	Unit Name	Unit Symbol	Derived Definition	Base Definition
force	newton	N		kg×m/s^2
pressure or stress	pascal	Pa	N/m^2	kg/(m×s^2)
energy or work	joule	J	N×m	kg×m^2/s^2
power	watt	W	J/s	kg×m^2/s^3
Celsius temperature	degree Celsius	°C		K
plane angle	radian	rad		m/m

Table B.5 SI Unit Prefixes

Factor	Name	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	m
10^{-9}	nano	n
10^{-12}	pico	p

B.4 Conversion Tables

B.4.1 Unit Analysis

Unit conversions can be accomplished by a method known as *unit analysis*. Each unit can be written as a combination of base units, such as length, time, or mass. Then conversion can be accomplished by multiplying by a unit ratio, canceling the unwanted units and thus leaving the desired value. This technique combined with the use of the SI unit prefixes can be used to accomplish most conversions.

Example:

$$5.0\ \text{m} \times \frac{3.28\ \text{ft}}{1\ \text{m}} = 16.4\ \text{ft}$$

$$5.0\ \frac{\text{mi}}{\text{hr}} \times \frac{5{,}280\ \text{ft}}{1\ \text{mi}} \times \frac{1\ \text{m}}{3.28\ \text{ft}} \times \frac{1\ \text{hr}}{3600\ \text{s}} = 2.2\ \frac{\text{m}}{\text{s}}$$

$$20.67\ \text{inHg} \times 3386.389\ {}^{*}\ \frac{\text{Pa}}{\text{inHg}} \cong 70{,}000\ \text{Pa} \times \frac{1\ \text{bar}}{100{,}000\ \text{Pa}} = 0.7\ \text{bar} \times \frac{1000\ \text{mb}}{\text{bar}} = 700\ \text{mb}$$

**This is a conversion for inches of mercury at 0°C*

The appropriate ratios can be easily constructed if you know the proper proportions.

Example:

There are 5,280 feet in 1 mile → $\frac{5{,}280 \text{ ft}}{1 \text{ mi}}$

There are 60 seconds in 1 minute → $\frac{60 \text{ s}}{1 \text{ min}}$

B.4.2 Time

There are:

60 seconds in 1 minute
60 minutes in 1 hour
24 hours in 1 day
365 days in 1 year (366 days in one leap year)

B.4.3 Temperature

For temperature conversions it is more appropriate to list conversion equations.

°C = K – 273.15	K = °C + 273.15
°C =(5/9)(°F –32)	°F = (9/5)°C + 32

B.4.4 Speed

1 mi/hr = 1.609344 km/hr	1 m/s = 3.6 km/hr
= 0.8689762 knots	= 2.2369363 mi/hr
= 0.44704 m/s	= 1.9438445 knots
1 km/hr = 0.6213712 mi/hr	1 knot = 1.1507794 mi/hr
= 0.2777778 m/s	= 0.514444 m/s
= 0.5399568 knots	= 1.852 km/hr

B.4.5 Pressure

1 Pa = 0.00001 bar
= 0.01 mb = 0.01 hPa
= 0.000295 inches of mercury at 0°C
= 0.007501 millimeters of mercury at 0°C
= 0.000009869 atm

B.4.6 Length

1 in = 2.54 cm
1 ft = 0.3048 m
1 mi = 1609.344 m

B.4.7 Density

The density of snow is usually calculated by weighing a sample of known volume.

Example:

If the mass of a 250 cm^3 snow sample is 70 g, then:

$$\frac{70\text{g}}{250\text{cm}^3} = 0.28\,\frac{\text{g}}{\text{cm}^3} \times \frac{1\text{kg}}{1000\text{g}} \times \frac{1{,}000{,}000\text{c m}^3}{1\text{m}^3} = 280\,\frac{\text{kg}}{\text{m}^3}$$

Simple relations can be determined for common calculations. For example if you typically use a 250 cm^3 cutter to take your snow sample then you can multiply the mass in grams by 4 to obtain the density in kg/m^3.

The percent water content of a snow sample is often communicated as a dimensionless ratio or percent. It is easily calculated by dividing the density of the snow by the density of water (1000 kg/m^3) and multiplying by one hundred. Using the density of water allows for an easy calculation by moving the decimal one space to the left (ie: 280 kg/m^3 = 28%).

The percent water content of a snow sample can also be obtained by dividing the height of its water equivalent by the height of the snow layer and then multipling by 100.

Example:

If you have 10 cm of snow whose water equivalent is 1 cm of water.

$$\frac{1\,(\text{cm})\ \text{water}}{10\,(\text{cm})\ \text{snow}} = 0.1 \times 100 = 10\%\ \text{water content}$$

B.5 Expanded Equations

Several equations are presented in abbreviated form in the text. The expanded versions below are intended to explain how the abbreviated versions were derived.

Section 1.22

$$\text{H2DW (mm)} = \frac{\text{mass of snow sample (g)}}{\text{area of snow sample (cm}^2\text{)}} \text{x10}$$

Expanded Equation

$$\text{H2DW (mm)} = \frac{\text{mass (g)}}{\text{area (cm}^2\text{)}} \text{ x } \frac{1(\text{cm}^2)}{100\ (\text{mm}^2)} \text{ x } \frac{1(\text{cm}^3 \text{ of water})}{1(\text{g of water})} \text{ x } \frac{1000\ (\text{mm}^3)}{1(\text{cm}^3)}$$

Section 1.23

$$\rho\left(\frac{\text{kg}}{\text{m}^3}\right) = \frac{\text{mass of snow sample(g)}}{\text{sample volume (cm}^3\text{)}} \text{x1000}$$

Expanded Equation

$$\rho\left(\frac{\text{kg}}{\text{m}^3}\right) = \frac{\text{mass of snow sample (g)}}{\text{sample volume (cm}^3\text{)}} \text{ x } \frac{1{,}000{,}000\ (\text{cm}^3)}{1(\text{m}^3)} \text{ x } \frac{1\,(\text{kg})}{1000\ (\text{g})}$$

Section 1.23

$$\rho\left(\frac{\text{kg}}{\text{m}^3}\right) = \frac{\text{H2DW (mm)}}{\text{H2D (cm)}} \text{x1000}$$

Expanded Equation

$$\rho\left(\frac{\text{kg}}{\text{m}^3}\right) = \frac{\text{water equiv. of snow sample (mm)}}{\text{height of snow sample (cm)}} \times \frac{1(\text{cm})}{10\ (\text{mm})} \times \frac{1(\text{g water})}{1(\text{cm}^3 \text{ water})} \times \frac{1(\text{kg})}{1000\ (\text{g})} \times \frac{1{,}000{,}000(\text{cm}^3)}{1(\text{m}^3)}$$