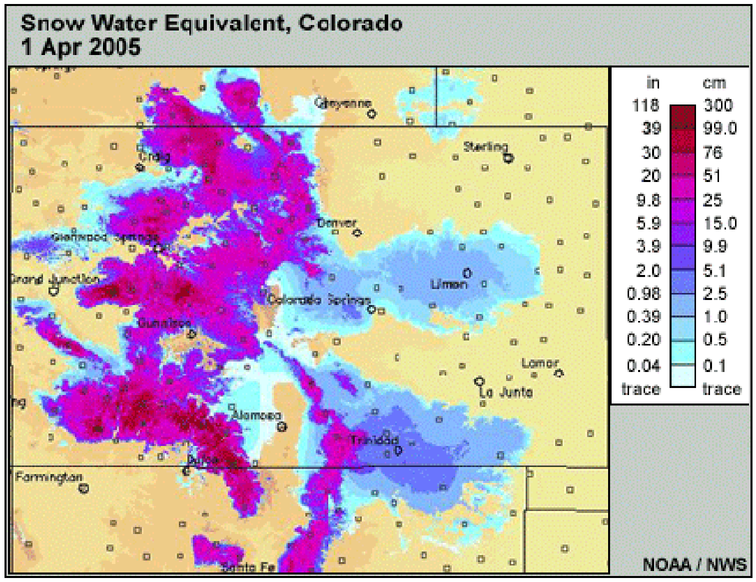
Basic Hydrologic Science Course
Understanding the Hydrologic Cycle
Section Six: Snowpack and Snowmelt
Produced by The COMET® Program

Snow and ice are critical parts of the hydrologic cycle, especially at higher latitude or mountainous locations. The water stored in a frozen state is released during the spring, providing water during the rest of the year.

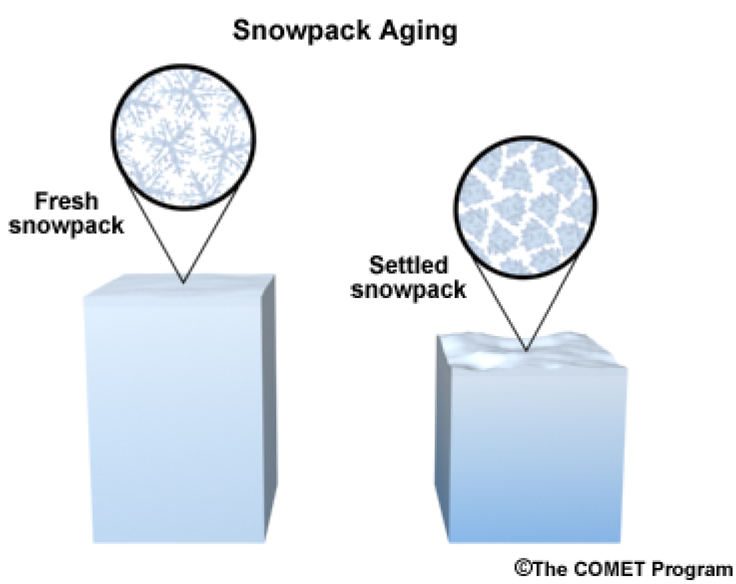
Snowpack Characteristics

A snowpack consists of a mixture of ice crystals, air, impurities and, if melting, liquid water. Snowmelt provides significant volumes of water to river systems. The timing, volume, and rate of the melting of a snowpack depend on several characteristics of the snowpack, local topography, and meteorological conditions. The specialty field of snow hydrology focuses on these factors.

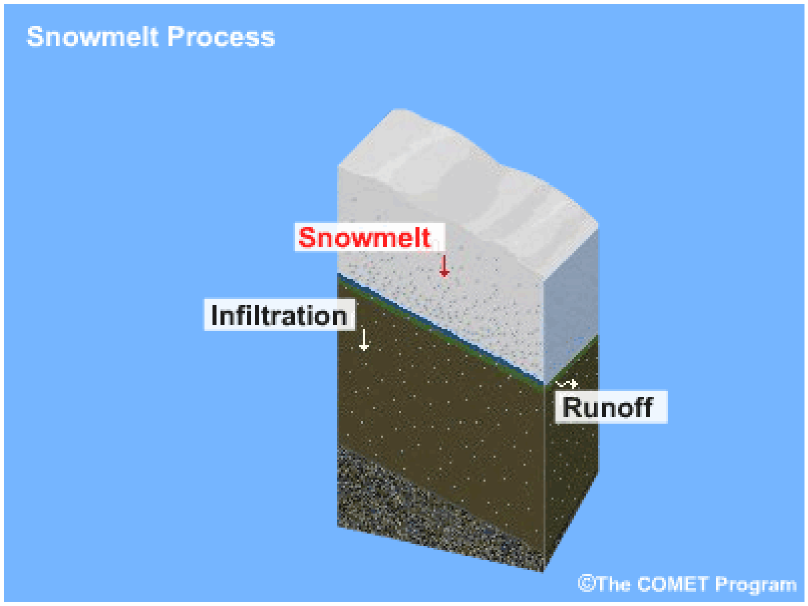


The characteristic of most interest to the hydrologist is the amount of water held within the snowpack. This is termed the "snow water equivalent" or SWE. Factors that affect melting rate include the snowpack temperature, albedo (the reflective property of the snow), density, and volume of the snowpack. Melting rate is also influenced by factors such as wind, relative humidity, air temperature, and insulation.

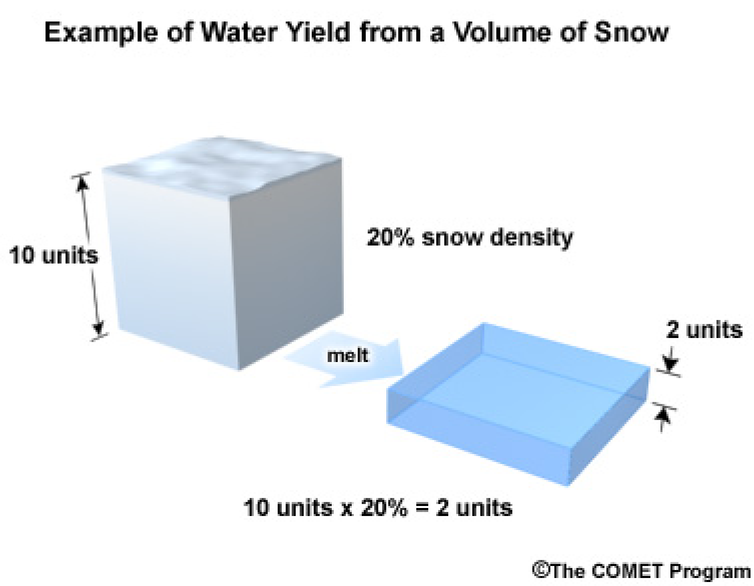
Snowmelt



The snowpack undergoes changes between the time snow first falls onto the basin and snowmelt occurs. The individual snow particles change from the crystalline snowflake that fell during a storm to a more granular form of ice as meteorological factors and liquid water come into play.



Initially the snow within the snowpack settles, resulting in a higher density. As thawing and melting starts at the snowpack surface, ice lenses may form. When spring and summer come to a basin, air temperatures increase and a warming of the snowpack occurs. The maximum temperature of the snowpack cannot exceed the melting point of ice. As the entire snowpack approaches this temperature, it becomes "ripe," or isothermic. When this condition is met, any additional energy added to the snowpack will result in snowmelt. The liquid water is usually released from the bottom of the snowpack. As the snowpack releases water, runoff factors become important.



Since the snowpack is ice, it contains a certain volume of water. As the snow melts, liquid water is released. The relationship between the volume of liquid water or snow water equivalent (SWE) and the depth of the snow will depend on the density of the snow. In all cases, the depth of the snow will always be larger than the equivalent depth of liquid water produced by the snowpack.

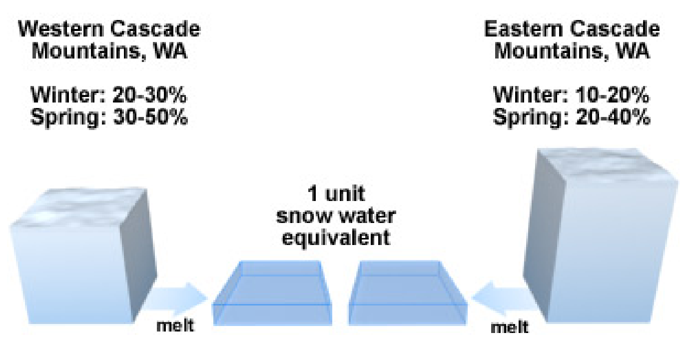
Snow/Water Relationship

Snow Type	Percentage of Water Content	Ratio of Snow Depth to Liquid Water Equiv.
Ordinary new snow immediately after falling in still air (-10ºC)	5%	20:1
Settling snow	10%	10:1
Drifted snow	33%	3:1
Ripe snow (Close to melting point) (0ºC)	50%	2:1

After the snow falls its density increases due to gravitational settling, wind packing, melting and refreezing. Snow densities are often expressed as a ratio of snow depth to liquid water equivalent. For example, one unit of liquid can equal 20 units of snow depth for fresh snow. As snow becomes more compacted and aged, the ratio decreases.

The percentage of water content of newly fallen snow ranges from about 5 percent when the air temperature is about -10°C to about 20 percent when the temperature is 0°C.

Snow Density Comparison



Most of the snow that falls in the western Cascade Mountains of Washington and Oregon tends to be slightly higher density snow than that in the eastern Cascade Mountains.

In the western Cascades, the percentage of water content in the snowpack is around 20 to 30 percent in the winter and increases to 30 to 50 percent in the spring. However, in the eastern Cascades, the snowpack density is much less as weather conditions are usually colder and drier. Percentage of water content for snowpack in this area ranges from 10 to 20 percent in the winter and 20 to 40 percent in the spring.

The following relationship can be used to calculate the liquid water equivalent of a snowpack, if the depth of snow is known or can be estimated:

Snow Depth x Snow-Water Ratio = Snow Water Equivalent

For example, if the snow depth was 125 centimeters and the snow-water ratio was three to one, the estimated liquid water within the snowpack would be:

125 cm snow x 33 per cent = 41.7 cm liquid water

Produced by The COMET® Program