The Basic Ideas Behind Snow Metamorphism

S. C. Colbeck
CRREL, 72 Lyme Road, Hanover **NH** 03755

The basic concepts of thermodynamics and crystal growth that account for the metamorphism of snow are presented. First, the differences between wet and dry snow are emphasized since these materials even appear differently to the naked eye. Then the basic environmental factors are introduced and their importance explained. These include temperature, temperature gradient, liquid water content, humidity, solar radiation and wind. The basic concepts of thermodynamics are introduced qualitatively just to explain how they influence ultimate crystal shapes. These include thermodynamic equilibrium among the water, vapor and solid phases, the equilibrium shape of ice crystals, the kinetic growth form of ice crystals, minimum surface energy, and capillary. Finally, these environmental factors and basic physical principles are combined to explain the basic shapes that are seen in the seasonal snow cover. The problem with applying these basic ideas to snow metamorphism is that there are many scenarios where the shapes of snow crystals that one sees are complicated by combinations of these factors. For example, melt-freeze particles result from cycles of dry-wet-dry and thus are not simply wet snow or dry snow. There are several intermediate stages of dry snow between purely rounded and purely faceted crystals. The origin of these partly faceted - partly rounded crystals in any particular situation depends on the path that the crystals took in their growth cycle and that in turn depends predominately on recent weather patterns. For example, similar looking crystals with some facets and some rounding can arise if their growth rate has not been high enough to make them purely faceted but is high enough to produce some facets. Alternately, they can form once the high growth rates of purely faceted crystals have ceased and the corners and edges of these crystals begin to round off. Finally, the implications for the physical properties of snow are discussed as the evolution of the shapes is explained. For example, sintering occurs with the development of the equilibrium form but is minimized in the kinetic growth form of dry snow. Likewise, wet snow is either ice-bonded or cohesion less depending on the amount of water present.