LIGHT TRANSMISSION THROUGH NATURAL SNOWCOVERS

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For over 40 years, many investigators have assumed that the transmission of light through a snowcover follows the same law as does the transmission of light through distilled water. Known as the Bouguer - Lambert law, this law describes the decay of light as a semi - logarithmic function of depth;

$$I_z = I_0 e^{-kz}$$

where, I_z is the intensity of light at depth z, I_0 is the intensity of light at the surface, k is the empirical extinction coefficient and z is depth.

The underlying assumption of the law is that the medium through which the light is passing is homogeneously diffusing, and in fact the Bouguer - Lambert law accurately describes the transmission of light through homogeneous snowcovers.

However, homogeneity in natural snowcovers is rare. Snow properties, such as density, water equivalent, grain size, grain shape and free water content display both spatial and temporal variability. As the behaviour of light cannot be expected to be the same on encountering such a wide range of optical media, varying optical characteristics throughout the layers of the snowpack are produced.

Winter 1980 - 1981 research in Peterborough, Ontario and Schefferville, Quebec snowcovers confirms earlier findings of Curl, Hardy and Ellermeier (1972) and suggests that the transmission of light through natural snowcovers does not follow the Bouguer - Lambert law.

To measure the downwelling radiation within a snowcover, ' snow probes', which encased photoconductive devices were constructed. These photoconductive cadmium sulphide cells, possessing peak spectral responses at 550 nm with 20% limits being at 440 nm and 660 nm, measured light intensity as an inverse logarithmic function of resistance. In total, nine snow probes were constructed and calibrated against a quantum sensor. Each probe was calibrated at least twice and great consistency both between probes and within probes over time was found to exist.

Snowpack characteristics were analyzed using the snow stratigraphy method described in Adams and Barr (1974). Radiation measurements were carried out on the same snow face following stratigraphy analysis. As well as the properties mentioned previously, temperature, the depth at which each of the radiation measurements were taken and the thickness of each layer were also recorded. Light measurements were taken at the top and bottom of each layer. This allows one to analyze the relative transmission of light through a homogeneous layer possessing certain natural snowcover characteristics. The surface intensity, albedo and emergent radiation of each snow pit were also recorded. Subsequently, all data was normalized, being expressed as a percentage of the light which actually impinged the snow surface.

The initial data analysis consisted of correlating the light transmission values (expressed as a percent of the normalized surface intensity) with the depth at which

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they were measured. Linear, semi - logarithmic and logarithmic treatments were performed on each of the snowpits. Of a total of 30 snowpits (19 from Peterborough and 11 from Schefferville), 16 of them possessed transmission vs depth relationships which were best explained semi - logarithmically. Of these 16 pits, 14 of them were from Peterborough sites while 2 of them were from Schefferville. Figure 1 shows the typical Peterborough relationship between light transmission and depth. A logarithmic relationship between light transmission and snow depth was found to exist in 13 of the 30 pits. In this case, the majority (9) were from the Schefferville area (Figure 2), while only 4 were from Peterborough snowpits.

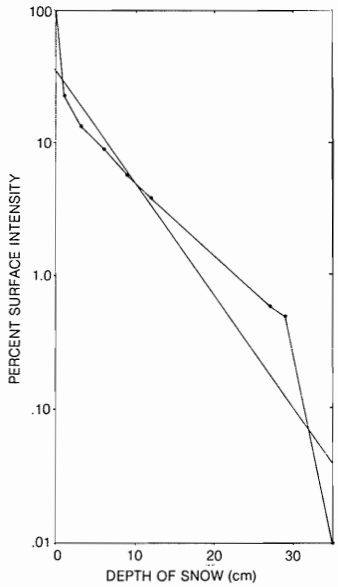

FIGURE 1 The semi - logarithmic decay of light with depth found in Peterborough, Ontario.

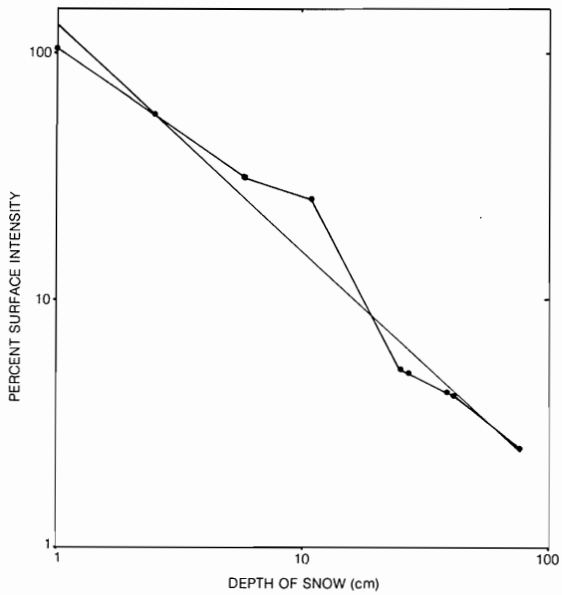

FIGURE 2 The logarithmic decay of light with depth found in Schefferville, Quebec.

One snowpit proved to be insignificant at the 0.05 level of confidence under all treatments. When all of the 242 radiation measurements (121 being from Peterborough and 121 being from Schefferville) were analyzed together, the logarithmic relationship,

$$y=102.5x^{-1.26}$$

was found to best describe the results (Figure 3). This supports the findings of Curl et al (1972) whose logarithmic relationship, $y=104.5x^{-1.39}$, is comparable to the one produced from this study. Further details (Outerbridge 1981)

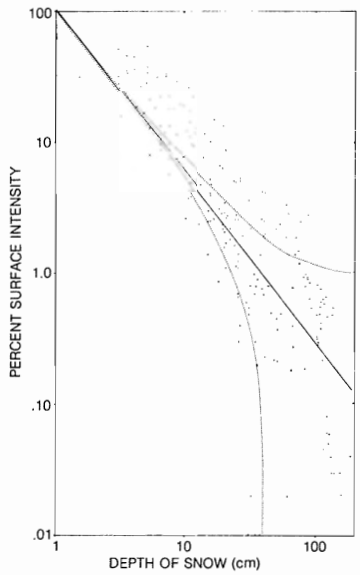

FIGURE 3

Adams, W.P., and D.R. Barr, 1974. Snowcover Properties. Occasional Paper 3, Dept. of Geography, Trent Univ.

Curl, H., J.T. Hardy and R Ellermeier, 1972. Spectral absorption of solar radiation in alpine snowfields. Ecology, 53(6):1189-1194.

Outerbridge, K.C., 1981. Light transmission through Snow. BSc. Thesis., Dept. of Geog., Trent University.