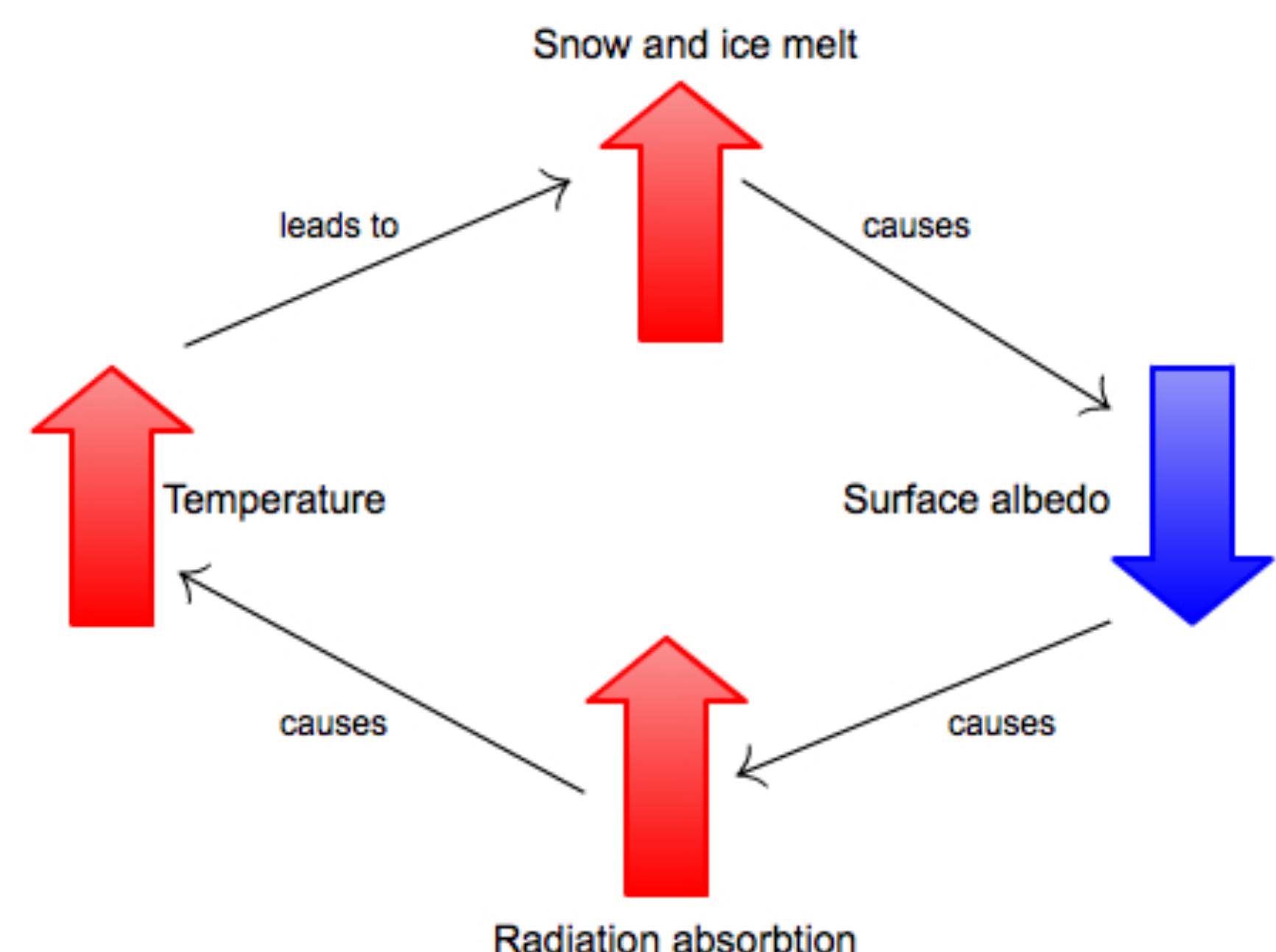




Albedo

The albedo of a surface is the ratio between the overall intensity of light reflected off it and the incident intensity.



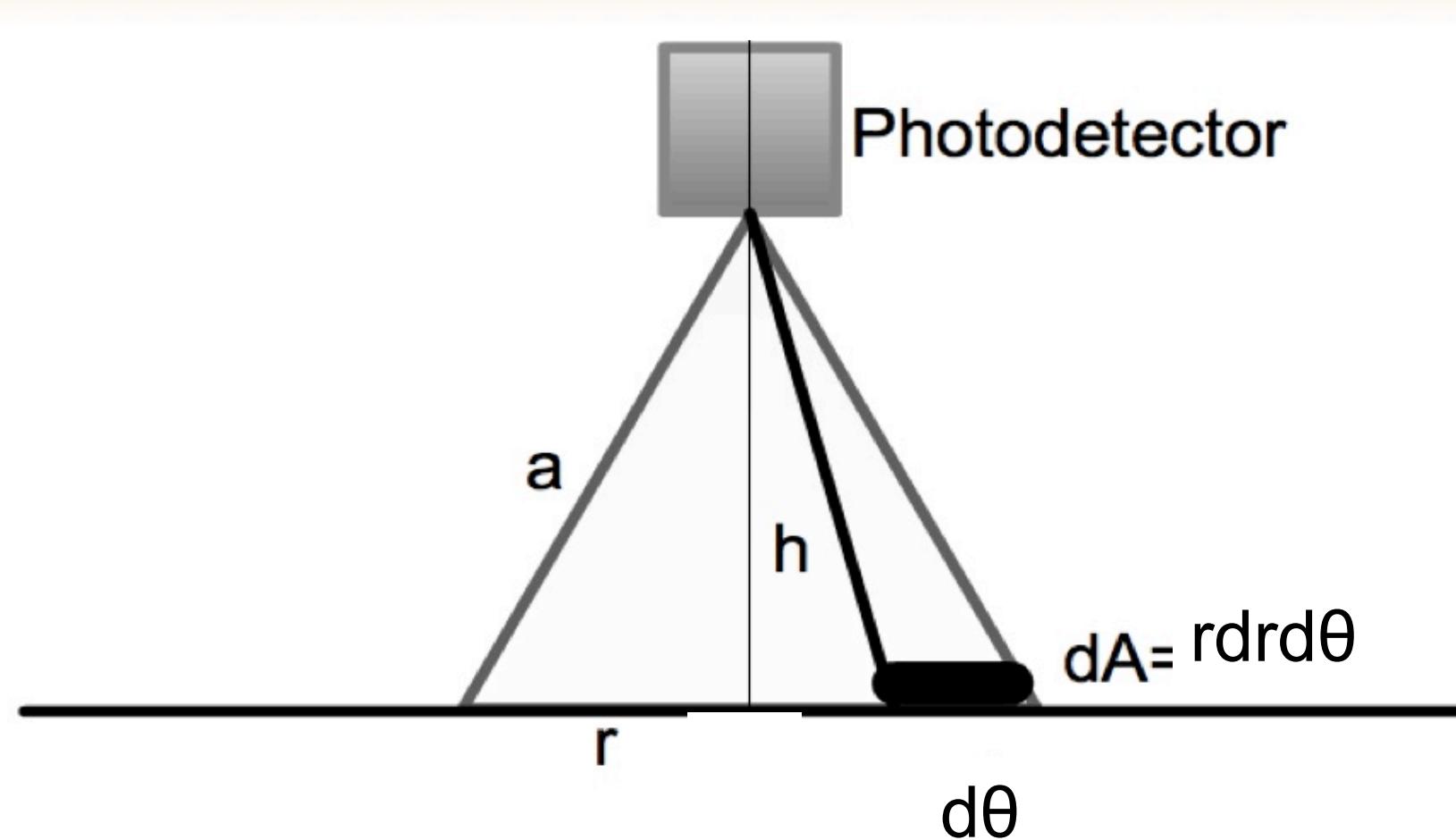
The albedo of snow and other terrestrial surfaces is a key factor in global climate change. For example if artic ice melts, the resulting water will absorb greater amounts of incident light, accelerating the melting process in a dangerous positive feedback loop.

Measuring Albedo of Outdoor Surfaces

We measured the albedo of snow and some other diffusely reflecting extended surfaces. Our measurement technique consisted of alternately taking readings of the incident direct sunlight and the reflected light with a silicon photodetector (Thorlabs DET-110) suspended face down from a tripod.



Mathematical Model

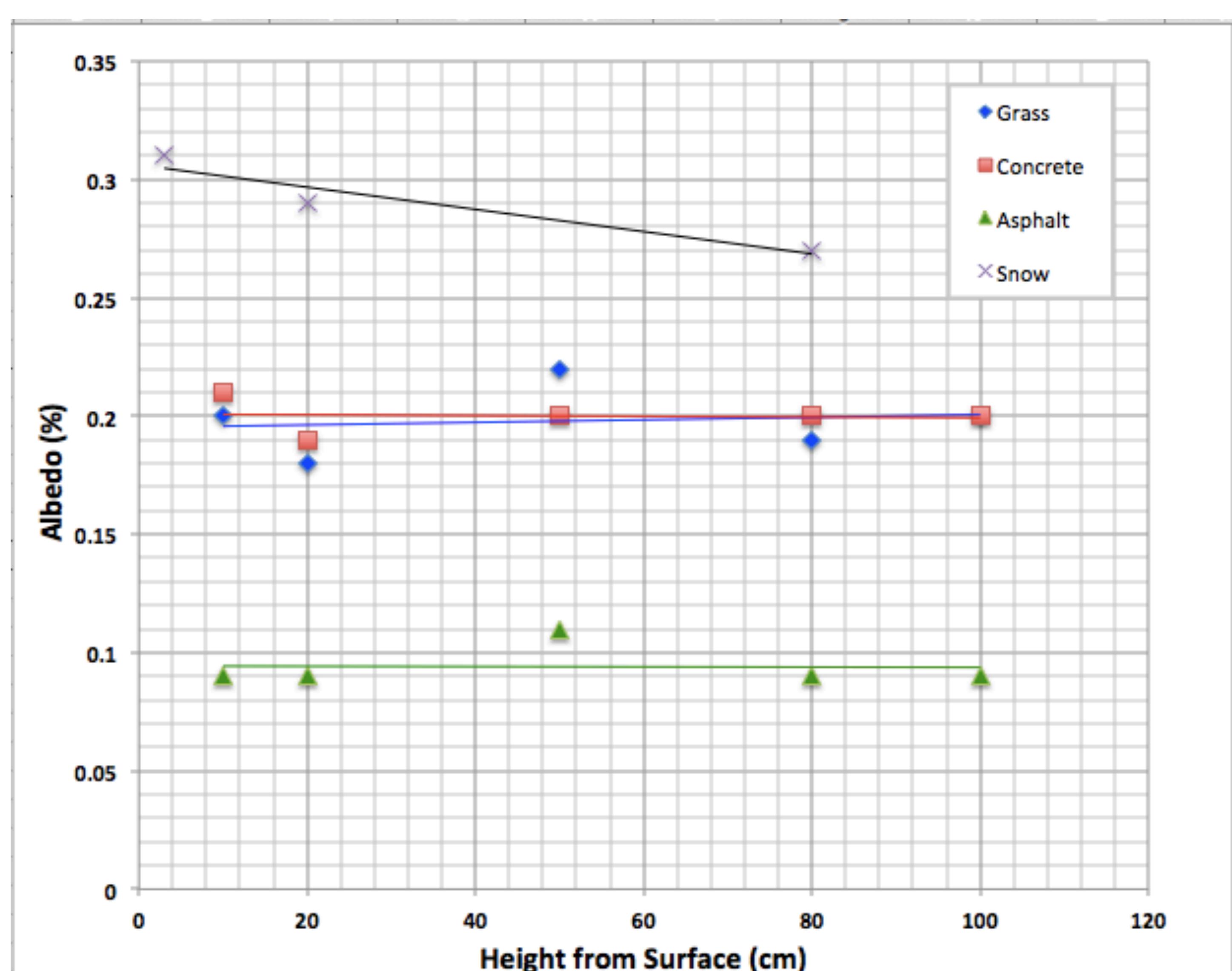


$$\begin{aligned}
 I &\propto \frac{dA}{A} \cos\theta \\
 I &\propto \frac{rdrd\varphi}{a^2} \cos\theta \\
 a &= \frac{h}{\cos\theta}; r = htan\theta; dr = \frac{h}{\cos^2\theta d\theta} \\
 I &\propto \frac{htan\theta hd\theta d\varphi \cos^2\theta}{\cos^2\theta h^2} \cos\theta \\
 I &\propto \tan\theta d\theta d\varphi \cos\theta \\
 &\iint \sin\theta d\theta d\varphi
 \end{aligned}$$

Our mathematical model of the albedo reflected off a Lambertian surface suggests that the albedo of the surface should be independent of height.

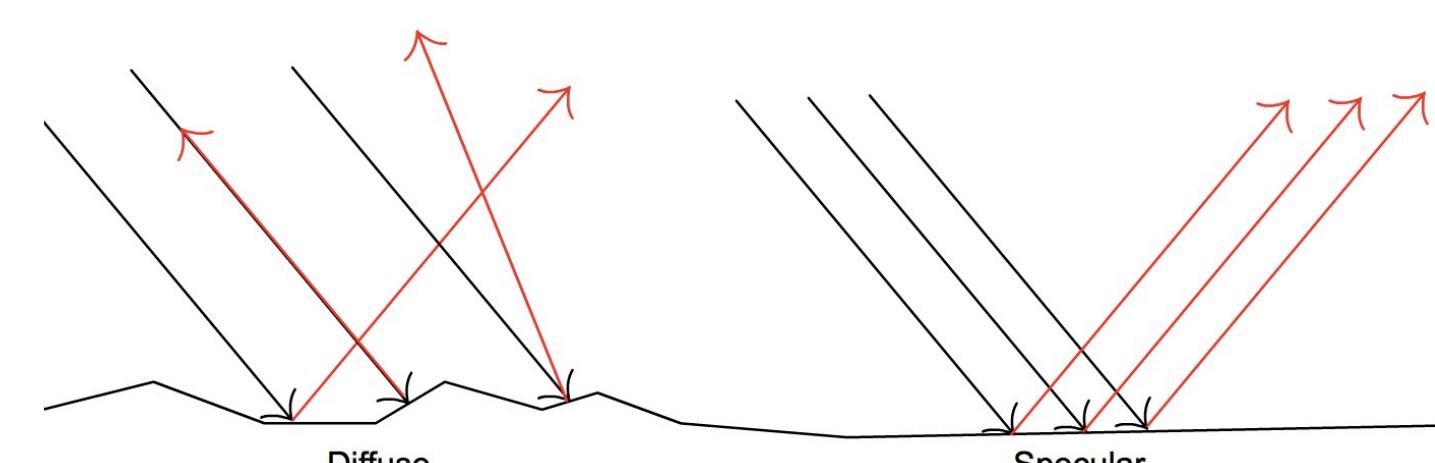
Albedo vs. Height

We found the albedo of snow and some other diffusely-reflecting surfaces to be independent of height from $h=100$ to 10 cm. This result is explained by the mathematical model we created. Our measured albedos were in good agreement with literature values, except for snow, where we found the albedo to be equal to 30%, quite lower than the 40-90% generally reported. This may be due to the fact that the photodetector was handheld for these measurements rather than suspended from the tripod. We did not have a chance to repeat the measurement though.



Types of Reflection

Two types of reflection are diffuse and specular reflection. In diffuse reflection, the incident light is reflected at many angles, rather than at one angle as in specular reflection.



Surfaces for which the reflection is completely diffuse are called Lambertian. Examples of Lambertian surfaces include fresh snow and many natural surfaces when viewed at an appropriately large distance (such as grass, soil, and concrete). Synthetic materials, such as Spectralon, which are optimized for this purpose provide the closest approximations to Lambertian surfaces.

Lambertian Surfaces

We measured the reflectance of a 30 mW HeNe laser off of two approximate Lambertian surface, Spectralon and paper towels. Both scattered the light equally in all directions. We found the reflectance of the Spectralon to be almost 100%.

