Who or what on earth is albedo?

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Hope you survived another winter in reasonably good shape. Like the last one, it has folks asking what happened to global warming. In spring, the sun is higher, the outlook brighter, although temperatures often remain below freezing. Despite cold air, snow is melting on the barn roof and the highways. How come?

Well, it's albedo! No, this is not a citizen of Naples; it is an important process for farmers to understand. In science, it's defined as "the fraction of incident electromagnetic radiation reflected by a surface, especially of a celestial body." In plain English, it's the percentage of sunlight reflected by a surface.

Eighteenth-century Hudson's Bay Company fur trade journals recorded whether snow was melting in the shade or only in the sun. Such a distinction was important in daily life. The recorders did not understand the mechanisms — these were not determined until the end of the nineteenth century — but it didn't much matter. Like the animals they depended on for furs and hides, and for their main food supply, these folks knew that snow and ice conditions vary significantly as temperatures change. They also knew that animal behavior changes with different snow conditions. That information was essential for hunting and trapping, and for survival!

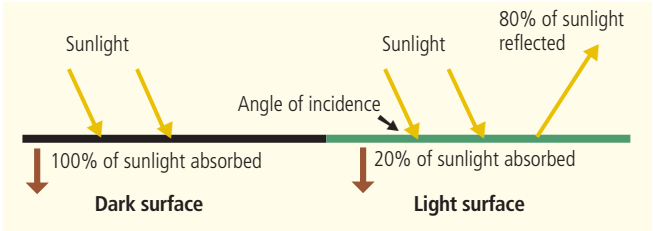
Equally important, snow conditions determined the ease and manner of bush travel. Anyone familiar with the bush knows travel in winter is easier with cold, "dry" snow. Melting, wet conditions in spring and fall cause much difficulty and consequent hardship. Most people prefer a cool, clear day of –15°C to the sloppy, slippery inconvenience of –5°C.

Snow melts in the shade when the air temperature is above freezing. It also melts on the roof in direct sunlight even though temperatures are below freezing. Dark surfaces absorb enough heat to cause local thawing. "Dark" is the key word here, because albedo varies with color. Generally, reflection increases with lighter surfaces; white has the highest albedo, and black the lowest.

Albedo is stated as a percentage of the amount of energy reflected. On the right side of Diagram 1, the green surface albedo is 80%. Assuming 100 units of sunlight with 80 units reflected, then albedo equals 80% (80 units out, divided by 100 units in, multiplied by 100).

Sunlight not reflected is absorbed and heats the surface.

Diagram 1



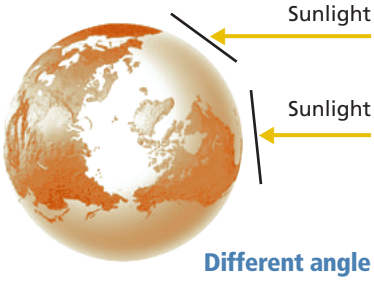
On the left side of the diagram, 100% of the sunlight is absorbed. Black (not glossy) solar collectors absorb maximum energy. Darker barn roofs and road surfaces absorb sufficient energy to melt snow in the immediate area even with air temperatures below freezing.

Albedo varies by color. Snow has the highest albedo, but it also varies the most. Fresh and clean, it reflects 95% of sunlight, but several days old, only 40%. Most other surfaces vary because of natural color variation, but generally to a much lesser extent: sea ice, 30% to 40%; concrete, 17% to 27%; green meadows, 10% to 20%; and coniferous forest, 5% to 15%.

Moisture content also causes variation. You have high albedo with a dry surface, lower with a wet one. Dry sand albedo is 40%, while wet sand is 25%. Dry clay soil reflects 30%, and wet clay soil only 15%.

With water, only 6% of vertical sunlight is reflected. Reflection changes dramatically as the angle of incidence moves from the vertical, as sparkling waters at sunset illustrate. Also, light penetrates water. Divers need artificial light below 50 meters in tropical oceans. Abundant animal life in polar waters make the waters bottle-green and reduce light penetration. Snow and ice surfaces and low angle of sunlight combine to make the polar regions cold (Diagram 2).

Diagram 2



Different angle of incidence with latitude

Changing a surface naturally changes the albedo. Forest cover changes a 10% albedo to at least 20%, depending on soil and tree type — one reason why I advised the Canadian Forestry Association to plant dark ground cover evergreens after clear-cutting. Reduction of soil erosion was another.

Fly over farmland as snow melts in spring, and you will see a chessboard pattern — stubble fields white with trapped snow and dark soil fields from which snow has melted. (Put black and white boards on the snow and watch the melting difference.) Summer differences are similar; a cropped field averages 20% albedo, dark soil about 10%. The result is more heat and higher soil temperatures for the unplanted field.

Earth's albedo, generally because of cloud cover, sends 38% of sunlight back to space. Thunderstorm clouds reflect 90% of sunlight. Note their sparkling white tops. We experience the dark shadow conditions underneath. Stratus or layer cloud reflects 70%. Altostratus, the cloud through which the moon or sun are faintly visible, is only 45%. These are the worst sunburn days because it is not a clear, sunny day, yet 55% of sunlight reaches the ground. I call those sneaky hot days.

Albedo is an important component of temperature and weather. You can use it to determine how it affects the way you farm and how conditions differ between fields. CG