Suggestions in Blue

89/100

Spectral Albedo Measurements Using a ~~Home-Made~~ Custom Spectrometer

Abstract

The albedo of seven objects surfaces with various textures and colors were measured and documented in this study. The experiment was carried out using a ~~home-made~~ custom spectrometer to detect irradiance from the incident radiation and radiance emitted from the surface. The results showed that albedo varies according to different colors and roughness of the surfaces with discernible characteristics. It was found that the concrete surface illustrated the highest overall albedo, even higher than old snow, spanning from visible (400-700 nm) to a portion of near-infrared (700-800 nm) wavelengths. Albedo also illustrated an increase in the corresponding wavelength depending on the object's color. The knowledge gained from this study should enhance interpretation of data collected from remote sensing instruments and consequently improve estimation of radiation budget and modeling performance.

climate and weather

Introduction

There is no disputation about the importance of solar radiation to life beings. However, albedo, the fraction of total incident radiation that reflects from the surfaces, is also essential because such reflectivity prevents the Earth's surface from overheating. Factors that determine the albedo of a surface include the roughness of the object, grain size (if the object consists of visible tiny particles such as snow), and wavelength by which the object reflects. Thus, this study seeks to understand the albedo variation at different wavelengths based on a number of solid surfaces with diverse textures and colors.

nice

Method and Instrument

The instrument was designed to encompass two spectrometers with one pointing upward for irradiance from incident radiation and the other downward for radiance emitted from the selected surface (Fig. 1). The instrument is connected ~~with~~ to a portable laptop in which the software Ocean Optics SpectraSuite is installed to show the measured energy intensity almost instantaneously after each time interval. Solid surfaces chosen for measurement are: 1) concrete, 2) red line on the curb, 3) red bricks, 4) rocks, 5) green grass, 6) grey/brown grass, and 7) old snow. There was a light snowfall the day after the measurement, but fresh snow melted almost overnight so the measurement could not be made. Background and reference measurements on each spectrometer are also conducted for obtaining the actual albedo values. The background is

measured with a non-conductive black rubber that is soft and thick enough to absorb light emitted at almost any wavelength. The reference is measured with a stainless steel board coated with Avian-B white reflectance paint to ultimately yield an albedo reading close to 1.0. Two stools, shown in the image, were used to keep the vertical level consistent throughout the measurement with 22 inches above the ground. The spectrometer pointed downward has a detectable circular area with approximately 2 inches in diameter. Despite its narrow dimension, it is ideal for this study because only surface objects with uniform substances are been examined, instead of a mixture of surface such as pond with weeds growing within. Could do pond as well but reflectivity would be a strong function of sky state,

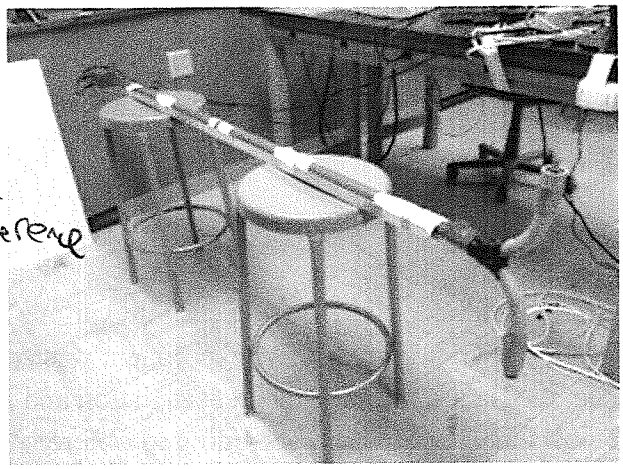


Figure 1. Home-made spectrometer.

The weather conditions during the measurement were cloudy, but not overcast, with breezy winds and occasional drizzle, so the sunlight was visibly more diffusive than specular throughout the measurement. A FORTRAN program has been written to read in the data from the software and output an albedo variation in visible (400-700 nm) and near-infrared (700-800 nm) wavelengths for each surface type.

This is cloudy? Do you mean Partly Cloudy?

Results and Discussion

The albedo graphs are placed along with corresponding images of the selected surfaces (Fig. 2 and 3). The concrete surface indicates a fairly uniform albedo around 0.58 between 400 and 800 nm with a little peak of 0.78 at 760 nm. Because the concrete floor is flat with the color of grey, it is reasonable to see an overall albedo plot with no apparent jump in the visible spectrum range and some variation in the near-infrared range.

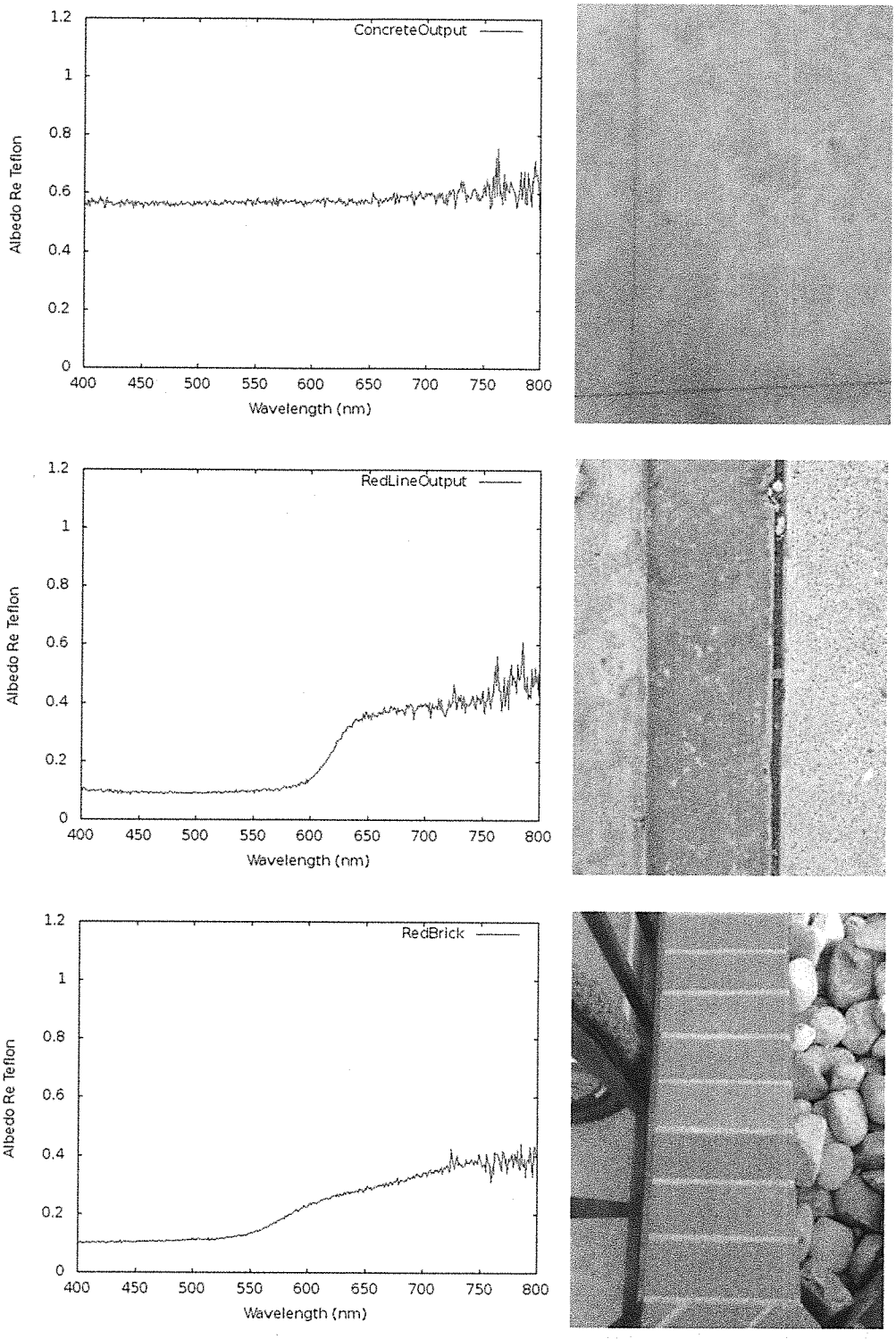
The red makes the concrete less reflective in the blue and green. That

For the red line on the curb, the albedo curve shows a gradual increase after 600 nm, which is where the visible spectrum of red light starts. Notice that the red paint on the curb has been slightly chipped and some grey spots are revealed underneath. However, the spectrometer is able to detect the dominating reflected wavelength as somewhere between 650 and 700 nm.

extra would make the surface (red) hotter on a sunny day

Intuitively, one would anticipate a large similarity between the albedo variation of the red bricks and of the red curb. However, the albedo starts increasing with a small slope after 550 nm, or where green dominates as the reflected light, and continues to increase through orange and red. This not only demonstrates the tendency of human eye to mix a set of reflected wavelengths into one, but also the sensitivity of a spectrometer to clearly distinguish various wavelengths emitting from an object. It is possible that the measurement was taken so the detectable area included the

concrete lines between the bricks. But the plot implies that, like the grey spots on the red curb, the lines should not pose any strong effect to noticeably alter the albedo variation.



Excellent data and Presentation.

Figure 2. Albedo plot and image of: 1) Concrete, 2) Red line on the curb, and 3) Red bricks.

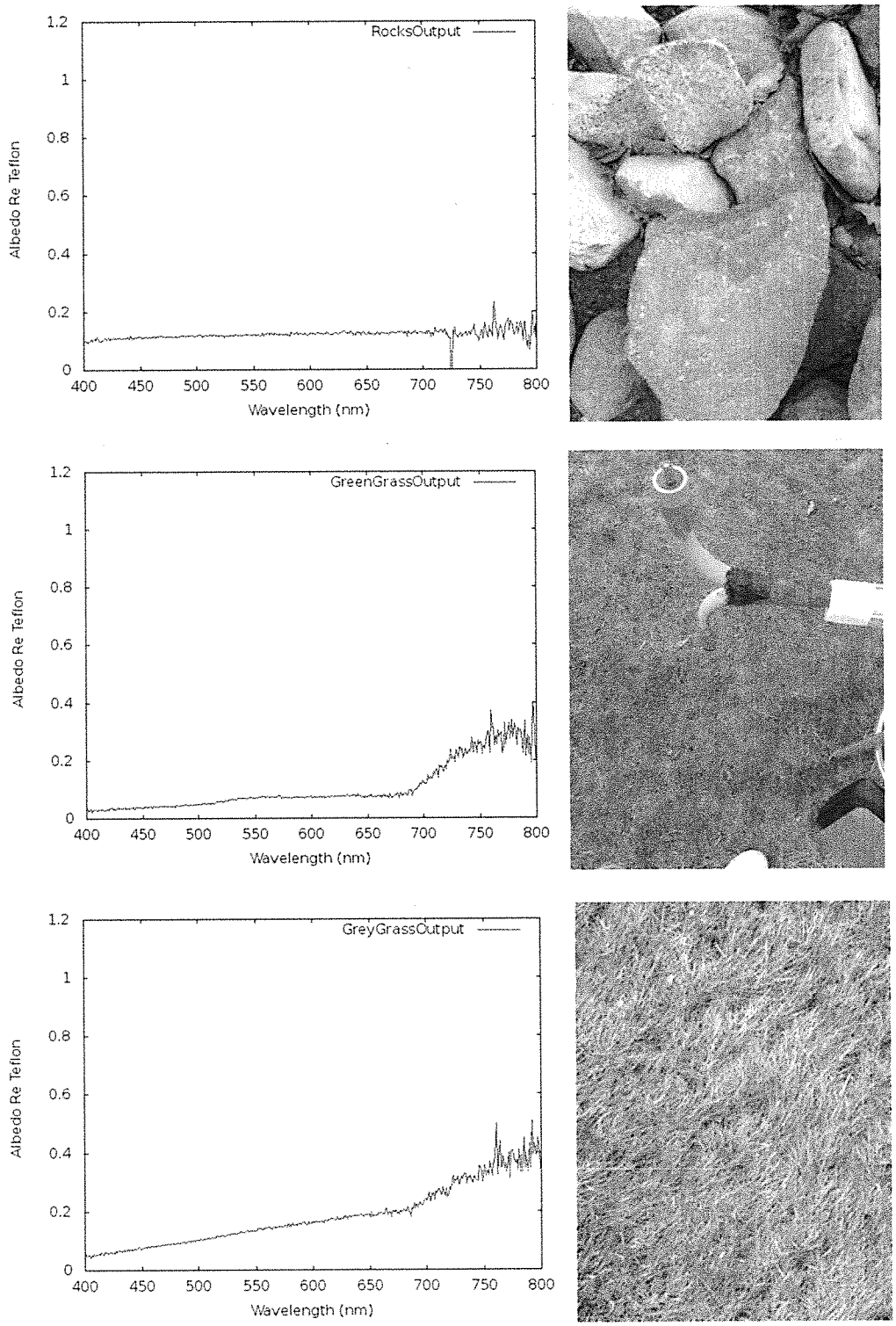
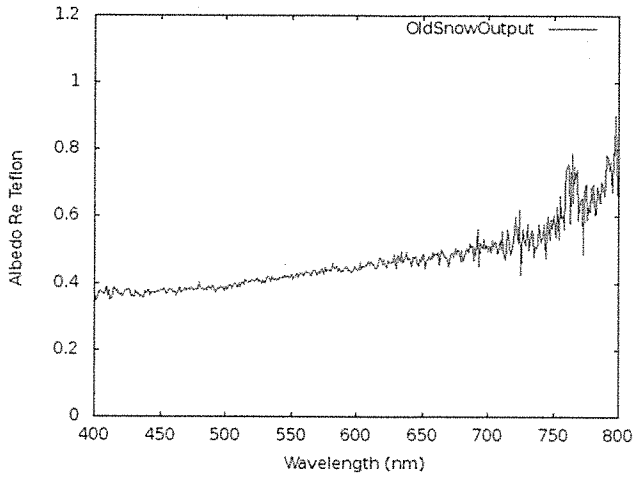


Figure 3. Albedo plot and image of : 4) Rocks, 5) Green grass, 6) Grey grass, and 7) Old snow. Continues to next page.



or shadows formed - rock edge tilts at an angle to give less radiation.

The average albedo for rocks remains around 0.1, implying that much light is being absorbed. There is a maximum of 0.2 near 760 nm and a minimum of 0.0 near 730 nm. The dip at 730 nm is interesting because none of the other surfaces shows such pattern. The trends of visible wavelengths for rocks and concrete surface are nearly identical, which may explain their similarities in color. On the other hand, the magnitude between these two surface types differs significantly. The average albedo of rocks is roughly five times less than that of the concrete surface! Such difference might be attributed to their textures and vertical levels relative to the spectrometer lens. The unevenness of the rocks causes the light to scatter in many directions with angles rather than reflecting back for the spectrometer to catch, while concrete surface is comparatively smoother, allowing more reflectance. The height difference between rocks can cause misinterpretation by the spectrometer as there is a level change within the detecting area, which may be the reason for a sharp dig of albedo in the near-infrared range.

Probably noise ?!

✓ good analysis

Green grass indicates a slight increase at 525 nm and a more sloppy increase right after 700 nm. It has the lowest average albedo among all surface types. Both the uneven grass surface and the quite saturated green color are likely to yield a low average albedo in the visible range. Another factor is the soil moisture. Even though from the image it seems that the surface is well covered with green grass, it is not impossible that the spectrometer detected some portion of soil. Because live, or green, grass is able to hold more moisture than withered grass, and that albedo decreases considerably with increasing moisture in soil (Ångström 1925), it is suggested that the moisture locked in the soil and grass could be one of the factors leading to such low albedo. This may also explain the slightly higher magnitude of albedo in the grey grass. The albedo pattern and magnitude for both green grass and grey grass within the near-infrared wavelength are much alike. The only difference is that the albedo plot for grey grass in the visible spectrum shows a rather smooth increase without any bump near green wavelength (~550 nm) as the green grass.

Would the soil lower or increase albedo?

the grey grass looks brighter. Probably soil is more visible underneath for dead grass?

The snow is estimated to be at least a month old. Since snow particles agglomerate and increase in size as they age, the snow pile measured is presumably high in density (Idso et al. 1975). Albedo remains near 0.4 in the visible wavelength range. A maximum albedo of 0.8 is recorded at 800 nm. Since the snowpack is fairly old, there should be a decent amount of aerosols deposited on it, reducing the strong reflectivity a snowpack usually has. But it seems that this old snow pile still has a strong reflectance in the near-infrared range.

Stronger

Conclusion

The plots indicate that albedo varies according to different colors and roughness of the surfaces with unique characteristics. The concrete surface illustrates the highest overall albedo, even higher than old snow, spanning from visible (400-700 nm) to a portion of near-infrared (700-800 nm) wavelengths. Red curb and red bricks show quite different albedo variations in the visible even though they both appear to have red hue in color. The green grass has noticeably the lowest albedo than any other surfaces in the visible wavelength with possible contributions from unevenness of the grass, the saturated color, and the moisture held by soil and live grass. All seven surfaces are likely to appear in large area and quantity on the planet. So the study of these different surfaces can be applied to remote sensing based on different albedo variation. Other types of surfaces, such as roof materials on the buildings, bare woods, water bodies, should be further studied in order to establish a more comprehensive albedo profile as a parameter. Understanding how each surface possesses its unique characteristics of albedo in different wavelength can effectively extend the accuracy of remote sensing in discriminating various land covers such as snow, grass land, and forest. Consequently, this improvement may also allow many climate and emission models to obtain more precise land cover types and solar budget input to perform better simulations.

Compared with other surfaces but well studied

I didn't see where this paper was referenced?

References

- Ångström, A., 1925: The Albedo of Various Surfaces of Ground. *JSTOR*, Vol. 7, pp. 323-342.

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- Grenfell, T. C., Warren, S. G., and Mullen, P. C., 1994: Reflection of solar radiation by the Antarctic snow surface at ultraviolet, visible, and near-infrared wavelengths. *J. Geophys. Res.*, **99**, 18,669-18,684.

One other useful thing would be to find other Albedo measurements and compare them with yours.