PICTURE OF THE MONTH

Dramatic Contrast between Low Clouds and Snow Cover in Daytime 3.7 μm Imagery

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A long-standing problem in satellite meteorology has been the discrimination of low clouds from snow cover. The basic difficulty is that clouds and snow have very similar radiometric properties in regions of the electromagnetic spectrum most often used for observation. In the visible window (near 0.5 μm) both clouds and snow have high albedos; in the 11 μm infrared window both clouds and snow have high emittances. Thus, low clouds and snow, which have similar thermometric temperatures, present little contrast in visible or 11 μm infrared satellite images. In the 3.7 μm window, however, clouds and snow can have different radiometric properties.

Figure 1 shows a daytime 3.7 μm image recorded by the Advanced Very High Resolution Radiometer (AVHRR) on board the NOAA-7 satellite. Figures 2 and 3 show 0.6 and 11 μm images for comparison. The 3.7 and 11 μm AVHRR data are quantified in terms of equivalent blackbody temperature ($T_{\rm BB}$), while the 0.6 μm data are quantified in terms of reflected solar energy (Lauritson *et al.,* 1979). The 0.6 μm data can be converted to albedo by dividing by the cosine of the solar zenith angle. Table 1 shows that the cloud[2] at A and the snow at B have similar 11 μm temperatures and 0.6 μm albedos. At 3.7 μm, however, there is a 35 K difference in $T_{\rm BB}$ between A and B.

This large contrast can be explained by reflected solar radiation. Snow, which has an albedo of only a few percent at 3.7 μm (Wiscombe and Warren, 1980), appears much the same in Figs. 1 and 3. Assuming that the sun radiates as a blackbody at 5780 K, and that the cloud at A has zero transmittance, isotropic reflection and a cloud top temperature equal to $T_{\rm BB}$ (11 μm), we calculate that the cloud has a 3.7 μm albedo of approximately 20%. The reflected solar radiation in addition to thermal emission causes (most) clouds to appear dark in the 3.7 μm image.

It should be noted that a 20% albedo at 3.7 μm appears to be somewhat higher than values computed from radiative transfer theory by Welch *et al.* (1980). Their Table 2.6 shows that over a range of microphysical conditions a 500 m thick cloud with its base

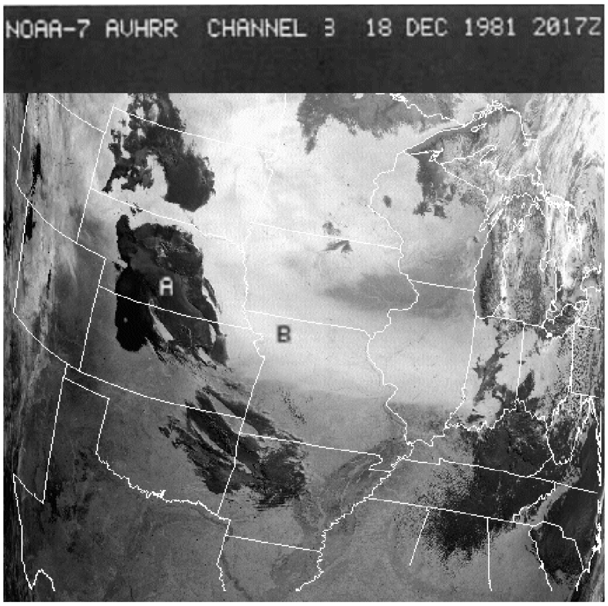

FIG. 1. 3.7 μm AVHRR daytime image of the central United States.

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[2] Note that at 2100 GMT, Grand Island, Nebraska, reported continuous light snow and a surface (shelter) temperature of 260 K.

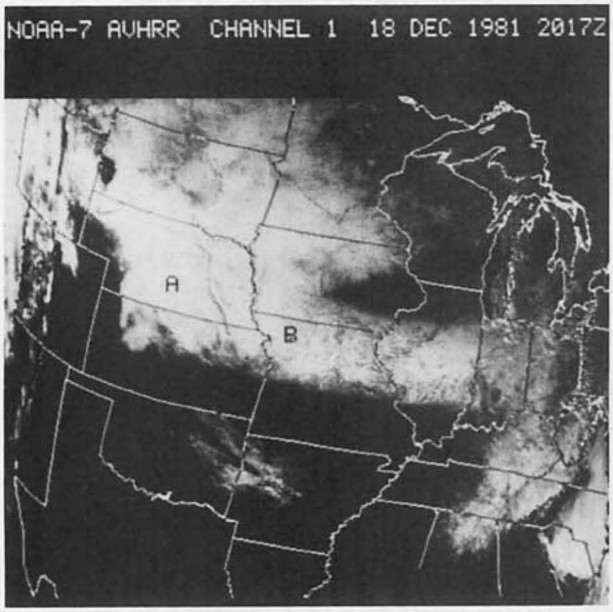

FIG. 2. 0.6 μm AVHRR image.

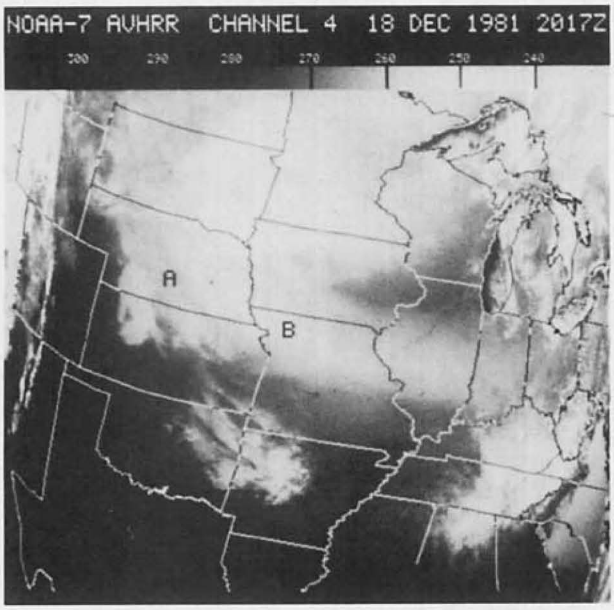

FIG. 3. 11 μm AVHRR image.

at 2 km and with the sun directly overhead has a maximum 3.3 μm albedo of 7.7% and a typical albedo of less than 3%.

Although many more images will have to be examined before a definite conclusion can be drawn, it is hoped that daytime imagery in the 3.7 μm window may be useful in the problem of cloud–snow discrimination. Perhaps imagery from the 3.94 μm channel of the VISSR Atmospheric Sounder (VAS) on board the GOES satellites may be of use in this task.

TABLE 1. Daytime AVHRR-sensed cloud versus snow properties.

Quantity	A (cloud)	B (snow)
T_{BB} (11 μm)	259.5 K	255.5 K
T_{BB} (3.7 μm)	295.0 K	258.5 K
Solar zenith angle	68.5°	70.0°
Albedo (0.6 μm)	52%	53%

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