NOTES AND CORRESPONDENCE

Comments on "Some High Values for the Albedo of the Sea"

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In a recent article Willis (1971) has described some sea surface albedo observations which he made from a ship in the Sargasso Sea. Two sets of data were presented: observations during 28 min on a clear day with a light wind (30 November), and observations during 80 min on a day when the sky was partially cloud-covered (2/8 to 4/8 low cumulus) and the wind strong enough to cause white caps (2 December). The sun altitudes, 30°–35°, were comparable during the two observation times.

Recently, I have completed a comprehensive study of the sea surface albedo (Payne, 1972) during which 15-min totals of upward and downward irradiance were recorded for four months, June–September, from a tower in Buzzards Bay, Mass. Willis' albedo values are substantially higher than the values my results would predict for his conditions (Willis' 30 November values are about 25% higher, and his 2 December values more than twice as high), and I believe that some of Willis' data are of questionable quality.

One important result of my study is that sea surface roughness has only a small effect on albedo. For sun altitudes in the range 25°–30°, albedo changes about 1% of its value per knot of wind speed, decreasing with increasing wind speed. For sun altitudes much higher or lower than this range, the effect of roughness is negligible. Willis' high albedo values on 2 December cannot be accounted for by the roughened sea surface.

TABLE 1. Downward irradiance and transmittance data (after Willis, 1971)

Time (GMT)	Solar height (deg)	Downward irradiance	Atmospheric transmittance
1330	25	0.698	0.88
1341	27	0.112	0.13
1352	28	0.646	0.73
1358	29	0.723	0.79
1408	29	0.782	0.86
1415	30	0.785	0.83
1425	32	0.813	0.81
1429	32	0.829	0.83
1436	33	0.848	0.83
1442	33	0.707	0.69
1450	34	0.820	0.78

Among the quantities calculated from my data was the atmospheric transmittance, the ratio of downward irradiance measured near the sea surface to the irradiance outside the atmosphere. During the four months of my study there were no values of the atmospheric transmittance >0.75. Lumb (1964) has found a similar result. For a sun altitude of 35° and clear sky, he obtains an atmospheric transmittance of slightly less than 0.75 for both OWS *J* and OWS *A*.

In Table 1 are presented some of the data from Willis' Table 3 for 2 December. Atmospheric transmittance has been calculated from his data according to the expression

$$T=E/(S\sin\theta/\gamma^2),$$

where T is the atmospheric transmittance, E the observed downward irradiance, S the solar constant (1.94 cal cm^{-2} sec^{-1}), θ sun altitude, and γ the ratio of earth-sun separation to the annual mean separation. It is apparent that the atmospheric transmittance values are higher than one would expect for even the clearest skies. Although it is possible for scattered clouds to have a focusing effect which momentarily increases irradiance at a particular point, this is a transient phenomenon, and for periods of more than a very few minutes one expects the presence of clouds to decrease the irradiance.

High downward irradiance values cannot account for the high albedo values Willis calculates, but they do call into question his instrumentation. For instance, a positive voltage offset in the microvolt amplifier used with the upward irradiance pyranometer would cause increasingly high albedo values with decreasing irradiance. Willis' exceedingly high albedo value of 0.49 at 1341 on 2 December when the downward irradiance dropped sharply suggests the plausibility of this explanation.

In summation, Willis' albedo values seem anomalously high and should not be relied upon until they are supported by other investigations.

REFERENCES

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