View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

N90-28236

Reflectivities of Uniform and Broken Stratiform Clouds--An Update

J.A. Coakley, Jr.
Department of Atmospheric Sciences
Oregon State University
Corvallis, OR 97331-2209

B.P. Briegleb
National Center for Atmospheric Research
Boulder, CO 80307-3000

We have compared the reflectivities of uniform and broken stratiform clouds obtained from the NOAA-9 and NOAA-10 overpasses collected during the FIRE Marine Stratocumulus IFO, and we have compared these reflectivities with those obtained through radiative transfer calculations performed for plane-parallel cloud models. Our objective was to determine the extent to which plane-parallel radiative transfer calculations could reproduce the reflectivities observed for uniform clouds and to determine the extent to which finite cloud effects cause broken clouds to reflect differently than uniform clouds. The latter study is to provide guidance in the parameterization of finite cloud effects in general circulation climate models as well as to assess the ability of plane-parallel theory, which is used by ISCCP to retrieve cloud properties, to treat the reflectivities of broken clouds.

Some results from this study were reported at the last FIRE Science Team meeting and some were reported elsewhere (Coakley and Briegleb, 1989). Improvements since the previous reports include 1) the analysis of additional satellite passes and 2) a modification to the analysis which helps to show the significance of the differences in reflectivities for uniform and broken clouds.

All NOAA-9 and NOAA-10 daytime passes for the FIRE IFO were processed using the spatial coherence method. For this study observations were collected for 60 km subframes which 1) contained a single layer of stratiform clouds, 2) of the 1 km fields of view, had greater than 10% that were overcast and 3) had a similar fraction that contained broken clouds. By restricting the observations to such subframes we are able to report on the properties of the reflectivities for uniform clouds, as deduced from the overcast fields of view, and the properties for the same clouds when they are broken, and thereby, are subject to finite cloud effects. For the broken clouds, we obtain the reflectivity by taking the mean reflectivity for the ensemble of fields of view containing broken clouds to be given by

$$r = (1 - A_c)\, r_s + A_c\, r_c \qquad (1)$$

where A_c is the fractional cloud cover for the ensemble, r_s is the reflectivity for the cloud-free ocean background and r_c is the desired cloud reflectivity. r_s is obtained from observations when the region is cloud-free. A_c is obtained from the spatial coherence results using radiances at 11 μm.

For the calculated results we used an adding-doubling method for solving the radiative transfer equation and Mie calculations for

PRECEDING PAGE BLANK NOT FILMED

representative droplet size distributions to obtain the single scattering phase functions. These phase functions were fit to double Henyey-Greenstein phase functions to capture both forward and backward peaks of the scattering. Because the AVHRR is uncalibrated, we normalized the observations so that a suitable average of the observed radiances was made to match a similarly derived average of the calculated radiances.

Figure 1 shows comparisons of the calculated and observed anisotropy of the 0.63 μm reflectivities for the NOAA-9 and NOAA-10 overpasses. The observed and calculated results match well within the uncertainties of the observations.

Figure 2 shows differences (uniform - broken) between the reflectivities of uniform clouds and their broken counterparts. Uniform clouds have significantly higher reflectivities for all satellite zenith angles. Nevertheless, at least for the stratiform clouds observed during FIRE, the anisotropy of the 0.63 μm reflected radiation seems to be unaffected by finite cloud effects.

The reflectivity of broken stratiform clouds would appear to be amenable to plane-parallel theory albeit at reduced reflectivities. The reduction in reflectivity might be due to finite cloud effects, but the reduction is also consistent with lower liquid water paths for broken clouds. We have performed similar analyses for radiation reflected at 3.7 μm. The absorption of solar radiation at 3.7 μm by water droplets substantially alters the findings.

Reference

Coakley, J.A., Jr. and B.P. Briegleb, 1989: Reflectivities of Uniform and Broken Marine Stratiform Clouds. Proceedings of IRS '88. (in press).

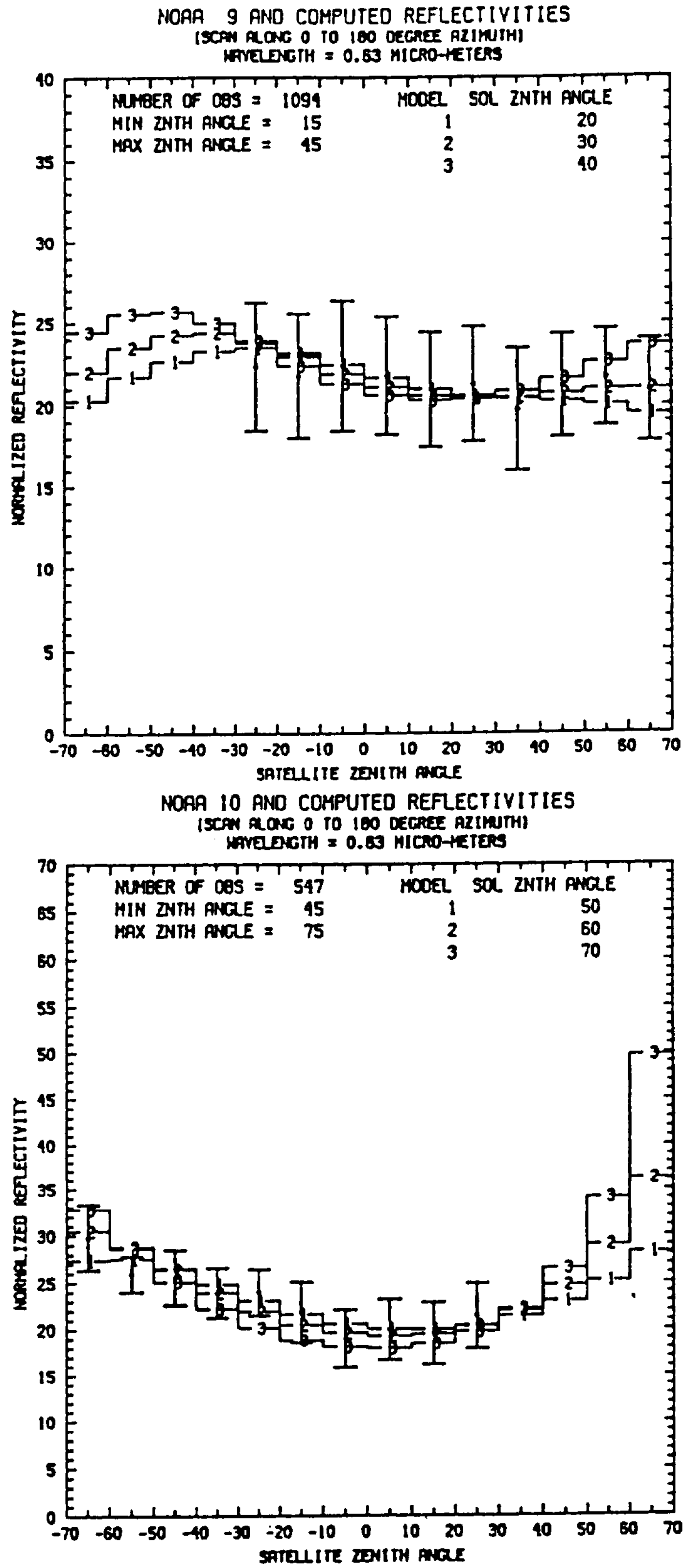

Figure 1. Observed and calculated normalized reflectivities for uniform stratocumulus. Negative satellite zenith angles indicate backscattered radiation; positive satellite zenith angles indicate forward scattering. The error bars indicate one standard deviation of the observed reflectivities.

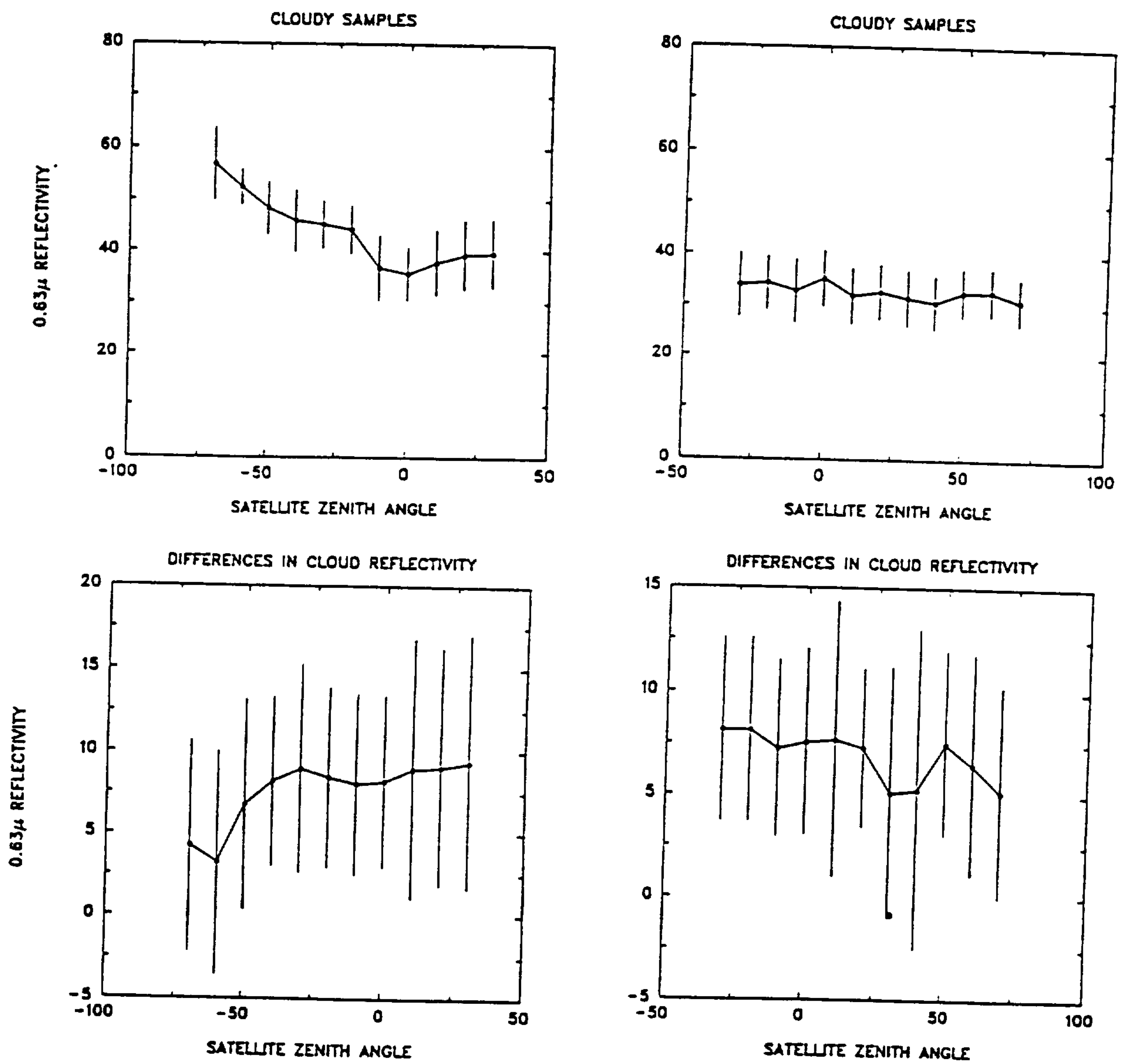

Figure 2. Observed reflectivities for uniform clouds and differences between reflectivities for uniform clouds and their broken cloud counterparts (uniform-broken). The error bars for the differences indicate one standard deviation for the difference.