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Cloud Properties Derived from Visible and Near-infrared Reflectance in the Presence of Aerosols.

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OVERVIEW

During the *ICARTT* campaign of 2004, we measured solar spectral irradiance with the SSFR (Solar Spectral Flux Radiometer) to retrieve cloud properties. We compare these cloud retrievals to *in situ* microphysical measurements by the FSSP (Forward Scattering Spectrometer Probe) and to other remote sensing observations from MIDAS (Miniturized Differential Absorption Spectrometer). AATS-14 (Ames Airborne Tracking Sunphotometer) aerosol measurements were used to examine the effects of aerosols on cloud retrievals. For four cases, we compare the SSFR retrieved cloud optical depths and effective cloud droplet radii with MODIS (Moderate Resolution Imaging Spectroradiometer).

SSFR Retrieval Method

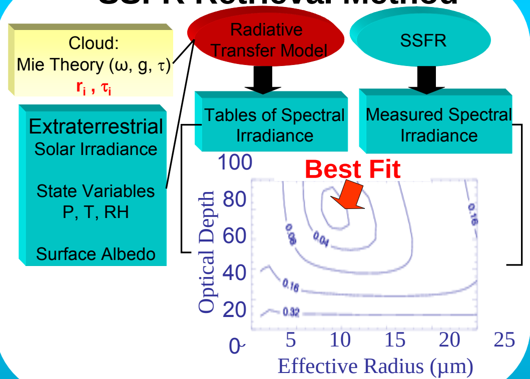

Figure 1: Details of the Forward Model and Inversion Procedure. Model inputs are profiles of state variables (P, T, RH), extraterrestrial solar irradiance and surface albedo. Scattering from water droplets is calculated from Mie theory over a range in effective radius (r_e) from 1-30 μm and cloud optical thickness (τ) from 0-100. A library of spectral irradiance values is calculated for clouds of various size distribution and optical depth. The best fit between the measured SSFR irradiance spectra and the library determines the r_e, τ pair.

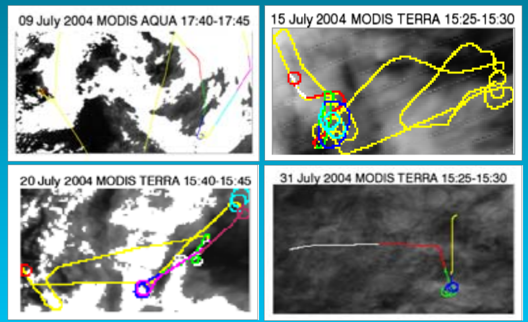

Figure 2: RGB MODIS images showing cloud cover and flight track of either Sky Research J-31 or NOAA WP-3D aircraft in yellow for four dates. Colored segments of flight track signify 1-hour of flight time encompassing satellite overpass period. Red circle identifies location of Pease AFB in Portsmouth, NH.

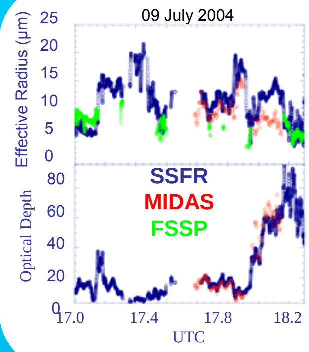

Figure 3: Comparisons of effective radii (top panel) from SSFR, MIDAS, and FSSP (on the NOAA WP-3D) and optical depth (bottom panel) from SSFR and MIDAS.

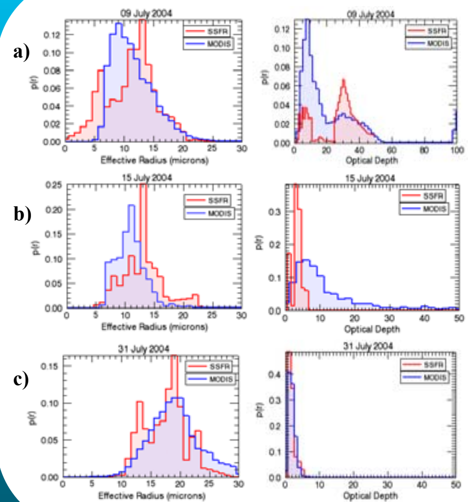

Figure 4: Histograms of MODIS and SSFR retrievals for 3 cases. Plot a) shows good agreement between mean effective radius, as well as first mode of optical depth. SSFR is biased toward thicker cloud because of non-simultaneity with MODIS overpass. The latter portion of the flight occurred when a thick convective cloud region to the north advected over flight track (see also figure 2). Plots b) and c) show good agreement under low to moderate optical depth and low aerosol loading.

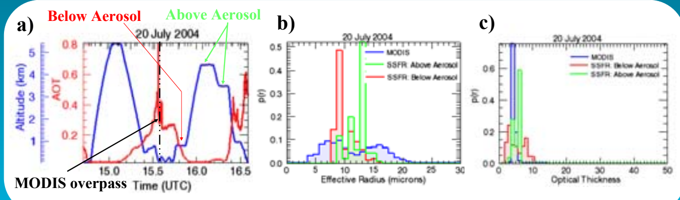

Figure 5: July 20, 2004 case with aerosol layer above cloud. Plot a) shows flight altitude (blue) and aerosol optical thickness (red). Histograms in b) indicate an increase in retrieved effective radius when derived from above overlying aerosol layer while optical depth is relatively unaffected (c). Note: Aerosols were NOT included in the SSFR retrieval forward model.

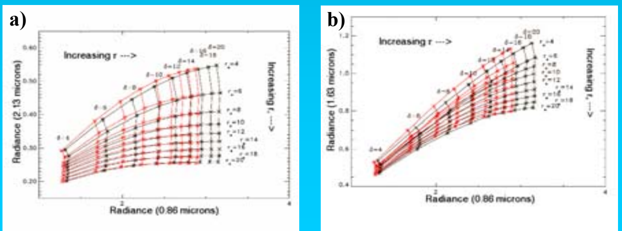

Figure 6: Effects of aerosols (red) on MODIS retrievals of r_e and δ_{cloud} (δ in the figures) compared to MODIS retrievals without aerosols (black). Plot a) compares MODIS radiances at 0.86 and 2.13 microns. Plot b) compares MODIS radiances at 0.86 and 1.63 microns. The presence of aerosols shifts curves up and to left, to smaller effective radii *(Haywood et. al. QJR, 2004)*, opposite to what was observed in this study. These results are dependent upon wavelengths of radiance used to derive (r_e, τ); the next phase of this work will be to examine influence of overlying aerosols on hyperspectral irradiance.

Summary

1. SSFR/MIDAS/FSSP are in close agreement.
2. SSFR/MODIS comparisons are excellent.
3. SSFR retrieval of r_e was affected by aerosol layer above cloud (to *larger* size) and in opposite direction to MODIS retrievals.

CASE STUDY RESULTS

	r_e (μm)		τ_c		τ_a
	SSFR	MODIS	SSFR	MODIS	AATS-14
09 Jul[1]	11.1	11.4	53	22	
15 Jul	12.9	10.9	7	14	0.02-0.15
20 Jul[2]	9.9,12.2	11.6	10.3,10.5	8.8	0.05-0.5
31 Jul	18	19	3.6	3.8	0.02-0.2

[1] Airborne in situ and remote sensing comparisons (P-3)
[2] High aerosol AOT case (J-31)

Acknowledgements
[1]University of Colorado at Boulder, [2]NASA Ames Research Center, [3]SRI International, [4]Bay Area Environmental Research Institute, [5]NASA Goddard Space Flight Center, [6]NOAA Aeronomy Laboratory, [7]University of Utah.

References

Haywood, J.M., S.R. Osborne, and S.J. Abel, *The effect of overlying absorbing aerosol layers on remote sensing retrievals of cloud effective radius and cloud optical depth, QJR Meteorol. Soc, 2004*

Contact Information

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