Final Report for NAG 2-1578:

Measuring Aerosol Size Distributions from the NASA DC-8 in SOLVE II

Award Period: 15 August 2002 to 14 December 2003

Dr. Michael Reeves, Principal Investigator
Research Assistant Professor
School of Engineering and Computer Science
University of Denver
Denver CO 80208-0177
Tel: 303.871.3283
Fax: 303.871.4405
jreeves@du.edu

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Introduction

The University of Denver Focused Cavity Aerosol Spectrometer (FCAS II) and Nucleation-Mode Aerosol Size Spectrometer (N-MASS) were successfully integrated and flown aboard NASA's DC-8 for the second SAGE III Ozone Loss and Validation Experiment (SOLVE II). Both instruments performed well during SOLVE, with virtually complete data coverage for all mission and test flights. The few exceptions to this were the occasional simultaneous zero-check for the instruments, and some data loss for channel 4 of the N-MASS. The only consequence of the latter is reduced resolution in the 15 to 60 nm range for the affected size distributions.

Archived Data Files

Three sets of files are being supplied to the archive. The CN*__DU.DC8 files contain total aerosol number, surface area, and volume concentrations from the FCAS II, and the number concentration from each of the five N-MASS channels, all at 30-second intervals. The FCAS data have been adjusted to account for evaporation of water, departures from ideally isokinetic sampling at the inlet, and counting efficiency. N-MASS channel data have been corrected for live-time only; this correction rarely exceeds a few percent. SD*.DC8 files are FCAS-only differential size distributions in the approximate diameter range of 80 to 2000 nm, with the same corrections as for the CN*__DU.DC8 data. The DS*.DC8 files contain *dry* aerosol size distributions covering the diameter range 4 nm to about 2000 nm, again at 30-second intervals, expressed as the mixing ratio of particle number per milligram of air in each size bin. Ambient air density, calculated from ICATS data, is also included for convenient conversion of the mixing ratio to ambient concentration if desired. These size distributions are obtained by inversion of combined N-MASS and FCAS II data using a modified Twomey technique. The inversion process incorporates both the channel responses of the N-MASS and a correction for size-dependent diffusion losses, the latter significant only for diameters below 100 nm.

Results

The measured differential size distributions have been used to calculate aerosol extinction, according to Mie scattering theory, for comparison with SAGE III version 2.00 extinctions at the nine wavelengths reported by SAGE III. The calculation assumes spherical particles of sulfuric acid and water in equilibrium with ambient water vapor concentration. Aerosol surface area and volume densities derived from the SAGE III

extinctions were not available. Comparisons were made for measurements coincident with 9 SAGE III occultations; 8 of these were planned, and a ninth happened to fall within the coincidence criteria of ±1° latitude, ±1° longitude, and ±3600 seconds relative to the SAGE III event. Figure 1 shows all comparison data in panel plots of extinction profiles by wavelength for each event. The FCAS data have been binned to the SAGE III altitude levels. Although some profiles were obtained, much of the FCAS data were acquired in approximately level flight, leading to overlaps in a limited altitude range. No SAGE III profiles at 385 nm extended down to the DC-8 altitude.

Agreement is generally good, and best in the lower stratosphere and tropopause layer (about 9 km and above). There is increased scatter in the upper troposphere and at shorter wavelengths. One reason for this is that the spectral dependence of the SAGE III profiles in the troposphere is at times inconsistent with Mie theory and the measured size distributions. This is demonstrated in Figure 2, where the spectral dependence of extinction for each comparison value is plotted. The FCAS data always show a smooth progression of decreasing extinction with increasing wavelength, and little variation with altitude. The SAGE III spectral dependence is generally similar, but in some cases deviates from the expected Mie dependence at shorter wavelengths, especially on January 12, 19, 24, and 31.

The comparisons in Figure 1 are also presented in scatterplot form in Figure 3. The spectral anomalies noted in Figure 2 are apparent here in the greater horizontal spread of the SAGE III extinctions.

Finally, comparison statistics are summarized in Table 1. At every wavelength the mean fractional extinction difference, (FCAS-SAGE)/Average, is less than one standard deviation. Although the differences are thus not statistically significant, it is interesting to note that the FCAS extinction is always slightly higher than the SAGE III value except at 1550 nm. It is possible that this is due to a small population of large particles beyond the FCAS size range.
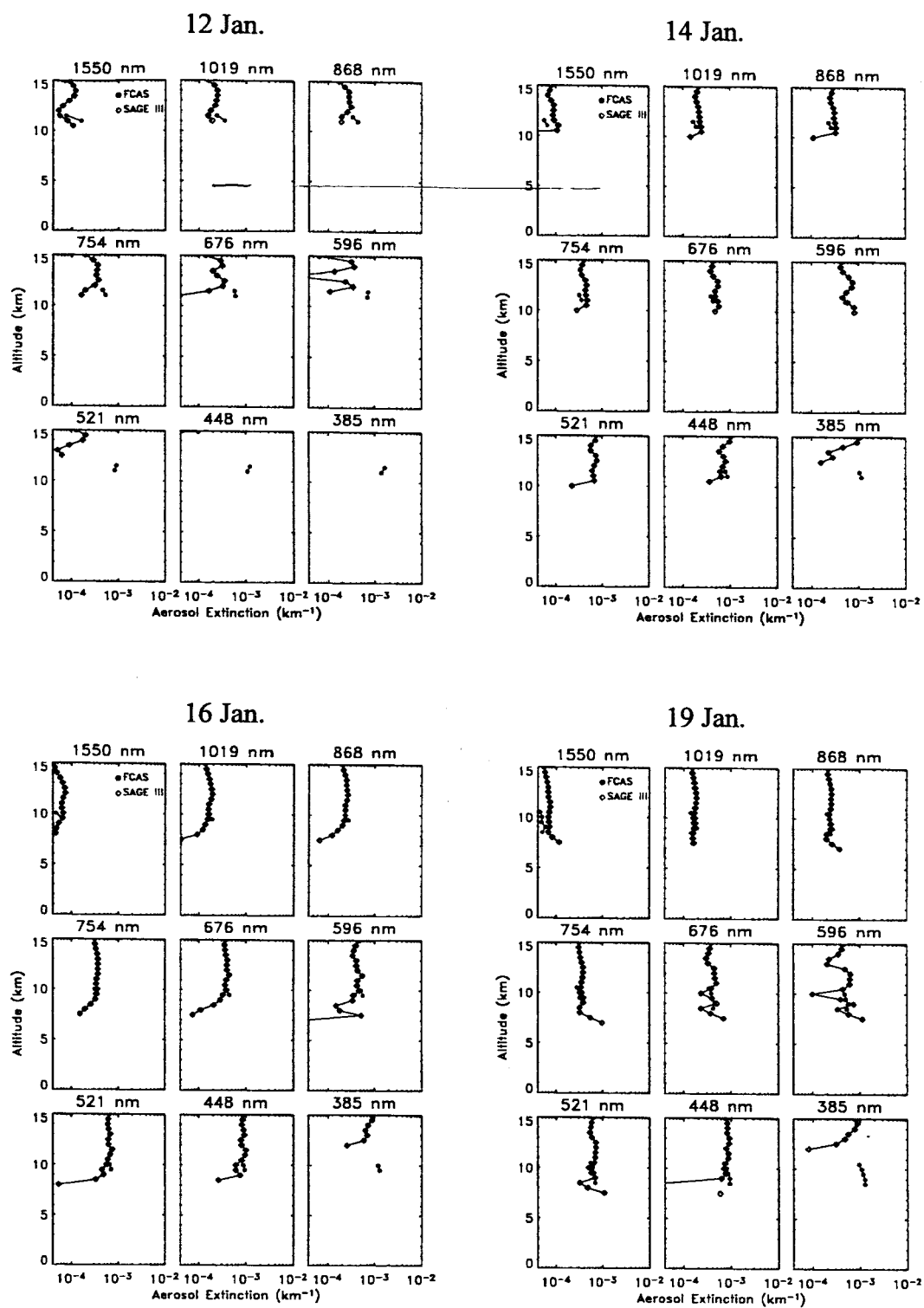
Figure 1. FCAS and SAGE III extinction profiles for the coincident measurements. FCAS data have been binned to the SAGE III reporting altitudes.
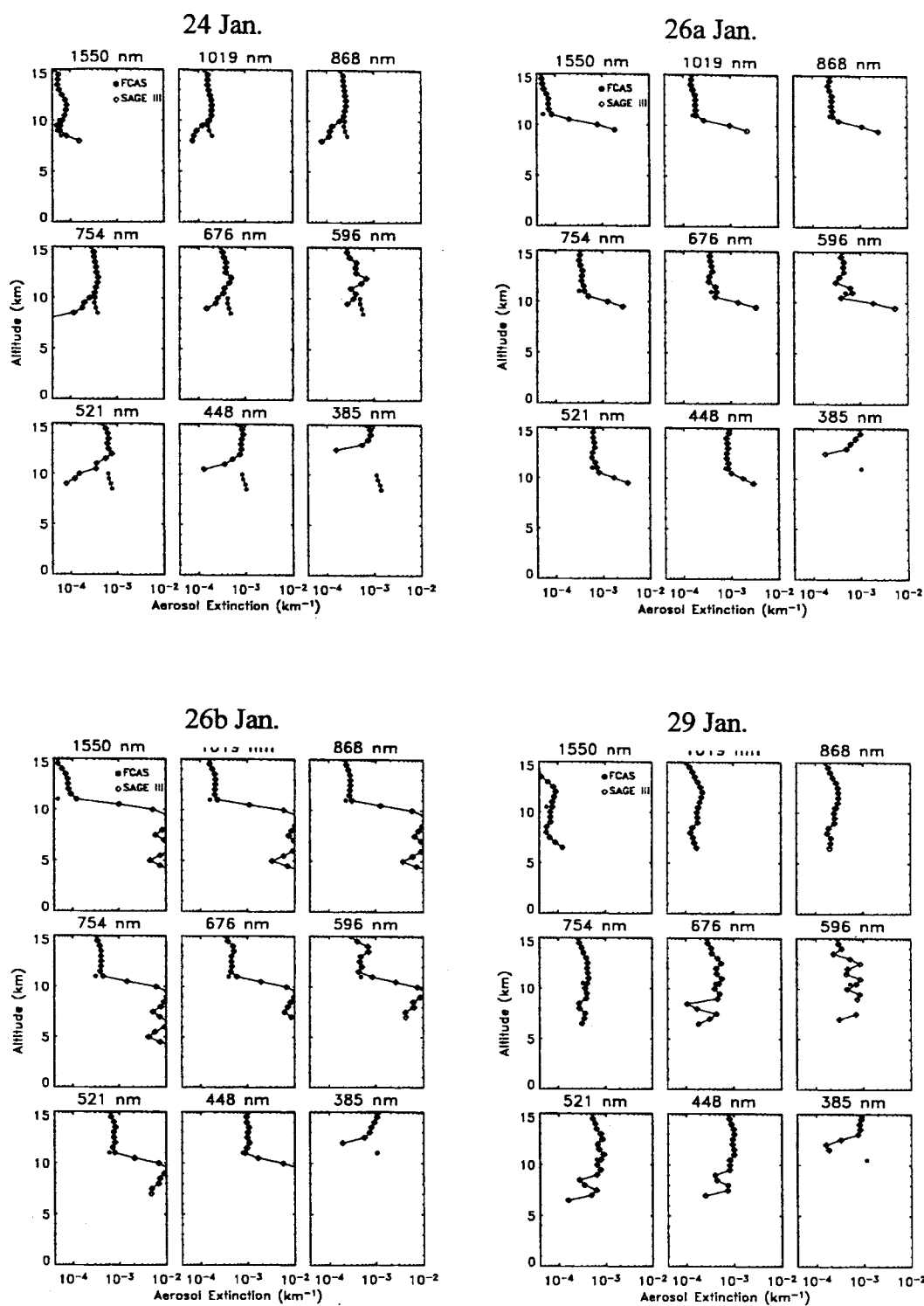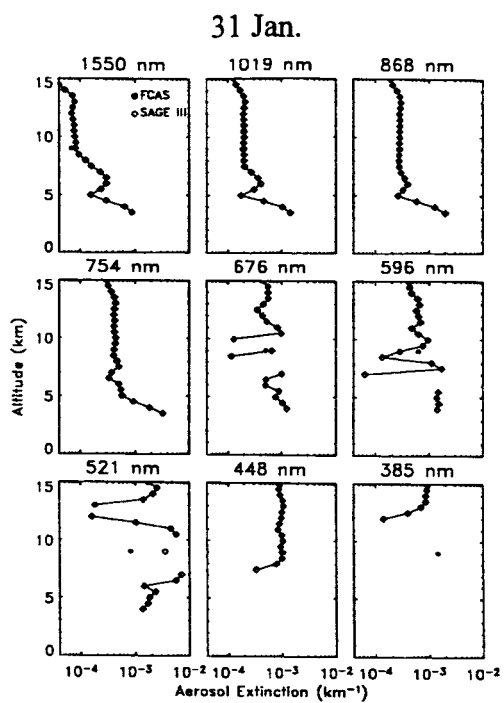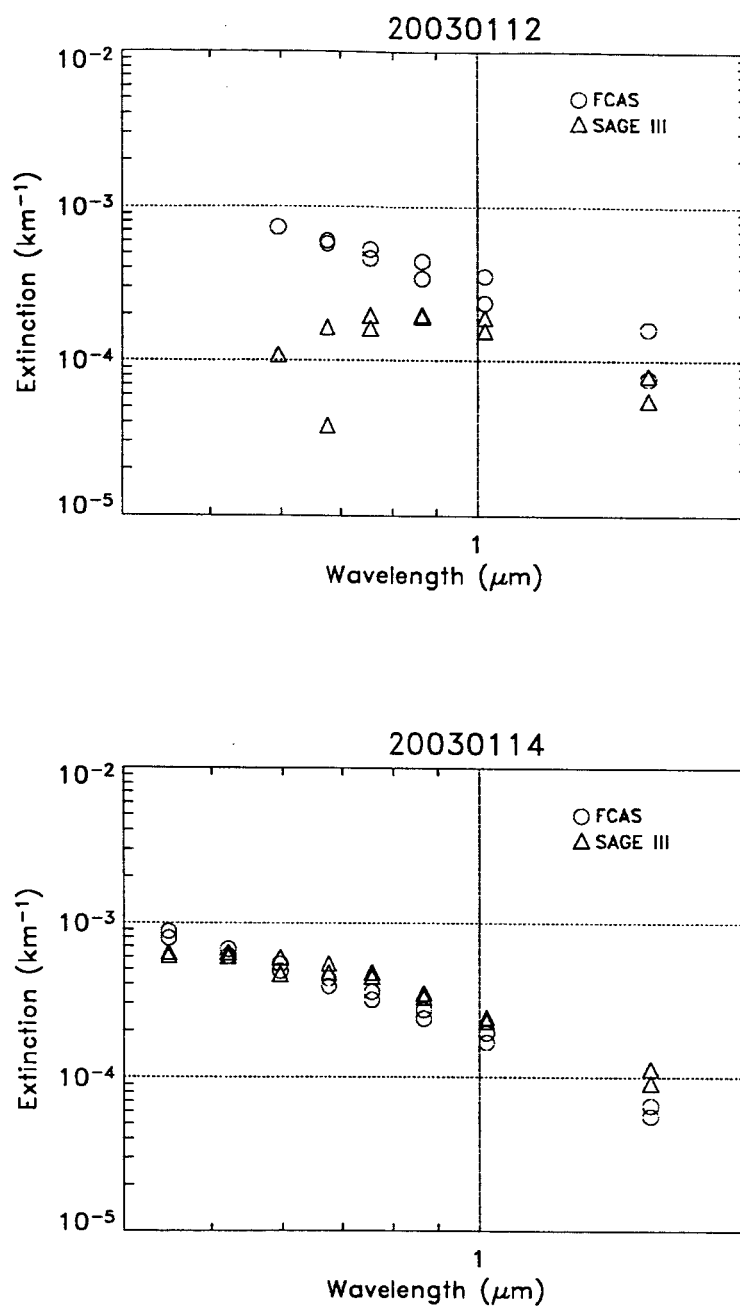
Figure 1 cont.

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Figure 1 cont.

Figure 2. Comparison of spectral dependence of extinctions from FCAS and SAGE III for the coincident measurements. There were no SAGE III data at 385 nm available at the altitude of the DC-8.
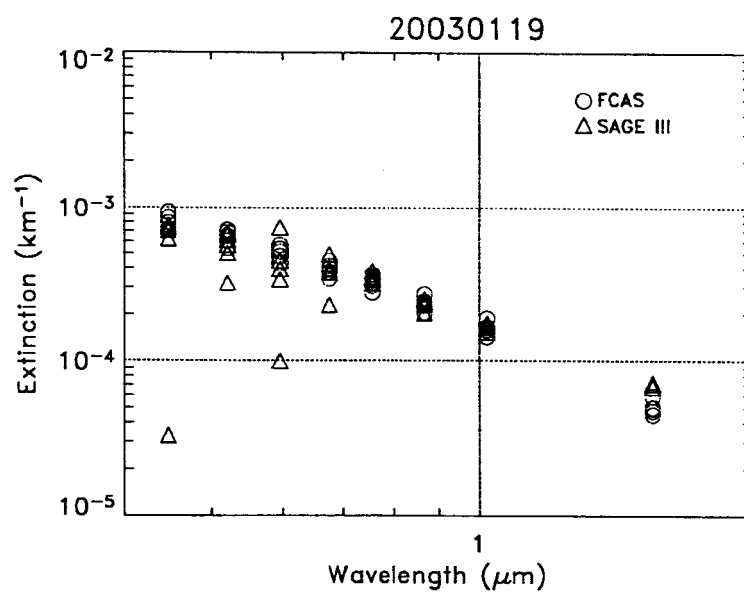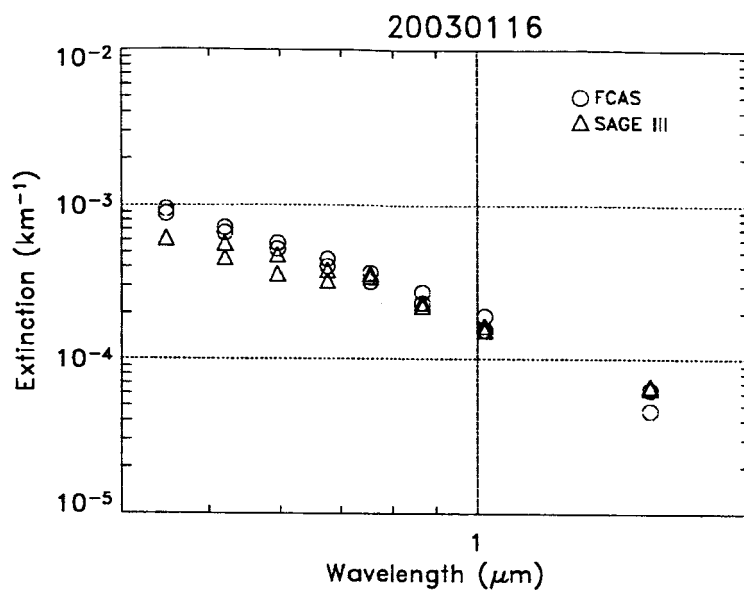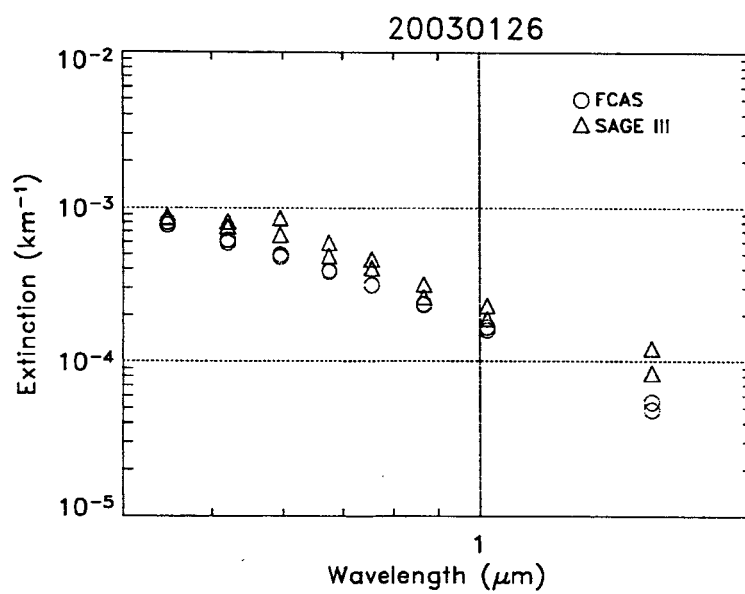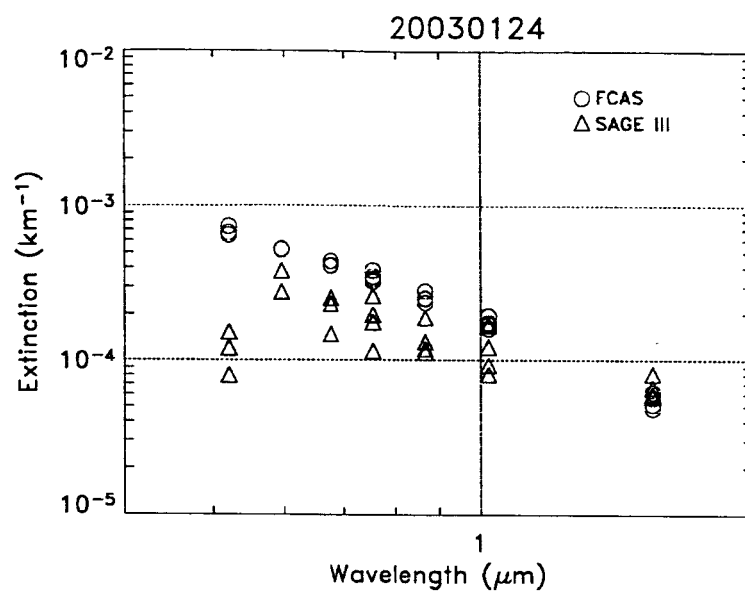
Figure 2 cont.

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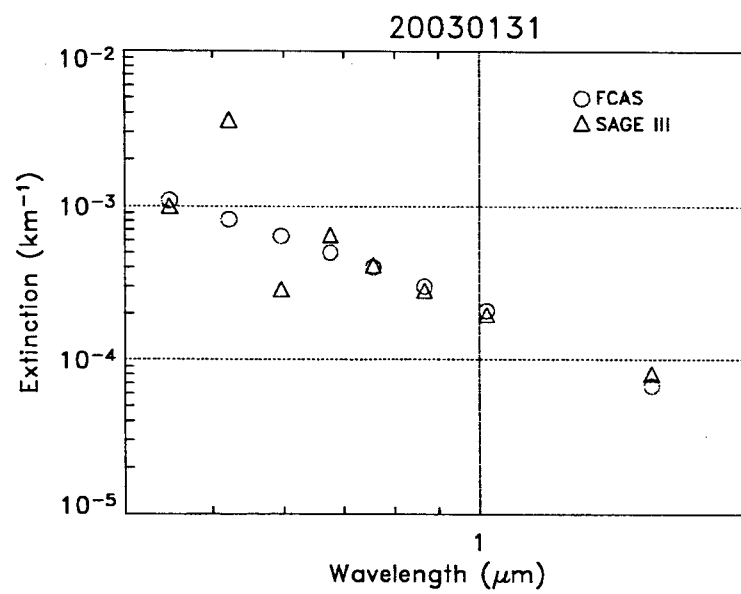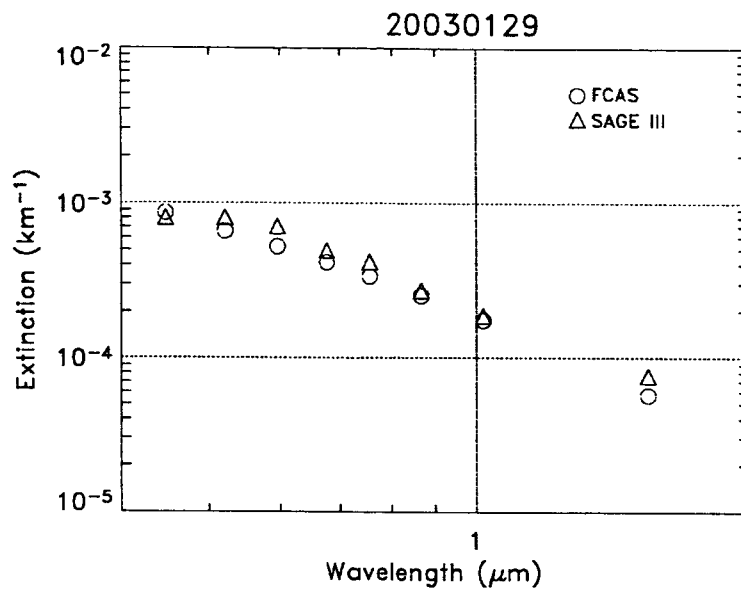Figure 2 cont.

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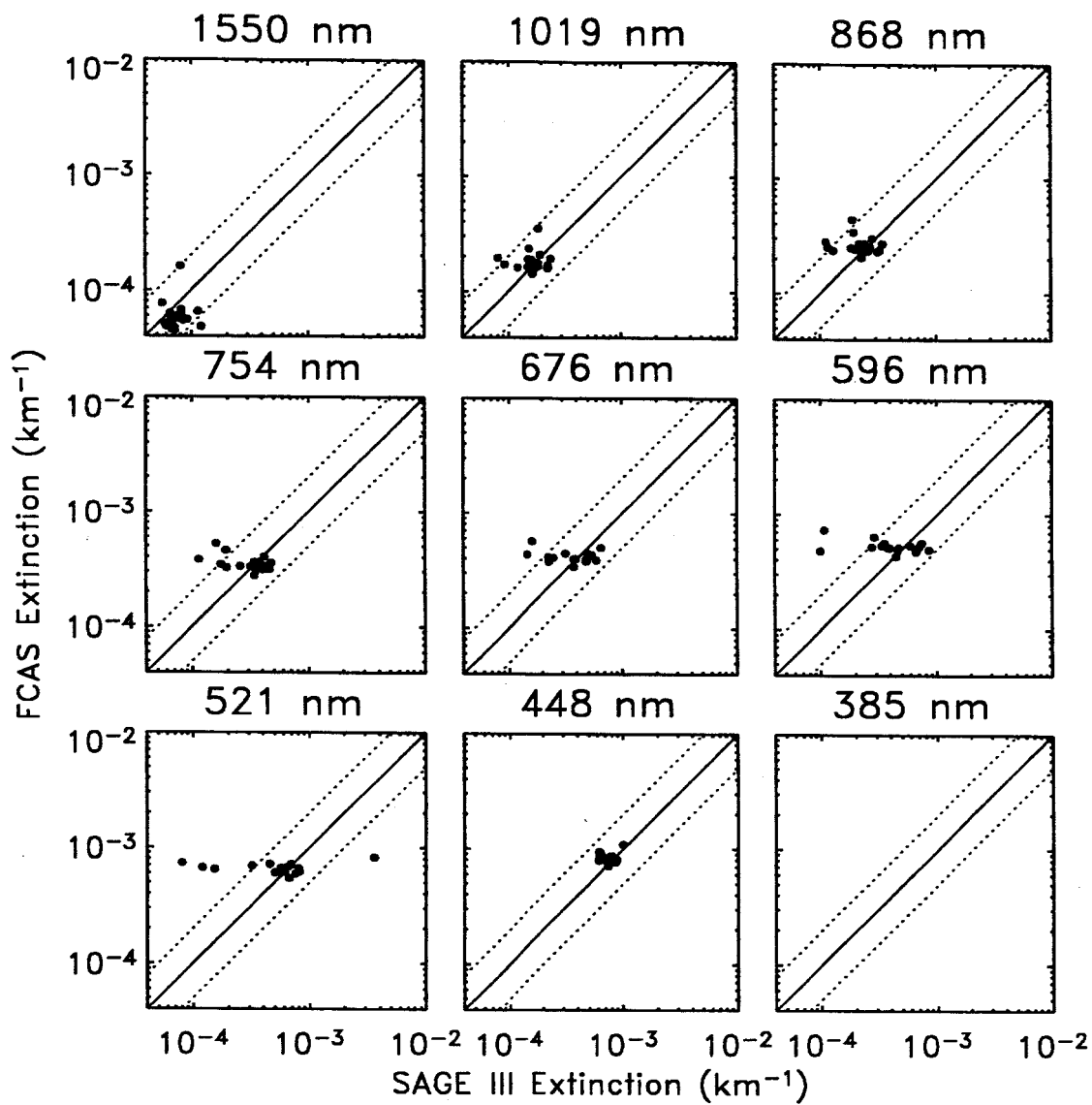

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Figure 2 cont.

Figure 3. Scatterplots of FCAS and SAGE III extinctions by wavelength. The solid line is 1:1, and the dotted lines indicate 2:1 and 1:2. No SAGE III profiles at 385 nm reached the DC-8 altitude.

Table 1. FCAS-SAGE III extinction comparison: (FCAS-SAGE)/(Average)

Wavelength (nm)	Mean Fractional Difference (%)	Std. Deviation (%)	Number of Points
1550	-24.2	32.2	19
1019	9.0	32.5	19
868	16.1	36.8	19
754	11.8	46.9	19
676	25.6	58.2	18
596	26.4	57.2	16
521	23.7	71.8	16
448	28.9	50.6	13
385	n/a	n/a	0