

time period. The second method, used for Tables 5.30, 5.31, 5.31 is more useful for examining the extremes and standard deviations of fractions which exist for each component, which is the purpose of this section.

5.6 Comparison to Previous Studies at Grand Canyon

WHITEX extinction budgets are similar to the results of at least two previous studies which have reported light extinction budgets for Grand Canyon National Park (Hopi Point) (Malm, et al.⁵ and Malm and Johnson⁷). Scattering by fine ammonium sulfate was found to be the dominant factor in the non-Rayleigh light extinction budget in all three studies even though WHITEX was during the winter, another study was for summertime data, and the third included data for a full two year time period. During WHITEX, the percent of the non-Rayleigh scattering at Hopi Point due to fine sulfates was 68%. Malm et al. found that 47-48% of the scattering during a two week period in August 1984 was due to fine sulfates and Malm and Johnson attributed 63% of the scattering during two years from December 1979 to November 1981 to fine sulfates.

5.7 Summary

The findings of this chapter are summarized below:

- The nephelometer underestimates the actual scattering coefficient by as much as a factor of three when the relative humidity is very high (> 90%). However there is evidence that it does not dry the particles completely.
- TOR light absorbing carbon measurements appear to be slightly too high and TMO concentrations are too low, but the TOR values are closer to what is expected based on the optical measurements.
- The largest fraction of mean non-Rayleigh extinction at Page, Canyonlands, and Hopi Point is scattering by fine sulfates. The two next largest fractions are absorption by light absorbing carbon and scattering by organics, with organics being more important at Page and particle absorption more important at Canyonlands and Hopi Point. (See Figure 5.3.)
- The extinction budgets vary considerably from time period to time period. Scattering by sulfates dominates on high extinction days. (See Figures 5.20, 5.21, and 5.22).
- Extinction budget results for the WHITEX time period are similar to those obtained in previous studies for the same area.

Table 5.30: Statistics for 12-hour, daily, and weekly averaged extinction budgets for Page.

	12-hour				Daily				Weekly			
	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
% scatter by gases	39	17	11	88	39	16	14	81	39	7	31	45
% coarse scatter	3	2	0	12	3	2	0	8	3	1	1	4
% sulfate scattering	21	15	2	75	21	15	2	70	21	5	15	31
% organic scattering	17	8	0	45	17	7	0	33	17	4	11	25
% nitrate scattering	2	2	0	8	2	2	0	6	2	1	1	3
% fine soil scattering	2	1	0	6	2	1	0	4	2	1	1	2
% particle absorption	13	7	0	35	13	7	0	33	13	5	7	21
measured b_{ext} (Km^{-1})	.0292	.0166	.0126	.1000	.0294	.0153	.0129	.0769	.0292	.0064	.0227	.0407
reconstructed b_{ext} (Km^{-1})	.0318	.0164	.0117	.0944	.0318	.0147	.0126	.0749	.0318	.0047	.0271	.0395

Table 5.31: Statistics for 12-hour, daily, and weekly averaged extinction budgets for Canyonlands.

	12-hour				Daily				Weekly			
	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
% scatter by gases	50	17	11	98	50	16	14	97	50	8	40	63
% sulfate scattering	23	14	1	80	23	12	3	65	23	9	14	40
% organic scattering	11	8	0	32	11	7	0	26	11	5	6	17
% nitrate scattering	3	2	0	11	3	2	0	8	3	1	2	4
% fine soil scattering	2	2	0	9	2	2	0	8	2	1	1	4
% particle absorption	11	7	0	28	11	6	0	25	11	4	4	16
measured b_{ext} (Km^{-1})	.0247	.0064	.0134	.0470	.0249	.0068	.0134	.0470	.0247	.0036	.0207	.0299
reconstructed b_{ext} (Km^{-1})	.0219	.0098	.0099	.0871	.0219	.0091	.0101	.0708	.0219	.0039	.0168	.0277

Table 5.32: Statistics for 12-hour, daily, and weekly averaged extinction budgets for Hopi Point.

	12-hour				Daily				Weekly			
	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
% scatter by gases	62	18	12	97	62	17	19	96	62	7	54	71
% coarse scatter	3	2	0	9	3	2	0	9	3	1	1	6
% sulfate scattering	18	17	1	86	18	16	1	70	18	7	6	25
% organic scattering	4	6	0	28	4	4	0	16	4	3	1	8
% nitrate scattering	1	2	0	9	1	2	0	8	1	1	0	3
% fine soil scattering	3	3	0	14	3	2	0	11	3	2	1	7
% particle absorption	9	5	0	26	9	4	0	20	8	1	7	11
measured b_{est} (Km^{-1})	.0161	.0041	.0099	.0270	.0164	.0040	.0113	.0268	.0161	.0024	.0123	.0184
reconstructed b_{est} (Km^{-1})	.0175	.0094	.0098	.0816	.0175	.0083	.0099	.0588	.0175	.0026	.0136	.0203

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