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Ozone absorption coefficients and haze corrections for total ozone measurements with Dobson spectrophotometer*

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ABSTRACT. From laboratory measurements of absorption in an ozone cell with a Dobson spectrophotometer and their comparison with the results of observations made with atmospheric ozone, Dobson has concluded that the absorption coefficients of ozone (from Vigroux' work) for the B and C wave lengths are too high and have to be revised. Observations made at Ahmedabad confirm this. Accepting that the difference of ozone absorption coefficients for A and D is 1·388 and assuming that by using the AD difference method the haze correction is eliminated, we determine the total ozone amount. Combining this with measurements of apparent total ozone with A wave-lengths alone, the haze correction is calculated. With this haze correction and known ozone amount, the absorption coefficients for C and B wave lengths can be calculated. The same absorption coefficients are obtained under varying conditions of haze. They are nearly the same as those obtained by Dobson from his laboratory measurements with an ozone cell.

When the absorption coefficients of ozone as determined by Vigroux are used to calculate the amount of ozone in the atmosphere from measurements with the Dobson spectrophotometer, the ozone values found with the different wave-length pairs A, B, C and D are not identical.

This may be due either to wrong values of the absorption coefficients used or the presence of some other absorbing gas in the atmosphere. In order to test this, Dobson made measurements of ozone absorption in a silica vessel placed immediately above the inlet slit of the standard ozone spectrophotometer, and calculated the relative absorptions of ozone for the different wave-lengths. He also calculated the absorption coefficients for the different wave-length pairs from atmospheric measurements made at Oxford (1957) and at Edmonton (1958) assuming that the difference between the absorption coefficients for A and D wave-lengths was equal to 1.388. The figures in the different rows of Table 1 give respectively the absorption coefficients of A, B, C and D, (1) according to Vigroux as determined from his laboratory measurements, (2) from atmospheric measurements at Oxford (1957) and (3) from atmospheric measurements at Oxford, Edmonton (1958) and Ahmedabad. Dobson suggested that if the absorption coefficients given in row 2 were used to get the ozone values from observations on different wave-lengths, the results would be identical.

It had been noticed in Ahmedabad that the ozone values determined from AD, AC and CD were not identical if Vigroux's values for the absorption coefficients of C were used. An attempt was made to use the new absorption coefficients given in row (2) of Table 1 to calculate the ozone amounts. There was much better agreement.

The difference of absorption coefficients $(\alpha-\alpha')_A - (\alpha-\alpha')_D$ for AD wave-lengths was assumed to be constant at 1·388 and the ozone amount x_{AD} was calculated using the standard difference formula. Assuming

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TABLE 1

Differences of absorption coefficients $(\alpha-\alpha')_\lambda$ of ozone for different wavelength pairs

		A	B	C	D	A—D
From Vigroux' observations		1·762	1·214	0·865	0·374	1·388
As determined from Dobson's laboratory measurements with ozone cell at Oxford assuming Vigroux' value of 1·388 for A—D		1·742	1·142	0·808	0·354	1·388
From atmospheric observations at (assuming A—D=1·388)						
	Oxford	1·741	1·144	0·791	0·353	1·388
	Edmonton	1·743	1·156	0·804	0·355	1·388
	Ahmedabad	1·742	1·143	0·799	0·353	1·388
	Kodaikanal	1·744	—	0·806	0·354	1·388

α and α' refer to the following pairs of wave-lengths used in ozone measurements

	λ	λ′		λ	λ′
A	3055Å	3254Å	C	3114Å	3324Å
B	3088Å	3291Å	D	3176Å	3398Å

$(\alpha-\alpha')_A$ to be 1·742 which is the mean of the values given in lines (2), (3) and (4) of Table 1, the apparent ozone values x_A were also calculated using the formula

$$\mu x_A \; (\alpha-\alpha')_A = \triangle N_A - (\beta-\beta')_A . (p/p_0).m$$

in which the correction due to haze has been neglected. Writing $(x_A - x_{AD})\,(\alpha-\alpha')_A = (\delta-\delta')_A$, $m\;(\delta-\delta')_A$ would represent the haze correction to be applied to $\triangle N_A$. Other evidence had shown that the haze correction was practically independent of wave-length when the wave-length difference did not exceed 200 A. The haze correction thus obtained from x_{AD} and x_A , together with the ozone value x_{AD}, was then used to determine the absorption coefficients of A and D separately. The same method was also used to calculate the absorption coefficients of B and C. Line (5) of Table 1 shows the absorption coefficients of A, B, C and D as determined from the atmospheric measurements at Ahmedabad. The ozone amounts and absorption coefficients on individual days and the corresponding haze corrections are given in Table 2. Table 3 gives the ozone values at Ahmedabad calculated by AD, AC and CD methods, and also the haze corrections to be applied to x_A , x_C and x_D to make them agree with one another and also with x_{AD}, x_{AC} and x_{CD}.

Similar calculations made from observations made at Kodaikanal where the mean atmospheric pressure is 772 mb on A, D and C wave-lengths gave equally good agreement when the differential absorption coefficient for C was taken to be 0·806 and the haze corrections for A, D and C wave-lengths were assumed to be the same.

The good agreement of the calculated values shows that it is possible not only to get consistent values of ozone amounts using observations with different wave-lengths, but also to determine the day-to-day variations of aerosols from Dobson spectrophotometer observations, if we use the new absorption

TABLE 2

Ozone absorption coefficients and haze corrections

Measurements at Ahmedabad (Direct Sun) — A, D and C

Date	μ_{AD}	μ_{C}	x_{AD}	x_{A}	$(\delta-\delta')_{A}$	$(\alpha-\alpha')_{A}$	$(\alpha-\alpha')_{D}$	$(\alpha-\alpha')_{C}$
3-7-63	2·106	2·081	0·260	0·264	+0·007	1·741	0·351	0·809
2-11-63	2·611	2·653	0·237	0·244	0·012	1·740	0·349	0·796
23-1-64	3·173	3·144	0·245	0·248	0·005	1·741	0·351	0·799
29-1-64	1·424	1·416	0·221	0·223	0·003	1·743	0·355	0·799
5-2-64	2·446	2·374	0·254	0·261	0·012	1·743	0·354	0·792
7-3-64	1·925	1·968	0·236	0·240	0·006	1·744	0·353	0·798
9-3-64	1·709	1·736	0·231	0·235	0·007	1·743	0·353	0·800
13-3-64	2·265	2·210	0·223	0·230	0·014	1·742	0·347	0·793
14-3-64	1·929	1·964	0·221	0·225	0·009	1·743	0·351	0·801
16-3-64	2·141	2·190	0·232	0·237	0·009	1·740	0·353	0·796
24-3-64	2·062	2·026	0·236	0·239	0·005	1·741	0·354	0·803
7-4-64	2·051	2·019	0·239	0·241	0·003	1·744	0·356	0·806
8-4-64	1·896	1·871	0 244	0·244	0·000	1·744	0·352	0·800
15-4-64	2·098	2·060	0·254	0·253	—0·002	1·741	0·351	0·794
16-4-64	1·888	1·915	0·257	0·257	0·000	1·739	0·352	0·797
18-4-64	1·621	1·645	0·251	0·253	0·003	1·743	0·351	0·802
20-4-64	1·960	1·995	0·234	0·233	—0·002	1·743	0·356	0·809
21-4-64	2·053	2·012	0·246	0·247	0·002	1·742	0·353	0·803
21-5-64	1·550	1·566	0·259	0·259	0·000	1·744	0·356	0·813
21-5-64	2·067	2·104	0·265	0·263	—0·003	1·742	0·352	0·796
21-5-64	2·786	2·835	0·261	0·261	0·000	1·742	0·352	0·792
25-5-64	1·166	1·172	0·259	0·262	0·005	1·741	0·354	0·801
25-5-64	2·244	2·202	0·269	0·272	0·005	1·743	0·355	0·801
26-5-64	1·279	1·288	0·262	0·264	0·003	1·741	0·352	0·793
26-5-64	2·487	2·537	0·269	0·272	0·006	1·740	0·351	0·790
26-5-64	2·768	2·721	0·266	0·270	0·007	1·743	0·353	0·791
					Mean	1·742	0·353	0·799

(Direct Sun) A, D, B and C

Date	μ_{AD}	μ_{B}	x_{AD}	x_{A}	$(\delta-\delta')_{A}$	$(\alpha-\alpha')_{A}$	$(\alpha-\alpha')_{D}$	$(\alpha-\alpha')_{C}$	$(\alpha-\alpha')_{B}$
3-10-64	2·842	2·766	0·243	0·248	0·009	1·742	0·352	0·810	1·143
4-10-64	2·178	2·163	0·248	0·256	0·013	1·742	0·352	0·793	1·148
6-10-64	2·259	2·333	0·254	0·257	0·005	1·742	0·352	0·798	1·148
7-10-64	2·737	2·842	0·247	0·252	0·009	1·742	0·352	0·799	1·135
12-10-64	2·045	2·167	0·238	0·243	0·009	1·743	0·357	0·805	1·143
					Mean	1·742	0·353	0·801	1·143

TABLE 3

Ahmedabad

Haze correction $(\delta-\delta')_\lambda = (x_\lambda - x_{AD})(\alpha-\alpha')_\lambda$

Date	Ozone amount (in D. U.)				Haze correction			Remarks
	μ_{AD}	x_{AD}	x_{A}	x_{CD}	A	C	D	
3-7-63	2·106	260	260	262	7·0	7·2	6·3	—
2-11-63	2·611	237	238	238	12·2	11·2	10·9	—
23-1-64	3·173	245	246	245	5·2	4·8	4·4	—
29-1-64	1·424	221	222	220	3·5	2·8	3·2	—
5-2-64	2·446	254	256	251	12·2	11·2	12·1	Haze
7-3-64	1·925	236	237	235	7·0	5·6	5·7	Haze
9-3-64	1·709	231	232	231	7·0	7·2	6·7	Haze
13-3-64	2·265	223	224	221	12·2	11·6	12·2	Haze
14-3-64	1·929	221	220	221	7·0	8·4	8·1	Haze
16-3-64	2·141	232	233	230	8·7	8·0	8·7	Haze
24-3-64	2·062	236	235	237	5·2	5·6	5·0	Haze
7-4-64	2·051	239	239	240	3·5	4·4	3·5	Thin *Ci*
8-4-64	1·896	244	244	243	0·0	0·8	1·2	Thin *Ci*
15-4-64	2·098	254	256	252	1·7	—3·6	—2·8	Low haze
16-4-64	1·888	257	257	256	0·0	—0·8	—0·5	Low haze
18-4-64	1·621	251	251	253	3·5	3·6	2·1	Haze
20-4-64	1·960	234	233	237	—1·7	0·0	—1·6	Low level haze
21-4-64	2·053	246	246	248	1·7	2·8	1·8	Slight haze
21-5-64	1·550	259	257	265	0·0	3·2	0·4	Low level haze
	2·067	265	266	263	—3·5	—4·0	—3·4	
	2·786	261	263	257	0·0	—2·4	—0·7	
25-5-64	1·166	259	259	259	5·2	5·2	5·1	Dust haze
	2·244	269	269	269	5·2	5·6	5·3	
26-5-64	1·279	262	264	258	3·5	1·2	2·5	Dust haze
	2·487	269	272	264	5·2	3·2	5·0	
	2·768	266	269	261	7·0	4·8	6·7	

coefficients of ozone. It is interesting to note that low level haze (such as occurred on 15-4-64, 20-4-64 and 21-5-64) tends to reduce the haze correction and even to make it negative.

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