Reply

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Dr. G. Shah has made a number of assumptions and has drawn some conclusions which are in no way implied in our article. Turbidity values listed in our Table 1 were not interchanged. First he comments on his inability to find $B_{380}<B_{500}$ during the time period from 1973–74. He failed to look at the 1972 data base, one of the years we referenced. Included here is Table 1, giving the observations of $B_{380}<B_{500}$ for 1972–75, despite the fact we did not include 1974–75 in our original analysis.

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TABLE 1. Occurrences of $B_{380} < B_{500}$ around the world.

	1972[a]	1973[b]	1974[c]	1975[d]
Number of stations listed	77	67	75	87
Number of stations reporting both B_{380} and B_{500}	50	53	53	58
Number of stations with at least one monthly mean $B_{380} < B_{500}$	4	0	9	5
Identity of these stations:	Adrigole, Ire. Alamosa, CO Bishop, CA Pago Pago, American Samoa	— — — — —	Adrigole, Ire. Bouerchalke, U.K. Marion Island, S. Africa Mount Hopkins, AZ Miami, FL Blue Hill, MA Elkins, WV Howard AFB, Canal Zone Aspendale, Australia	Mount Hopkins, AZ Blue Hill, MA Howard, AFB, Canal Zone Raleigh, NC Aspendale, Australia
Number of stations with at least 1 day $B_{380}<B_{500}$	26	28	35	27
Number of stations with at least 1 day $B_{380}<B_{500}$ in				
1 month	13	6	12	0
2 months	3	8	8	3
3 months	2	6	1	1
4 months	2	2	5	0
5 months	2	2	3	0
6 months	0	3	1	0
7 months	0	0	1	1
8 months	1	0	1	0
9 months	1	0	1	0
10 months	0	0	0	0
11 months	0	1	0	0
12 months	0	0	2	0

[a] Environmental Data Service, 1974.
[b] Environmental Data Service, 1975.
[c] Environmental Data Service, 1976.
[d] Environmental Data Service, 1977.

Rechecking the published turbidity data for the world (Environmental Data Service, 1974, 1975, 1976, 1977), we find it surprising that Shah found no cases of $B_{380}<B_{500}$ during 1973 and 1974. During 1974, nine stations reported at least one monthly mean $B_{380}<B_{500}$ and 35 stations reported at least 1 day with $B_{380}<B_{500}$. Note that our paper did not cover 1974 as we indicated by the references. During 1973, which we did cover, no stations reported monthly mean $B_{380}<B_{500}$, but 28 stations reported at least 1 day with $B_{380}<B_{500}$. During 1972, which we also covered, four stations reported at least one monthly mean $B_{380}<B_{500}$ and 26 stations reported at least 1 day with $B_{380}<B_{500}$. During 1975, which we did not cover, five stations reported at least one monthly mean $B_{380}<B_{500}$ and 27 stations reported at least 1 day with $B_{380}<B_{500}$. Therefore, our mention of eight stations reporting $B_{380}<B_{500}$ was erroneous, but the important argument still stands; the condition of monthly $B_{380}<B_{500}$ is not common, but also not unique to our station. Bishop and Alamosa, CA, are among the stations reporting this condition. Any interested reader can get the exact dates of all occurrences from the references.

Second, Shah refers to "observations" that yield $\beta>2$, where β is one of the adjustable parameters in the Junge power law. As indicated in our March 1977 paper, our measurements made at ground level, 150 m and 4000 m yielded values for β that fell between 1.24 and 2.1 with an average of 1.87, the higher values of β corresponding to larger aerosol number concentrations. He then goes on to rederive, from (1), a well known expression for the scattering coefficient in terms of the efficiency factor Q and the size parameter X. If the integration limits are taken from $X=0$ to $X=\infty$ the ratio of B_{500}/B_{380} is equal to $(0.5/0.38)^{(2-\beta)}$. This expression is true if 1) $\beta>2$ (the integrals do not converge for $\beta<2$) and, 2) the integration limits are from $X=0$ to $X=\infty$.

To evaluate (1) with $\beta<2$ we chose an upper integration limit that coincided with observed average particle size cutoffs. Under these conditions detailed calculations show that $B_{500}/B_{380} \approx 1$ for $\beta < 2$ and $B_{500}/B_{380} < 1$ for $\beta > 2$. Shah's simplified calculation also shows $B_{500}/B_{380} < 1$ for $\beta > 2$. He failed to recognize the significance of these calculations. Measurements show that within the mixing layer the aerosol size distribution follows the Junge power law with $\beta \approx 1.8$. This implies that aerosols within the mixing layer tend to add equal amounts of turbidity at 500 and 380 nm. Our 1974 data shows just this effect. As the turbidity of the atmosphere changed, B_{380} and B_{500} were shifted by approximately equal amounts. However, due to the increased magnitude of β at high aerosol concentrations within the mixing layer, the summer months show B_{500} increasing more than B_{380}. Consequently, if an aerosol size distribution is to be responsible for the anomaly, it must occur at someplace other than in the mixing layer and it probably does not follow the Junge power law.

As shown in our March 1977 paper, an almost monodisperse aerosol concentration located somewhere above the mixing layer could be partially responsible for the observed anomaly of $B_{500}/B_{380} > 1$. Comment 6 of Shah's letter once again reflects his misunderstanding of our calculations. He refers to our 25 April 1975 aerosol size distribution measurement as having a geometric mean of 1.59 and 3.35. First, this measurement was not made in the stratosphere, but rather at ground level and is consequently not representative of stratospheric aerosol as he suggests. Second, the point of the cumulative frequency plot was to show that the size distribution is not log-normal. However, the cumulative frequency plot did show that sections of the size distribution were log-normal with geometric standard deviations of 1.50 and 3.35. He goes on to state that geometric standard deviations > 1.5 give $B_{500}/B_{380} < 1$. All standard deviations varying from 1 to 2.5 can yield $B_{500}/B_{380} < 1$. The parameter which determines if B_{500}/B_{380} is less than or is greater than 1 is the geometric mean radius while the geometric standard deviation merely determines the degree to which B_{500}/B_{380} exceeds 1. His conclusion that stratospheric aerosol could not account for $B_{500}/B_{380} > 1$ assumed 1) we measured stratospheric aerosol size distribution with $\sigma_g = 1.59$ and 3.35 and 2) that $\sigma > 1.5$ yields $B_{500}/B_{380} < 1$. We *did not* measure stratospheric aerosol size distributions and $\beta > 1.5$ does not imply that $B_{500}/B_{380} < 1$.

The purpose of our paper was to investigate *possible* reasons for $B_{500}/B_{380} > 1$. We do appreciate his comments with respect to NO_2. It may be an additional factor in our observed ratios of $B_{500}/B_{380} > 1$.

REFERENCES

Environmental Data Service, NOAA, 1974: Atmospheric Turbidity and Precipitation Chemistry Data for the World 1972. National Climatic Center, 255 pp.

——, 1975: Atmospheric Turbidity and Precipitation Chemistry Data for the World 1973. National Climatic Center, 259 pp.

——, 1976: Atmospheric Turbidity and Precipitation Chemistry Data for the World 1974. National Climatic Center, 304 pp.

——, 1977: Global Monitoring of the Environment for Selected Atmospheric Constituents 1975. National Climatic Center, 378 pp.