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Lidar Ratio Climatology for Dust, as Computed from AERONET Retrievals

G.L. Schuster (1), M. Vaughan (1), D. MacDonnell (1), W. Su (1), D. Winker (1), C. Trepte (1), O. Dubovik (2), and T. Lapyonok (2)

(1) NASA Langley Research Center, Mail Stop 420, Hampton, Virginia, 23681, USA (gregory.l.schuster@nasa.gov), (2) Laboratoire d'Optique Atmospherique, Universite de Lille 1, CNRS, Villeneuve d'Ascq, France

Recent Raman lidar measurements by Tesche et al. (2009) and Wandinger et al. (2010) indicate lidar ratios of about 55 sr in Morocco and Cape Verde, which is significantly higher than the value of 40 sr assumed for the CALIPSO aerosol optical depth retrievals. Hence, we investigated the dust lidar ratio by analyzing the aerosol climatology at AERONET sites in the dust belt. In order to limit our analysis to "pure" dust retrievals, we restricted the data to depolarizations of 0.2 or greater and fine volume fractions of 0.05 or less, and thereby focused on 1714 retrievals at 22 AERONET sites in non-Sahel regions of north Africa, Sahel Africa, the Middle East, and India. The AERONET climatology indicates that the real refractive index increases from n=1.49 for 229 retrievals in non-Sahel Africa to n=1.53 for 929 retrievals in the Sahel, and that the largest refractive indices occur in the Middle East and Kanpur, India (n=1.57 for 489 and 67 retrievals, respectively). Dry dust mixtures with refractive indices that are less than $\sim$1.5 require high fractions of illite (which has a refractive index of 1.41), since the other common minerals in dust - calcite, quartz, gypsum, montmorillonite, kaolinite, and hematite - all have refractive indices greater than 1.49. Hence, the AERONET refractive indices are consistent with Chester et al. (1972), who measured the relative fraction of illite during a research voyage near the west African coast; they found that illite decreases from a maximum mass fraction of $\sim$0.53 at 15-20 degrees North to a minimum of $\sim$0.09 at 0-5 degrees North. These illite fractions correspond to a refractive index change from 1.48 to 1.54 as the source aerosol region changed from the Sahara to the Sahel (if the average refractive index of the other minerals in the mixture is assumed to be 1.55).

We then used the AERONET refractive indices with the AERONET size distributions, "percent spheres", and forward optics code for spheres and spheroids to compute the lidar ratio of retrievals at AERONET sites located in the dust belt. The highest lidar ratios of our analysis occur in the non-Sahel regions of northern Africa, where the median lidar ratio is 55.4 sr for 229 retrievals. Lidar ratios are somewhat lower in the African Sahel (49.7 sr for 929 retrievals), the Middle East (42.6 sr for 489 retrievals), and Kanpur, India (43.8 sr for 67 retrievals). We attribute this regional variability in the lidar ratio to the regional variability in the real refractive index, as these two parameters are highly anti-correlated (R ranges from -0.51 to -0.85 for the various regions). Thus, the AERONET climatology indicates that although a lidar ratio of 55 sr is appropriate for Saharan dust, much lower values are required for dust from the Sahel or Middle East.

References

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