論文の内容の要旨

論文題目　Dust optical properties over the Sahara and Asia inferred from Moderate Resolution Imaging Spectroradiometer (Moderate Resolution Imaging Spectroradiometer により推定されたサハラとアジアにおけるダストの光学的特性)

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There is a great deal of uncertainty surrounding the role of mineral dust aerosols in the earth's climate system. One reason for this uncertainty is that the optical properties of mineral dust, such as its single scattering albedo (the ratio of scattering to total extinction), are poorly understood because ground observations are limited to several locations and the satellite standard products are not available due to the excessively bright surface of the desert in the visible wavelength. In this study, we develop a method of estimating dust absorption averaged over large area, and a method of estimating the optical properties with daily 1 degree x 1 degree resolution. These approach are based on the theory that the critical surface reflectance, the observed radiance of which is uninfluenced by the variability in dust's optical depth, depends on the single scattering albedo (Kaufman et al., 1987, Kaufman et al., 2001).

First, we estimate average dust single scattering albedo (ω_0) over the Sahara using four years of Moderate Resolution Imaging Spectroradiometer (MODIS) data. Our method can estimate ω_0 from the data with various aerosol optical thicknesses using samples in the vicinity of critical TOA reflectance. The estimated ω_0 is approximately 0.976 and 0.912 at 0.555 μm and 0.412 μm, respectively. The estimated uncertainties are less than 0.022 at wavelengths shorter than 0.858 μm, and 0.05 at 1.24 μm. The results suggest that the average dust absorption over the Sahara is smaller than that previously reported in the literature, and possibly indicates cooling of the regional climate system.

Next, we estimate the spatial distributions of ω_0 and aerosol optical depth (τ_a) over the Sahara and Asia using nine years of MODIS satellite data. By estimating τ_a simultaneously, we can estimate the spatial distributions of ω_0 at inland desert areas for which limited observations are available. We calculate the uncertainties in ω_0 over the Sahara (Asia) to be approximately 0.018 and 0.009 (0.021 and 0.015) for bands 9 and 1, respectively, while the uncertainty in τ_a is approximately 0.226 and 0.221 (0.370 and 0.339) for bands 9 and 1, respectively. To validate our results, we compare our estimations of ω_0 and τ_a with ground observations and find that ω_0 is consistent with the observations, while τ_a is overestimated. However, we confirm that the overestimation of τ_a does not affect the results for ω_0.

We find significant spatial distributions of ω_0 and τ_a over the Sahara and Asia. The results for the Sahara indicate good correlation between ω_0 and the surface reflectance and between ω_0 and τ_a. Therefore, ω_0 is determined mainly by the mineral composition of surface dust and/or the optical depth of airborne dust in the Sahara. On the other hand, the relationships between ω_0, τ_a, and the surface reflectance are less clear in Asia than in the Sahara, and the values of ω_0 are smaller than those in the Sahara. The regions with small ω_0 values are consistent with the regions where coal-burning smoke and carbonaceous aerosols are thought to be transported, as reported in previous

studies. Because the coal-burning and carbonaceous aerosols are known to be more absorptive and have smaller ω_0 values than dust aerosols, our results indicate that the dust aerosols in Asia are contaminated by these anthropogenic aerosols.

The dust optical properties obtained in our work could be useful in understanding the roles of dust aerosols in the earth's climate system, most likely through future collaboration with regional and global modelling studies.