Multi-angler polarized remote sensing of non-spherical aerosol particle

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Abstract:

Aerosol particles in the atmosphere are known to play an important role in the climate system by altering the earth's energy budget through the scattering and absorption of radiation [1, 2]. Aerosol has been known to be a source of significant uncertainties in studies of earth's climate, which is explained by difficulties in monitoring spatially- and temporally-variable aerosol properties [3]. The only way to obtain the aerosol particles properties on a global scale is by means of satellite remote sensing. Several approaches to the satellite remote sensing of aerosol particles optical and microphysical properties using measurements of solar reflectance have been developed [4-6]. Despite this multitude of approaches, the AOD retrieval from satellite data is still not satisfactory [7]. The accuracy of remote sensing aerosol characterization is limited by the difficulty to model the optical properties of non-spherical aerosol particles [8, 9]. Earlier on, and in some applications even today, aerosol particles have been assumed to be isotropic, homogeneous, and spherical. With these assumptions one can apply the Mie theory and compute the exact single-scattering properties of aerosol particles. There is sufficient experimental evidence that the non-spherical of aerosol particles can cause scattering properties significantly different from those predicted by the Mie theory. Many research efforts have focused on the improving the accuracy of aerosol retrievals in the presence of non-spherical particles. However, dealing with non-sphericity is not a completely resolved issue.

It is a challenge to develop the retrieval algorithm to obtain the microphysical and optical properties of non-spherical aerosol particles using remote sensing data.

Multi-angle and multi-channel measurements of linear polarization make it possible that both aerosol optical depth and the aerosol shape are retrieved simultaneously. Indeed the polarized surface contribution is smaller than, or equal to, that the atmosphere. Moreover it shows little spectral dependence and generally weak spatial contrast [10,11].

In this paper, the microphysical and optical properties of non-spherical aerosol particles are studied, and the TOA reflectance and polarized reflectance are studied with the vector radiative transfer model. The sensitivity of reflectance and polarized reflectance to non-spherical aerosol particles microphysical optical parameters and surface albedo are evaluated. Based on the studies of the sensitivity, the basic theory of using the remote sensing data of multi-angular polarized to retrieve the properties of non-spherical aerosol particles is proposed. The conceptual aerosol retrieval was evaluated using the multi-angle polarized remote sensing data: POLDER/PARASOL, GLORY.

Main works are summarized as follows:

1）The T-matrix [12] method is used to compute the single-scattering properties of non-spherical aerosol particles; the phase functions of different aerosol shape are compared.

2）The vector equation of radiative transfer was solved by using the successive order of scattering approach which includes the BRDF model and BPDF model of surface reflectance.

3）The multi-angular polarized characteristics in non-spherical atmospheric particles conditions are simulated. The sensitivity of top of atmosphere (TOA) total and polarized reflectance to non-spherical atmospheric particle and surface parameters are studied. Finally, based on the sensitivity study, a conceptual approach is presented to simultaneously retrieve both optical thickness and aerosol shape using the TOA total and polarized reflectance at multiple viewing angles.

4）The algorithms for the simultaneous retrieval of aerosol shape and aerosol optical depth are applied using POLDER/PARASOL, or GLORY data. The retrieved optical depth is compared with those derived from the AERONET products.

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