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Interactive Comment

Interactive comment on "On retrieving refractive index of dust-like particles using shape distributions of ellipsoids" *by* O. Kemppinen et al.

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Accurate determination of the refractive indices of irregular dust particles by comparing laboratory measurements of the optical properties (e.g., the phase matrix) and model-simulated results is an important research subject in atmospheric radiation and remote sensing. In this manuscript, the authors investigated this problem by comparing the ellipsoid-model simulated results with theoretical data from the stereogrammetry dust model. Hereafter, this approach is referred to as the model-to-model comparison concept/approach. This novel concept can be employed to study the performance of the retrieval mechanism itself more easily than comparing laboratory measurements and model-simulated results. The manuscript used this novel concept along with detailed modeling analysis and the results will likely be valuable to the community as a reference for dust-optics modeling.

My comments on improving the manuscript are as follows:

(1) It might be better to state in the Introduction the necessity of detailed modeling analysis due to a lack of a rigorous mathematical formulation of the retrieval approach.

(2) It might be better to summarize the virtues of the model-to-model comparison method in the Introduction or the Summary. For example, (a) it is more convenient than laboratory measurements to obtain the reference data; (b) the reference data from simulations does not suffer uncertainties (the results can be sufficiently accurate by increasing relevant computational parameters); (c) the measurement data normally has a limited range of scattering angles; (d) the measurement data cannot provide the extinction/absorption coefficients and the phase matrix simultaneously; and (e) as already mentioned in the manuscript, the refractive index would be uncertain if the measured scattering matrices are used as the reference.

To summarize, the model-to-model comparison approach could be useful in finding an optimal retrieval approach, which can be finally used in comparing measurements with model simulations to retrieve the refractive indices of dust particles.

(3) The approach to retrieving the refractive index is entirely based on an assumed "optical equivalence" concept. Two different ensembles of particles may yield a complete set of similar or identical optical properties. Mathematically, this "optical equivalence" is not justified, which explains the findings reported in the manuscript.

However, it is possible to explore the use of a "weak optical equivalence" principle, i.e., two different ensembles of particles may yield some similar or identical optical properties (extinction, absorption, phase matrix elements or phase matrix elements over a particular range of scattering angles rather than a complete set of optical properties). Therefore, it is practical to find an optimal approach to retrieve the refractive index using those optical properties that are more sensitive to the refractive index than the particle shapes. This approach is similar to using the forward diffraction rather the phase matrix to retrieve the particle size information.

For example, a method to retrieve the refractive index is to compare the measured spectral absorption efficiency with the model simulations to obtain the imaginary part of the refractive index and then use the Kramers-Kronig relationship to obtain the real part of the refractive index. According to the model-model-comparison concept, it is possible to examine the aforementioned possibility and the resulting accuracies. Of course, this can be an independent research topic.

(4) It would be more suitable to separate the role of model particles in the forward modeling and the inverse retrieval as two independent problems. (a) Based on the comparison of the ellipsoidal-model simulated results and the target-model simulated results with the same refractive index, the ellipsoid is a good model candidate for the forward modeling simulations. (b) From this manuscript, the use of the phase-matrix comparison approach based on an ellipsoidal model may not a good approach to dealing with the inverse problem.

The use of "weak optical equivalence" in the retrieval method may be inappropriate in the forward modeling, which normally requires stronger optical equivalence.

(5) Lastly, in addition to the shape-matrix method, a recent development of invariant imbedding T-matrix method (II-TM) in computing the optical properties of randomly oriented ice crystals (Bi, L., and P. Yang, "Accurate simulation of the optical properties of atmospheric ice crystals with invariant imbedding T-matrix method," J. Quant. Spectrosc. Radiat. Transfer, 138, 17-35 (2014)) is also suitable for efficient modeling of dust optics.

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