Radiative transfer in a medium with oriented particles

Ping Yang[a,b,c,*], Jiachen Ding[a], Kerry Meyer[d], Kirk Knobelspiesse[d], Santiago Gassó[e]

[a]*Department of Atmospheric Sciences, Texas A&M University, College Station, TX, USA*
[b]*Department of Oceanography, Texas A&M University, College Station, TX, USA*
[c]*Department of Physics & Astronomy, Texas A&M University, College Station, TX, USA*
[d]*NASA Goddard Space Flight Center, Greenbelt, MD, USA*
[e]University of Maryland, College Park, MD, USA

[*]*Presenting author (pyang@tamu.edu)*

Radiative transfer computations involving atmospheric and oceanic particles typically assume that scattering particles are randomly oriented and have equal numbers of mirror-symmetric counterparts. Some natural particles may have preferred orientations or be specifically oriented, such as dust aerosols forced by electric field [1], and oriented ice crystals, which can result in fascinating optical phenomena such as sundogs [2]. With oriented particles in radiative transfer computation, the extinction must be expressed as a 4-by-4 matrix. This implies that the direct transmitted light would be polarized. Furthermore, the scattering phase matrix depends on four angles, namely, incident zenith angle, scattering zenith angle, incident azimuth angle, and scattering azimuth angle.

We developed a radiative transfer model to account for multiple scattering by oriented particles, which outputs Stokes vectors at the top and bottom of scattering layers. The computational result shows that the intensity and polarization from a medium with oriented particles are distinctively different from the result with randomly oriented particles. In particular, the scattering medium with oriented particles can have strong circular polarization. This presentation will introduce the theory and techniques in radiative transfer computations involving oriented particles. We will also illustrate the difference between the media with randomly and specifically oriented particles in terms of reflected and transmitted Stokes vectors.

References

[1] Gassó, S., and K. D. Knobelspiesse, 2022: Circular polarization in atmospheric aerosols. *Atmos. Chem. Phys.,* **22**, 13581–13605.

[2] Saito, M., and P. Yang, 2019: Oriented ice crystals: A single-scattering property database for applications to lidar and optical phenomenon simulations. *J. Atmos. Sci.*, **76**, 2635–2652.

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