

A Novel Passive and Active Sensor-Based Remote Sensing Consistent Ice Cloud Optical Property Model

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Ice clouds play a significant role in Earth's radiation budget and climate as they can occur globally with up to 40% coverage in tropical areas alone [1]. Obtaining a fundamental understanding of the optical, microphysical, and radiative properties of ice clouds is critical to accurately analyzing Earth's radiation budget and climate. Various ice cloud optical property models have been developed to represent the microphysical and optical properties of ice clouds in radiative transfer and global climate models. A primary issue with current broad-spectrum ice cloud optical property models such as the Moderate Resolution Imaging Spectroradiometer (MODIS) Collection 6 (MC6) [2] are their failure to provide accurate active sensor-based (e.g., lidar) retrievals of ice cloud radiative properties. This is due to inaccurate visible to near-infrared phase matrix backscattering calculations which significantly affect the retrievals of lidar ratio (S), linear depolarization ratio (δ), and integrated attenuated backscatter (IAB) which are influenced by ice cloud optical thickness (ICOT) as well as ice particle size and shape. These ice cloud models were partly developed using the Improved Geometric Optics Method (IGOM) where phase matrix backscattering is insensitive to wavelength as well as particle size and shape which results in inaccurate lidar-based retrievals of ice cloud properties.

For this study, we develop a broad-spectrum ice cloud optical property model, namely the Passive-Active Remote Sensing Consistent (PARSC) model, that achieves consistency between passive and active sensor-based ice cloud property retrievals. This is primarily due through the use of the Physical Geometric Optics Method (PGOM) [3] for phase matrix backscattering calculations of moderate to large size parameters. The PARSC model is a direct improvement of the MC6 model by being optically consistent, maintaining passive sensor-based ice cloud radiative property retrieval accuracy, and maintaining polarimetric accuracy. The PARSC model is comprised of a mixture of a 20-particle ensemble of randomly distorted 8-column aggregates, a regular 8-column aggregate, and a slightly distorted hexagonal column. Analysis of 532nm S , δ , and IAB retrieval consistency are conducted using Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument. The ensemble of randomly distorted 8-column aggregates of PARSC emulates particle surface roughness which is considered for MC6. A comparison of satellite observations such as from 3MI and radiative transfer simulations for the polarimetric properties of ice cloud are conducted to ensure PARSC is as accurate or is even improved over MC6.

References

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