

Cloud Glories as a New Window into Cloud-Top Droplet Size Distributions

Ilan Koren^{a,*}, Alex Kostinski^b and Uri Wollner^a

^a Weizmann Institute of Science, Rehovot, Israel

^b Michigan Technological University, Houghton, MI, USA

*Presenting author (ilan.koren@weizmann.ac.il)

Colorful glories, concentric rings around the antisolar point, are faint but information-rich single-scattering optical features found in satellite images of marine stratocumulus. Beyond their visual appeal, glories contain a distinct single-scattering signal from cloud droplets and can therefore provide a passive remote-sensing constraint on cloud-top microphysics, complementary to classical Nakajima–King retrievals [1].

Here, we show how the angular and spectral structure of glories can be used to retrieve key moments of the cloud droplet size distribution. Using diffraction-like scaling and Mie calculations, the glory ring spacing, width, and amplitude modulation are linked to the mean droplet radius and the width of the droplet size distribution [2]. We further extend this approach by introducing a Differential Glory Signal (DGS), obtained from differences between nearby spectral channels, such as red–near-infrared or red–green reflectance [3]. This spectral differencing suppresses the broad multiple-scattering background while preserving the spectrally structured single-scattering glory signal.

The method enables robust mapping of cloud-top droplet size distribution moments from existing unpolarized satellite sensors, including MODIS and VIIRS. Because glories sample the upper optical depths of clouds, the retrieved information is especially relevant to the cloud-top region, where entrainment and mixing with overlying environmental air can modify droplet number, size, and spectral width [4,5]. This opens a new path toward long-term, global observations of cloud-top droplet distribution moments, providing an independent constraint for studies of marine boundary-layer cloud microphysics, aerosol–cloud interactions, drizzle susceptibility, and the evaluation of LES and climate-model cloud schemes.

References

- [1] Nakajima, T. and King, M.D., 1990: Determination of the optical thickness and effective particle radius of clouds from reflected solar radiation measurements. Part I: Theory. *Journal of Atmospheric Sciences*, 47(15), pp.1878–1893.
- [2] Koren, I., Kostinski, A., Wollner, U. and Dubrovin, D., 2022: Faint yet widespread glories reflect microphysics of marine clouds. *npj Climate and Atmospheric Science*, 5, 87.
- [3] Koren, I., Kostinski, A. and Wollner, U., 2024: Spectral differencing of glories reflects cloud droplet size distribution. *Geophysical Research Letters*, 51(24), e2024GL110631.
- [4] Baker, M.B., Corbin, R.G. and Latham, J., 1980: The influence of entrainment on the evolution of cloud droplet spectra: I. A model of inhomogeneous mixing. *Quarterly Journal of the Royal Meteorological Society*, 106(449), pp.581–598.
- [5] Warner, J., 1973: The microstructure of cumulus cloud: Part IV. The effect on the droplet spectrum of mixing between cloud and environment. *Journal of Atmospheric Sciences*, 30(2), pp.256–261.

Preferred mode of presentation: Oral