ABSTRACT

A general setting for halo theory

Walter Tape and Günther P. Können

We describe a general framework for systematically treating halos due to refraction in preferentially oriented ice wedges, and we construct an atlas of such halos. Initially we are constrained neither by the interfacial angles nor the orientations of real ice crystals. Instead we consider "all possible" refraction halos. We therefore make no assumption regarding the wedge angle and only a weak assumption regarding the allowable wedge orientations. The atlas is thus a general collection of refraction halos, which includes known halos as a small subset. Each halo in the atlas is characterized by four parameters: the wedge angle, the sun elevation, the zenith angle of the spin vector, and the spin vector expressed in the wedge frame. Not only do the parameter values for a halo permit calculation of the halo shape, they also give much information about the halo without extensive calculation, so that often a crude estimate of the halo's appearance is possible merely from inspection of its parameters. As a result the theory reveals order in what seems initially to be a staggering variety of halo shapes, and, in particular, it explains why halos look the way they do. Having constructed and studied the atlas, we then see where real or conceivable refraction halos, arising in specific crystal shapes and crystal orientations, fit into the atlas. Although our main goal is to understand halos arising in pyramidal crystals, the results also clarify and unify the classical halos arising in hexagonal prismatic crystals.

W. Tape is with the Department of Mathematical Sciences, University of Alaska Fairbanks, Fairbanks, Alaska 99775-6660. G. P. Können is with the Royal Netherlands Meteorological Institute, P.O. Box 201, 3730 AE De Bilt, The Netherlands.

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