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On the relationship of polar mesospheric cloud ice water content, particle radius and mesospheric temperature and its use in multi-dimensional models

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Abstract. The distribution of ice layers in the polar summer mesosphere (called polar mesospheric clouds or PMCs) is sensitive to background atmospheric conditions and therefore affected by global-scale dynamics. To investigate this coupling it is necessary to simulate the global distribution of PMCs within a 3-dimensional (3-D) model that couples large-scale dynamics with cloud microphysics. However, modeling PMC microphysics within 3-D global chemistry climate models (GCCM) is a challenge due to the high computational cost associated with particle following (Lagrangian) or sectional microphysical calculations. By characterizing the relationship between the PMC effective radius, ice water content (*iwc*), and local temperature (*T*) from an ensemble of simulations from the sectional microphysical model, the Community Aerosol and Radiation Model for Atmospheres (CARMA), we determined that these variables can be described by a robust empirical formula. The characterized relationship allows an estimate of an altitude distribution of PMC effective radius in terms of local temperature and *iwc*. For our purposes we use this formula to predict an effective radius as part of a bulk parameterization of PMC microphysics in a 3-D GCCM to simulate growth, sublimation and sedimentation of ice particles without keeping track of the time history of each ice particle size or particle size bin. This allows cost effective decadal scale PMC simulations in a 3-D GCCM to be performed. This approach produces realistic PMC simulations including estimates of the optical properties of PMCs. We validate the relationship with PMC data from the Solar Occultation for Ice Experiment (SOFIE).

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