

Interactive comment on “Understanding effective diameter and its application to terrestrial radiation in ice clouds” by D. L. Mitchell et al.

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1) Thank you for pointing this out; we will address this in the revision.

2) The only reason photon tunneling is mentioned in this paper is because it was felt that a scientific paper should not only identify a problem, it should also provide an explanation for why the problem is occurring. This physical insight may empower future investigators addressing the problem. Figure 18 shows the percent error in Qabs due to “transition absorption” as a function of ice penetration depth, where error relates to the De-IWC assumption. It would not be possible to produce this figure and demonstrate the break-down of the De-IWC assumption resulting from transition ab-

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sorption without removing the tunneling contributions from Qabs. If tunneling contributions were not removed, the curves in Fig. 18 would not asymptote to zero for area- and mass-dependent absorption, nor would a coherent relationship be evident. By removing tunneling contributions, MADA behaves essentially like ADA (simple form of the anomalous diffraction approximation), since internal reflection/refraction contributes little to Qabs at terrestrial wavelengths. That means only radiation incident on the particle cross-section can be absorbed, and this condition makes it possible for the relationship in Fig. 18 to be revealed. MADA’s ability to approximately remove tunneling also shows that tunneling itself is partly responsible for the error in the De-IWC assumption. The ability of MADA to address optical processes is exploited here to understand the reasons for error in the De-IWC assumption. Section 3, titled “Physical processes limiting the usefulness of De”, is the “understanding” component of the paper. If readers do not care about the “why” aspect, they can easily skip this section. Alternatively, this could be placed in an appendix. Another reason MADA was used is that the Yang ice optics database does not address solar wavelengths in the near IR, and Qabs here can be substantial for broad PSD. Thus it is not clear whether significant errors may occur when using the De-IWC assumption with near-IR absorption bands. This question needed to be addressed, and MADA could address it.

3) The overstated sentence will be modified to address the reviewer’s concern. It is true that the parameters in the parametric photon tunneling terms in the MADA are determined from fitting the MADA results to Mie theory calculations, and the tunneling efficiency terms for various ice crystals are estimated by fitting MADA results to FDTD calculations. Prior to this fitting, internal reflection and refraction contributions (which are quite minor at thermal wavelengths) were already parameterized, leaving external reflection as the main process unaccounted for. Thus, the MADA tunneling parameterization absorbs some of the error in external reflection when fitting MADA results to Mie theory. Thus the MADA tunneling contribution is not the “pure” tunneling contribution that electrodynamic theory would predict (if it were possible to isolate, which currently is not possible). However, the MADA tunneling contribution should be a reasonable

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estimate since external reflection errors are generally less than 10% of Q_{abs} and less than 5% of Q_{ext} . This is why MADA calculations of Q_{abs} and Q_{ext} were within 10% of Mie theory calculations for terrestrial radiation (Mitchell 2000, JAS). An exact treatment of photon tunneling or resonance effects is not needed for the purposes of this paper. However, the parameterized treatment of tunneling used here captures the behavior of tunneling and is sufficient to identify tunneling as one reason why ice optical properties are not always well predicted by De and IWC.

4) Reference will be included.

5) Reference will be included.

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