

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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The referee is correct in that many scientists have been uncomfortable with the use of only De and IWC to characterize ice cloud optical properties. However, to our best understanding, only Mitchell (2002, JAS) has demonstrated errors in ice optical properties resulting from this assumption. If other studies exist that also demonstrate this, we will gladly reference such studies. The Sun et al. paper as it relates to this topic will certainly be cited.

The referee points out that in spite of a great deal of effort and progress in representing ice cloud optical properties in climate models, the uncertainty in ice cloud PSD shape

C12913

remains a major obstacle limiting the accuracy of predicted optical properties. In this regard it will be mentioned that the MADA ice optics scheme is explicitly formulated in terms of the PSD parameters (assuming a gamma distribution) and ice particle shape parameters (projected area- and mass-dimension relationships) and thus does not depend on De. While MADA has its own uncertainties, these appear to be much less than those associated with the De-IWC assumption (Mitchell et al. 2006, JAS). This is one way to avoid the PSD uncertainty conundrum. Anthony Baran at the U.K. Met. Office is also working on this problem (improving accuracy in ice optics by avoiding the use of De), and his work will also be cited.

The following are our responses to specific (numbered) requests from the referee:

1) As indicated in our responses to the other referees, we will streamline and shorten the text. However, as stated in our reply to referee #1, Section 3, which provides physical reasons for why the De-IWC assumption is not always valid and under what conditions it breaks down, will remain in the paper. This is important since understanding why this approach does not work will empower future investigators to develop creative solutions and more accurate formulations of ice optical properties. As explained in our reply to referee #1, it is not possible to account for the errors in the De-IWC assumption without addressing wave resonance or tunneling effects, as this is one of the reasons for the errors. To really understand this requires some deep thinking; hence some length of text is unavoidable. It is our view that scientific papers should strive to not only identify problems but also to understand the problem, which is essential for future progress. Furthermore, it would not be possible to clearly demonstrate that the optical property errors result from “transition absorption” without first removing tunneling effects (see our reply to referee #1). This is another reason tunneling needs to be mentioned.

2) We acknowledge in Section 3.4 that more research is needed regarding the De-LWC assumption used to represent the optical properties of liquid water clouds. This issue may be worthy of a separate paper on this subject, and such research is outside the

C12914

scope of this paper, which is clearly focused on ice clouds. However, we will underscore the need for more research on water clouds.

3) Yes, we agree.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 29405, 2010.

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