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Reply to comment

Reply to comment by Lemke, Okamoto and Quante on 'Error analysis of backscatter from discrete dipole approximation for different ice particle shapes' (by Liu and Illingworth Atmos. Res., 1997, 44, 231—241) by C.-L. Liu and A.J. Illingworth, University of Reading, UK, October 1998

The major thrust of our paper was summarised in the abstract: ''Based on the backscatter calculation using a cube and a hexagon column randomly oriented in space, it was found that the backscatter error from the inaccurate representation for the particle surface shape is much smaller than that from the neglect of the magnetic dipole.''

In their comments Lemke, Okamoto and Quante discuss only spheres. When the DDA method is applied to spheres there are two potential sources of error: firstly, the cubic sub-units cannot perfectly represent the spherical surface, and, secondly, the effect of higher multipoles is neglected. The advantage of spheres is that an analytic expression is available and this can be compared with the DDA approximation as N, the number of unit dipoles, is increased. In both our original paper (Fig. 1c) and in Lemke, Okamoto and Quante's comments (Fig. 2) the DDA error for 700 μm radius spheres of ice represented by 47,833 dipoles is about 10 or 20%. The disagreement over the precise error is not fundamental but is due to different assumptions of dielectric constant. As N increases then both figures show that the error compared to the analytic solution decreases, but only slowly; the increase in N means that the both the error due to the representation of the surface and the error due to multipoles should decrease.

In our paper, we drew attention to calculations using DDA for cubes. In this case the error due to imperfect representation of the surface should be zero, and the only error should be that due to the neglect of multipoles. The difficulty is, of course, that we no longer have an analytic solution for comparison. The different solutions in the resonance region as N increases were displayed in Fig. 3b of our original paper, where we assumed that the value with $N = 32,768$ was 'true'. The rate of convergence for the unknown solution for cubes as N increases from 6859 to 15,625 is not very different from the convergence to the analytic solution for spheres as N increases from 8217 to 17,256. Yet for the cubes there is no error due to the representation of the shape, hence we were forced to our conclusion that this error is due to neglect of multipoles. This then leads to the question that if the multipole error is large for the cubes, why is it not large for the spherical case when the size of the sub-units is the same?

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In their Fig. 4 Lemke, Okamoto and Quante point out that for a single sphere of radius about 30 μm the neglect of multipoles leads to an error of less than 1%; they then compare it with the error of 10% when a large sphere is represented by 47,833 DDA cubic sub-units, with each sub-unit being of size close to 30 μm and assert that the multipole error must still be less than 1%. This implies that multipole errors add linearly and independently, but it is not at all clear that they will do so when the large sphere is of a size so that resonance effects are important.