Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-382-SC1, 2019

Atmospheric Measurement Techniques Discussions

Open Access

AMTD

Interactive comment

Interactive comment on "Microwave and submillimeter wave scattering of oriented ice particles" *by* Manfred Brath et al.

Davide Ori

dori@uni-koeln.de

Received and published: 3 December 2019

The paper presents an important step forward in the currently available scattering databases of snow particles at microwave frequencies by assuming the possibility of ice particles with preferential orientations. This is an important contribution which I recommend for publication, but I would also like to list some comments aiming to improve the value of the paper.

1. The orientation averaging technique lacks some validation. A very basic sanity check would be to calculate the integral over $\cos(\beta)$ at the various θ_{inc} and compare with the previously published database (DB) for total random orientation (TRO). Another useful plot to include would be the convergence of the integral

Printer-friendly version

Discussion paper

with respect to the number of points of the icosahedral grid. At line 195 it is stated that a variable number of points is used (between 162 and 2562), perhaps these convergence plots would clarify why, sometimes, a smaller number of orientation samples is sufficient.

2. The averaging scheme is presented as a solution to various challenges that sequentially appear in the text. It is hard, sometimes, to follow this approach because it requires to rethink about the setup many times without a clear final goal to aim to. I want to suggest to introduce the three main reference frames of the problem from the beginning: these are the laboratory (satellite) reference frame, the particle reference frame, and the wave reference frame. By doing so, one can states from the beginning that the scope is to have the polarized scattering properties defined with respect to the satellite reference frame and some transformations are needed because for scattering calculations the wave reference frame is a more natural option used in scattering codes. Also what is called the orientation of the non-rotated particle is nothing less than the particle reference frame.

3. Line 62. This phrase, somehow implies that there is a special subset of rotation matrices that are orthogonal and no couple of rotation matrices are commutative with respect to multiplication. I think all rotation matrices are orthogonal and some rotation matrices do commute (the ones around the same axis).

4. Line 87. For TRO p_β should be $\frac{1}{2}$ and β should be uniformly distributed in terms of $\cos(\beta)$. Otherwise, the integral does not compute to 1 when K=1

5. Line 110. I think here the non-symmetry is respect to the scattered azimuth, not the incident which is actually irrelevant for Z_{aro}.

6. Line 121. ADDA can actually also compute scattering properties for distributions of angles through input files, this includes azimuthally averaging. The reason

why this is not used in the study is that this approach involves the solution of the computationally demanding DDA problem for slightly different orientations many times (for the different combinations of tilt angle and wave incidence).

7. Line 130. D_0 should have explicit units, which I assume are μm.

8. Line 179-182. I do not see why a regular grid is advantageous for resolving the for/back-ward scattering peaks. A regular grid means that the azimuth and polar angles are equally spaced. The points at the same polar angle are getting closer in azimuth distance as the polar angle approaches the poles. The scattering peaks mean that there is a high variability of the scattering intensity with respect to the polar angle and thus would demand an increased resolution in polar angles. The polar angle resolution is always the same here.

9. Lines 209-214. In my opinion, two points are missing in the list of steps: first is the projection over spherical harmonics of the scattered fields. And the second is the barycentric interpolation of the gridded data. The second is important because it clarifies that the computed properties for a certain β and θ_i are actually coming from slightly different angles.

10. Line 220. The three rotation matrices are different. Perhaps a better notation would be $R_{\alpha\beta\gamma} = R_z(\alpha)R_y(\beta)R_z(\gamma)$

11. Line 284. What is called accuracy ϵ=1% I think is the internal stopping criterion for the ADDA iterative solver and should not be confused with the accuracy of the calculations which is hard to evaluate and yet not clearly understood. Perhaps the authors should include in the supplementary material, for just one particle and one orientation what is the effect on the scattering properties (just plot phase functions) of this choice of ϵ with respect to the default value of 10^{-5} (three orders of magnitude smaller!).

12. Line 381. In the figure, I see β = 0, 50, 90 but in the text, β=30 is mentioned, perhaps there is a typo?

13. Line 397-402. Here the authors state that the database is not optimized for radar calculations because the spherical harmonics projection is not good at forward and backward scattering. Perhaps the authors should better describe what they meant at line 177 with RMSE of less than 0.5% due to the spherical harmonics. 0.5% is actually quite insignificant for radar applications. Also this problem can be immediately solved by making available the original DDA computations at single orientations, perhaps by request to the corresponding author. I think this last piece would also make the paper fully compliant with the Copernicus open-data policy.

14. The scattering properties of hexagonal crystals are symmetric with respect to θ_i due to the planar symmetry of the particles. This is not true for aggregates that are not symmetric. The authors have oriented the aggregates according to their principal axis of inertia. This is, in general, a good fast approach, but it introduces an arbitrary decision about what is the direction of the main (vertical) axis of inertia. In my opinion, there is no clear criterion to decide whether this axis should look up or down. As a consequence, one could argue that the scattering properties for $\theta_i = \lambda$ should be averaged with those for $\theta_i = 180 - \lambda$ giving planar symmetry also to the aggregates and reducing the storage footprint of the database.

15. Equations (20) and (21) show how to rotate the polarization vectors of the Mueller matrix. I wonder if this is done before the barycentric interpolation. In my view, the scattering properties of the three vertexes should be first aligned with the direction and polarization of point D. If the forward/backward scattering direction lies within the triangle ABC this can cause quite dramatic cancellation due to the flipping of the polarization direction among the points A, B, and C.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-382, 2019.