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Interactive comment on "snowScatt 1.0: Consistent model of microphysical and scattering properties of rimed and unrimed snowflakes based on the self-similar Rayleigh-Gans Approximation" *by* Davide Ori et al.

Anonymous Referee #2

Received and published: 2 January 2021

Summary:

The paper's primary purpose is to present and describe snowScatt 1.0, a toolkit for computing the scattering properties of unrimed and rimed aggregates from microwave to sub-millimeter electromagnetic wavelengths using the Self-Similar Rayleigh Gans Approximation (SSRGA). A secondary purpose of the paper is to illustrate the value of the SSRGA in the first place.

Review:

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Discussion paper

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The paper is certainly relevant to GMD, and the toolkit will be of value to the community in the years to come. Given the primary purpose of the paper, Sections 2 and 3 are most important and must be written perfectly, providing all of the details necessary to understand the code in detail and to apply it without error. In this regard the paper needs more work, and the focus of this review is on these two sections. Because there are no major issues with the approach, the required revisions suggested for the paper are listed as minor in nature, though certainly required in order to maximize impact of the paper.

McCusker, Westbrook, and Tynella have just come out with a paper in QJRMS with results that address some of the issues raised in this paper. The reference for this paper is

An accurate and computationally cheap microwave scattering method for ice aggregates: the Independent Monomer Approximation Karina McCusker, Chris Westbrook, and Jani Tyynelä

By incorporating relevant results from McCusker et al., e.g., problems with forward scattering in the RGA, the authors will strengthen this paper as well.

Finally, all qualitative comparative language should be removed from the paper and replaced with quantitative measures. This will not be hard to do because quantitative measures appear to be readily available where qualitative language is used.

The PDF file returned to the authors contains mark-up using Acrobat Comments that indicates some of these places. The mark-up also contains other issues the authors might consider addressing.

Detailed Comments on Sections 2 and 3:

0) For an algorithm/data product paper such as this one, every parameter in every algorithm and data product must have clearly specified units. Lacking clear, correct, and internally consistent units, things will get confusing in a hurry.

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1) Calling sigma on Line 118 an intensity is confusing. Intensity in the SI system has units of W / sr. Sigma on this line seems to have units of mˆ2 / sr based on Eq. (8). (Eq. 8 is an integral over all 4*pi steradians of solid angle and the result is in mˆ2.) So, it is probably better called a differential scattering cross section if it does indeed have units of mˆ2 / sr.

2) Why have the word "Rayleigh" in front of "dielectric factor" on Line 119?

3) The form factor, itself, has nothing to do with deviations from any quantity. As one factor in a bunch of factors, it might be interpreted as creating deviations in the product of other factors, but to present it as such is to hide its own direct physical significance. So, much of the sentence on Line 120 is not helpful in the context of this paper. Lines 121 and 122, together with Eq. 4, make this clear. For example, there is no deviation involved in Eq. 4, just phase changes as a result of location and direction. Simple and clear these lines are.

4) Is phi in Eq. 3 the same thing as phi_RGA in Eq. 4? If so, please give them the same label. If not, explain the difference between the two. If the same thing, phi_RGA should be a function of x and theta, similar to phi in Eq. 3, and as stated on Line 125.

5) Line 128, Eq. (5), and Line 129 are out of context. Probably best to move them to just before Eq. 8.

6) On Line 12 of the Abstract reference is made to "the set of SSRGA coefficients", and these words occur elsewhere throughout the text. What these coefficients represent is never made perfectly clear. Are these the "five parameters (Hogan et al., 2017, alpha_e, kappa, beta, gamma, eta_1)" that occur on Lines 132 and 133? If so, make this perfectly clear and always use the same words (e.g., "coefficients" or "parameters") to describe them. Otherwise, things get confusing in regards to them.

7) The shape and orientation of any particle to which Eq. 4 is applied are both captured by the integral over V, i.e., where the ice volume elements are actually located. Line

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125 correctly characterizes this state-of-affairs. From this perspective, Lines 131 and 132 need more clarity because as currently written Eq. 6 has no dependence on theta. Eq. 6 looks exactly like the phi_SSRGA from Hogan et al. (2017) which is for the backscattering direction only. Hogan et al. (2017) do not seem to ever write their phi_SSRGA as phi_SSRGA(x sin[\theta/2]), but if doing so is correct it would have been clearer if they had done so. If this is correct, you should do so here to make things perfectly clear. And if this is correct, one could then write something as follows:

For the RGA approximation, phi(x*sin[theta/2]) in Eq. 3 is equivalent to

phi_RGA(x,theta) = Your Equation 4.

...

And in the SSRGA approach of Hogan et al. (2027) phi(x*sin[theta/2]) becomes

phi_SSRGA(x*sin[theta/2]) = Your Equation 6

...

Is this correct? If so, then when it comes to Eqs. 8, 9, and 10 later on, the reader will know exactly that it is phi_SSRGA(x*sin[theta/2]) that is to be used in them. If not, perhaps you can see from what is written here the confusion that needs to be cleaned up.

8) Figure 1 looks like it has 35 Dmax bins. If this is correct, then does the database upon which the figure is based have 35 Dmax values for its aggregates? And does each Dmax value lead to an independent set of SSRGA coefficients (or parameters, depending upon what you end up calling them)? If this is correct, then the database upon which Figure 1 is based has 35*kappa, 35*beta, 35*gamma, 35*eta, and 35*alpha_e coefficients. Is this correct? Not sure, especially for alpha_e. Hogan et al. (2017) define alpha_eff on the top right column of their Page 839 as an average over all D / D_max for 50 random orientations of each on n particles of size Dmax and with the radiation moving in the x, y, and z directions, or an average over 50 * 3 * n samples.

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If this is the case, then does x in Eq. (7) have a single value for the single averaged value of alpha_e? Generally, one might think of x as a continuously changing variable, but here this may not be the case. Perhaps it is fixed for each Dmax? Anyways, it being fixed would explain why it is not written as part of the functionality in Eqs. 3, 8, 9, and 10. But then to have it as part of the phis is confusing. Perhaps the phis in Eqs. 3 and 6 should be functions of the fixed alpha_e, rather than a presumed continuously changing x? Not sure what is best here, but this is confusing. Clearly written, with a clear recipe as to how to get the coefficients, how to use them to interpolate/extrapolate to new Dmax values, exact units provided for everything, etc..., would be a gift to the community and make this paper an invaluable partner to your algorithms and data bases.

All in all, the paper needs a very clear recipe as to how the SSRGA coefficients (parameters) are generated, how they are used, etc..., perhaps building appropriately on what Hogan et al. (2017) provide in their Section 3.2. With such a clear recipe, this paper gains value, at least to this reviewer.

9) Along the lines of the last part of the previous comment, perhaps Section 3 could also carry along an explicit example of one of the aggregate databases and how it is used to develop a SSRGA approach and then to use the results of the SSRGA approach in an application to arbitrary particle size distributions. Perhaps this could be done with one of the 4 sets of results used in Figure 5. For example, consider LS15 B05. How many Dmax values does this database contain and how many aggregates per Dmax value? Is all of this information in the snowTable? How many SSRGA coefficients are there associated with it? Are these coefficients also stored in the snowTable or are they generated by the SSRGA core module? If by the core module, are they never saved, as they are not listed as part of the Scattering ouput? The results for it in Figure 5 are shown as a continuous curve. But are its results really for discrete values of alpah_eff and hence x? If so, where are these discrete values along the x axis? How is r_eff in Figure 5 related to Dmax or alpha_e? Do all of the

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aggregates with the same Dmax in the database have the same mass, so that r_eff is computed directly from this mass? In Figure 2, exactly how are the data products output by SSRGA mapped to the PSD in the radar simulator? Are SSRGA outputs for a particular Dmax mapped/interpolated to corresponding diameter values in the PSD? Making all of this explicit and clear will save interested readers from having to do a lot of work to fill in the details. And making this all clear here in the paper will make using the algorithms perfectly much easier as well.

Please also note the supplement to this comment:
https://gmd.copernicus.org/preprints/gmd-2020-359/gmd-2020-359-RC2-supplement.pdf

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