Dear Editor, dear reviewer,

Thanks for the valuable comments, which help to improve the quality of the paper. The detailed replies are addressed below point by point in blue.

Best regards,

Linlu Mei on behalf of all co-authors

The paper describes a comprehensive sensitive study of a new retrieval algorithm to derive snow properties using passive remote sensing. The topic fits TC. The paper is well-written and easy to follow. The main findings in this paper are important for the whole community. For instance, the impact of the ice crystal shape and atmospheric effects on the snow properties retrieval will provide very valuable information for the whole community. Moreover, the authors try to explain the understanding gap between the remote sensing community and the campaign-based community and made a great effort to minimize such gaps. I would suggest the paper to be published after addressing the following minor aspects.

The authors highlight that the current snow shape assumption, such as spherical shape, may be valid for snow albedo estimation, but not for the directional reflectance estimation, due to the different impacts of ice crystal shape on the phase function and extinction/absorption coefficient, by citing the previous publication, it will be helpful if the author can extend the explanation of this part (L134), does the snow albedo purely depend on the particle extinction/absorption coefficient?

Response: As presented in the cited paper such as Jin et al (2008), directional quantities, such as bidirectional reflectance and radiance, are however more sensitive to scattering phase function and hence to particle shape, while the hemispherically averaged radiative quantities, such as albedo is not very sensitive to the finer aspects of the scattering phase function.

The snow albedo does not purely depend on particle extinction/absorption coefficient, but also on how those single particle aggregates.

We included more explanations in the revised version.

Jin, Z., Charlock, T. P., Yang, P., Xie, Y., & Miller, W. (2008). Snow optical properties for different particle shapes with application to snow grain size retrieval and MODIS/CERES radiance comparison over Antarctica. Remote Sensing of Environment, 112(9), 3563–3581. doi:10.1016/j.rse.2008.04.011

I don't think that the SSA is an independent retrieved parameter in the XBAER algorithm, although the author has mentioned in the abstract and also in the introduction part, it will provide a better understanding for the reader, that is, are the snow size and shape the two fundamental inputs for the XBAER algorithm, especially, as the author highlighted, the ice crystal shape cannot be precisely validated and I think it is also very difficult for the user to use the shape rather than SSA, so can the author directly retrieve size and SSA?

Response: There are at least two different manners to describe the snow properties, one is to use the combination of ice crystal shape and grain size as inputs, the other is to assume that the snowpack is a medium consisting of grains and bubbles. However, in both way, there are parameters, which cannot be precisely validated in the reality. For the size-shape manner, the particle shape is difficult to be validated while the mean photo path length cannot be evaluated for the grains-bubbles way. So it is impossible to estimate SSA without certain assumption in advance. In our case, we cannot retrieve SSA without a knowing or assuming ice particle shape.

Some names, for instance, snow particle shape, ice crystal shape should be harmonized in the paper

Response: The names are harmonized in the revised version.

Why there are obvious oscillations in Fig 2 and Fig. 3, especially for the phase function?

Response: The oscillations comes from the original Yang's database.

What is the typical valid range for SSA? How strong the SSA variability is?

Response: The valid range of SSA depends on the snow properties, and it differs from region to region. For instance, in the paper of Picard et al (2009), the SSA varies from 0 – 35 m^2/kg while the results from Kokhanovsky et al (2019) shows a range of 0 – 80 m^2/kg. And the variabilities of SSA is quite large, depending on the snow metamorphism due to changes in thermodynamic conditions.

Picard, G., Arnaud, L., Domine, F., & Fily, M. (2009). Determining snow specific surface area from near-infrared reflectance measurements: Numerical study of the influence of grain shape. Cold Regions Science and Technology, 56(1), 10–17. doi:10.1016/j.coldregions.2008.10.001

Kokhanovsky, A.; Lamare, M.; Danne, O.; Brockmann, C.; Dumont, M.; Picard, G.; Arnaud, L.; Favier, V.; Jourdain, B.; Le Meur, E.; Di Mauro, B.; Aoki, T.; Niwano, M.; Rozanov, V.; Korkin, S.; Kipfstuhl, S.; Freitag, J.; Hoerhold, M.; Zuhr, A.; Vladimirova, D.; Faber, A.-K.; Steen-Larsen, H.C.; Wahl, S.; Andersen, J.K.; Vandecrux, B.; van As, D.; Mankoff, K.D.; Kern, M.; Zege, E.; Box, J.E. Retrieval of Snow Properties from the Sentinel-3 Ocean and Land Colour Instrument. *Remote*

What is the physical reason behind that the roughness plays such a minor role in the snow properties retrieval? Are those definitions of the snow surface roughness, with those three values, reasonable? Or those values themselves are too small?

Response: The roughness defined in the Yang database describes the roughness of each ice crystal particle, not the roughness of the snow layer (or the surface homogeneity). And those three values (and we believe they represent the typical snow conditions) are provided by the Yang database, thus no other values can be used for the test. Please be noted, that the surface roughness of ice crystal may occurs for ice cloud, but it is quite rare that it may occurs in case of snow on the ground due to much slower and small surface irregularities, which are bound to disappear very fast because of basic thermodynamics (Colbeck, 1980, 1983). However, we would prefer to perform a comprehensive sensitive study, including all possible ice crystal properties into account, thus, we believe that the test of roughness is still needed and useful. A similar investigation of impact of snow particle roughness is also presented in Picard et al (2009).

Colbeck, S. C.: Thermodynamics of snow metamorphism due to variations in curvature, J. Glaciol., 26, 291-301, 10.3189/S0022143000010832, 1980.

Colbeck, S. C.: Theory of metamorphism of dry snow, J. Geophys. Res., 88, 5475-5482, 1983.

Picard, G., Arnaud, L., Domine, F., & Fily, M. (2009). Determining snow specific surface area from near-infrared reflectance measurements: Numerical study of the influence of grain shape. Cold Regions Science and Technology, 56(1), 10–17. doi:10.1016/j.coldregions.2008.10.001

The authors make a good effort to investigate especially the aerosol impact, I can clearly see that aerosol play a very important role in the retrieval, the authors propose some Arctic aerosol scenarios, however, snow occurs also in high polluted regions, at least during winter, the authors should include some explanation for this situation.

Response: The impact of aerosol, as we presented in the paper, is one of the most important parameters, needing to be addressed. For regions with strong pollution condition, the uncertainties of the retrieval will be larger. This condition may be quite critical over relatively lower latitude regions, where pollution may transport to snow covered regions. We added some more explanation in this section in the revised version.