Review of manuscript submitted to The Cryosphere:

Title: The retrieval of snow properties from SLSTR/ Sentinel-3 - part 1: method description and sensitivity study

Authors: Linlu Mei et al.

General Comments

The authors discuss a method to retrieve three snow properties: (i) snow grain size (SGS), (ii) snow particle shape (SPS), and (iii) specific surface area (SSA) from data collected with a two-channel radiometer with dual-viewing observation capabilities flown on the Sentinel-3 satellite. Supposedly this article is just the first part of a two-part paper describing the retrieval algorithm (with acronym XBAER). Although the authors claim in the abstract that XBAER "has been applied on the Top-Of-Atmosphere reflectance measured by the Sea and Land Surface Temperature Radiometer (SLSTR) instrument onboard Sentinel-3 to derive snow properties", no evidence of any such application is provided in the present article. Hence, there is no way of judging from the work presented in this article how this method will perform when applied to actual data collected with the SLSTR instrument. I therefore recommend that the authors merge the essence of this paper with part II that I expect will present results of applications of the retrieval algorithm to data collected with the SLSTR instrument.

The authors provide a useful discussion of how a database of optical properties of ice particles developed by Ping Yang and co-authors for application to cirrus clouds can be used also to study snow properties. Their study of the impact of model parameter uncertainties in Section 5 is also useful. But the paper has some important limitations:

1. Any credible remote sensing algorithm has to include a robust cloud screening tool. How to construct such a cloud screening tool for the SLSTR instrument is a challenge that warrants serious consideration. As alluded to in Section 6 of the paper, identifying and removing the contribution of an ice cloud to the measured signal is a very challenging problem as discussed by Chen et al. (2104, 2018).

2. Atmospheric correction is another important issue that requires serious consideration. A revised version of this paper merged with the promised part II must include a discussion of this issue.

3. The description of the SLSTR instrument in Section 2.1 lacks important information about the spectral response of the two channels at 0.55 μm and 1.6 μm. As discussed by Chen et al. (2017) the response function of the 1.6 μm channel requires careful consideration because the optical properties of snow/ice varies considerably over small wavelength intervals in the 1.6 μm spectral range.

4. The SLSTR instrument has a total of nine channels. The authors provide no explanation for why they have decided to use only two of those channels for this work. It would seem that using more channels should be helpful.

5. In Section 2.1 the authors state "The statistical analysis has been performed using observations over Greenland during April and September 2017. April and September are reported to be representativeness months of the Arctic..." This focus on the months of April and September only is a serious limitation. We would like to know how the snow properties evolve over the summer season from the beginning of the melt in April/May to the freeze-up in August/September.

6. In Section 4 describing the XBAER algorithm, the authors state "The first stage includes the estimation of SGS using the effective Lambertian surface albedo after atmospheric correction ...". The authors must explain what is meant by "effective Lambertian surface albedo" and also how "atmospheric correction" is performed. This information is essential.

7. The modeling carried out in this paper is based on the assumption that the snowpack is vertically homogeneous and consisting of a mono-dispersion of snow particles of a pre-defined shape. In reality these assumptions are not fulfilled. Also, the light penetration depth at wavelength 1.6 μm is much shorter than at 0.55 μm. The impact of these circumstances are not discussed.

Specific Comments

- The Bidirectional Reflectance Factor (BRF) is introduced at line 206, but defined only at line 307.

- The authors state (line 445) that field-measurements of SSA are based on the assumption that snow grains have spherical shapes. What are the uncertainties in the field-measured SSA values incurred by this assumption?

References

Chen, N., W. Li, T. Tanikawa, M. Hori, T. Aoki, and K. Stamnes, Cloud mask over snow/ice covered areas for the GCOM-C1/SGLI cryosphere mission: Validations over Greenland, J. Geophys. Res. Atmos., 119, 12,287-12,300, 2014. doi: 10.1002/2014JD022017.

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