The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-270-RC1, 2020

The Cryosphere Discussions

Interactive comment on "The retreival of snow properties from SLSTR/Sentinel-3 – part 2: results and validation" *by* Linlu Mei et al.

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Received and published: 10 November 2020

Review "The retrieval of snow properties from SLSTR/Sentinel-3 -part 2: results and validation" by Mei and colleagues

The paper aims at validating an algorithm to retrieve snow grain size and shape, and snow specific surface area from the space-borne SLSTR sensor. The algorithm was described in another paper in review (companion part 1), the present manuscript is dedicated to the validation.

The overall goal of these two parts is of interest for the cryosphere community, in particular because SLSTR is on the Sentinel 3 series of satellite which will be able for decades. The paper is original and clear. Nevertheless, my recommendation is to

postpone the acceptance of this paper for three main reasons:

- The validation is based on a too limited set of in-situ data, part of it is discarded because of cloud contamination (SnowEX17). The text truly dedicated to the algorithm performance evaluation is also relatively short and seems unfinished, most of text is about the difficulty to perform the validation, which in the end does not contribute to give confidence in the retrieval algorithm. The conclusion about the algorithm performance therefore lacks of support. There are also several technical issues (see below in the detail comments) in particular one on the RMSE definition. The lack of datasets is a common problem, but not to the extent depicted by the authors. The main example is for the snow grain size. The manuscript cites Kokhanovsky et al. 2019 which pursues a very similar objective as the present manuscript but uses OLCI, (on Sentinel 3 as well as SLSTR) to estimate grain size and SSA (not the grain shape). For the validation these authors used an extensive dataset with 100s of SSA field measurements in Greenland and in Antarctica. These data can be either retrieved from the graphs or in principle obtained from the authors, and should be used here to complete the validation (or even replace the 3 SnowEx measurements). Moreover the performance between the SLSTR and OLCI algorithms could be analyzed at these in-situ points. At last, the authors "emphasize that the results presented in this section is considered as preliminary" (L373). They indeed propose to include Mosaic data in their analysis in the future. My concern is whether it is worthwhile for the community to publish "preliminary results" in two papers. My suggestion is indeed to wait for complete results and include Mosaic dataset.

- the grain shape is a big issue of this study. It is claimed to be a major advantage compared to other algorithms (e.g. L617) but the demonstration is missing. First because it is difficult if not impossible to validate. I acknowledge that snow shape is a difficult topic. However as for the validation of the grain size, the choices of the authors are limiting the ability to perform the validation. The algorithm assumes and retrieves geometrical shapes that are representative of precipitating crystals, not of snow on the

ground although the algorithm is supposed to be used for snow on the ground. A first consequence is that the algorithm can not perform well, because the phase function of such shapes does not apply to snow on the ground (expect for fresh snow). Snow on the ground is usually more rounded and irregular than crystals in the atmosphere. The second consequence (and the main one) is the difficulty to perform the validation. Data recorded by snow practitioners and scientists in the field usually follows the international classification of seasonal snow on the ground (Fierz et al. 2009, not cited in the manuscript) which has some shortcomings but is widely used. Since the algorithm does not use these "standard" shapes, it is inherently impossible to perform a fair comparison with external data. It follows a third consequence about the usefulness of the shape information retrieved by the algorithm. I'm wondering how useful is this retrieved "grain shape" for snow community since it does match with its standards. I suggest that to solve this major issue, ideally by adapting the shapes used by the algorithm, and if not possible at least by establishing a link between the different shape systems. Even if imperfect and highly uncertain, this link will benefit to the whole clarity of the paper and will help to shorten the validation section (see comments below). They should also explain why retrieving the shape is useful for the algorithm. The algorithm uses a first guess grain size from another algorithm but no comparison is given. I would expect the authors to demonstrate that taking into account the grain shape has an effective positive impact on the SSA or grain size estimates. This would be very useful for the snow remote sensing community to know if such an approach is fruitful.

- the benefits to split the study in two parts is not clear. The paper (part 2) presents the validation of an algorithm that is not described, which raise several questions and make it be difficult to read without reading the other paper (part 1). For the review, I didn't read the part 1 (I just browsed it) to be in the same position as a normal reader. I found that reading part 2 was difficult with many open questions about the algorithm and was sometimes annoying because of a few elusive statements referring to the part 1 without providing information. E.g. "The similarities and differences of the required snow parameters and their accuracy between the snow remote sensing community

and other communities (e.g. field-measurement community) are detailed discussed in part 1 of the companion paper (Mei et al., 2020), thus we will not summery again in this paper. ". The length of this part 2 is normal and the information density is relatively low. For the comfort of the reader, I suggest to shorten or remove some sections (e.g. the first results section on Greenland), and merge with the part 1. Only if extending the validation as proposed above with a complete dataset and with Mosaic data, it would be justified to make two papers.

Detailed comments:

L63. What is the definition of "grain size" used here ?

L 69: correct "detailed discussed"

L70: "summery" → "summary"

L91-L92: I'm not sure to understand "to be with good quality"

L98-L99. Please add a reference / name for the operational product.

L104 I'm not sure to understand "to partly taking snow irregular ".

L118: "Details of these issues have been discussed in Part 1 of the companion paper.". Please remove and add a proper reference. Or just remove.

L120-122: This sentence is strange, "no publication. . . especially using" seems contradictory.

L 124-126. I don't understand the sentence. What is an "optimal complex shape". The part 1 paper seems to use very geometrical/simple shapes and the goal of the retrieval algorithm is to retrieve SPS. How does this apply to this sentence ? Also, what do you mean by the e.g. TOA ?

L147-149. I suggest to move this statements to the conclusion.

L150. I suggest to remove this statement or merge the two papers.

L152 – L162. I suggest to move this paragraph to the discussion because it is a typical analysis of the uncertainties of the results/validation. The representativeness issue is a general problem, that affects any in-situ vs remote sensing comparison. Why the SPS would be particular ? This also concerns SGS and SSA.

L170. Remove double “show”.

L215. I suggest to remove SnowEx17 grain shape from the table because it is misleading even with the warning in the legend caption. Instead it is possible to list these grain type in the caption and/or in the main text. Note that the grain type measured by SnowEx17 are not specific to this campaign but refer to the international classification (Fierz et al. 2009).

L253 have→are

L276. Could you give a definition of spherical albedo and Lambertian surface albedo ?

L281. Could you indicate the resolution of MERRA ?

L282. Our → a

L339-355. The comparison is very qualitative and referring to generic and broad “classification” of “polar snow” does not bring significant information for this validation, especially because not all the existing references about snow grain shape and size have been taken into account. It must be taken into account that July is warm with a large proportion of the ice-sheet subject to melt, which unequivocally leads to rounded coarse grains very quickly.

Because the validation can not be done with information that are not available, I suggest to convince the reader that the results are plausible using cross-analyzed external data: - use MERRA to separate where the snow is fresh and for which the present discussion in these lines apply fairly well. - where snow is fresh use successive image to show that SGS increases (and SSA decreases) as predicted by metamorphism (as you suggest, July is interesting for the most rapid metamorphism). - use passive

microwave (or MERRA or SLSTR thermal channels) to separate where melt is active and where the grains are very likely to be rounded. - use the images next 28 July 2017 to demonstrate that the blue shape for instance in NW Greenland are not due to clouds/aerosols. (I’ve made this comment before reading the discussion, see further comments below).

I also suggest to mask out areas in the ablation zone with ice and dirty snow, as the algorithm does not work in these cases. This should be emphasized.

Fig 3. adding a scatterplot with relevant statistics (R2, RMSE, bias, . . .) is common for a more quantitative validation. In particular, it would be useful to compute the same statistics with the first guess to really show the benefit of the algorithm.

L371. The previous section was titled “Results” but was also a comparison (and validation to some extent). Why not a unique Result section that includes both comparison ?

L372. I suggest to remove “validate”. L373. ground-based/aircraft → ground-based and aircraft

L377- 379. I’d remove this introductory sentence that starts by concluding that the algorithm is good although the actual goal of the present sessions is to perform the validation.

L 385. “time and location” or “times and locations”.

L394. Why the rows are not sorted chronologically as in next figure ? What is the order ? Has the gray shade in the last row a meaning ?

L398. This is the second “Fig 4”. Review numbering. +Please add a scale to the maps.

L406. How does this perform in the case of thin clouds ?

Fig 4 and Fig 5. I don’t understand why two figures ? If I understand well, Fig 4 is a zoom of Fig 5 ? They should be merged in a single composition using the same

symbology / graphic style.

L412-413. “is not correctly avoided”. This is a bit confusing. The next sentence is clearer to me but seems to be in contradiction with Table 3 indicating “cloud contaminated snow” for this date (which seems accurate based on Fig 4). L388 indicates that the comment in Table 3 is obtained with the algorithm. Please clarify.

L413. Give → gives.

L421. Add a ref to the study.

L442. “Our → a” or “our calculations with”

L444. Fig 1 → fig 1 with a lowercase as it is referring to another paper. Add the ref.

L451-452. “cloud effective radius” → “cloud ice crystal effective radius”. SGS and “ice crystal size” are used interchangeably in the paper which is sometimes (and especially here) confusing.

L464. “”This is similar to the issue in field measurements.” what do you mean ? L465. “ (e.g.,the measurement of SSA),”. This is generally not true. Do you refer to a precise device and processing ?

L466-470. I’d suggest to define in the method section (Table 2) the most-likely correspondence between Yang’s shapes and the snow type defined in the international classification (that used in SnowEx) so it is possible here and in the Section 4 in the results section to assess the algorithm performance in a more rigorous way.

L473. “A previous publication” or cite more than one L474 are → is

L479 “is ‘facet’ while XBAER says ‘droxtal’ both tend to be roundish”. Facets according to Fierz et al. 2009 is not rounded. If the retrieval algorithm SPS can not distinguish rounded grains from faceted grains because both are droxtal, how useful it this for field practitioners ? This asks an important question that is not addressed in the introduction: why and for what usage to retrieve SPS from satellite ?

L483. I do not agree. It is also believed that grains get rounded due to sublimation in blowing snow (Domine, 2009). This probably depends on the conditions, on the actual grains available on the surface, and the strength and duration of the saltation/reptation process.

L493-496. Please indicate the number of points of each comparison (n=...) and the statistical significance of the results. By “difference” do you mean “rms difference” or “difference of the average” ?

L548. Here it would be particularly interesting to see how good the first guess predictor of SGS. I’m really interested by knowing if the algorithm sophistication is worthwhile.

L533. I’m not sure to understand how the RMSE is calculated. The RMSE includes both systematic and random errors, and here given the difference of the mean, the RMSE should be at least 165 – 138 = 17 microns while the text indicate 12 microns. Please check also “lower grain sizes”.

L550. The same question applies for SSA, with a difference in the mean of 3 m2/kg, it is not possible that the RMSE is 2 m2/kg.

Fig 8. This figure is interesting but should be used earlier in the validation to infer the errors of estimations. I see the following possible artifacts: - The presence of undetected clouds in the NW Greenland. - The dramatic grain size decrease after 28 July in Eastern Greenland (analysis around L588) is very suspicious and stronger evidences are needed to prove that it would be related to a massive drift event, and not to a retrieval artifact. In particular it would be necessary to demonstrate that the wind sustained over 6m/s for a sufficient long period of time to really bring sufficient quantities of small grains over the considerable distance. - Why grain shape changes so fast between a Droxtal to a column in central Greenland ? Wind is able to drift fresh snow, but in the absence of recent snowfall, if snow was already Droxtal at the surface, wind can not transform it into more elongated crystals. Faceting of grains at such a pace is suspicious. - The Western side is also affected by the grain size change. The

shape change is also marked and different from that observed in the Eastern side. Why this is not discussed ?

L590. The weblink does not point to any data. A figure should be added in the supplementary with direction and wind speed.

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