

**Author Responses to the Referee Comments 1** on “ *Marked decrease of the near surface snow density retrieved by AMSR-E satellite at Dome C, Antarctica, between 2002 and 2011* ”

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Referee comments are in normal text ; Author responses are in italic.

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The authors present an interesting, and potentially promising, method of retrieving a time series of values of derived surface snow density from AMSR-E data, in combination with radiative transfer modeling through DMRT-ML. There are a few minor clarifications that are warranted in order to make some points clearer. Most notably, there are some seemingly contradictory statements about the trends of surface roughness features (see specific notes for Page 18). There are also several technical/grammatically errors to fix.

*We thank the first reviewer for the general positive remark as well as for all the minor remarks and the technical/grammatical comments. All the errors and clarifications, including the explanations on surface roughness features, are addressed in the following.*

Page 4, Line 9: is it standard formatting for the data set title to be in italics? I don't think I've seen that before.

*Replacing the data set title in italics by quotes.*

Page 4, Line 23: is this phrase, “full-polarization mode with nadir looking” correct? seems like something is missing? should it be "nadir-looking in full-polarization mode"?

*Changing the sentence as follow: “The first dataset was acquired by the nadir-looking Radar Altimeter (RA-2) instrument onboard ENVIronment SATellite (ENVISAT) at 13.6 GHz (Ku-band).”*

Page 5, Line 1: again, why is the dataset name in italics, or is that standard formatting for TC.

*Again, replacing the data set title in italics by quotes.*

Page 5, Line 8: Figure 1 shows measured snow density, measured SSA (assuming that) and modeled/derived snow radius, not snow temperature.

*We remove the “Fig. 1“ reference page 5, line 8 because there is indeed no snow temperature profile in Figure 1. We add the “Fig. 1“ reference page 6, line 16 (section 2.2.3), page 7, line 9 (section 2.2.4) and page 7, line 26. Also, we do a slight addition in the Figure 1 caption: “The measured profiles of ...”*

Page 5, Line 13: Should report the height the samples were taken here to be consistent and to be able to compare to the other measurements.

*Modifying the sentence as follow: “Surface snow density was measured every 3 to 5 days from 3 February 2010 to 4 October 2011 by using a cylinder cutter (10 cm length and diameter of 5 cm) inserted horizontally so that the cutter top grazes the surface.” We also add the following*

sentence page 5, line 23: *“The density is representative of the topmost 5 cm of the snowpack for the CALVA dataset and of the top 10 cm for the two PNRA datasets.”*

Page 5, Line 15: missing "The" in the front of the sentence.  
*Change done.*

Page 5, Line 16: should be "contains the surface snow density measurements...".  
*Removing the word surface.*

Page 5, Line 18: should be, "The last dataset...".  
*Change done.*

Page 5, Line 23: datasets instead of dataset.  
*Change done.*

Page 5, Line 23: should be "associated with" instead of associated to.  
*Change done.*

Page 6, Line 4: should be “west”.  
*Change done.*

Page 6, Line 9: is should be are after “measurements”.  
*Change done.*

Page 6, Line 9: There are no measurements taken in the upper part of the snowpack towards the end of the data record, but there would be some in the beginning of the experiment, in 2006. Can this be clarified? And/or report the rate of burial maybe?

*The burying rate at Dome C is  $0.1 \text{ m yr}^{-1}$ , as mentioned page 6, line 6. It is right that there is measurements from the beginning of the experiment in 2006, and the measurements continue until October 2011. However, after a year or so, the topmost probe installed at 0.1 m depth was then at 0.2 m depth and no new probe was inserted so that no measurement is available at 0.1 m depth anymore. And the temperature measurements taken at the beginning at 0.1 m depth in 2006 can not be confidently used for the other years because of the high natural variability encountered on the Plateau.*

Page 7, Line 1: should be "measured in a snowpit".  
*Change done.*

Page 7, Line 5: to should be with after associated.  
*Change done.*

Page 7, Line 10: need to define the acronym POSSSUM.  
*Acronym is explicitly written.*

Page 7, Line 16: delete "allow to" as the sentence as written is not grammatically correct.  
*Change done.*

Page 7, Line 16: POSSSUM and ASSSAP don't actually measure SSA directly, but they do allow for SSA to be determined from light reflectance measurement, so should not refer to a “measurement” of SSA from POSSSUM.

*Changing measure by “determine”.*

Page 7, Line 16: to should be with after associated.

*Change done.*

Page 8, Line 14: should have “the” in front of “phi parameter”.

*Change done.*

Page 8, Line 24: should have “the” in front of Antarctica Plateau.

*Change done.*

Page 9, Line 14: I think that the authors mean that the snow properties also vary with time, instead of depth?

*You are right, change done.*

Page 9, Line 27: “the” should be in front of Sea Winds instrument.

*Change done.*

Page 11, Line 20: should have “the” in front of DMRT-ML.

*Change done.*

Page 11, Line 21: term should be terms.

*Change done.*

Page 13, Section 5.2 in general: I understand that this sensitivity analysis was done using the DMRT-ML model to simulate the PR variations, but this should be explained or added in the description.

*The end of the sentence page 13, line 9 is modified as follow: “Then, a sensitivity analysis of PR37 to the snow parameters of this top layer is performed using the DMRT-ML model.”*

Page 13, Line 15: delete "permit to".

*Change done.*

Page 15, Line 4: delete "around" or should be "which corresponds to around the top 3 centimeters of the snowpack" (i.e. not grammatically correct as is).

*Modify with “which corresponds to around the top 3 centimetres of the snowpack.”*

Page 15, Line 14: this word is not used as frequently as "accumulated" when referencing snow since cumulated means gathered together or combined.

*Modification of “low cumulated snowfall“ by “low accumulated precipitation“.*

Page 15, Line 15: Grain-Index should be defined.

*Because we are not using the term Grain-Index in the rest of the paper, I prefer not mention the term Grain-Index but what is happening. Thus, the sentence becomes: “... and a large increase of the snow grain size in the 5 first centimetres of the snowpack.”*

Page 15, Line 15: is there any possible physical/meteorological explanation for the lack of annual cycle?

*The lack of annual cycle is for the years 2008 and 2011. We remove the year 2011 from the text because the time series end up in the middle of 2011, and thus we cannot confirm the absence of annual cycle. The physical explanation could be the opposite of that holding for years with large annual cycles. High accumulation of snow involves a probable low metamorphism of snow near the surface, and thus a weak formation of hoar crystals on the surface keeping the surface snow density high during the austral summer 2008.*

Page 18, Line 23: Should be "It results in an estimation..." .

*Change done.*

Page 18, Line 26: This sentence seems counter to the sentence two paragraphs above that "We can conclude from the absence of trend in sigma<sub>v</sub> time series that surface roughness has not evolved much between 2002 and 2009." Think that either the scale of the changes that are detectable, or more quantification of this trend is warranted. Or clarification of the contradiction.

*We think the two sentences are not in contradiction. The first comes from observations of the QuickSCAT satellite and concludes that a weak evolution of the surface roughness occurred between 2002 and 2009. The second concludes that in theory the backscatter coefficient can be reduced by an increase of the surface roughness, and thus the linear trend could be affected by changes in surface roughness if such changes were observed. We think that there is no high changes in the surface roughness between 2002 and 2009 as demonstrated by QuickSCAT observation stability. In addition, the surface roughness can have different effects on the two satellites (ENVISAT and QuickSCAT) for two main reasons: the different zenith viewing angles and the acquisition mode. The negative trend deduced from ENVISAT observations can also be over estimated by the Lacroix et al., 2008, 2009, relationships. To increase the clarity of the text, we remove the last sentence of the paragraph 5.4.3, and we add at the beginning of the paragraph "The surface roughness" in the section 5.5.2 the following sentence: "The radar backscatter is often reduced by an increase of the surface roughness (Adodo et al., 2018)."*

Page 19, Line 10: should have "the" in front of "authors".

*Change done.*

Page 20, Line 3: it is not clear what two faces are being referred to in this sentence, should clarified.

*What "on the two faces" referred to is too distant in the text. Thus, it is removed.*

Page 20, Line 18: should be "the azimuth angle would have no effect..." .

*Change done.*

Page 21, Line 3: should either be "passive microwaves are less sensitive" or "passive microwave is less sensitive".

*Change to "Furthermore, passive microwaves are less sensitive than active microwaves ..."*

Page 22, Line 3: delete "is" in front of "the frequency" and "the sensitivity".

*Change done.*

Page 22, Line 8: should be written "the minor impact on satellite observations has been previously discussed."

*Change done.*

Page 22, Line 10: "influence" should be "influences".

*Change done.*

Page 22, Line 16: this sentence is very confusing. Is it "either the number of layers with different dielectric constants in the snow or the amplitude in density variations"?

*The sentence is removed because it is confusing and do not provide significant new information. Indeed, the main idea we want to highlight is that the biggest effect of an increase of the density stratification on PR comes from an increase of the amount of internal reflections. That is explained in the page 22, line 18.*

Page 22, Line 24: is this an error, or do the authors intend to say that the figure is not shown or is it a typo from the editing program used? seems like you do not need to specify that you are not showing it.

*Removing "(figure not shown)".*

Page 22, Line 27: remains should be remain.

*Change done.*

Page 24, Line 9: should be "have highlighted".

*Change done.*

Page 24, Line 14: should be "snow precipitation over the East Antarctic Plateau is" not "are".

*Change done.*

Page 25, Line 5: should be "for making" instead of "to make".

*Change done.*

Page 25, Line 9: should be "was supported".

*Change done.*