The Cryosphere

Discussions

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Interactive comment on "Seasonal variations of the backscattering coefficient measured by radar altimeters over the Antarctica Ice Sheet" *by* Fifi I. Adodo et al.

Anonymous Referee #2

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The authors have in this study analyzed seasonal variations in observed radar backscatter over the Antarctic ice sheet from two different altimetry missions spanning three different frequency bands (S, Ku, Ka). They identify two clearly marked zones over the continent exhibiting different and common frequency dependent characteristic. Exemplified, with a peak in backscattered power in the summer for the S-band, in winter for the Ka-band and for both winter and summer in the Ku-band. They attribute the difference in the observed radar backscatter to the different bands sensitivity to volume/surface scattering. To quantify the governing parameters in the snow-properties at each frequency a sensitivity study was undertaken, which took into account the snow density, grain size and snow temperature using an electromagnetic model. I find the

contribution of the paper timely and interesting, as many of these issues are not deeply looked at in altimetry. However, if find some specific sections lacking in grammar and scientific explanations.

General comments:

(1.) The font needs to be increased on all figures, currently they are to small and the text is difficult to make out. Please, also put the units of each figure inside brackets, such as "/dB" to "(dB)". Add more text to the captions that provide more explanation of what they describe, or what to look for; what should the reader look at? This helps the reader, as they do not need to go back into the manuscript looking for the associated information. I personally don't like the use of yellow in the figures, as it is hard to see sometimes, but that I will leave up to you.

(2.) The latter part of the introduction needs to be reorganized, as it jumps between altimetry missions and snowpack properties.

(3.) I would also like the boundary of the two zones to be drawn on each map to easily identify them.

(4.) Further, you say that a major limitation of the work is the lack of knowledge of the surface roughness. Have, you explored the use of ICESat for this (good overlap with Envisat)?

(5.) I think the last paragraph in the conclusion (L.310-L.316) should be re-written to more clearly state your conclusions, as I don't agree with the statement that "This as "this study mitigates". This implies that you have somehow "physically" reduce the error or corrected for it. I think its fairer to say that you have pointed to important factors that has to be considered when choosing or selecting frequency bands for new missions. Further, I would like (ii) and (iii) to be slightly more informative; how should (ii) be interpreted and why does (iii) undergo large changes etc.

Detailed comments:

L.8 "altimeter" to "altimeters"

L.9 "snowpack" to "snowpack,"

L.15 "S, Ku and Ka bands" to "different frequencies"

L.16 "Ka-band" to "Ka frequency"

L.17 "In contrast, the cycle is dominated by the surface echo at the S band" to "In contrast, at the S band, the cycle is dominated by the surface echo"

L.18 "At Ku band, which intermediate in terms of wavelength between S and Ka bands, the seasonal cycle is in the first zone dominated by the volume echo and by the surface echo in the second one" This sentence is confusing what is the first and second zone? Also, you can remove the points that Ku is between S and Ka-band as it is redundant.

L.20 You say that seasonal and spatial variations should be accounted for, but how should this be done?

L.23 Remove "within"

L.23 "of polar" to "of the polar"

L.24 "changes in volume" to "the volume change"

L.29 "distance observed" to "observed distance"

L.30 "leading" to ", leading"

L.33 "called" to "called the"

L.35 "correct" to "corrects for"

L.36 Change to: "To reduce the effect of the spatially varying radar penetration bias"...

L.37 "use" to "used"

L.37 Zwally et al (2005) used elevation residuals (crossover differences) not elevation.

L.38 As far as I know Flament et al (2012) used a linear model, solved with OLS, to estimate the sensitivity gradients. Where does the non-linear relationship come from?

L.39 "the whole" to "all"

L.42 "of" to "in the"

L.44 "of" to "of the"

L.44 "penetrating" to "interacting with"

L.45 What information on the snow pack properties does it provide?

L.50 "The ENv…" This entire section and the SARAL/Altika section should be moved down

L.60 "The radar wave…" This section should be moved to L.49

L.66 "This study is structured…" Remove this section it's redundant the reader can already understand it from the headlines.

L.80 "vertical sampling resolution" to "range gate resolution"

L.82 "25 of February" to "25th of February"

L.85 same as L.80

L.86 remove "thus"

L.87 Rewrite sentence "The frequency ..." by remove ratios

L.95 "cycles of" to "cycles of Envisats"

L.97 "cycle sigma of" to "cycle of sigma"

L.98 "fitting the time series of the observations with the following function" to "fitting the observations with the following model"

L.103 "i is the index of the along track data" Comment: This needs to be explained more

thoroughly! How large are the bins (search radius). Can you also further elaborate on how you get the number of equations in more detail.

L.104 "leading to robust inversion" Comment: How is this a robust inversion? Do you edit the data (3-sigma)? I think you mean as you only have three parameters to fit? If so just remove robust and say you solve with OLS. Further, how was the gridding performed you need to elaborate on that.

L.108 "on snow" to "of snow"

L.110 "echo and" remove echo

L.111 "been previously..." to "been previously studied by Lacroix et al (2008)"

L.112 Remove everything after Remy et al. (2015)

L.114 Rewrite first sentence to something "The snow surface can be modeled as..."

L.115 "from rough" to "from a rough"

L.116 Change to "The effective dielectric constant of the snow is"

L.117 "of snow" to "of the snow" and "and ice" to "and the ice" and "prescribed" to "modelled". Remove "statistical geometries"

L.118 "height" Comment: Use either height or elevation

L.119 put "compared to the radar wavelength" into brackets, and add "," after "coefficients" and add "a" after "from".

L.120 remove "the roughness has" and "as follows"

L.122 "at normal" to "at the normal" and add "angle" after "incident"

L.125 Remove entire sentence "When the surface snow..." it's redundant.

L.149 Remove "all"

L.150 Remove "first"

L.168 "appears in yellow" Comment: I think you should draw the boundary of the area in your figures to allow the reader to easier detect them.

L.175 When using Julian days please also provide the months inside brackets

L.195 please change "dhds" to "dh/ds" (s=sigma)

L.203 Remove "the" before "snow" and put "it is poorly known" inside brackets

L.211 "on volume" to "on the volume"

L.212 "bands" to "band levels."

L.217 "volume" to "medium"

L.217 "Along increasing" Comment: Long sentence, should be re-written.

L.218 "which increases" to "which in turn increases"

L.222 "temperature wave" maybe to "temperature gradient" and replace "to the subsurface of the" with "into". Further change "The volume echo variation" to "The variation in the volume echo"

L.224 "echo increases" Comment: Increases in what; magnitude? Make clearer!

L.239 remove "that of"

L.244 "the increase" Comment: See L.224

L.247 "which one among . . ." Sentence is worded strangely; please re-write

L.256 Remove "which" after matches, replace "greatest" with "large" and replace "of" before "radarsat" with "from".

L.269 "the distribution" to "the spatial distribution"

L.277 "in blowed" sounds strange please change sentence structure or remove.

L.283 add months after Julian days and change "By blowing" into "Persistent winds" or similar

L.288 "highest grain size vertical gradient" to "the highest vertical gradient in grain size"

L.290 "difference observed" to "observed difference"

L.294 This sentence sounds strange, maybe start something like this: "This study, using 35-day repeat radar altimetry data, allowed for…"

L.295 "used 8-year" to "used an 8-year"

L.296 "band," to "band a" and "and 3-year" to "and a 3-year"

L.297 "band all" to "band" and "covering 2002" to "covering the time period of"

L.300 remove "on the AIS", add "with a" before "maximum" and "the" before "winter"

L.302 Remove "the" before "snow" and add "the seasonal changes in the" before "volume echo"

L.303 Remove "the" before "snow properties"

L.304 replace "because" with "due to" and "those properties" with "those parameters"

L.306 Remove "which is between the S and Ka bands"

L.307 "zones is" to "zones are"

L.308 "or not" to "lack of"

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