

Response to R2 on the submitted paper *From ice core to ground-penetrating radar: representativeness of SMB at three ice rises along the Princess Ragnhild Coast, East Antarctica*

The paper deals with an interesting and important topic, representativeness of point SMB observations in Antarctica. But it mainly uses data of ice rises, which are known to have a significant impact on precipitation amounts. This means that the context is different from what the reader could derive from the title, and the title and text should be changed to reflect this. See more detail in Major Comments below. The paper is also overly long and sometimes difficult to read, with rather long-winding sentences, and I invite the authors to attempt to write more concisely and shorten the paper. The figures are of good quality.

We thank the reviewer for their constructive review. We have addressed all comments here below and in the manuscript. To answers a few of the specific points raised here:

- We have modified the title in light of your and the other reviewer's suggestions to *Investigating the spatial representativeness of East Antarctic ice cores: A comparison of ice core and radar-derived surface mass balance over coastal ice rises and Dome Fuji*, so that readers are clear on the focus of our study.
- We agree that the paper is rather long but we wanted our work to be clear so that the same methodology could be applied elsewhere. We prefer to keep all the elements in the main manuscript rather than have a long supplement.
- We have gone through the manuscript and split long sentences for clarity (see marked-up copy).

Major comments

My main concern is the context and framing of this study. Upon first sight, the study is positioned as quantifying the representativeness of point SMB measurements. This implies that you are mainly interested in the impact of post-depositional processes (sublimation, drifting snow etc.) that introduce SMB differences in otherwise homogeneous terrain. But this is not so. The work compares ice core-derived SMB from the summit of ice rises to radar-derived SMB measurements in the vicinity and intersecting the summit. Ice rises cannot be considered homogeneous terrain. Several studies (e.g.: doi:10.3189/2014JoG14J040) show that ice rises cause important depositional (precipitation) SMB gradients, which are qualitatively well understood and modelled. In other words, nobody would normally claim that an SMB record of the ice rise dome is representative for its surroundings. And this paper shows this is indeed the case. This is different for Dome F, where the terrain is smooth, accumulation amounts are much lower, and the topographic precipitation effect is expected to be small. This is confirmed by the much smaller regional differences there. So the authors should include a discussion in which they motivate their choice for using ice rises to address the issue of SMB representativity, and how depositional and post-depositional signals can be disentangled.

We state explicitly in the last paragraph of the introduction that *The nine sites studied in this work were chosen because of their data availability and the grid-like design of the surveys which sample SMB in all directions over varied surface topography more homogeneously*. We have now added in the same paragraph that we *expect* ice rise to not be very representative of SMB spatially due to these SMB depositional gradients, as follows:

These eight sites can thus be easily compared. These eight sites can thus be easily compared. We do highlight that because of their topography, ice rises cause significant spatial variability of the SMB that is qualitatively well understood and modelled (Lenaerts et al., 2014). Ice core records from ice rises are therefore expected to be representative of a small surface area but it is important to quantify how small. Because ice rises are coastal with a simple ice flow regime and high accumulation, they have been strategic drilling sites that produce high resolution records. Consequently, ice rises will certainly continue to be drilled in the coming future and it is highly relevant to quantify their regional representativeness. The ninth site is the Dome Fuji plateau region which has a low accumulation rate and very gentle surface slopes as opposed to the coastal sites, where the orographic precipitation effect is expected to be small.

Finally, we have added a sentence to state explicitly that depositional and post-depositional processes cannot be disentangled using our method:

Note that depositional and post-depositional processes both reduce the spatial representativeness of the SMB signal but these cannot be disentangled from the method we outline.

l. 18: "However, these data clearly indicate that local spatial SMB variability must be considered when assessing mass balance as well as comparing modeled SMB values to point field data." Yes, but how must they be considered? By assigning an uncertainty to the observation?

Yes, that is what we suggest, and we now make it explicit in the abstract: *However, these data clearly indicate that local spatial SMB variability must be considered when assessing mass balance as well as comparing modeled SMB values to point field data and must therefore be included in the estimate of the uncertainty of the observations.*

l. 23: "rising specific humidity" It is not specific humidity, but the saturation specific humidity that will increase.

Modified.

l. 29: "The Antarctic coastal region is getting most of the accumulation due to source proximity and low elevation (e.g., Lenaerts et al., 2019)" Yes, but the main reason is topographic precipitation forcing, which also explains why local accumulation rates can be higher over the lower grounded ice sheet compared to the neighbouring flat ice shelves.

We agree and have modified our sentence to reflect this: *The Antarctic coastal region is getting most of the accumulation due to a combination of source proximity, low elevation and topographic precipitation forcing [...]*

Minor comments

l. 1: over – > of

Done.

l. 3: validate – > evaluate (this is about models, which cannot be validated by default)

We have used the word *assess* instead to avoid redundancy.

l. 8: "between annual and sub-decadal resolution": annual is also decadal, please make more concrete.

We have changed it to *yearly and multi-year*.

l. 14: areas – > area

Done.

l. 41: "In addition, it is not simple case of averaging many records in close proximity to reduce noise in ice core records". This sentence is unclear, please reformulate.

We have reformulated to: *And averaging many records in close proximity does not improve signal-to-noise in the ice core records [...].*

l. 58: "...and example their spatial variability referenced co-located ice core SMB". This sentence is unclear, please reformulate.

The sentence now reads: *In this study, we compile various radar-derived SMB datasets and describe their spatial variability referenced to co-located ice core SMB.*

l. 62: " multi-annual ". Can you be more specific?

We have changed it to: *where radar stratigraphy has a vertical resolution of a few years.*

l. 64: "lack of surface topography" Do you mean no pronounced surface topographical features? But ice rises can also be featureless. Please be specific and precise.

We have changed it to *and very gentle surface slopes.*

l. 208-214: Please consider presenting uncertainties with single decimal (i.e. 1.87 -; 1.9%).

We have rounded all uncertainties to a single decimal.