

Response to the Referee 1 comments (RC1 - Joshua Chambers) on manuscript TC-2020-51: Temporal and spatial variability in surface roughness and accumulation rate around 88° S from repeat airborne geophysical surveys

We use the following color and font coding scheme in our response:

Referee's comments

Response: authors' response to comments.

We thank referee Joshua Chambers for the positive general comments and many helpful specific suggestions. We have revised our manuscript accordingly.

Lines 94-94 – what is the normal annual layer thickness? An example and a citation here would be helpful

Response: There are two aspects to this question. The first one is whether the radar has sufficient resolution to resolve the layers and the second one is whether annual layers actually exist. We have reworded the sentence in lines 93-94: “At these low accumulation sites, preservation of reflection horizons is greatly reduced due to a slow rate of burial. Also, the ambient conditions required to generate seasonal reflections might not always be present (such as depth hoar).”

Line 106 – insert (sastrugi) after “distinct elongated snow surface features” and delete next sentence on line 107.

Response: done

Lines 131, 160, 182 & 185, 324 – ‘herein’ should be ‘therein’

Response: done

Line 134 – no need to define sastrugi again. This sentence can be merged with the following sentence.

Response: done

Line 160 – Merge Gow (1965) citation into previous citation, separated by a semicolon.

Response: done

Line 165 – change “Slope-dependent accumulation are” to “Slope-dependent accumulation is”).

Response: done

Line 188 & 191 – I guess by ‘3rd order polygon’ you mean 3rd order polynomial?

Response: We have replaced “polygon” with “polynomial” in lines 188 and 191.

Line 189-191 – did you test the different methods of detrending? If so, I think including a brief summary in the supplementary information would be appropriate; if not, I’d change the language (‘significant difference’ implies a statistical test was applied) and cite a study that has shown this to be the case.

Response: We have deleted the sentence.

Line 192-194 – you refer to range bins in the sentence before defining them in the next sentence. These two sentences can be merged.

Response: We have merged the two sentences.

Line 198 – how many points were discarded? Maybe include a value or percentage here

Response: 1.8% of the data points were discarded. We have added the percentage to the sentence.

Line 201 – include velocity value here for reader-reference

Response: The velocity of electromagnetic waves in air is approximately the speed of light in vacuum. We have added $2.998E^8$ m/s.

Line 203 – ICESSN doesn’t seem to be defined anywhere

Response: Correct. The ICESSN format was created in the early 1990s and information for what it initially stood for has been lost. ICESSN has been known in the community for over 25 years and is now used as a name, rather than an acronym. We have rephrased line 203 to clarify that: “For a closer look at temporal changes in surface roughness around 88° S we use the roughness estimates contained in the ATM Level 2 smoothed ice surface data product, known as ICESSN (Studinger, 2014, updated 2018).”

Line 235 – is the reason for discounting ice-dynamics related roughness just to be sure that features interpreted as sastrugi are sastrugi, for mapping wind direction? Otherwise, why make the distinction?

Response: As described in lines 129 – 134 surface roughness caused by ice flow has very different length scales compared to the features we describe here, which is the reason we are confident that these sastrugi are in fact wind-related. We reiterate this argument again in lines 234 – 236 of the initial manuscript.

Line 252-253 – if the dunes move ~60m in 34 years, would the ~7 m movement in 4 years make that much difference to the coverage of the data? Also, what kind of process moves the dunes, is it aeolian or ice dynamics?

Response: In line 251 we state “The temporal stability of megadune fields remains poorly understood.” To our knowledge there is only one published dune migration rate which is the 60 m in 34 years from Fahnstock et al. (2000), which is for a mega-dune field in the vicinity of Vostok and far away from the one we describe. If the underlying ice moves, the dune field on the surface moves with the ice. But dune fields can also migrate independent from ice motion, a process that is not well understood. Given the lack of satellite imagery at 88°S we don’t know what the migration rate of this particular dune field is but we have to at least consider dune migration a

possibility. We have described this in lines 252 – 253 of the initial manuscript: “Since our survey area is near the edge of the dune field we cannot rule out that over the course of 4 years the edge of the dune field has migrated out of the coverage of the airborne geophysical data.”

Figure 5 – do the semi-circular artefacts in panels (a) and (b) have elevation values, or are they no-data? (My eyes aren’t good enough to tell!). Do they affect the roughness values at all? Why do they not appear in (e)?

Response: We assume the reviewer means instrument-related elevation biases that are a result of occasional scan azimuth biases in the ATM instrument. The effect is described in Yi et al. (2015, DOI: 10.1109/TGRS.2014.2339737). These small elevation biases become visible over extremely flat surfaces and are of the order of several cm. We do not believe that they significantly impact our roughness estimates since the elevation range that defines the surface roughness is on the order of several tens of cm. These artefacts do not appear in panel (e) because the data shown here were collected with the Riegl scanner, a linear line scanner, which is different from the conically scanning ATM instrument used for (a) and (c).

Line 324 – units missing from slope value, i.e. slopes ≥ 0.002

Response: The quoted slope value from Das et al. (2013) is in meters per meter and is therefore dimensionless.

Figure 6 – Slope units also missing here, assuming the correct unit for MSWD is degrees?

Response: The slopes are in meters per meter and are therefore dimensionless.