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Interactive comment on "Subglacial roughness of the Greenland Ice Sheet: relationship with contemporary ice velocity and geology" *by* Michael A. Cooper et al.

Anonymous Referee #2

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This study estimates the subglacial roughness under the Greenland Ice Sheet by two methods (along track topography and radar scattering) using comprehensive radar data sets. While not new in the methods and results, this study complete previous studies by presenting up-to-date results for the whole GrIS. The roughness is compared to the observed surface velocities and to other geophysical informations.

The methods and data are clearly described. My main reserve is about the interpretation of the roughness in terms of sliding law and processes controlling the basal friction. The fact that the interior (slow flow regions) appears to be smoother than the margins (fast flow regions) is used to invalidate the applicability of the Weertman law to model

the basal friction conditions under the GrIS (Section 4.1, Page 13, Lines 4-16 and Section 5, Page 18, Lines 2-5). This discussion is rather hypothetic as, as you mention several times (e.g. page 14 lines 10-20), Weertman theory is based on the influence of the small scale rugosity (centimeters to meters) while you measure the topographic rugosity (at least with R). Moreover, in Weertman theory the sliding speed is function of the friction coefficient (depending on the rugosity, higher rugosity leading to higher friction coefficient) and of the basal stress. As the basal stress vary from place to place, it is not possible to draw conlusions on the influence of the rugosity using only the velocities. This would require to use an ice flow model to estimate the basal stress and correlate the rugosity with the effective friction coefficient.

From the abstract and more clearly page 14 lines 10-20, we understand that it is better to interpret the relation between the topographic rugosity and the velocity, in terms of erosion processes, and so the effect of the velocity on the topography. I think this should be clarified and the interpretations in terms of rugosity affecting the velocity should be let aside.

Also, I think it would be more clear if you give more details about what is known from the subglacial geology under the GrIS in the Introduction (e.g. introducing the volcanic province, the known igneous intrusions and other related geological informations).

1 Minor comments

- Page 1, Line 18: *primarily driven by mass loss over the grounding line [...]*; I think this should be rephrased to reflect the fact that the mass loss of the Greenland ice sheet is partitioned between increased ice discharge and increased surface melt. The exact numbers for the contribution of each component depends on the studies and time periods. It could be useful to include references to the most recent studies.

- Page 2, Line 22: reference to *Durand et al., 2011* is not appropriate in this context. Better to cite Gillet-Chaulet et al., The Cryosphere, 2012 for the inversion of the basal conditions under the GrIS.
- Page , Line 5: *the causes and controls smooth-and rough-beds [...]*. "of" missing between controls and smooth?
- Page 4, Line 6 and 7: *higher abruptness and associated*. "and" should be "is"? idem latter in the sentence *lower abruptness "is" associated with fine scale [...]*
- Page 6, Line 8: *to insure only independent measures of bed elevation were used*. Could you explain this?
- Page 6, Lines 17-24: Maybe you could illustrate the influence of L in Fig. 2, to show how sensitive are the results to this value?
- Page 6, Line 18: *for a length scale not less than 100m*. Could you explain this value of 100m for the lower bound.
- Page 6, Lines 23-24: *This repeated sampling approach for small* n *[...]*. I don't understand the meaning of this sentence.
- Section 2.2.2: I think you should include a discussion on the uncertainty on the flow direction especially for the 'slow' flow regions.
- Section 2.3.2: explain how A_{max} depends on the radar system.
- Page 9, Line 10: *[...] and then re-scaled amplitude on the interval [0,1]*. Explain the rescaling, Is it A/A_{max}?
- Figure 4: (a) and (b) x-axes have different units (ξ and ξ/λ) but same values (between 0 and 0.25), is this correct?

- Section Results and associated Figures; Please when you discuss specific areas in the text (e.g. Petermann, Humbolt, NEGIS, Camp Century, etc...) mare sure that the names are given in the corresponding figures, or include a figure with names of the places that are cited in the manuscript
- Section 3.2.1 and Figure 7: The fact that the mean velocity do not exceed 250 m a^{-1} for $R_\perp$ but is > 350 m a^{-1} for $R_\parallel$ is only possible because the spread of the velocity is larger in the bins for $R_\perp$? I think it could be interesting to use box and whiskers in Fig. 7 to discuss this? Idem for Fig. 8.
- End of Section 3.2.1, discussion on the anisotropy for slow flow regions: Could this be due to the uncertainty in the flow directions (cf comment above)?
- Section 3.2.2, Page 11, Line 30: $R_\perp$ should be $R_\parallel$.
- Page 12, Line 1: *Regionally, [...]*: include a reference to Fig. 10.
- Page 13, last paragraph: you seem to suggest that the smoother interior could have been produced by the waxing and waning of the ice sheet, however your results suggest that fast flow at the margin produces rougher bed, is this not a contradiction?

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