

## ***Interactive comment on “Dark ice dynamics of the south-west Greenland Ice Sheet” by Andrew J. Tedstone et al.***

**Anonymous Referee #1**

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This is an informative study that combines remote sensing measurements of albedo with regional climate modeling to identify some of the factors that are associated with dynamics of the dark ice zone in southwest Greenland. The study does not offer any definitive conclusions about the actual processes governing these dynamics. But given that our understanding of biological controls on surface ice albedo is in its infancy, I think the associations between variables that are described here constitute a worthwhile contribution to the literature. The paper is quite well-written and includes insightful, if sometimes rather speculative, discussion.

The issues I describe below may require a bit of attention, though they are generally minor. I should add that a very similar remote sensing analysis was presented by Shimada et al (2016), and it seems important that the authors of that study should

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review and comment on this study. From my perspective, the present study seems to adequately describe its results within the context of Shimada et al. Furthermore, a novel component of the present study is that it combines regional climate simulations with the remote sensing analysis.

General issues:

The fact that the JJA melt-out-flux (MOF) is universally negative (Figure 4C) leads me to question the utility of this quantity. It is argued that when this quantity is positive conditions are favorable for melt-out of particles and unfavorable for cryoconite hole formation. But since the quantity is always negative during the summer, and since there is evidence (?) for melt-out of particles during summer, this quantity does not appear to be a good predictor of melt-out conditions. If this reasoning seems sound, I suggest that the authors consider removing this quantity altogether from the manuscript.

Sensible heat flux is deemed to be an important correlated variable with dark ice dynamics. How closely does the sensible heat flux track near-surface (or lower tropospheric) air temperature? They may be closely linked over Greenland. Sensible heat flux should loosely track (1) the difference in temperature between the air and surface, and (2) the near-surface wind speed. Since the ice surface is always at 0C when melting, the temperature difference is governed exclusively by air temperature. It is unclear, though, how important the wind speed is.

The first paragraph of Data and Methods indicates that both MOD09GA and MOD10A1 MODIS reflectance/albedo products are used, but it is not clear to me which analyses and sections of the paper use which products. Please clarify this. Is MOD10A1 perhaps a derived product from MOD09GA, and it is really the former that is applied here? If so, please clarify this. Secondly, why is MOD10A1 used instead of other MODIS albedo product(s), like MCD43 for instance? Thirdly, please describe the native resolution of the MODIS data applied in this study.

p.4, line 29: "It is also noteworthy that R620-670nm straddles a transition zone be-



tween wavelengths mostly influenced by LAIs and wavelengths mostly influenced by grain evolution and interstitial water." - In that case, why is this wavelength chosen to discriminate dark ice (as darkened by LAIs), instead of a shorter wavelength?

The definition of intensity ( $D_I$ ) given on p.5 is slightly unclear to me. Is  $D_I$  the average reflectance over the entire common area, or the average reflectance of the "dark" pixels within the common area? If it is the former, then  $D_I$  is affected both by the extent and the darkness of the dark ice, and it is therefore not independent of  $D_E$ . Please clarify this.

The term "melt-out", as in "melt-out of particulates" is used frequently in this manuscript, but the precise meaning or process indicated by this term was at times unclear to me. I suggest clearly describing what is meant by "melt-out", at least at the first instance of its use.

Minor comments:

p2, line 6: "Surface melting is controlled primarily by albedo" - I agree, but it would bolster your case to include one or more references in support of this claim.

p2, line 18: "The GrIS-wide bare-ice ablation zone extent increased by 4.4% per year..."  
- Is this a relative or absolute (as in percent of whole ice sheet) change? I assume the former, but please clarify.

p3, line 22: Is it necessary that the cryoconite reside beneath a layer of meltwater for the albedo increase to occur? Perhaps the melt layer augments the change, but I suspect the hole depth is the more important factor for hemispheric albedo increase. You might want to add nuance to this statement.

p4, line 28: "precisely identify precisely"

p.5, line 18: "Only days in which at least 50% of the common area was cloud-free were included in the calculation" - And furthermore, were only cloud-free pixels used in this average? I assume so, but please clarify.

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p.6, line 4: "... equal-area 7.5 x 7.5 km..." - Earlier it is stated that model pixels are 600m x 600m. Please rectify this.

Equation 4: It appears that SHF is defined as positive into the surface, but please confirm.

p.7, line 13: "were been"

Figure 2 caption: "... the entire common area had  $D_I < 0.45$ ." - Just to be sure, do you mean that every pixel in the common area had  $D_I < 0.45$  (as communicated) or that the average  $D_I$  of the common area was less than 0.45?

Figure 2: What do the black triangles represent?

p.12, line 10: "...The only published measurements of black carbon on the GrIS are from the north-west (Aoki et al, 2014; Polashenski et al, 2015)" - This statement needs refining, as there have been BC measurements from elsewhere on Greenland, including, e.g., by McConnell et al (2007, doi:10.1126/science.1144856) and Doherty et al (2013, doi:10.1002/jgrd.50235).

p.13, line 2: missing citation

p.14, line 23-25: Please see general comment about relationship between air temperature and SHF. I am wondering if the two quantities referenced in this sentence are closely related to each other. If so, it would be worth commenting on that here.

p.15, line 14: "... versus concentration of algae ( $D_I$ )..." - Related to my earlier comment, is  $D_I$  a true measure of algae concentration, or is it also affected by the extent of the dark zone?

p.15, line 35: "across across"

In the figure captions, please describe the variables in addition to using their symbols.

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