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The Cryosphere Discussions

Interactive comment on "Dust from the dark region in the western ablation zone of the Greenland ice sheet" *by* I. G. M. Wientjes et al.

Anonymous Referee #2

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Dust from the dark region in the western ablation zone of the Greenland ice sheet.

By IGM Wientjes et al.

General Coments

The paper analyses the causes of the so-called "dark region" on the western side of the Greenland ice sheet. It concludes that the low regional albedo is related to the outcrop of dust-bearing ice in the region, and enrichment of the ice-derived dust by atmospheric deposition of particulates associated with anthropogenic activity, and by locally produced organic matter containing algae and cyanobacteria. Arguments for the localization of anthropogenic deposition and organic matter production are, however, speculative, and there is no quantitative demonstration that the causes invoked to

explain the dark region are sufficient to account for the locally low albedo in the region. The paper seems rather poorly informed about recent literature on microbial activity in cryoconites, and I found it overall unconvincing. I also wondered whether the group maybe lacked the geochemical and SEM expertise needed to fully interpret the data collected. With some further work the paper could make a useful contribution, but for now I recommend possible acceptance following major revision.

Specific Comments

On p2 (abstract) the authors state that dust and cryoconite are equivalent – this is not correct (also p3 last paragraph).

Provenance of dust (p2 and elsewhere) – it might be valuable to investigate the radiogenic isotope composition of the dust (Pb, Sr, Nd) for comparison with other ice core based investigations of dust provenance.

P3, line 2: "More knowledge. . .." – this is a very vague statement – whether or not "more knowledge" will be helpful in this regard surely depends upon the form that knowledge takes. More careful argument is needed.

P3, line 9 "showing a pattern that is typical for ice containing more dust. . .. – be explicit about what this pattern is.

P3, line 17: horizontal profile represents a time-line - yes, unless (a) basal ice is exposed in the profile, or (b) there is recumbent folding within the ice.

P4, para 2 - sampling was carried out in dark region and from "brighter ice" nearer the margin – why no sampling above the dark region? Potentially important as both meltwater and katabatic winds will transport material downslope

P4, para 2 – need to explain why grain analyses focused on mineralogy and elemental composition, as opposed to isotopic composition. Are these the optimal approaches for determining grain provenance – or just convenient?

P4, para 2: why not try to characterize the organic carbon, since composition likely has some bearing on its optical properties? For instance, Bhatia et al (GCA 2010) found that OM on the west Greenland ice sheet contained lipid-like and protein-like molecules, and also condensed hydrocarbons.

P5, para 2: Explain how samples were prepared for XRD analysis.

P5, para 3: previously (p4, penultimate line) it was stated that it was S8 that yielded small samples, not S7

P8, para 1: What is the basis for saying that the samples analysed "originate from a period within the Holocene"? Was the age of the source ice analysed – or even just characterized isotopically?

P9, para 1: explain why aluminum is used as the reference element.

P9, para 1: why are the results for SHR not plotted – even if there is only 1 sample?

P9, para 2: could abundance of metals like Cs, Pb, Sb and Hg in the dark region be linked to a tendency to bind to organic matter, which is relatively abundant there?

P9, para 2: what is the seasonality of dust deposition, and how might this affect the extent and manner of redistribution?

P10, para1: "all these different periods" – which periods are being referred to here?

P10, para 2: "higher accumulation rates" – of what? Dust or snow? I would use the term deposition for dust and reserve accumulation for snow.

P11, para 3: What controls the abundance of P – supply or degree of biological utilization

P11, para 3: pH of the ice. . ..in the cryoconite holes. What is meant by the "ice in the cryoconite holes"? – or do you mean the pH of the waters?

P12, para 4: why does the sharp-edged nature of volcanic grains indicate glacial trans-

port?

P13, para 1" enrichment of dark region with elements from atmospheric sources – could this be an issue of binding to organic matter, which is more abundant in this region? (rather than evidence for localized deposition of such material)

P13, para 2: organic matter in cryoconite has a high light absorbency – here is where there should be more detailed description of optical properties of OM cf those of the various minerals detected.

p13, para 3: by "meteorites" do you mean micro-meteorites?

P13, para 3: can't the elemental analyses help you determine whether there is volcanic material present? Isn't volcanic glass pretty diagnostic under an optical microscope? Doesn't it have distinctive optical properties? Is it really only Icelandic volcanoes that deposit material on Greenland?

P13, para 3, penultimate line: "outcropping" seems to imply an origin from within the ice sheets as opposed to from local atmospheric deposition. Is this intended, and, if so, why? "multiplying rapidly" – I don't see any basis at all for this statement.

P14, para 1: "age of the outcropping dust" – do you mean the age of the dust, or the age of the ice it came from ? I suspect the latter – if so, wouldn't it be worth at least analyzing the stable isotope composition of the source ice to see if it is of Holocene or Wisconsinan age? If you mean the dust – how could it be dated ? By OSL or TL perhaps – or would the dust be re-zeroed following surface exposure?

Editorial comments (page and line number)

2.2: A dark region tens of kilometres wide is found in the . . ..

2.3: " higher" than what?

2.4: by melting of outcropping ice. . .

2.7: unravel its composition. . .

2.8: material is indeed derived from the outcropping ice. . .

2.9: delete “Although. . .”

2.14: Earth’s. . .. . .cryoconite probably does not. . ...

2.21: they produce contribute. . ..

2.24: region that appears darker (in visible band satellite imagery) than . . ..

2.26: implies a lower albedo

3.1 “ enhanced” – relative to what? The abstract says melt rates here are lower than at the ice margin.

3.1: “force the low albedo” – I would say “account for the low albedo”

3.4: mass balance of Greenland – you mean of the ice sheet.

3.10: through melting of outcropping ice that contains old dust layers.

3.12: the dust is unlikely to be derived only from. . .

3.15: transported throughthe ice sheet. . ... and released in the ablation zone. . ..

4.3: Because the water in the cryoconite holes contains nutrients. . .

4.10: polymeric substances. . ...

5.10: studied using both an optical microscope and a scanning. . .

5.12: performed to. . .. . .composition of individual grains.

5.22: weight loss during decalcification.

6.6 with the exception of. . .

6.10: SEM revealed that. . ...

6.13: However, large amounts of these. . .in both the dark region and the reference ice. . .

6.16: is by settling. . .

6.19: However, grains transported together. . .should also accumulate there.

6.20: acute edged particles. . .. .grains suggests . . ..

6.21: grain-to-grain

7.2-3 sentence needs rewriting

7.10: Minor amounts of phyllosilicate were also detected.

7.12: coarser than that at the other sites. . .. . . Visual inspection. . .

7.15: the abundance of palgioclase and feldspar seems higher relative to that of quartz.

7.17: influx of wind-blown

7.18: It is also possible that some material. . .

7.22: because the dust from such sources consists mainly of quartz.

7.24: changes in the mineralogy. . .

7.28: consists mainly of. . ..

7.29: our samples do not. . .

8.1: Our samples are most similar to the. . ..

8.2: source for the dust.

8.6: They found higher. . .

8.23: which is 12:30

8.24: obtained in this way was used..

8.26: plotting element concentrations against. . ..

9.3: into two groups. . ..

9.10: but heavy metals such as. . .. . ..(Hg) also have larger. . .

9.19: due to uptake by. . ..

9.29: dust samples often show more variation

10.2: different distances. . .

10.3: delete “would have”

10.4: and is now outcropping. . .

10.6: as a possible source for the dust.

10.8: provides dust to. . .. . .in (which periods?)

12.2: the ice is covered by snow fro a greater proportion of the year. . .. . ..algal growth.

12.3: altitude on the. . . because of decreasing. . ..

12.7: contains coarser material than the other sites,

12.13: Takeuchi (2001)

12.15: We only found green algae in abundance at the higher elevations, suggesting that they could have been flushed away from the glaciers at the lower sites due t the higher melt rates and runoff.

12.20: As these granules are abundant in the dark region. . .activity certainly contributes to. . .

12.25: Using both transmitted. . . and electron. . .

13.1: derived from the outcropping ice, in both the dark region and the reference area.

13.7: much higher than in the area where the reference ice outcrops. It is not clear. . ..might play roles.

13.8: The TOC values found for sediment from the. . ..

13.10: caused by dust from the outcropping ice

13.14: delete “incidentally”

13.15: seem not to be present in the dust samples.

13.20: in ice deposited during glacial periods.

13.22: basally-entrained material. . .

14.1: dust from the outcropping ice, ice cores from several metres below the surface need to be analysed to avoid. . .

14.7: in which the dust settled on. . .

14.11: potentially important positive feedback. . ..

Figure 3: Why show Site 9 as it is not relevant to this study? Mark the upper limit of the dark region on this figure.

Interactive comment on The Cryosphere Discuss., 4, 2557, 2010.