

Article Title: MODIS observed increase in duration and spatial extent of sediment plumes in Greenland fjords

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Overview:

This paper provides a thorough study of river plumes over a 13-yr period in southwest Greenland, and compares MODIS-derived plume suspended sediment concentration (SSC) to observed and modeled runoff. The paper also provides a study on the effect of clouds obscuring plume detection. The authors find that metrics describing plume SSC and extent have increased over the study period, and that fjord-aggregated plume SSC is related to river discharge. This paper is well written and presents important and timely insight into sediment plume dynamics, and I believe that with mostly minor revisions and clarification of terminology and datasets it will be a valuable addition to *The Cryosphere*.

Comments:

- 1) Could the catchment delineations for the different rivers (or just for the three fjords) be included in Figure 1 (perhaps by using a larger scale inset map) or in a separate figure? It would help illustrate the statistics in Table 1 and inform the readers about the study region. Additionally, it would be useful to other researchers creating catchments in these regions.
- 2) In both the introduction and discussion, distinguish studies on sediment dynamics in rivers and plume sediment dynamics in fjords. On Page 6103, Lines 26, the previous studies refer to river SSC, whereas the Chu reference and this paper's hypothesis refer to fjord plume SSC. Include a sentence to transition the discussion from river SSC to fjord plume SSC. In the last paragraph on Page 6116, also clearly state whether references and results refer to river or fjord plume SSC.
- 3) I suggest reviewing the use of "truth" as the name of that dataset, and providing some clarification in dataset production. Perhaps define variables for the "truth" 13yr mean SSC dataset and the cloud-masked "truth" dataset. So is this "truth" dataset only spatially based on the 13yr mean cloud-free SSC (and is this the same as SSC_{msm} ?), with temporal variability derived from a scene-based I_s ? On Page 6111, Lines 3-4, is the range of y 1 to ~300? How many scenes were there on average per day? Clarify Page 6111, Lines 5-7: the range of which parameter was selected by tuning the "truth" SSC values to the range of MODIS SSC?
- 4) The annual fjord ROI SSC metrics play a large part in the analysis, and they should be introduced more explicitly and all together in Section 3.4. The last paragraph in Section 3.3 (Page 6111, Line 8) introduces $P_{>t}$ metrics indirectly as a means of exploring cloud bias, and they are explored more thoroughly in Section 3.4. I suggest reframing that paragraph as the first paragraph in Section 3.4 to introduce the variables $P_{>t}$ and t as important metrics for analysis of interannual plume area. Perhaps include a more descriptive title for Section 3.4,

such as “Plume extent and SSC metrics.” The variables can be defined earlier ($P_{>t}$ was not explicitly defined as the percent of available fjord pixels above an SSC threshold until Section 3.4). Metrics can be referred to by their variables rather than using difference phrases for consistency (e.g., $P_{>t}$ instead of “ROI metrics”, Page 6111, Line 24). It can also be stated more clearly that $P_{>t}$ and SSC_{msm} are computed from the 13yr mean cloud-free MODIS SSC dataset (distinguishing this from the “truth” MODIS SSC dataset).

5) Figures 6-8 and 10 are not referenced in the text.

Minor comments:

- 1) Page 6103, Line 2: Include citation for “mass loss has accelerated since the 1990s”.
- 2) Page 6103, Line 7: Liquid runoff occurs at marine terminating glaciers too. Instead of separating mass loss into marine- vs. land-terminating glacier regions, perhaps separate it in terms of solid ice discharge vs. liquid runoff.
- 3) Page 6103, Lines 25-27: Consider combining this reference with the Østrem (1975) reference (line 22) in a more general statement that a simple relationship is not always found between discharge and SSC. It makes the Fenn (1985) reference a nice cap to this discussion before transitioning to the limited but more positive results from Greenland.
- 4) Page 6104, Lines 16-17: Specify for river study areas.
- 5) Page 6104, Lines 18-19: Specify for fjord study areas.
- 6) Page 6104, Lines 19-22: Consider also including the broader goal of assessing how fjord SSC is related to proglacial runoff.
- 7) Page 6104, Lines 24-25: Should start with “Three major fjords...” since the three fjords are named and the paper is structured around the fjords.
- 8) Page 6105, Line 4: Is the CRESIS Jakobshavn dataset basal or surface topography?
- 9) Page 6105, Line 1-6: State the spatial resolution of these three datasets.
- 10) Page 6106, Lines 4-5: Suggested wording: “...each ~34 km in length...”
- 11) Page 6107, Line 6: Would be helpful to see the different drainage catchments.
- 12) Page 6107, Lines 7-8: State the larger size too.
- 13) Page 6107, Lines 8-9: Which catchment do you use for the rest of the paper?
- 14) Page 6108, Lines 6-8: Check sentence wording. Suggested wording: “Exelis ENVI 4.8 software, including the MODIS Conversion Toolkit (<http://www.exelisvis.com>), was used for

georeferencing, bow tie effect correction, and atmospheric correction (using dark object subtraction).”

- 15) Page 6108, Line 12: Was it only a linear shift?
- 16) Page 6109, Line 8: “We developed an SSC retrieval algorithm...”
- 17) Page 6110, Line 2: “...observations have provided...”
- 18) Page 6110, Line 4: “...presence of clouds compromises...”
- 19) Page 6113, Lines 2 and 6: spell out “years”.
- 20) Page 6116, Line 6: “...River plume, with a...”
- 21) Page 6116, Line 10: “Both the Watson and Umiiviit have...”
- 22) Page 6116, Line 12: “...while the Umiiviit metric was...”
- 23) Page 6116, Line 24: Remove comma.
- 24) Page 6118, Line 3: “...MODIS record is complex...”
- 25) Page 6118, Line 5-7: Perhaps comment on whether the fjord-aggregated mean plume SSC (since it does relate better to modeled runoff) can be used as a broad spatial proxy for runoff.
- 26) Figure 1: Include fjord names in the (a), (b), and (c) descriptions in the figure caption.
- 27) Figure 3 caption: Is the Scene Mean SSC the “truth dataset?”
- 28) Figure 4 caption: “masked with clouds” redundant” (b). State the day of year of this example image.
- 29) Figure 5: Can use “SSC_{msm}” or “melt-season mean SSC” instead of “Mean SSC” for consistency. Confusing caption wording, perhaps, “Percent deviation of annual plume metrics (SSC_{msm} and $P_{>250}$) from “truth” dataset was used to constrain...”
- 30) Figure 9: Larger font in figure labels.