The Cryosphere Discuss.,
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The Cryosphere Discussions
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Interactive comment on "Surface emergence of glacial plumes determined by fjord stratification" *by* Eva De Andrés et al.

Anonymous Referee #1

Received and published: 28 February 2020

GENERAL COMMENTS:

Using ocean observations from two successive years in combination with the commonly used buoyant plume model, De Andres et al. (2020) show that increased ocean stratification can explain the absence of a surface plume in a Greenland fjord during a high runoff year. They go on to generalize their results using the model, hypothesizing that due to the sensitivity to stratification, increased meltwater discharge may in fact act to suppress the vertical extent of glacial plumes and limit their surface expression.

In general, I found this to be a well-reasoned and well organized paper. The methodology is appropriate, the line of reasoning is clear, and the limitations of the study are acknowledged. I believe the key point made in this paper is of relevance to many aspects related to tidewater glaciers and glacial fjords, and should therefore be of in-

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terest to readers of The Cryosphere. I recommend the publication of this manuscript with some modifications, which I have outlined below.

SPECIFIC COMMENTS:

1.

I missed a discussion of the effect of the choice of entrainment coefficient. Quite a large range of values are used in literature, and I suspect that this parameter might have a strong impact on NBD/MHD.

The value used by the authors is not unreasonable, and I do not suggest that an extensive sensitivity analysis is necessary. However, their choice of 0.09 should be justified, and it should at least be discussed how another choice of entrainment parameter might influence the results.

2.

Section 3.1.1. is very short despite the fact that it provides the key observation motivating the study. It should be extended to provide some additional information, directly or through references: Is there more evidence beside these three photographs for the prescence/absence of a plume? Approximately how far did the plume extend along the glacier and into the fjord when it was observed? Was the glacier terminus was located in approximately the same position during 2012 and 2013?

Without a spatial scale in Figure 4 it is also somewhat difficult for a reader to compare the three photographs - please add some sort of reference to the extent of the plume, and ideally to the scale of the images.

3.

Line 275: Please elaborate on how agreement between model and observation is improved in this study compared to these previous studies.

4.

Section 2.3, which describes the methodology wrt. the plume model, should be made clearer. Please provide appropriate references to easily direct the reader to the exact set of equations and parameter values used here, and state explicitly what exactly is meant by "running the plume model" in Section 2.3.2. Are the equations numerically integrated using the observed T/S profiles as boundary conditions? On Lines 99, 107 and 111 the authors refer to Slater (2016) for a description of the model: however, this paper only explicitly contains the plume equations for a half-conical plume, and furthermore discusses both numerical and analytical solutions.

Please also specify the plume water properties with which their plume model was initialized.

5.

It is stated on Lines 123-125 that Qsg and W are both varied at set intervals. Is it not it the combined value Qsg/W that impacts the model, or do these quantities also come into play individually in some other manner? Please clarify.

6.

As far as I understand, it an assumption of the line plume model that the discharge is distributed over a wide enough area that the side interfaces of the plume can be neglected. Using the line plume model with a 10-m width (Line 124) seems likely to violate this assumption. Please justify the use of a line plume model with W as low as 10 m, or acknowledge this as a limitation of the study.

7.

Section 1: This is an excellent introduction section!

8.

The first paragraph of Section 4.2. should be moved to Results, e.g. merged into Section 3.1.2.

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9.

Section 2.3.3. should also briefly state how the integrated melt rate is calculated.

10.

Line 284: Please elaborate on, or provide a reference for, why there is a characteristic "plume distance" that might be approximately equal to the grounding line depth.

11.

Line 360-362: This is not new, please remove or modify to reflect that this is in line with previous studies.

12.

Line 371-377: The modelling experiments seem to suggest that the maximum plume height in July 2012 was only a few meters below the surface - I think this should be acknowledged when the reduced nutrient fluxes to the photic zone are discussed.

13.

Line 406: Please explain here or around Line 235 why the jet might be more diffuse in 2012 (reduced stratification?).

14.

The map figure (Figure 1) should be made visually clearer and perhaps used to clarify the description of the study area (see the comment below). It is a little difficult to differentiate between ocean, lakes and land, as well as between sea-ice covered water and glaciers, in the current figure. If possible, I suggest superimposing coastlines in a distinct color.

15.

It was not entirely clear to me from the figure and the text how far the area referred to as SF in fact extends. The text can be read as meaning that SF extends all the way to

the sill near the opening to JI, but the placement of the SF and TF labels in Figure 1 makes it a little unclear e.g. whether the area between the two sills belongs to SF, TF or to the unlabelled fjord to the right. There also seems to be a discrepancy between the length of SF between line 57 (35 km) and line 61 (15 km). Please clarify.

TECHNICAL CORRECTIONS

There are many inconsistencies in the use of past vs present tense throughout the manuscript - I recommend sticking to one or the other through each section.

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Abstract: "Ice Sheet" should be "ice sheet" or "Greenland Ice Sheet".

—-

Line 61: Missing space after "(2019)."

—-

Line 106: "tidewater face" should be "glacier face"?

—-

Section 2.3.3: Please specify that the N2 used in the scaling is the mean stratification of the upper layer (not the entire water column) if that is the case.

—-

Line 170: Should 0.11 s-2 be 0.011 s-2? It should also be clarified that this refers to the *maximum* of the mean N2 profile if that is the case.

—-

Line 192: This sentence should be revised for clarity.

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Line 204: please specify: "while it did in July 2013" if that is the case.

—-

Line 217-218: Exponentials should be in superscript.

—-

Line 219: Unclear what is meant by this sentence ("Our goal is to identify the model parameters.."). What model parameters are you referring to exactly? Please clarify.

—-

Line 231: "sigma_theta" should be "theta"?

—-

Line 235: "Properties" should be replaced with e.g. "waters".

—-

Line 247: For clarity, please replace "stratification" with "N2" or " B-V frequency squared", etc..

—-

Line 283: Missing "the" before "plume model".

—-

Apparent discrepancy between Line 310 on one hand and Line 248/Figure 11/Table 1 on the other. The latter say the exponent is 0.24, the former says it is 0.26. Please correct or elaborate.

—-

Line 329: There already seems to be strong variability. Do you mean "increased" variability?

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—-

Line 368: The meaning of "reaching the fjord surface less" is not clear. Please revise this sentence and clarify.

—

Line 380: Should be plural: "act as atmospheric CO2 sinks".

—

Figure 2: Please revise the colour scheme used in this figure. It is currently difficult to distinguish the black points from the background in the figure on the right. I suspect the figure on the left would be challenging to colorblind readers. I also recommend labelling the subfigures a and b.

A scale bar should also be added to this figure.

—-

Figure 5 caption, first line: should "density" be "potential density"?

—-

Figure 5: I cannot see the horizontal dashed lines referred to in the label.

—-

Figure 7ab: I assume the contours are isolines of sigma theta? They should be explained in the figure caption.

—-

Figure 8: I would suggest replacing the x-axis units (DOY) with dates, as it would make for easier comparison with the rest of the manuscript.

Ctot and C1 in the figure caption should be formatted with subscripts.

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Figure 9: Please specify exactly what the vertical shaded regions represent (one and two standard deviations? standard deviations for the two different years?).

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Figure 11a: Please add some information indicating the location of the surface and the top layer here - e.g. as horizontal lines in the plot or as a second y-axis showing "depth below surface".

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