

Interactive comment on “Dynamic response of an Arctic epishelf lake to seasonal and long-term forcing: implications for ice shelf thickness” by Andrew K. Hamilton et al.

Anonymous Referee #2

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Hamilton et al. present a novel investigation of the last known Arctic epishelf lake system, trapped between the Milne Fjord glacier tongue and proglacial ice shelf. The authors collected CTD, remote sensing and meteorological data on a range of timescales in order to determine what factors control seasonal and interannual lake extent and halocline depth. They then use the halocline depth record to reconstruct ice shelf thickness and state changes through time. The paper convincingly demonstrates a need for constraints on epishelf lake seasonality, hydraulics and fresh water budget in order to use halocline depth as a proxy for ice shelf thickness change. After taking these factors into account, the authors conclude that the lake and ice shelf are shoaling at an increasing rate. The lake could disappear within the next decade at the current

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rate of ice shelf (ice dam) thinning.

In general, the paper is well written with precise, detailed and logical arguments. The authors present the best kind of process study – they describe the system in great detail with observations and then investigate the system’s dynamics with simple, clear models and supporting math. In summary, I think the paper is well suited for publication in The Cryosphere.

However, I would like to raise several points that, if addressed, would strengthen the paper presentation and science. I hope these issues are straightforward – most are relatively minor. I follow these points with a small number of line edits.

First, the authors could perhaps be more careful in clarifying whether the epishelf lake depth is a proxy for mean ice shelf thickness or only the ice dam/basal channel area. Perhaps this difference is worth stating up front in the introduction? On a related note, the authors discuss (on page 27, second paragraph) the large spatial heterogeneity in ice shelf mass balance measured over the last few decades. The inner ice shelf (closest to the glacier) thinned an order of magnitude more than the outer shelf – potentially from differential submarine melt. However, the authors attribute lake shoaling to surface ablation, which would affect the ice shelf more homogeneously. Does this change the interpretation? Is most of the ice shelf responding to surface melt or basal melt?

Second, while the paper presents a succinct and convincing correspondence between seasonal lake (halocline) depth and PDD – the freshwater budget in section 4.2/4.4 would be strengthened by more explicitly considering inflow from submarine melting of the ice tongue, lake ice or ice shelf. Much of the ice tongue and ice shelf draft is above the halocline, which could result in large ambient melt fluxes, particularly as the lake warms in summer. It would be good to acknowledge/quantify this affect, or show that it does not have a significant role in setting lake stratification.

Third, section 4.4 notes that the majority (likely more than 70%) of meltwater runoff

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enters the fjord as subglacial discharge. As freshwater, subglacial discharge will rise buoyantly to the halocline, possibly contributing to seasonal lake lowering and/or driving turbulent entrainment and submarine melting of the ice tongue. Can this process be more fully appreciated (mentioned) or discredited?

Fourth, as sort of an aside, I'm interested in understanding why the inner ice shelf (closest to the glacier) is the first to break up. This must be a consistent pattern in creating epishelf lakes. Through what mechanism might this occur? Is it due to glacier retreat?

Line comments:

Page 4, line 6 in 3rd paragraph: "an region" should be "a region"

Page 6, line 28: Move "We present this data" to the start of the sentence to make it more clear.

Section 3.1, first paragraph: It might make things smoother to state you'll investigate these factors with more detail in the sections that follow.

Section 4.1, third paragraph: Are large calving events and their oceanographic signature observable at other times in the record? It would be interesting to see.

Section 4.4, line 19: "across" and "at the bed" could be taken out in favor of "the fjord at the grounding line of the Milne Glacier..."

Figures: Figures 1, 2, 4, 6, and 8 could use larger label sizes similar to those in figures 3 and 5.

Figures 2 and 3 should have coordinates for reference.

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