

Review of Savignano et al., 2026

EGU-2026-1396: Temporal evolution of the Petermann Ice Shelf estuary constrained by remote sensing observations

General comment

The manuscript describes an innovative remote sensing technique for exploring supraglacial channel incision rates in ice shelf settings. The authors calibrate an optical water depth retrieval method with IceSat-2 data in supraglacial lake settings, before applying the method to the Petermann Ice Shelf estuary to calculate bathymetry and incision rates of the river channel in 2014 and 2016. They use their incision dataset, combined with manual interpretation of optical satellite imagery and modelled runoff data, to discuss the timing, evolution and persistence of the estuary between 2013 – 2018. The manuscript is well-written and has a clear and logistical structure. The data is excellently presented, and the figures are clear and easy to interpret. However, I have some methodological and data interpretation concerns which require addressing before publication. I would also encourage the authors to provide more discussion on the wider relevance of their findings.

Main comments

- 1) My main methodological concern is whether a relationship derived for supraglacial lakes is suitable for application in a river channel setting, where the water is much deeper, and contains a mixture of freshwater and seawater. Optical depth-reflection methods for deriving supraglacial lake depths have been shown to work reasonably well for shallow lakes, but typically lose accuracy with deeper water. Supplementary Figure 3 shows that out of the 12 supraglacial lakes used to derive the IceSat-2 optimized formula, nine lakes have a maximum depth of one metre or less. None of the lakes have a maximum depth greater than ~2.5m. By comparison, Figure 7 shows that the channel depth is often greater than 8 metres deep. This raises the question of how accurately the method works for deeper water. I would like the authors to provide some reassurances relating to this, justifying why they deem the transferability of the method to be appropriate.
- 2) The incision dataset does not appear to support some of the interpretation made relating to estuary formation timeline (Section 3.2). The authors state that the estuary was '*present for the majority of the 2016 melt season*' (Line 368). This conclusion is based on visual interpretation of Worldview images, where it is stated that all images after 7th July confirm the existence of an estuary (Line 324). However, Figure 7b shows that the channel didn't incise below sea level until 15^h August at Transect 0, which is almost at the ice-shelf/ocean boundary (hence presumably key for determining the timing of estuary establishment). On 7th and 13th July the channel is shown to still be above sea level. Is there a reason for this inconsistency? Presumably once channel incision becomes close enough to sea level, diurnal tidal range causes sea level to fluctuate between above/below the channel lip? I think more clarification and explanation on this is required, as the relative timings of estuary formation and

persistence are central to most of the discussion. I also suggest adding the Worldview images for 2016 to the Supplement.

- 3) The main stated motivation for the work is that the formation of ice shelf estuaries via supraglacial channel incision might inhibit meltwater export and reduce ice shelf stability. However, there is no discussion of the wider implications of the work presented – it is only really mentioned in a line or two in the conclusion. Given you have constrained the timings and evolution style of the estuary over several years (thus extending the work of Boghosian et al., 2021), can should discuss how important you think the estuary is for ice shelf stability. For example, how much seawater is actually getting into the channel? Is seawater intrusion necessarily preventing simultaneous meltwater export, or could both be happening at the same time? Is the estuary currently having any effect on ice shelf stability given how spatially and temporally limited (Fig 6 & 7) the seawater intrusion is? I realise in-situ or modelling would be required to answer some of these questions, which is likely outside the scope of the study, but I think there should at least be more discussion of these sort of ideas.

Line-by-line comments

Line 37: This is an odd sentence as it gives no timescales for former ice shelf extent – I'd just state the present day percentage or area that is buttressed by an ice shelf.

Line 39: Be clear if you are talking about Antarctica, Greenland, or both in relation to projected melt increases.

Line 122: The maximum depths of Ponds 2 and 8 are 2.5 m and 2 m respectively (Supplementary Fig 3). Unless I have misunderstood what is being shown, Figure 7 shows that water depth within the river channel typically ranges between 6-9 m. They therefore do not have 'very similar depth', which you go on to say is important for calibrating the depth model. See Main Comment 1 for more details.

Line 162: I'm confused by the need for identifying water-marginal pixels. Is this not just your lake outline? Is two-pixel width to allow for error in the lake outline mapping? Please clarify.

Line 228: In the example shown in Figure 5, the original DEM (dashed line) shows the same elevation either side of the lake. In this example, it is therefore obvious what elevation to take as the smoothed lake surface. Did you have some lakes where the two sides of your lake outline didn't match in DEM elevation? If so, how did you select what elevation to take as the lake surface?

Line 255: Do you remove sea ice pixels from within the channel that fall along either the cross-sectional or longitudinal transects? The presence of blocks of sea ice within the channel would presumably impact bathymetry results if not identified and removed prior to data extraction.

Line 284: I'd avoid using the term 'downstream' and 'upstream' given the potential for flow reversal!

Figure 6: This figure shows that even by mid-August, only the very end of the channel (~100-200m) gets incised enough to drop below sea level, and even then only by a few centimetres. Do

you think the amount of seawater that is currently getting in actually enough to do anything to the ice shelf? I'd bring this into the discussion.

Line 324: See Main Comment 2.

Figure 8: This is a really nice figure! I'm a bit confused by some of the time bar colourings though – for example, in 2017 and 2018, why does the coloured line turn red (indicating confirmed estuary presence) before you have a red circle indicating a cloud-free image? How do you know there was an estuary before this? Similarly, what marks the end of the timeline for each year – do you just assume that the same conditions persistent until mid-September as observed in the last cloud free image? Can you please also add a scale for the Worldview images.

Line 371: When you say that estuary formation '*inhibits efficient meltwater export to the ocean*', do you mean it stops it entirely? Or is it possible that lots of meltwater continues to flow out into the ocean, even if ocean water is also getting in?

Line 382: The image you show in Figure 8e is taken on 1st September 2014. So how do you know that the estuary persisted for the rest of the month if you don't have a later image?

Line 389: It would be useful to see these images in the Supplement, given they seem to contradict the timing of channel incision dropping below sea level (see main comment 2).

Figure 9: This is another really nice figure!

Line 415: This is a really interesting point, which I feel needs more discussion. Estuaries are only likely to form on thin ice shelves where the freeboard is relatively low, and where supraglacial melt is high (i.e. turbulent melt channels that can incise). At the point at which the freeboard is low enough that supraglacial channels can incise to below sea level, it's likely that the whole ice shelf area has already been weakened substantially by surface meltwater ponding and hydrofracture, and could already be near to collapse. Could this potentially limit the importance and impact of these estuaries? i.e. By the time an estuary forms, the ice shelf may be near to collapse already. Does the fracture that appeared in 2018 mean the river no longer reaches the ocean? If so, could large supraglacial channels elsewhere also be impacted by ice shelf fracturing, precluding the potential for estuary formation?

Line 451: Data availability is mentioned as a limitation in terms of image acquisition, but I think you need to also mention that WorldView data is not open source. This is likely to be a major limitation on who else within the research community can implement this method.

Supplementary Figure 6 & 7: Why does the tidal correction change the elevation y-axis from 20-30m down to 0-10m, given the tide only changes water level by a maximum of ~2m?