

## **Review of “Speed-up, slowdown, and redirection of ice flow on neighbouring ice streams in the Pope, Smith and Kohler region of West Antarctica”**

Selley et al. document a velocity change in 8 glaciers that feed the Dotson and Crosson ice shelves over a recent 17.5 year period. They found most of the glaciers accelerated, with the exception of one tributary, Kohler West, which slowed down. This resulted in a change in the location of the ice divide separating the two ice shelves. The authors infer one step further and suggest the change in the mass flux into the two ice shelves contributed to the disintegration of part of the Crosson ice shelf.

The Amundsen Sea Embayment is a “hot topic” for Cryospheric studies due to the warming of the region and the sea level rise potential of the outlet glaciers. This study contributes unique findings on the less studied glaciers of the region (relative to Pine Island Glacier and Thwaites). However, some issues need to be addressed prior to publication. Please see my comments below.

### **Major comments**

Structure of the text:

I found that several areas of the manuscript text needed more clarification or slight reorganization.

Section 2.1 is highly detailed. It is refreshing to see the intricacies of the analysis; however, it is not necessary to include everything described in the main text. I suggest including the specifics in the supplemental information and keeping the main text clear and concise.

Section 3.3 the possibility of “ice piracy” and its relationship to other “ice piracy” events. This is a fascinating topic and I believe this would fit much better in the discussion. Most past papers on ice piracy have invoked changing subglacial hydrology, but I think using the term here is fine. Notes posted in the marked-up text suggest a few additional references.

The discussion requires more coherent organization and clearer key take-aways. There were many aspects of the results that felt thrown into the discussion (e.g., Lines 218-220 – this observation should be mentioned in Results first). I suggest reorganizing the paragraphs into three main sections: Long-term trends – where you compare to PIG and MISI; Short-term periodicity – where you discuss the variability in the velocity on the annual scale and potential causes; and the connection to Dotson/Crosson – the “ice piracy” event, movement of the ice divide, and the subsequent deterioration of Crosson. It would also be interesting to see more information in the discussion about the ice shelf ice front and the rift propagation, and any connection between those results and the velocity results.

A quick note on the short-term periodicity – could it be driven by ungrounding of the numerous ice rises in the Crosson-Dotson (especially the latter) system? It is important to entertain the other possibilities that it is not related directly to the ocean dynamics – without more oceanographic observational data in this local region and time period. It seems far more likely to me that the loss of the pinning points, indirectly related to warm ocean conditions at depth (and

not necessary linked to ocean circulation events at PIG) are the cause of the rapid speed-up periods.

Regarding the very interesting “ice piracy” event - it would be beneficial to include more information about the thinning that occurred specifically during the period of the ice flow change. Additionally, it would be advisable to discuss the widespread thinning throughout the region and why the diversion of flow did not happen there.

I also found the font to be blurry on most of the figures, I suggest making sure the plots are of a higher DPI (300 minimum), especially in the supplemental figures.

Figures:

The figures in the text show a lot of important information, but are a bit hard to follow in some cases. For all of the figures that show spatial data it would be better to move the legend scalebar into each respective panel -- following which scale bar belongs to which panel takes significant effort.

Figure 1: I suggest making each panel larger to fit more information on the panel itself. For example, each panel needs a label and legend. I suggest moving the profile line labels/glacier names so that they are more clearly associated with each profile line. I'm not sure the ‘bed topography data is very useful – it does not show up under any ice-covered area (where it would be more interesting – either it should have its own panel or perhaps just remove it. If you keep it, re-consider the scale – perhaps just -3000 to 0 meters is adequate? The 0-25km scale should be located on one of the panels. I suggest including an Antarctica overview map in one of the inset panels (preferably with ASE and PIG labelled since you discuss these in detail). The period of the “rate of speed change” should be labelled on the panels

Figure 2:

I suggest labeling the profile in 2b with ‘Grounding Line profile’, and also increase the size of the font of the glacier names and center them on the panels. You can gain space for your graphic panels by putting the labelling letter inside the panel (e.g. bottom left corner). The ice speed legend could be inside panel A. Panels C-J could be expanded to be the same size as the upper two panels (see below – red arrow) and tighten the spacing between panels C-J. Make the “distance along gate” legend larger (now that the scale bars are moved), and change “gate” to profile. In legend, “surface” and “bed” could be on the panels themselves to make the figure space more efficiently used.

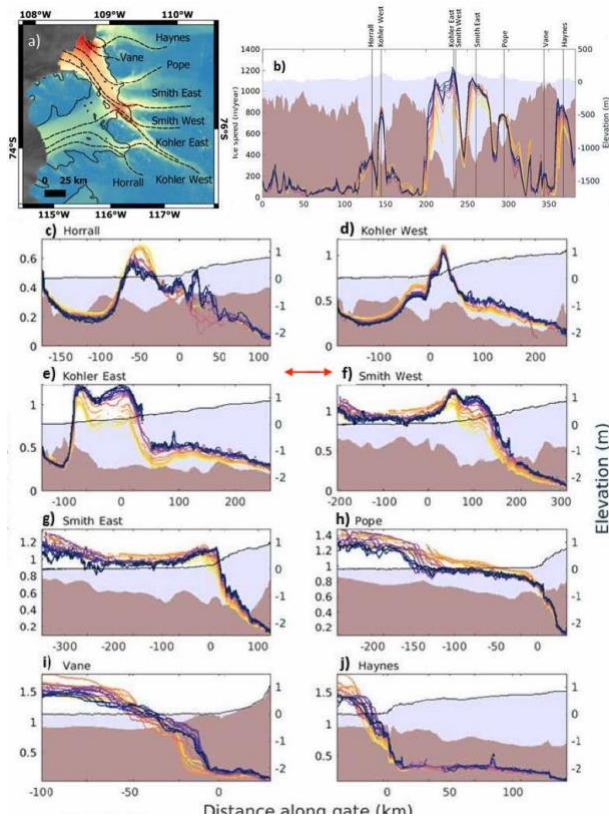


Figure 5 – The calving front is difficult to distinguish for Crosson, especially in the north west corner. I suggest a zoomed in inset. The scale bar legends should be placed into the panels and Panel B made larger. The rift time series could be labeled with the year instead of the color bar (It would be clearer this way and since there are only 7 years and it won't take up too much space – especially when you make the panel larger). Scale bar is too small – make a bit longer and less bold (0-50 km? with ticks instead of a solid black square). I suggest labeling Bear Island on both panels. Place panel label “B” in top right corner to match panel A. Specify panel B is the orange rectangle in panel A.

Figure S1 – Please see the comment about the DPI quality of the figure. I also suggesting aligning the legend scales with the respective panels. I am wondering how panels H-J are different than Figure 4?

### Minor comments

There are more significant figures than can be justified - rounding to the nearest 10<sup>th</sup> for the error and velocity measurement would be better.

Line 26: I suggest including a definition of MISI.

Lines 30-36: I think it is better to introduce dynamic details after the introduction of geography of the area. See comment in general comments. Also, A newer paper by Clark et al., 2024

provides further support for the 1940s kick-off for ice loss  
<https://doi.org/10.1073/pnas.2211711120>

Lines 41-42: It would be better to include this before line 36 before talking about Kohler dynamics. Throughout this paragraph I suggest to only use East and West *Glacier Name* instead of alternating between East/West/Singular Glacier Name. It is unclear which tributary of the glacier stream you are referring to when you only use the singular name.

Lines 42-43: I suggest adding rifting detail “ice shelf has extensive rifting, particularly on its eastern side” after line 43-45.

Line 45: I suggest revising this sentence “Kohler West Glacier and the Dotson Ice Shelf into which it flows have changed less over the last 30 years” to – “Kohler West Glacier, which flows into the Dotson ice Shelf, have changed less over the last... attributed to the prograde slope..”

Lines 45-50: I suggest revising these sentences as the structure is a bit confusing.

Line 51: I think you mean this ‘...speed change since 2015 is not well characterized, and....?’

Line 55: for 17.5 years from 2005-2022.

Figure 1 caption – I suggest shortening the figure caption. For example, “Average 2015 to 2022 ice speed over the PSK region, measured using interferometric Wide (IW) mode synthetic aperture radar (SAR) data acquired by the Sentinel-1a/b satellites.” It would be sufficient to say “Sentinel 1 SAR derived averaged ice speeds over PSK region from 2015-2022.” It is also not mentioned where the velocities from 2005-2015 come from – I thought they were from 2005-2022? It alternates throughout the text, please be consistent. Additionally, please write the dates with backslashes or dashes instead of periods. The periods make it look like a number and not a date. Please fix this throughout the text. As a quick note, if you include the method of measurement for one panel in the caption please then do so for the others – however, I suggest not including it in the caption and reserve the details for the manuscript text.

Line 69: “which” should have a comma beforehand

Line 70: Here you list features and then say “stable amplitude variations”, which is not a feature.

Lines 72-74: I suggest including this in the supplemental information.

Line 76: I suggest changing to “...and signal propagation speeds in the ionosphere... etc”

Lines 78-79: please report the lowest error and average error. Additionally, Figure S2 was not referenced before, so I suggest changing S3 to S2 and correcting the text and supplemental information to have the correct figure numbers.

Figure S3: Please clean up the figure and follow suggestions made in Figure 1 and general comments (e.g. legends, scale, etc. also, the lat/lon does not need to have the minutes or seconds included as they are all 0. Keep it simple and clear).

Line 83: I am wondering which reference speed map is this? How is it different than the MEASURES data also used? I suggest restructuring the sentence to include “First” so it matches the rest of the paragraph.

Line 84: I suggest removing passive voice (ie. rewrite as: “we remove..etc”)

Line 104: See comment about dates.

Lines 110-112: Can you comment on the limitations of only using imagery from 1-2 months of the summer season?

Line 117: There is not a Figure 1E.

Line 121: You use both flow units and ice streams here. What delineates a “flow unit” if not an ice stream? Please use consistent terminology. Additionally, what is meant by ice streams penetrating 75 km inland of grounding line? What happens after that?

Line 125: Which part of the time series was used for the averaging? I also suggest putting these circles on Figure 1 or in a supplemental figure. It is also not clear which grounding line was used for this calculation as many are possible according to your Figure 1D.

Line 127: I suggest adding “Kohler Range” to your map so the reader knows exactly where this is relative to the glaciers.

Lines 125-130 and throughout the text: “respectively” should go at the end of the sentence.

Line 128: To focus purely on the glaciers, I suggest removing the clause “to the east of Crosson ice shelf.”

Figure 2 caption – see suggestions for figure 1 caption.

Table 1 – I suggest adding which ice shelf the glacier feeds in the “region” column. I suggest bolding the glacier that slowed down (lines 136-137).

Section 3.2: It is not clear why comparing 2005-2022 and 2015-2022? Why is the percentage speed change the best way to report these results? I also suggest adding a sentence about how you calculated the change in speed in the methods or supplemental information. Also, is the rate of speed change from 2005-2022 including the Sentinel 1 velocities or only the measures product?

Line 151: Can you specify what you mean by increased 1.5 times from 2015 to 2022? Also, there is a not a 2005-2015 mean in Table 1.

Line 152: I suggest using a different word than “around” in this context.

Line 155: How are you defining “short term”? Depending on the audience, some might say “from 2005 to 2010 and from 2014 to 2017” are longer term changes.

Figure 3: Overall, this is a nice figure. Can you detail in the methods section how you detrended the velocity? I suggest including in the caption what the yellow shading is. It is difficult to tell which glaciers are which color. Please use different distinct colors for each glacier instead. Previously, you say it is a 17.5 year study period so I am confused here. I also wonder if it is better to use the average of multiple years (say 2005-2008) as a reference year due to the possibility that 2005 could be anomalous in any way.

Line 164: Which panel in Figure 4?

Figure 4: The aesthetic of this figure is very nice! Try to make the other figures more like this one! Please do make the panel letters larger and more in the corner.

Lines 163-165: Is it possible to determine whether the thinning occurred first or that the thinning was a result of the ice flow change? Can you comment on the possibility that the mass input changed or the ice shelf thinning cause a decrease in buttressing stress? It also looks like the thinning is widespread in both the Smith (East and West) and Kohler (East and West) ice streams, according to Figure 1d.

Line 172: There is a new paper by G. Collao-Barrios that discusses a different kind of flow variation that is tidally driven. I suggest including it somewhere in this section. Also, I suggest starting a new paragraph here.

Line 173: Can you elaborate on this sentence and where “elsewhere” is?

Line 174-177: I suggest including this in the discussion and clarifying what you mean. This **has not** occurred on ice caps/glacier scale in a 15 year period or it HAS? It is unclear in the current wording. I also suggest incorporating these references in this portion of the text: Catania et al., 2012 - <https://doi.org/10.3189/2012JoG11J219> and Conway et al., 2002 <https://doi.org/10.1038/nature01081>

Line 178: Please take a look at these references and revise this sentence: Conway et al. 2002; and Price et al, 2001 <https://doi.org/10.3189/172756501781832232>

Figure 4: This is an interesting plot (4b)! However, the axis label should read 'downstream flux', correct? Smith East seems a bit suspect - is that far upstream increase in flux due the small speed increase? I guess I'm saying, check the numbers for this one specifically, the others look good! Also, are there 'no data' areas in here? What do the pure white patches mean?

Line 190: I'm not sure there is a clear compressive arch for Crosson, or if so, how are you defining it? Do you have strain rate data? I think it's best to just say “inland.”

Lines 191-194: This rewording is confusing, consider revising. Additionally, why is the “distance decreasing from the island” of importance?

Line 194: How did you measure the increase in damage?

Figure 5: See general comments.

Line 220: This slow down is difficult to see in Figure 3.

Lines 225-231: This section is very lengthy and needs to be more concise. Can you be more specific what the hydrographic surveys and numerical models show? It is necessary to include the location of PIG on one of your figures so the readers know where the glacier is relative to PSK. PIG also has a very unique geometry compared to PSK (in a relatively narrow embayment compared to Thwaites/Dotson/Crosson/etc); is it reasonable to assume the same oceanographic mechanisms are happening there? From 2017 onwards, Kohler East/Smith West Vane/Haynes (Can't tell the color differences) continued to speed up. What would cause this difference between all of these glaciers, is the acceleration different?

Line 238: how does the 82 m/yr compare to your observed data?

Line 240-244: see previous comment

Figure S2: Can you include your method on how you calculated “damage” and how you defined it? In the main text as well as the supplemental information.

Line 246-247: Please include details on how calculated the mass flux? What did you use for bedrock/ice thickness?

Line 245-250: I suggest can marking (maybe on fig. 4) where the ice shelf divide migrated from and by how much it migrated by?

Line 256-258 – The paper you cite suggest that grounding line retreat will resume. “Ice speed did not decrease until 2012 when the cold-water anomaly began. The slowdown was likely also partially a result of the advection of thicker ice onto the bathymetric ridge [Joughin et al., 2016]; the lower ocean heat content likely lowered basal-melt rate, allowing thicker ice to advect farther downstream. As the water in the cavity subsequently warmed, however, speeds increased to their precold anomaly rates, suggesting grounding line retreat will resume.” I think the use of “thermocline” is misleading, as it was cold water that entered the cavity below PIG, slowing it less than <4%, then when the warmer water came back the speed went back to accelerating. Though recent modelling studies suggest PIG’s GL may be temporarily stable, it’s continued thinning and acceleration suggest otherwise. I would not say the Christianson paper agrees with the Hill 2023 paper. They have fundamentally different conclusions. Additionally, to say that none of the glaciers in the PSK region are susceptible to MISI on shorter timescales disregards the recent results by Reed et al., 2024 on the significant GL retreat from 1970-1990 (<https://www.nature.com/articles/s41558-023-01887-y>).

Line 261: I suggest rephrasing this sentence as the wording is confusing.

Lines 255-268: This part of the discussion needs to be revised to be organized and include clear key takeaways. Please see the suggestions in the general comments.

Morlighem 2017 is not in the reference list.

Equation S1 – please format the units correctly, like you did for the others:

**A = rate factor for ice (9.3e-25; s<sup>-1</sup> Pa<sup>-3</sup>)**