

Dear Reviewer,

We would like to thank you for your review and pertinent suggestions to improve the manuscript. We have taken into account all of them in the new version of the manuscript. We have also performed an important review of the grammar and spelling in order to correct the remaining mistakes and improve the readability of the article.

We answer below to all the points raised by the reviewer in [blue](#).

Sincerely,

Floriane Provost, on behalf of all co-authors.

**

Thanks to the authors for a thorough response to my revision suggestions; I think the manuscript has improved a lot. I've made a few more suggestions below, including a couple of incorrect statements that will need to be corrected before publication, as well as a few more suggestions to improve readability.

Use of sea ice vs. fast ice: To be honest, I'm still not completely convinced by the arguments in the review response about why the sea-ice patterns can be regarded as the same as fast-ice patterns. There are only a few years available for correlation and they're not all strong. That being said, I think the modifications to the text take care of this issue; it's fair to refer to these as being sea-ice changes. It might be helpful to include some of the info from the review response in the discussion suggesting that fast-ice patterns are similar to the measured sea-ice patterns, but that future work would benefit from better fast-ice data availability.

[There is 18 years of overlap between the sea-ice extent dataset from Fetterer et al., 2017 and the fast-ice dataset from Fraser et al., 2020. Over 12 years \(from 2000 to 2012\), the general trend of seasonal disappearing of sea-ice and fast-ice during the summer season is observed on both datasets. From 2013 to 2018, the two dataset are in agreement that sea-ice and fast-ice is not disappearing except for austral summer 2012-2013 and summer 2015-2016. For austral summer 2015-2016, the disappearing of sea-ice and fast-ice at the vicinity of the Astrolabe glacier is clearly observed on Landsat images. For austral summer 2012-2013, we already discussed this in the previous review response, showing the development of a polynya around the Astrolabe glacier which may explain the difference between the two datasets due to their different spatial and temporal resolution. This is the only difference observed in the 18 years of comparison if we only account for the cycle of presence/absence of sea-ice/fast-ice at the vicinity of the Astrolabe. This cycle is also the only criteria that is](#)

compared with the Astrolabe calving cycle in the paper. We do not consider any other properties (i.e. thickness, regional extent, etc.).

Finally, we do agree that a deeper analysis is needed but this is beyond the scope of the present work. We do think the current version of the manuscript presents a fair comparison between sea-ice changes and the Astrolabe tongue calving cycle. It is also in line with recent studies that made use of the same dataset to analyze the calving cycle of other ice tongues (Gomez-Fell et al., 2022). We do think that without any detailed analysis on the local fast-ice/sea-ice evolution, comparing the two datasets may lead to more confusion rather than clarification. We prefer to keep the analysis as such and point that a deeper investigation including the role of fast-ice, especially in the rifts, is needed.

Use of airborne imagery: I think this is a good addition to the paper, and that the other reviewer was correct that using the full span of available historical data is required for some of the claims in the paper. However, I don't think the use of this has been adequately explained. First, any statement that lists 1947 as the first date must acknowledge the use of airborne imagery (e.g. Lines 4-5: Add "...airborne and satellite imagery," as the 1947 imagery is not from satellites. Also true in line 54).

We agree, and corrected them accordingly.

Second, the use of these data needs a bit more info in the methods. Most available historical air photos are not currently accurately georeferenced, which makes it more challenging to delineate terminus positions. The methods just mention using the "sketch of the photography," and just the resulting ice front is shown in the figure. More info about how that sketch was made and how the georeferencing was done should be included.

We attempt to clarify the sources and the methodology adopted for this image (L 68-71):
« In 1947, the US Navy Operation Highjump took several aerial photographs of the Adélie coast, including over the Astrolabe glacier. We used a sketch derived from the photograph (<https://archives-polaires.fr/idurl/1/14865>) to extract the ice front position (Figure 1c). We manually coregister the photograph and attempt to compensate for most of the distortions, although significant shifts remain visible. We hence account for ± 1 km of error in the ice front position. »

The uncertainty on the terminus position is significant for this image but we are certain it can support the statement that the tongue terminus position reaches an unprecedentedly observed position from 2019 to November 2021.

Grammar: There are still quite a few issues with grammar in many spots in the paper. In Line 14, the hyphen was correct before the edit: "sea-level rise" should be hyphenated, as should

all pairs of nouns acting as compound adjectives before another noun. Other examples include “ice-tongue fracturing” and “sea-ice extent” in the abstract and elsewhere. “Sea-ice-free” should have two hyphens. Many examples are hyphenated correctly in the document, but it is not consistent. Note that hyphens aren’t necessary when the two nouns are not modifying another noun. For example, “sea ice” used on its own does not need to be hyphenated, but it does when it modifies “extent.” While not always necessary, I think this would improve the readability of the paper.

We thoroughly reviewed all hyphens and corrected them accordingly. We also reviewed thoroughly the entire text and corrected many sentences in order to improve the readability of the paper.

Some other minor grammar points:

Lines 20-24: Format citations correctly and revise grammar; does not currently make sense

We corrected the format of the citations and revised the grammar.

Line 44: Adjust to “i.e. sea ice fastened to the glacier/to the coastline”

We corrected them accordingly.

Line 51: Should be a period rather than a question mark

We corrected them accordingly.

Line 133: “velocity” is singular; should use “velocity is” rather than “velocity are,” or conversely use “velocities are”

We corrected for « velocities are ».

Line 260: “traducing” is not the correct word here

We changed « traducing » to « reflecting ».

Lines 268-269: Put citations in parentheses. Note that I have not marked everything that should be corrected.

We corrected accordingly and reviewed and corrected the format of all citations including in the “References” section.

Message: I really like the last sentence of the introduction, but those ideas don't come through quite as clearly in the abstract. Consider revising the abstract, perhaps by using this sentence.

We rewrote the abstract to include the statement at the end of the introduction:

« The recent calving of the Astrolabe glacier (Terre Adélie, East Antarctica) in November 2021 is an opportunity to better understand the processes leading to ice tongue fracturing. The archive of Sentinel-2 optical images is used to measure the ice motion and the ice strain rates for the period 2017-2021 in order to document fractures and rift evolution that lead to the calving. Additionally, the long-term evolution of the Astrolabe ice tongue is mapped with airborne and satellite imagery from 1947 to November 2021. These observations are compared with sea-ice extent and concentration measurements. We show that calving occur almost systematically at the onset or during the melting season and that a significant change in the sea ice periodicity surrounding the Astrolabe glacier in the last decade (2011-2021) in comparison to the previous observations (1979-2011) lead to a change in the Astrolabe calving cycle. Indeed, one can observe a decrease of the duration of sea-ice-free conditions during austral summer after 2011 at the vicinity of the glacier that seems to have favored the ice tongue spatial extension. However, the analysis of strain rate time series revealed that the calving of November 2021 (20 km²) occurred at the onset of sea ice melting season but resulted from the glacier dislocation that took place suddenly in June 2021 in the middle of the winter. **These observations suggest that although sea ice acts as a protection favoring spatial extension of glacier ice tongue, its buttressing is not sufficient to inhibit rifting and ice fracturing.** »

Other comments:

Lines 67-68: I believe Landsat 4 ceased transmissions in 1993, and therefore could not be the source of a 1999 image

The two cloud-free images of 1999 are from Landsat-7 archive. We corrected the text.

Line 72: Landsat-8 did not launch until 2013

Indeed, we actually did only mention « Landsat » in the text. We now precise that it is Landsat-7 and ASTER for the period 2000-2013 (L 73).

Figure 2a: I realize that I can reference Figure 1 to see the glacier outline, but it would be useful to have that mapped here.

We do not think this is necessary. We believe the reader can easily refer to Figure 1.

Line 125: Reference Figure 1c here for the profile positions

We refer here to the location of the profiles AA', BB', and CC' that are presented on Figure 1b. We add a sentence to refer to the terminus position: « The delineation of the terminus positions are mapped on Figures 1c-f. » We hope this is much clearer for the reader.

145-146: “in 2017 and 2018, the limit between stable ice and the flowing ice tongue is retrieved in the wrong position with the GDM-OPT-ICE products.” I think you're saying that the GDM-OPT-ICE results show velocities in the wrong direction near the western shear margin. That looks to be true in all years, not just 2017 and 2018. It would help to clarify this.

Here we do not refer to the western shear margin but to the 9 bamboo stick locations at the western side of the bamboo stick profile. We try to precise the comment:

« One can observe that the gradient of velocity from the western border to the center of the glacier is well retrieved with the GDM-OPT-ICE products of 2019-2021 (Figure 3b) while in 2017 and 2018, the limit between stable ice and the flowing ice tongue is retrieved in the wrong position with the GDM-OPT-ICE products. Indeed, in 2017, the GDM-OPT-ICE velocity of the 9 bamboo sticks located on the western side of the profile is almost null for all locations. Conversely, a progressive increase of the velocity is measured during the bamboo stick campaign (Figure 2b) and by the ITS_LIVE products (Figure 2c). The same is observed in 2018, although the velocity derived from GDM-OPT-ICE is slightly larger than in 2017 (Figure 3b). The small number of cloudless Sentinel-2 acquisitions for those years may explain the low RMS error of these two years, as well as the wrong estimation of the ice tongue limit. »

For years 2019-2021, the gradient of velocity from the western margin to the center of the glacier is accurately retrieved.

Edit the caption of figure 5. I think the second sentence is explaining panel b but is not labeled that way, and the arrows showing the main rift and secondary fractures are shown in c and d, not b and c

We corrected the caption to take into account the comment of the reviewer.

Line 176: Add “with absolute value of the strain rate” larger than... for clarity

We corrected them accordingly.

Figure 6 caption: The 25 km x 25 km pixel is in a dotted yellow line in Figure 1, not blue

We corrected them accordingly.

Lines 259-261: "...lead to severe modifications of the sea ice production and location, traducing regional changes in the oceanic and atmospheric currents (Campagne et al., 2015). This event is likely at the origin of the transition of the sea ice seasonal cycle at the Astrolabe glacier." It would be helpful if this section was more specific, for the benefit of a reader not deeply familiar with the Mertz ice tongue calving. Can you explain a bit more about what the modifications were, and why this is likely the origin of the transition of the sea ice cycle?

We added subsequent details on the Mertz calving and its impact on its western region (L310-317). We hope this answers the reviewer's comment and helps the reader to understand the regional context. As stated at the end of the article, the impact of the Mertz glacier calving along the Adélie coast remains only partially known as most studies focused so far on the Mertz glacier surroundings and/or on the one or two years following the calving events.