Response to anonymous referee 1

We would like to thank the reviewer for the detailed and useful comments, which have helped to improve the quality and readability of our manuscript. In the following, we provide a reply to the points discussed by the reviewer as well as changes in the manuscript.

The comments of the reviewer are written in **bold**, the extracts of the manuscript in *italics* with changes highlighted in blue and line numbers referring to the revised manuscript.

The manuscript deals with a relevant and up-to-date topic concerning coastal retreat rates of Arctic rock cliffs located on the Brøgger peninsula in Svalbard, Norway. In times of ongoing and projected future climate change more detailed scientific results on coastal erosion particularly in permafrost regions are indeed necessary. The main aim of the study is to detect long-term trends in differently exposed coastlines and linking these changes to available climate date. Results are achieved by using high-resolution orthoimagery combined with dGNSS measurements. In addition a short term dataset of rock surface temperatures was acquired and topography-based downscaling of atmospheric reanalysis data was utilized. While the presented results elucidate the contrasting trends of retreat rates on the northeast and southwest facing coastlines very nicely, the given explanations for the detected differences as well for the potential main climatic drivers are too general and leave a lot of room for improvement. A one-year dataset of rock surface temperatures is certainly quite short for a more comprehensive temperature analysis.

The manuscript is well presented and has a logical structure. All tables and figures including the appendix are well prepared. While the method and result sections are quite detailed, the introduction and discussion sections need to be clearly revised and improved. In its current state, the manuscript has the character of a regional case study with limited novelty for a broader and international readership. I recommend to widen the author's perspective from Svalbard also to other Arctic coastal areas worldwide and to include references of similar or comparable studies from these regions too. A short compilation of published coastal retreat rates in the Arctic would certainly be interesting. I have listed some international references at the end that the authors might find useful. The study site description needs to be revised significantly. For readers unfamiliar with Svalbard, the given study site description is not helpful at all. Please see my detailed comments below. The discussion section needs to be significantly revised as well. At the moment, I can't see a wider geoscientific relevance of the presented research. In addition, by placing your results achieved in an international context, you will definitely reach a larger readership. Under 5.2 it might be worth to discuss actual and potential implications of an increased susceptibility of the coastline. For instance what does enhanced coastal erosion mean for the population and infrastructure of Svalbard? I think the manuscript could benefit from illuminating these points in a more detailed and broader perspective as well as to discuss possible implications of the achieved findings in more detail

and in an international context.

We followed the suggestions of the reviewer and revised the manuscript with a focus on the introduction and the discussion:

- Introduction: We widened the perspective and included more references from similar studies. In particular, we added a compilation of published coastal retreat rates from Arctic coastlines worldwide. Here, we included the references suggested by the reviewer. Please find the changes in the revised manuscript below.
- Study site description: We added the information suggested by the reviewer. For a detailed answer, please refer to the detailed comments below.
- Discussion: We placed our results in an international context as suggested by the reviewer. Please find the changes in the revised manuscript below.
- Discussion: We extended the explanations for the detected differences between the northeast and southwest facing coastline as suggested by the reviewer. Please find the changes in the revised manuscript below.
- Methods, results and discussion: We followed the suggestion of the reviewer and added a more detailed analysis of the potential main climatic drivers. To do so, we added a new section in the methods (Sect. 3.5) and the results (Sect. 4.5) and extended significantly the discussion (Sect. 5.2). Hereby, we focused on the wind regime and the potential fetch, as these have a main influence on the mechanical abrasion, which is expected to have the strongest influence on erosion along the coastline of Brøgger peninsula. Other minor factors are presented in the appendix to not distract from the important discussion points in the main manuscript.
- We agree with the reviewer that the one-year data set of rock surface temperatures is short. However, it shows that the rock surface temperatures are falling into a temperature range with decreased stability (as discussed in Sect. 5.2). Therefore, adding this data on the permafrost conditions along Brøgger peninsula can be valuable for the interested reader.
- We included a paragraph about the impacts on settlements and infrastructure as suggested by the reviewer. Please find the changes in the revised manuscript below.

Changes in the introduction to widen the perspective with a compilation of published coastal retreat rates from Arctic coastlines:

Line 21: *Therefore, Arctic coasts are often eroding more rapidly than coasts in temperate regions and the average retreat rate is estimated to 0.5* $\mathrm{m\,a^{-1}}$ *(Lantuit et al., 2012). However, the variability of coastal retreat rates across the Arctic is pronounced, both on a regional and local scale. Lantuit et al. (2012) present a circum-Arctic database, where the highest rates are detected in the Laptev Sea (0.73* $\mathrm{m\,a^{-1}}$*), the East Siberian Sea (0.87* $\mathrm{m\,a^{-1}}$*), the US Beaufort Sea (1.15* $\mathrm{m\,a^{-1}}$*) and the*

Canadian Beaufort Sea (1.12 $\mathrm{m\,a^{-1}}$*). Numerous regional studies corroborate these numbers, for example with retreat rates along the Bykovsky peninsula (Laptev Sea) of 0.59* $\mathrm{m\,a^{-1}}$ *between 1951 and 2006 (Lantuit et al., 2011), along the US Beaufort Sea of 1.8* $\mathrm{m\,a^{-1}}$ *between 1940 and 2010 (Gibbs and Richmond, 2017) and along the Canadian Beaufort Sea with 0.7* $\mathrm{m\,a^{-1}}$ *(Irrgang et al., 2018). The highest erosion rates are often found in ice-rich permafrost bluffs and barrier islands. Jones et al. (2018) present a maximum of 48.8* $\mathrm{m\,a^{-1}}$ *in such a setting along the US Beaufort Sea from 2007 to 2008.*

Changes in the discussion to place the results in an international context:

Line 376: *The calculated retreat rates are lower than the average change in Arctic coastlines of 0.5* $\mathrm{m\,a^{-1}}$ *(Lantuit et al., 2012). This is expected as high retreat rates are typically found along unlithified coasts, which account for 65 % of the Arctic coastline (Irrgang et al., 2022). In contrast, the coastline along Brøgger peninsula is formed by bedrock, being characterized by a higher resistance against mechanical abrasion compared to unlithified coasts, and the unconsolidated sediments on top are not exposed to wave action. However, we detected higher retreat rates compared to other lithified coasts in the Arctic, e.g. the Canadian Archipelago with 0.01* $\mathrm{m\,a^{-1}}$ *(Lantuit et al., 2012). This can be explained by the long open water season at the western coast of Svalbard (Sect. 5.2), resulting in the high importance of mechanical abrasion by wave action (Sect. 5.2). Other contributing factors might be the highly fractured bedrock, decreasing the resistance of the material towards erosion and the permafrost conditions, which show a temperature range with decreased bedrock stability (Sect. 5.2).*

Changes in the discussion for a more detailed explanation of the detected differences between the northeast and southwest facing coastline:

Line 429: *However, the impact of windiness and wind-induced wave action is expected to vary along the coastline of Brøgger peninsula. The northeast facing coastline is characterized by a relatively sheltered position within the Kongsfjorden system, with land in most cardinal directions within a range of 10 to 15* km*. This likely restricts the fetch and consequently wave activity, which may explain the lower coastal retreat rates in this sector. In contrast, the southwest facing coastline is more exposed to the open sea, especially in westerly and northwesterly directions in which the potential wave fetch is controlled by the distance to the sea ice edge in Fram Strait, which has clearly increased in the last decades (Sect. 4.5). Previous studies have shown that an increasing fetch results in wave growth (Casas-Prat and Wand, 2020b), increasing the capability for wave-driven erosion (Casas-Prat and Wang, 2020a). Therefore, the increasing distance to the sea ice edge towards the open Fram Strait likely increases the wave activity and thus mechanical abrasion along southwest sector of Brøgger peninsula, likely explaining the higher erosion rates found here.*

Changes in the revised manuscript for a more detailed analysis of the potential main climatic drivers:

Changes in the methods:

Line 249: ***3.5 Analysis of climate conditions***

We analyzed trends in wind speed and changes in the distance to the sea ice edge (potential wave fetch), as these factors control the interaction between wind and water and therefore the wave field (Barnhart et al., 2014), playing an important role along the coastline of Brøgger peninsula due to mechanical abrasion through wave action. The wind speeds records were taken from the Ny-Ålesund climate station SN99910 (78°55'23" N, 11°55'55" E; Fig. A1), covering the time period 1975 to 2020 (Norwegian Centre for Climate Services, 2023). We extracted days during which mean hourly wind speeds of at least 10.8 $\mathrm{m\,s^{-1}}$ *(strong breeze or stronger) were recorded, corresponding to large waves of approximately 3 to 4* m *(NTNU, 2023).*

We also analyzed the distance to the sea ice edge in northwesterly direction (corresponding to the open Fram Strait), which is the potential distance over which waves can build up. The analysis of this potential fetch was based on data provided by the Norwegian Meteorological Institute (2023) for the time period 1997 to 2023. Hereby, we define the sea ice edge as the given category of 10 to 40 % sea ice concentration, following Meier and Stroeve (2008) and Overeem et al. (2011), who applied a threshold of 15 %. We determined the mean distance to the sea ice edge for September for which 22 ice charts per year were available on average. For trend detection, we applied a Bayesian regression analysis (Särkkä, 2013), which is explained in Appendix A. In all other cardinal directions, land is found in about 10 to 15 km *distance, so that the potential fetch is limited.*

In addition, we used hourly ERA5 reanalysis data (Hersbach et al., 2020) in conjunction with the topography-based downscaling routing TopoSCALE (Fiddes and Gruber, 2014) to analyze trends in mean annual air temperature, annual rain- and snowfall, as well as mean annual incoming longwave and shortwave radiation. The methods and detailed results for these climatic parameters are presented in Appendix A and Appendix B.

Changes in the results:

Line 349: ***4.5 Changes in climatic conditions***

Given the lithology along the coastline of Brøgger peninsula, mechanical abrasion through wave action is likely a dominant factor for erosion. Therefore, we focus in this section on the wind conditions and changes in the sea ice cover. Other factors, such as precipitation patterns, air temperature and radiation, are presented in Appendix B.

The trend analysis of wind speeds in Ny-Ålesund defined as a strong breeze or stronger (wind speeds >= 10.8 $\mathrm{m\,s^{-1}}$*, corresponding to large waves of approximately 3 to 4* m*; NTNU, 2023) shows an increase by 5.4 days per decade from approximately 65 days on average in the 1970s to 90 days in the last decade (Fig. 8a). However, due to the strong variability, the evidence* *in favor of a trend remains weak (Bayes factor < 0.5, Appendix A). Years with exceptionally many days of high wind speeds occurred in the early 1990s, while they decreased slightly in recent years. We emphasize that the climate station providing the data, is located approximately 8* km *away from the field area inside Kongsfjorden, where wind speeds are lower compared to the investigated field site. Wind speed measurements at the tip of Brøgger peninsula (available only since 2021) recorded 112 days with strong breezes in 2022 compared to 84 days in Ny-Ålesund (Norwegian Centre for Climate Services, 2023), thus highlighting the potential differences in wind regimes.*

In most cardinal directions, land is found in about 10 to 15 km *distance, so that the potential wave fetch over open water is limited here. However, in northwestern direction, the coastline of Brøgger peninsula is exposed to the open sea towards Fram Strait and the potential wave fetch is limited by the distance to the sea ice edge, which is displayed in Fig. 8b for the month of September. We detected an increasing trend from about 150* km *to 250* km *between 1997 and 2023, which accounts for approximately 39* km *per decade (Bayes factor 1-2, strong evidence in favor of the trend, Appendix A). The largest values with a mean distance to the sea ice edge of more than 300* km *were observed in 2020 and 2021.*

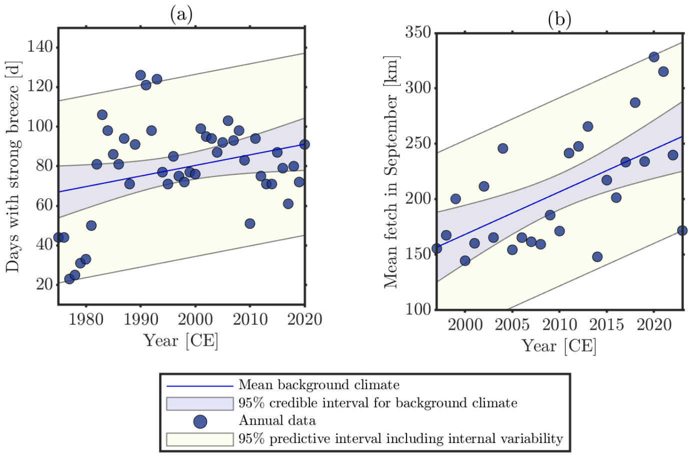

Figure 8. *(a) Days with a strong breeze (wind speeds >= 10.8* $\mathrm{m\,s^{-1}}$*) measured by the Ny-Ålesund climate station SN99910. They increased by 5.4 days per decade between 1975 and 2020. (b) Mean distance to the sea ice edge (potential wave fetch) in September in northwesterly direction. The distance to the sea ice edge increased by approximately 39* km *per decade between 1997 and 2023.*

Changes in the discussion:

Line 418: *Retreat rates of Arctic coastlines are governed by various drivers, dependent on the local coastal setting and environmental conditions (Irrgang et al., 2022). The lower part of the coastal cliffs* is *prone to abrasion, acting through the* *thermal and wave-driven mechanical energy of the sea (Are, 1988a, b) and intensive wetting-drying during open-water season (Strzelecki et al., 2017). We assume that these factors play an important role in coastal erosion along Brøgger peninsula, as overhanging rock walls with a retreated foot of the cliff can be observed (Fig. 1c). Abrasion is especially effective during stormy weather, which likely intensified in the area around Brøgger peninsula during the past decades, showing a positive trend of days with a strong breeze in the last decades (Fig. 8a). Furthermore, extreme cyclone events regularly occur in the Arctic North Atlantic, with 20 to 40 events during winter. In Ny-Ålesund, an increasing trend of six cyclones per decade was detected from 1979-2015, which can be related to a decreasing sea ice extent in the region and large-scale atmospheric circulation changes (Rinke et al., 2017). Single weather events like this can support landsliding and consequently, they can have a localized but pronounced influence on the retreat rates.*

However, the impact of windiness and wind-induced wave action is expected to vary along the coastline of Brøgger peninsula. The northeast facing coastline is characterized by a relatively sheltered position within the Kongsfjorden system, with land in most cardinal directions within a range of 10 to 15 km. *This likely restricts the fetch and consequently wave activity, which may explain the lower coastal retreat rates in this sector. In contrast, the southwest facing coastline is more exposed to the open sea, especially in westerly and northwesterly directions in which the potential wave fetch is controlled by the distance to the sea ice edge in Fram Strait, which has clearly increased in the last decades (Sect. 4.5). Previous studies have shown that an increasing fetch results in wave growth (Casas-Prat and Wand, 2020b), increasing the capability for wave-driven erosion (Casas-Prat and Wang, 2020a). Therefore, the increasing distance to the sea ice edge towards the open Fram Strait likely increase the wave activity and thus mechanical abrasion along southwest sector of Brøgger peninsula, likely explaining the higher erosion rates found here.*

In addition to the large-scale sea ice conditions in Fram Strait, local sea ice coverage around the Brøgger peninsula can influence the thermal regime of the rock walls (Schmidt et al., 2021) and potentially also wave action and mechanical abrasion (Barnhart et al., 2014). Dahlke et al. (2020) provides an overview of sea ice extent around Svalbard from 1980 to 2016. The results show a considerable decrease in sea ice coverage during winter and spring in Forlandsundet (where the southwest facing coastline is located), decreasing from 50-70 % until the early 2000s to below 10 % in recent years. Kongsfjorden (where the northeast facing coastline is located) experienced an increase in sea ice extent from around 40 % to 60 % in the 1990s and a subsequent decrease to around 10 %. However, as our field area is located in the outer parts of Kongsfjorden (NE sector) and near the open Arctic ocean (SW sector) where typically less sea ice develops, even lower percentages of sea ice coverage are likely, with mostly ice-free conditions in the last decade.

The following information about the impacts on human infrastructure were added in the revised manuscript:

Line 484: *With no infrastructure along the investigated coastline of Brøgger peninsula, the consequences for the population are expected to be minor. Widening the perspective on Svalbard, settlements and infrastructure are concentrated along lithified* *and unlithified coastlines, such as the major administrative center Longyearbyen. Jaskolski et al. (2018) identified ports, quays and structures for coastal protection as the most endangered infrastructure along the coast in Longyearbyen, where not only coastal retreat but also river erosion, permafrost thaw and solifluction play an important role. In addition, the cultural heritage of Svalbard is severely affected by coastal erosion (Nicu et al., 2020, 2021). Pan-Arctic, increased coastal erosion threatens Arctic communities, e.g. in Alaska (Bronen and Chapin III, 2013; Brady and Leichenko, 2020) and Canada (Andrachuk and Pearce, 2010; Radosavljevic et al., 2016; Irrgang et al., 2019), and even forced relocation of some settlements (Bronen and Chapin III, 2013). As the results from our study show, this may not only concern unlithified, ice-rich coasts, which are known to be highly affected by coastal erosion (Irrgang et al., 2022), but also lithified coasts in the Arctic.*

Under point 2: Some more details on the climatic setting of your study site are needed here, e.g.:

- geographical coordinates of the study sites

We added the coordinates of the field site.

Line 75: *The study area is the northwestern part of the Brøgger peninsula, located on the west coast of Spitsbergen. It stretches from the southwest at approximately 78°55' N, 11°15' E to the northeast at 78°59' N, 11°40' E.*

- mean annual air temperature for the period of recorded data

We added data on the mean annual air temperature.

Line 103: *Station data shows that air temperatures increased from an average of -5.9*°C *in the 1970s to -3.1*°C *in the 2010s (Norwegian Meteorological Institute, 2022b). This corresponds to a linear increase in mean annual air temperature for the time period 1971 to 2017 of 0.71* °C *per decade, with the strongest increase in the winter season of 1.35* °C *per decade (Hanssen-Bauer et al., 2019). Maturilli et al. (2015), who looked at a shorter time period from 1994 to 2013, detected an even stronger trend of 1.3±0.7* °C *per decade, with a winter warming of 3.1±2.6* °C *per decade. Hereby, the month with the lowest air temperatures is typically February, while the highest values are found in July (Hanssen-Bauer et al., 2019). The observed winter warming is associated with an increase in incoming longwave radiation of 15.6±11.6* $\mathrm{W\,m^{-2}}$ *per decade. As the duration of snow cover is shortened and, hence, the reflection of shortwave radiation is reduced, the net shortwave radiation is slightly increased in the spring and summer seasons (Maturilli et al., 2015).*

- any information about the wind regime

We added information on the wind regime.

Line 119: *The wind regime of Brøgger peninsula is notably influenced by the mountainous terrain, the topography of Kongsfjorden and katabatic winds originating from the glaciers, resulting in a complex wind field (Svendsen et al., 2002; Maturilli and Kayser, 2017). In Ny-Ålesund, the occurrence of days, where mean hourly wind speeds with a strong breeze or stronger (wind speeds >= 10.8* $\mathrm{m\,s^{-1}}$*) have been recorded, has increased from an average of around 65 days in the 1970s to 90 days in recent years (as described in Sect. 4.5; Norwegian Centre for Climate Services, 2023). It is important to note that the wind characteristics in Ny-Ålesund are not directly applicable to the study site because the influence of the mountains and the fjord diminishes and likely plays a lesser role. At the tip of Brøgger peninsula, which is part of the study site, wind speed measurements are available since the summer of 2021 (Norwegian Centre for Climate Services, 2023). These data reveal stronger wind speeds, with 112 days with strong breezes recorded in 2022, compared to 84 days in Ny-Ålesund, but long-term trends in wind speeds for the investigated field site are not available.*

- general information on snow cover and more specific information on the mentioned reduced snow cover

We added more information on the snow cover.

Line 112: *The mean annual precipitation between 2010 and 2021 in Ny-Ålesund was 526* mm*, showing an increasing trend in the last decades since the 1980s with 384* mm *(Norwegian Meteorological Institute, 2022a). Both snowfall and rainfall can occur at any time during the year, but the snow season typically lasts from October to June (Hop and Wiencke, 2019). Following the trend of warming air temperatures, a shifting of the onset of snow melt to earlier dates is observed with -5.8±8.3 days per decade (Maturilli et al., 2015). At the Bayelva soil and climate station typical snow depths between 0.65 and 1.4* m *are observed (Boike et al., 2018). The steep coastal cliffs of Brøgger peninsula are typically snow-free. Here, snow accumulations are limited to edges in the bedrock and snow accumulations at the foot of the rock walls (Schmidt et al., 2021).*

- permafrost distribution

We added information on the permafrost characteristics.

Line 87: *The field site is characterized by continuous permafrost, even though the presence of taliks cannot be excluded. At the Bayelva soil and climate station, which is about 8* km *distance to the investigated field site, mean annual ground temperatures in a depth of 9* m *are recorded with -3.0 to -2.6*°C *between 2009 and 2016 (GTN-P, 2018). Measurements of rock surface temperatures in the coastal cliffs of Brøgger peninsula in about 8* km *distance to the field site also revealed relatively warm permafrost, with annual values between -0.6 and -3.6*°C *in the years 2016 to 2020 (Schmidt et al., 2021).*

- important denudational processes

We added information on the denudational processes.

Line 92: *The bedrock cliffs on Svalbard are exposed to several denudational processes. At the shore platform and the lower part of the coastal cliff, abrasion is likely the main controlling factor with wave action acting upon the bedrock (Are, 1988a, b), redistributing beach sediments and consequently polishing the bedrock (Strzelecki et al., 2017). In addition, wetting-drying cycles by tidal water level changes and freeze-thaw processes can weaken the bedrock, especially where open cracks are present. In winter, an icefoot or snowdrift can develop, protecting the shore platform and the lower parts of the coastal rock wall from denudational processes. Above, where waves cannot reach the coastal cliff, periglacial weathering is controlling the erosion (Strzelecki et al., 2017). Here, rock fracturing through ice segregation may contribute to an increased susceptibility of the bedrock (Ødegård and Sollid, 1993). The unconsolidated sediments on top of the bedrock rest with their natural friction angle, following the erosion of the bedrock.*

I think it is necessary to explain the permafrost situation of your study site in more detail here. For readers who are not familiar with the study site or the special conditions of Svalbard, it is not clear how the permafrost distribution looks like in Svalbard and where and how it is measured. What is the specific permafrost situation along the coastal rock cliffs?

We added information about the permafrost conditions at our field site. Please see above.

Concerning the actual cliff study sites:

- information of the entire actual cliff height (if possible differentiated in bedrock height and the height of the unconsolidated marine deposits on top)

We added the information on the cliff height including the bedrock height.

Line 84: *The coastal cliffs have a mean height of 15.5* m *with a maximum of 28.0* m*, whereof the bedrock accounts for approximately 10.5* m *on average.*

- information on crack and fracture density if available

Unfortunately, there are no data available for the crack and fracture density of the coastal cliffs of Brøgger peninsula. Own observations are restricted by the difficult access to the shoreline. The only statement that we could find is that they are "generally highly fractured". We included this statement in the manuscript.

Line 78: *The bedrock is typically highly fractured (Ødegård and Sollid, 1993) and dominated by conglomerates, sandstones, shales and carbonates from the Carboniferous to Permian age, which often form overhanging cliffs.*

Under point 3: The "accuracy and error analysis" is clearly structured and reasonable explained. It is obvious that the orthoimages from 1970 are the most critical ones. However, the shown example of the digitized coastline from 1970 is not clear to me. Why is the digitized line so far away from the "coastline" and how did you manage to recognize the notches?

Thank you for your comment. We agree that the quality of the 1970 orthoimage can significantly impact the accuracy of the digitized coastline. We have updated the main text as follows.

Line 186: *The cliff top was digitized manually in a GIS environment using the WGS 1984 UTM Zone 33N at a scale of 1:400 by the same operator. The digitization process relied on visually interpreting the coastline from the orthophoto, with additional visual support from topographic maps, including hillshaded DEM and slope.*

Line 190: *The digitization along the bedrock coast was interrupted sporadically due to (1) rivers feeding into the fjord, which incised into the bedrock, (2) closely spaced thermo-erosional gullies, which prevented a clear detection of the coastline, and (3) the quality of the orthoimages. The last point affected only the digitization of the southwest facing coastline in the 1970 data, a challenging area due to unfavourable illumination conditions and excessive blurring of the orthoimage. In areas where the 1970 orthoimage met acceptable quality standards (i.e., exhibited less blur and higher contrast), we mapped the coastline and the notches by tracing the boundary between the dark and light grey areas (as shown in Fig. 3). In this case, we assumed that the lighter area in the orthoimage corresponded to the steeper terrain of the cliffs. The hillshade and slope maps were very noisy and thus were not considered in the digitization process.*

Figure 4: This is a very nice figure but it is a bit confusing that the retreat rates for all three time intervals are shown on the same orthoimage. I can understand the decision in order to have a good visibility. However, you could maybe mention the actual date of the orthoimage for clarification.

As the reviewer mentions, we tried in the beginning to use different orthoimages in the background, but that disturbed the visibility of the results. We added the date of the orthoimage in the caption.

Caption of Figure 6: *Cliff top retreat rates at the northeast and southwest facing coastline of Brøgger peninsula for the time periods 1970-1990, 1990-2010 and 2010-2021. The background shows the orthoimage of 2021. Source of the orthoimage:*

Svalbard Integrated Arctic Earth Observing Systems SIOS, not publicly available.

Under point 4.2: It would certainly be interesting if you could elaborate on possible reasons for the different detected retreat rates on the NE and SW facing side in more detail, as this is one of your main findings.

We extended our discussion about the detected differences along the northeast and southwest facing coastline. However, this was not done in Sect. 4.2 as this section is describing the results, but in the discussion under Sect. 5.2. The manuscript was changed as following:

Line 429: *However, the impact of windiness and wind-induced wave action is expected to vary along the coastline of Brøgger peninsula. The northeast facing coastline is characterized by a relatively sheltered position within the Kongsfjorden system, with land in most cardinal directions within a range of 10 to 15* km. *This likely restricts the fetch and consequently wave activity, which may explain the lower coastal retreat rates in this sector. In contrast, the southwest facing coastline is more exposed to the open sea, especially in westerly and northwesterly directions in which the potential wave fetch is controlled by the distance to the sea ice edge in Fram Strait, which has clearly increased in the last decades (Sect. 4.5). Previous studies have shown that an increasing fetch results in wave growth (Casas-Prat and Wand, 2020b), increasing the capability for wave-driven erosion (Casas-Prat and Wang, 2020a). Therefore, the increasing distance to the sea ice edge towards the open Fram Strait likely increase the wave activity and thus mechanical abrasion along southwest sector of Brøgger peninsula, likely explaining the higher erosion rates found here.*

Under point 4.3: Please see comment under point 2.

We agree with the reviewer that the one-year data set of rock surface temperatures is short. However, it shows that the rock surface temperatures are falling into a temperature range with decreased stability (as discussed in Sect. 5.2). Therefore, adding this data on the permafrost conditions along Brøgger peninsula can be valuable for the interested reader.

Line 230: from 1 September 2020 to 31 August 2021

We corrected the spelling error in the manuscript.

Line 335: *The measurement period of the logger RW-SW close to Kjærsvika lasted from 1 September 2020 to 31 August ~~31~~ 2021.*

Line 342: September 2020 to August 2021?

Of course! We corrected it in the manuscript.

Line 506: *Installed temperature loggers recorded rock surface temperatures in the time period September 2020 to August 2021.*

Fig. 4: “however” is redundant here

We removed "however" in the figure caption.

Fig. 6: *Source of the orthoimage: Svalbard Integrated Arctic Earth Observing Systems SIOS, ~~however,~~ not publicly available.*

References:

Barnhart, K.R., Overeem, I., Anderson, R.S., 2014. The effect of changing sea ice on the physical vulnerability of Arctic coasts. The Cryosphere. 8, 1777-1799.

We included this reference in the revised manuscript.

Lantuit, H., Overduin, P.P., Couture, N., Wetterich, S., Aré, F., Atkinson, D., Brown, J., Cherkashov, G., Drozdov, D., Forbes, D.L., 2012. The Arctic coastal dynamics database: a new classification scheme and statistics on Arctic permafrost coastlines. Estuar. Coasts. 35, 383–400.

We included this reference in the revised manuscript.

Overduin, P.P., Strzelecki, M.D., Grigoriev, M.N., Couture, N, Lantuit, H., St-Hilaire-Gravel, D., Gunther, F., Wetterich, S., 2014. Coastal changes in the Arctic. In: Martini, I.P. and Wanless, H.R. (eds). Sedimentary Coastal Zones from High to Low Latitudes: Similarities and Differences, Geological Society, London, Special Publications, 388, 103–129.

We included this reference in the revised manuscript.

Reimnitz, E., Maurer, D.K., 1979. Effects of storm surges on the Beaufort Sea coast, northern Alaska. Arctic, 324, 329–344.

We decided to not include this reference in our manuscript, as it describes a storm surge inundating low-lying tundra plains, while the coastal cliffs in this study have an average height of 15.5 m, so that similar events are not expected here.