REVIEWER 1

Author Response:

We appreciate the constructive review and comments by Anonymous Review 1. We agree with the major comments and we will introduce changes in the manuscript to address the reviewer's concerns. Also, we will clarify and correct the manuscript considering the specific comments. We think that these changes will improve the manuscript. Here, we provide a brief point-by-point response to the general and specific comments and concerns by the Anonymous Reviewer 1 (in bold):

Summary

In this paper, Bravo and coauthors study an unusual July 2021 atmospheric river (AR) that contributed positively to the mass balance of glaciers in the subtropical Andes during what is normally the ablation season. They use a combination of station observations, atmospheric reanalysis, remote sensing data, and a glacier mass balance model to show that this AR halted the seasonal progression of Olivares Alfa Glacier mass loss, resulting in near-equilibrium mass balance for the year. They conclude that a single major AR event can exert a dominant influence on annual glacier mass balance, even when the large-scale climate conditions would normally be expected to favor mass loss.

The paper presents a compelling scientific story and is a novel contribution to the literature, as AR impacts on the cryosphere have not been studied in detail in this region of the subtropical Andes. The paper is generally well-written with sound scientific methods, and the references are comprehensive and appropriate. The main aspect the paper lacks is a more thorough exploration of how this AR event compares to the long-term climate context of this study region, as described in my major comments. I also have a large number of minor comments and technical corrections that do not represent fundamental flaws, but should be addressed before the paper can be of a publishable standard.

Major comments

- Since the ERA5 data are available for a longer time period than 2014–2021, it would enhance this study to see how the January 2021 compares to all summer ARs during the multi-decadal ERA5 record. I understand that running the COSIPY model for this long time period is likely beyond the scope of this analysis, but I don't expect it would be too difficult to extend the record of AR events and their categories to the full time period of the ERA5 data. This would provide some valuable long-term background to determine how unusual the January 2021 AR was. Some of this information may be provided at the regional scale by previous studies (e.g. Valenzuela et al., 2022), but the long-term context that is directly relevant to the glacier mass balance of this study area should be provided and interpreted for the reader in this paper. See also my minor comment on L356–358.

We thank the reviewer for this suggestion. We will add an analysis to emphasise the extraordinary occurrence of this event. For one side, we will use ERA5 to catalogue the Atmospheric Rivers in summer to demonstrate the historic low occurrence of this synoptic feature. Effectively, as the Reviewer mentioned, a longer mass balance modelling using for instance ERA5 data, is beyond the scope of this work as we focus on feeding the model using the available meteorological observations.

- How does the total accumulated precipitation compare to past AR events, both during summer and during all seasons? Is there precedent for this type of summer accumulation event if you look at a longer time period than 9 years? Is there any way for the authors to quantify this with the available data? I expect that the record-high IVT values relative to the Jan/Feb 2013–2021 climatology (L354–361) would translate to precipitation accumulation at the high end of the climatology, but this isn't guaranteed to be the case.

In the same line as the previous answer, we will add an analysis to show how the rate of precipitation was also extraordinary for summer. In this case, we will use available data observed at Lagunitas weather station. This station, although located at a lower elevation (2765 m a.s.l.), shows one of the longest precipitation records, so we can put this event in the context of an observed precipitation climatology. We will replace Figure 3 with a Figure to remark this. Regarding a comparison, we mention that the IVT is not the highest in the period, as winter ARs events showed the highest IVT. The January 2021 event was the one with the highest IVT in summer since 2014. We expected from the analysis of the extended AR catalogue (previous answer) to determine if this event was the one with the highest IVT on summer in a longer period.

- Figure 3: It's not clear why this figure is included in the paper. The only references to this figure in the text are to mention that the station data exist (L175, 177) and the figure is not used to support any of the paper's main findings. It should either be removed from the paper, or some text should be added to the paper describing how the figure contributes to the study's results. See also my minor comment on L424–425.

We agree with this comment. However, the Figure will be moved to Supplementary Material as we still want to show and remark on the importance of this high-elevation meteorological observation that has been recorded data since 2013. Also, we estimate that this figure still is important to demonstrate the validation of the ERA5 incoming longwave radiation used to feed COSIPY as, unfortunately, not all the period has available data of this variable.

Minor comments

- L32–45: This is a long paragraph. I suggest starting a new paragraph at L38 with the sentence starting with "In the subtropical Andes..."

We agree. We will start a new paragraph at L38.

- L38: It would be helpful to give some more detail about what region the term "subtropical Andes" refers to. What countries / areas of countries are considered the subtropical Andes? L42 implies that this mainly refers to Chile and Argentina, but it would be useful to define this region in more detail at its first mention in L38.

Generally, subtropical Andes encompassed the area between south of the tropic until around the 40°S, however, in this paragraph, we refer to the area between 32° and 36°S. We will add a sentence to clarify this.

- L88 (last paragraph of introduction): This paragraph jumps abruptly to discussing the January 2021 AR event without any transition from previous paragraphs. It would be helpful to at least briefly discuss the seasonal climatology of precipitation and ARs in this region as context for the January 2021 AR studied in this paper. This type of information is provided to some extent later in the paper (e.g. L128–129), but it would be helpful for developing the paper's story for it to be included in the introduction.

We will move a couple of sentences from L128-129 and add some climatology context using the work of Viale et al. (2018). The paragraph will be:

"According to Viale et al. (2018), in the subtropics, ARs are much more frequent in winter. Further, precipitation and ARs are almost absent in summertime (dry season) over the western slopes of the subtropical Andes and the central Chilean lowlands (Viale and Garreaud, 2014; Viale eat al., 2018). Despite these overall characteristics, intense precipitation occurs in summer (Poveda et al., 2020). In this work, our objective is to evaluate…"

- Figure 1: A large-scale map, showing the study region's location within the broader context of southern South America, would be helpful for readers unfamiliar with the region's geography.

- Figure 1: Do the blue areas on the large map show the outlines of glaciers? Please clarify.

Thank you for these observations, we will add a broader regional context and also the location of Lagunitas weather station (following a specific comment below). Blue areas do represent the glacier areas on the basin, we will detail this information in the figure caption.

- L110–141: I suggest reorganizing this section to cover only the study area. I think the paper will flow better if the description of the January 2021 AR event is refactored into the Introduction and Results sections. Any background information on the January 2021 AR that is based on previous studies (e.g. Valenzuela et al., 2022) should be moved to the Introduction, and any analysis of this event that is a new result of this study should be moved to the Results.

Given the major comments, the new analysis aimed to remark on the extraordinary of this event will be presented in the Results section. The background information in this section will be moved to the Introduction.

- L122: Is there any way to label the two accumulation zones of the Olivares Alfa Glacier on the large map in Figure 1?

We will add this detail to the map in Figure 1.

- L131–132: The climatology of AR category 1 events during summer in this region is helpful context for the reader. Is summer defined as December-January-February? Please clarify.

Yes, it is DJF, we will add this information. This section was now moved to the Introduction.

- Figure 2: It would be helpful to mark the location of the Maipo and/or Olivares River basin on either panel A or C.

- Figure 2: It doesn't make sense to me to have a combined y-axis with IVT magnitude on the left axis (units of kg m^-1 s^-1) and IVT direction (angular units) on the right axis. I suggest splitting this into two separate panels with different y axes.

We change this Figure, including as a subset the orientation of the AR in comparison to summertime AR from the catalogue. This is now the Figure 3 in the new version of the manuscript.

- L152–169: These methods for determining the snowline elevation and freezing level are a nice, creative blending of remote sensing, radiosonde, and station data.

Thank you for your comment.

- L153–154: Is this product, which I presume is based on visible imagery, affected by cloud cover? Are there places / times where the snowline elevation can't be determined due to clouds?

The method employed relies on the MODIS snow product (MOD10A1), which is known to be susceptible to cloud cover, limiting its accuracy in areas with frequent cloud coverage. However, the approach proposed by Krajčí et al. (2014) overcomes this limitation by offering improved tolerance to clouds. By allowing a higher cloud cover threshold —90% in our case— this method can still provide reliable snow cover information, even in cloud-prone regions. This enhanced cloud tolerance results in better accuracy compared to other snow detection methods, such as those by Parajka et al. (2010) and Da Ronco and De Michele (2014), which perform less effectively under heavy cloud cover.

- L179–180: From what source(s) are the medium and high resolution imagery?

We will add a table in the supplementary material showing the satellite images used to outline the glacier. Overall these are Landsat, Spot6, Kompsat3 and Pleiades images.

- L183–184: Do the authors anticipate that initializing the model with a no-snow starting condition for each year will have an influence on the results? It would be helpful to include at least a brief discussion of the implications of this decision.

During the study period, the subtropical Andes of Chile has been affected by an extensive mega-drought. Most of the years has shown a deficit of precipitation. On the other side, MODIS derived snowline shows higher elevation at the end of the hydrological years, even over the maximum elevation of the Olivares Alfa Glacier. Moreover, experienced in fieldworks in the area since 2013, shows that during summer most of the snow deposited on the glacier was melted leaving the ice exposed at the end of each hydrological year. With this in mind, we decided to initialize the model with no snow to maintain consistent parameters across the

study period (L341-342), however, we are aware that some snow could exist at the start of the hydrological year in the highest elevations of the glacier, especially the hydrological year following years with highest rate of precipitation (see Figure S3). Considering this, it is probably that the mass balance of these years will be a bit higher. We will add this in the Discussion section 5.1. as a source of uncertainties.

- L189–195 and L296–299: I like the idea of simulating a hypothetical scenario for seasonal mass balance evolution without the AR's influence, but I'm not sure I completely follow the method and the conclusions that can be drawn from it. How was the detrending of the mass balance time series post-event performed? Am I interpreting L193–195 correctly to mean that this method isn't capable of assessing the influence of the albedo increase during the AR event?

Thank you for your comment. We will clarify this statistical method. We decided on this approach because we discarded the influence of the feedback related to the albedo increase post-event as well as the feedback related to other variables during the event such as incoming shortwave and longwave radiations, wind speed, relative humidity, atmospheric pressure and air temperature. Effectively it is possible to run COSIPY assuming no precipitation during the days of the events, but the event itself also forces other meteorological variables impacting mass balance. An option would be to create an artificial time series for each variable, but we decided on a statistical approach so we could obtain a range of hypothetical values of mass balance.

- L208–221: Is this analysis of ARs during 2014–2021 for all seasons? Or summer only? Please clarify.

We will clarify this. It is for all seasons.

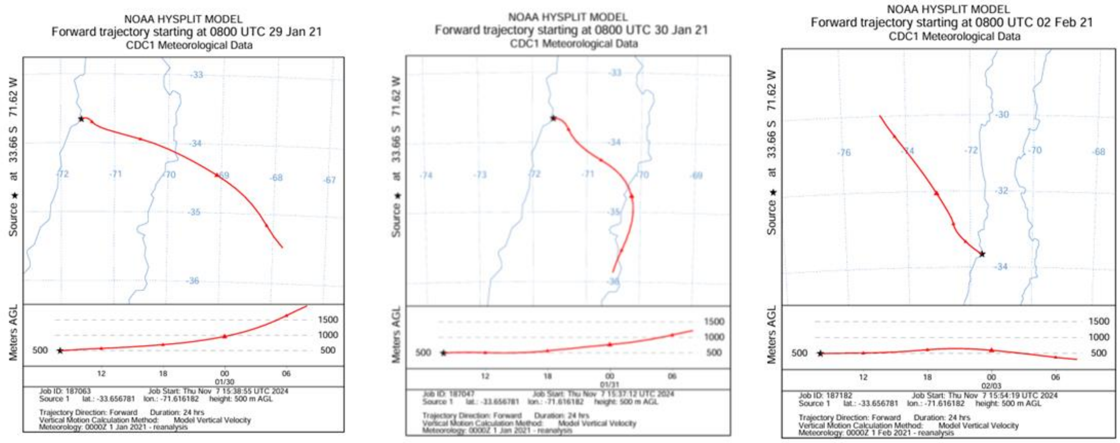
- L231–232: I'm not sure I agree with the statement that the snowline elevation did not return to its pre-event elevation by the end of the hydrological year. If I am interpreting Figure 4 correctly, it looks like the snowline returned to its pre-event elevation by early March, then another snow event in mid-March decreased the snowline elevation once again.

Actually, the day previous to the event the snowline was 4693 m a.s.l. and the mean of the 10 days previous to the event was 4654 m a.s.l. After the event and until the end of the hydrological years these values were not reached again. The maximum value was on 25 march (4493 m a.s.l.) and the mean was lower.

- L249–251: Do the authors have any hypotheses for why there was a greater discrepancy in the 0 degree isotherm from radiosondes vs in-situ temperature sensors during the post-event days? Is there a physical reason for why this might be the case, or is it just a random occurrence?

Checking the HYSPLIT model (attached Figure), the 29 and 30 of January show that the radiosounding launched from Santo Domingo was in the direction to the Andes,

while the 2 of February shows a trajectory to the north-west, to the Pacific. We hypothesise that this difference in trajectories determines the discrepancy. Anyway, the good match between radiosonde and observations probably responds to the dominant synoptic conditions of the days of the event, despite the direction of the radiosonde is not exactly over the Olivares basin.



- Figure 4: This is a nice plot that does a good job of illustrating the radiosonde and station comparisons. However, I have a couple of comments on this plot:

- Similar to my comment on Figure 2, I suggest splitting the plot into 2 separate panels with separate y-axes, rather than having two different scales on the same y-axis

We will keep this figure as is as our scope is to show that the high rate of snow accumulation occurred during the lowering of the 0°C isotherm

- The two rightmost x-axis tick marks are incorrectly labeled as January. These dates are in February.

Thank you for your comments and our apologies for the wrong labelled marks, we will change this.

- L258–274: Be clear that the energy fluxes reported in this section are based on the COSIPY model simulation rather than observations. This is discussed in Section 5.1 but this point should also be made clear here.

We agree and we will add a clarification.

- L282: I don't see the support for the statement that "Typically, ablation in April dominates the mass balance". If I am interpreting Fig. 7 correctly, it looks like the largest mass loss months in the 2014–2021 COSIPY simulations were February and March.

We agree with the reviewer that the statement is not clear. We refer that overall, along the study period, April of the different years shows a predominance in the ablation processes over accumulation, not that the rate of ablation is larger than in the other summer months. To clarify, we will start this sentence: "*Typically, ablation*

in April is larger than accumulation…"

- L288–289: This sentence states that "As expected, the ablation season started in September 2020", but the x-axis label in Fig. 7 labels Oct 1 as the start of the ablation season.

We agree with the reviewer's comment. Actually, the ablation starts earlier than expected. To avoid confusion, we will edit this sentence, adding "*early than expected…"*

- L337: Nice job compiling the estimates of glacier mass balance from previously published sources and comparing them with the COSIPY simulations. This lends credibility to the study results.

Thank you for your comment.

- L356–358: Be clear that the record of historical January-February events, to which the IVT value is being compared, covers only the period from April 2013 to March 2021 (according to Table S1).

We will add the requested information. Is compared with January and February between 2014 to 2021.

- L366–376: This is an interesting discussion of the discrepancy between the observed snowline and the height of the 0 degree isotherm. Do the authors have any hypothesis for why the snowline was anomalously low relative to the 0 degree isotherm during this event?

We don´t have a hypothesis regarding this discrepancy observed here and also in the Andes at 30°S (Schauwecker et al., 2022), however Minder et al. (2011) present an experiment to understand the difference between 0°C isotherm and the snowline. From this experiment, three physical processes are discussed as responsible for this behaviour. An important conclusion is that the difference increases with increasing temperatures. Considering that ARs are relatively warmer storms, the difference found in our work could be explained by this condition in comparison to the more recurrent cold fronts. We will reference Minder et al. (2011) in this section.

- L410–429: This is a nice discussion of how one extreme event can counteract the evolution glacier mass balance expected from the large-scale climate state. This is a good story for the reader to take away from the paper.

Thank you for your comment.

- L424–425: This appears to be an erroneous reference to Fig. 3. Fig. 3 does not say anything about how the snowline elevation has changed over the past 20 years.

We apologise for this mistake.

- L424–426: Where is the Lagunitas meteorological station located? This station should be shown on a map in one of the figures, and also described in Section 3 (rather than introducing this dataset for the first time near the end of the paper).

We will add the location to the map of Figure 1. Also, we will introduce it early, considering that we will use this data to remark on the extraordinary rate of precipitation of this even in summer (mayor comment).

- L463–464: The two papers referenced in this sentence describe projected future changes in global AR conditions. Are there any references that provide projections that are more directly relevant to the study region? Or do the two referenced papers include results that can be used to describe projections more specifically for this study region?

Both studies remark as main conclusion the increase of AR and precipitation associate to AR at global scale. Specifically, the study area seems to be in the limit where increase of AR and extreme precipitation associated to is projected. This agree with the results of a recently published work that shows an increase in AR south of 50°S and a decrease north to 30°S (Li and Ding, 2024). However, this analysis it is just for the boreal winter

Technical corrections

We are very grateful for the technical corrections by the reviewer. We will introduce all the changes suggested by the Reviewer and rephrase some of the sentences. We apologize for the typos and erroneous grammar.

- L20: "over" --> "in"

- L37: "are" --> "is"

- L39: insert "the" before El Niño

- L50: "role of glaciers" --> "influence on glacier"

- L53: "its" --> "their"

- L60: "mid-latitudes" --> "mid-latitude"

- L64: "ARs" --> "AR"

- L65: "its" --> "their"

- L73: "over" --> "above"

- L90: "and characterized" --> "and was characterized"

- L90: "mountain" --> "mountains"

- L96: "the well-known large-scale glacier mass balance forcing as ENSO" - this does not make grammatical sense, please rephrase

- L136: "fuel" --> "fueled"

- L145: IVT stands for "integrated vapor transport" or "integrated water vapor transport", not "integrated vertical transport"

- L147: "Ralph's scale" - please rephrase

- L147: Remove the word "current"

- L150: "scales" --> "scale"

- L159: "was" --> "were"

- L212: "into" --> "over"

- L226: "glaciers" --> "glacier"

- L227: "at this summertime" - this phrase does not make grammatical sense, please rephrase

- L244: "increases" --> "increase"

- L246: "similar values of" --> "similar values to"

- L257: "Surface fluxes energy" --> "Surface energy fluxes"

- L262: "nigh" --> "night"

- L280: "are" --> "is"

- L285: It is not clear what "particular" means here. Please choose a different word.

- L354: "At synoptic-scale, significant moisture transport." - This sentence is a fragment, please revise.

- L367: Remove the word "up"

- L367: "occurs" --> "occurred"

- L394–395: "heat turbulent" --> "turbulent heat"

- L396: "Glaciers" --> "glaciers"

- L401: "influx longwave radiation" - This phrase does not make grammatical sense, please rephrase.

- L453: "mass glacier" --> "glacier mass"

- L461: "202/21" --> "2020/21"

New references

Minder, J. R., Durran, D. R. and Roe, G. H.: Mesoscale controls on the mountainside snow line, J. Atmos. Sci., 68, 2107–2127, https://doi.org/10.1175/JAS-D-10-05006.1, 2011.

Li, Z., and Ding, Q.,A global poleward shift of atmospheric rivers. Sci. Adv.10, eadq0604(2024). https://doi.org/10.1126/sciadv.adq0604, 2024.

REVIEWER 2

Author Response:

We appreciate the constructive review and comments by Dr. Alvaro Ayala. We agree with the major comments and we will introduce changes in the manuscript to address the reviewer's concerns. Also, we will clarify and correct the manuscript considering most of the specific comments and suggested Figure editions. We think that these changes will improve the manuscript. Here, we provide a brief point-by-point response (in bold) to the general and specific comments and concerns by Dr. Ayala:

PAPER SUMMARY AND RECOMMENDATION

Bravo et al. analyse the impact of an unseasonal atmospheric river (AR) on the annual mass balance of Olivares Alfa Glacier, subtropical Andes of Chile. The AR occurred at the end of January 2021and resulted in a strong precipitation event over central Chile, which is very rare to occur during the austral summer. The authors conducted their analyses using remote sensing products, meteorological observations, and energy and mass balance models. They found that the event produced an accumulation of 164 mm w.e. (measured near the glacier tongue) and lowered the 0°C isotherm from typical summer elevations of 4000-4500 m a.s.l. to 3000-3500 m a.s.l., as well as lowering the snowline elevation to about 2500 m a.s.l. Glacier mass and energy balance modelling shows that the annual mass balance of Olivares Alfa Glacier was close to neutral as a consequence of the AR. Synthetic simulations indicate that without the event the annual balance of Olivares Alfa would have been very negative (between -0.5 and -2.5 m w.e., approximately).

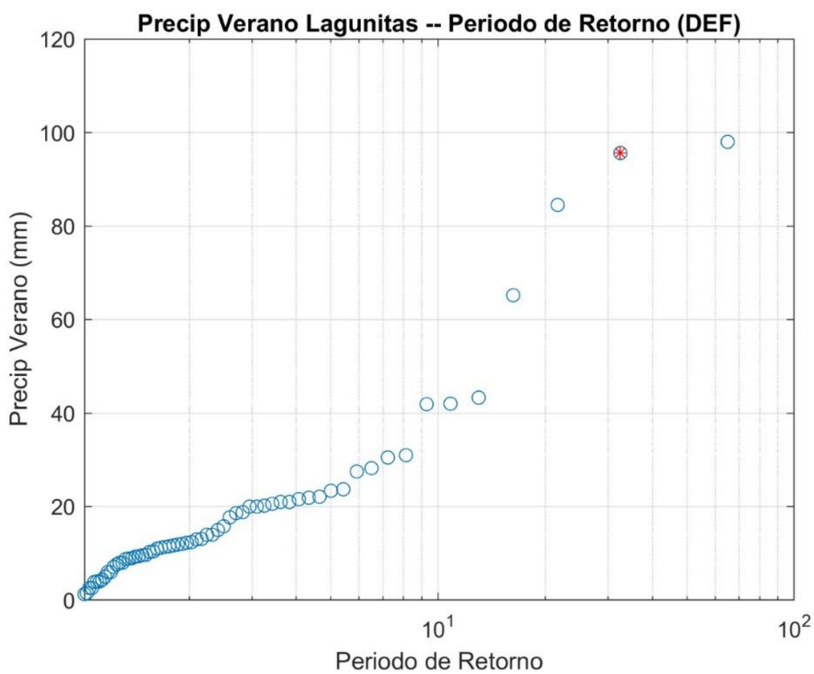
The topic of the article is novel and appropriate for The Cryosphere. The analyses seem adequate, and the main message is interesting and useful for future studies. I suggest that the authors add a few more analyses and clarifications to make the article ready for publication.

MAJOR COMMENTS

1. How rare was this event on glaciers?

I agree with the main comment of reviewer 1. I understand that Valuenzuela et al. (2022) showed a detailed analysis on a regional scale, but it would be useful to know how often such an accumulation event occurs on glaciers in the study area. Can you add some more analysis in this direction? Calculate a return period from Lagunitas data? Or maybe add data from ERA5 and El Yeso meteorological station?

We thank the reviewer for this suggestion in line with a Major comment of Reviewer 1. We will add an analysis to emphasise the extraordinary occurrence of this event and its accumulation. For one side, we will use ERA5 to extend the catalogue of the Atmospheric Rivers in summer to demonstrate the historic low occurrence of this synoptic feature. Also, we will add an analysis to show how the precipitation rate was also extraordinary for summer. In this case, we will use available data observed at Lagunitas weather station. This station, although located at a lower elevation (2765 m a.s.l.), shows one of the longest precipitation records so that we can put this event in the context of an observed precipitation climatology. We previously performed this analysis (see Figure attached, in Spanish) but we didn't include it in the manuscript. We will do it in the potential new draft. Events with almost 100 mm in Lagunitas occur between 35 to 65 years. In the figure, the red asterisk is the January 2021 event and the analysed period is 1960-2024.



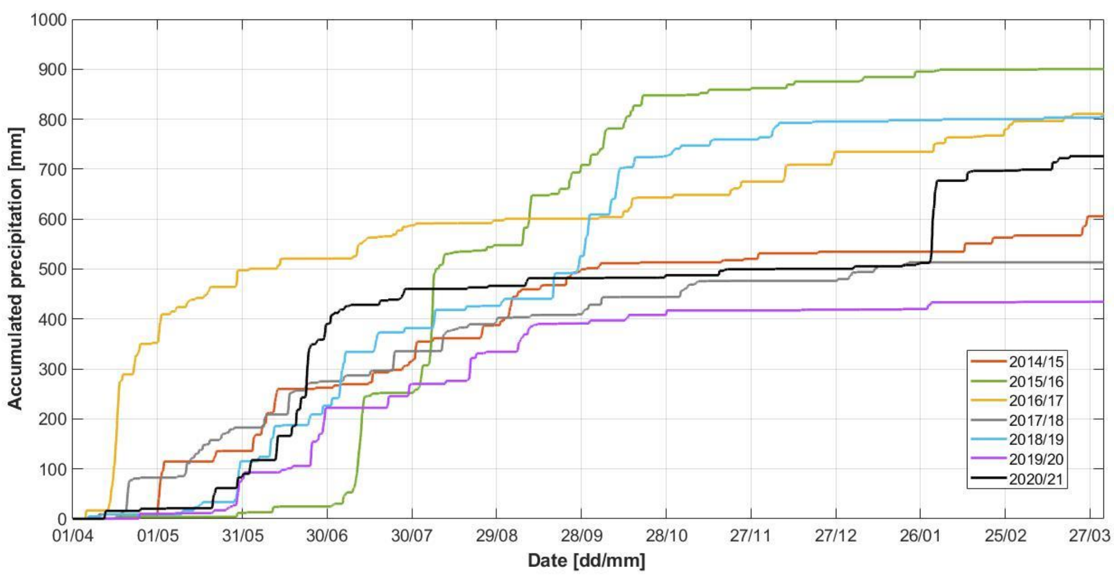
2. Mechanisms that explain the mass balance change

The authors state that "… the impact is not solely from the event itself. Feedback mechanisms related to snow accumulation also impact the mass balance. After the event, ablation diminished due to reduced surface temperatures and increased albedo, which lowered net shortwave radiation, which is the main source of energy for melting during summer" (lines 438-440). So, which was more important? It would be good to answer this question very clearly in the abstract and conclusions. I see that the total snow accumulation at the location of AWS was 164 mm w.e. (Fig. 5) and that the expected ablation without the event ranges between -500 to -2500 m w.e. (Fig. 8). Can you conclude that the main effect of the event was to change the energy balance rather than the mass gain during the event? If this is the case, I think it could be stated more clearly.

I have other suggestions along these lines that could help to understand the effect of the storm on the glacier energy and mass balance.

- Figure 6: Can you add two more panels showing i) albedo and ii) surface temperature? It would be interesting to know for how long the albedo remained high.
- Satellite images: Can you show satellite images to better understand how the AR affected the glacier surface during the rest of the summer? For example, I can see from a Sentinel image of 09.03.2021 that the glacier was already quite dark on that date, but a few days later, a small snowfall brought the albedo back to high values again. So, maybe there were other snowfalls that contributed to keeping the mass balance neutral by increasing the albedo?

Checking the albedo outputs of COSIPY, we agree that the post-event feedback is not directly related to the event. As is parametrized, the albedo reduces quickly, which seems to agree with Reviewer's comments on the satellite images. The low ablation rate in the last two months of the hydrological year seems to be related with two smaller events of snow accumulation in February and March and also to relatively lower air temperature on these months (Fig. S4). The magnitude of these events is not unusual in summer (see Figure below), but it forced a similar impact on the albedo. With this in mind, we will change our statement, and concentrate on the importance of the 164 mm w.e. is quite extraordinary for the date if compared with previous years (e.g. Lagunitas precipitation data) and this was due to the AR. Also, we mentioned that the albedo parametrization is a source of uncertainty (L312-317), to be consistent we will not discuss in detail the post-event albedo. However, we will add in the discussion section that the two accumulation events impacted, reducing the ablation. Just briefly, both, albedo and surface temperature during February are lower than the previous years for the same month, but we recognize this is not solely by the AR event but also for other events. An analysis using satellite images is beyond the scope of this work.



3. Hypothetical scenario (“no event”)

This is a very interesting and useful exercise, but the description provided by the authors is very brief. What were the main assumptions made? What were the time series of precipitation, temperature and the other variables that you used? The same as those recorded, except for precipitation? Is surface albedo calculated by the model? How low would have been the glacier albedo without the event?

Figure 8: Can you add a panel showing the albedo in the actual and hypothetical scenario? What was the effect of the small events after the AR on surface albedo?

The approach here was statistical, using the time series of the mass balance of similar behaviour years (L190-195). Therefore, no time series of air temperature and other meteorological variables. We decided on this approach because we discarded the influence of the rest of the variables during the event such as incoming shortwave and longwave radiations, wind speed, relative humidity, atmospheric pressure and air temperature. Following also comment of Reviewer 1 we will add more details to clarify this approach. We will provide more details about this procedure as follows: "The mass balance time series from previous years were decomposed to extract the trend for each year (Box et al., 2015). Then, the 2020-2021 mass balance series was detrended, and the average, maximum, and minimum trends derived from previous years, in terms of the final mass balance result, were applied to the analysed hydrological year."

MINOR COMMENTS

Title: I think that the title is not fully accurate. "Glacier accumulation" is not the most common term. Maybe change to "snow accumulation", "glacier mass accumulation", "glacier snow accumulation" or "glacier mass gain"? E.g. "Unseasonal atmospheric river drives anomalous summer snow accumulation on glaciers of the subtropical Andes".

Thank you for your suggestion. We will modify the title.

Data availability: Are the meteorological data going to be available?

In the short-term, by request.

21: "… led to substantial snow accumulation on the Maipo River glaciers, confirmed by the post-event snowline …" I don't think that the low snowline confirms a substantial snow accumulation, because a cold event with low precipitation can also produce a low snowline.

We agree, we will change to: "… led to substantial snow accumulation on the Maipo River glaciers and post-event snowline observed at …"

58-62: Can you briefly explain how an AR could produce more melt? Is it because it rains on the glaciers? I thought that an AR was always associated with a precipitation event.

AR originate in the intertropical zone. Therefore, both, water vapour and high temperature are transported poleward by the AR, are transferring to the glacier as energy available for melt. According to Kropač et al. (2021), this is through

longwave radiation and strong turbulent heat fluxes. Rain heat flux also plays a role in fuelling melt.

112: The 70% number is originally from a DGA report, maybe check if there is a more recent number? Maybe Álvarez-Garretón or CR2 have calculated a more updated number in recent years.

We will update this. Although is not the same, we agree that is more relevant to mention that 60% of the water of the basin is used in the agricultural sector and 35% is for drinking water and sanitation.

122: I'm not sure if "two accumulation zones" is technically correct. Maybe say that the accumulation zone is divided in two valleys or cirques.

We agree.

159: Can you show the sensors along the Olivares Basin on a map?

We will add the location of the air temperature sensor in the new map of Figure 1.

181: Can you briefly explain how the model distributes meteorological variables? Precipitation, winds? How is snow and ice albedo calculated by the model? What value did you use for ice albedo? From observations or the literature?

These steps are explained in the paper by Sauter et al. (2020). Briefly, the model used lapse rates for air temperature, and relative humidity. The barometric formula for atmospheric pressure and modelling approaches for shortwave and longwave radiation. Wind speed is constant. For albedo, the Oerlemans and Knap (1998) approach is used, assuming theoretical values of 0.3 for ice and 0.85 for fresh snow.

191: "detrending the mass balance time series post-event" This is not clear, how was this procedure? Can you provide more details about this experiment? Did you remove all the summer precipitation? Is albedo adjusted by the model? See my major comment 3.

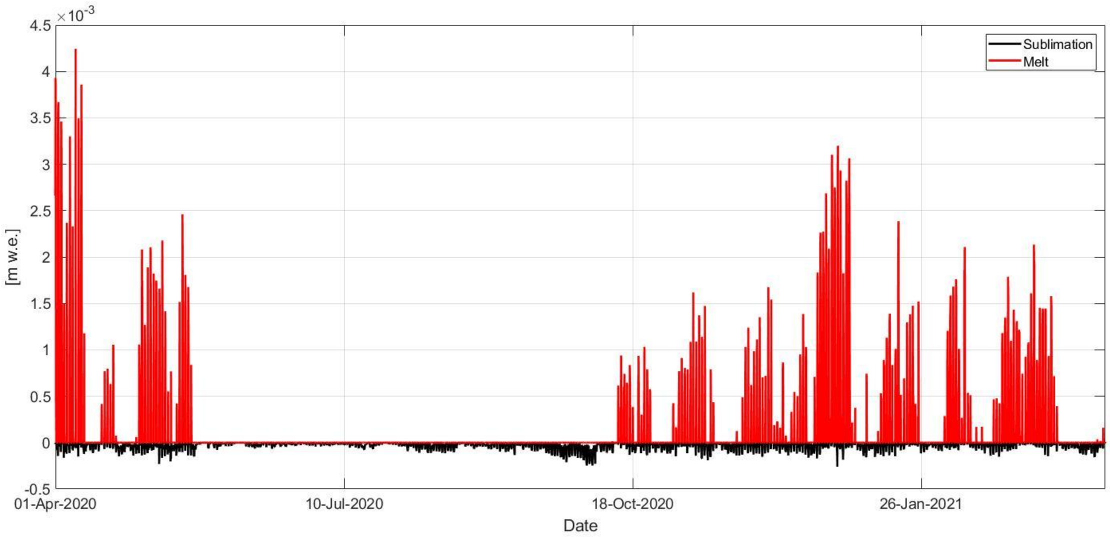
192: "The behavior from previous similar years … was derived and applied to the detrended 2020/2021 accumulated mass balance time series" I don't follow the procedure. I thought that the experiment consisted only of running the model without the AR event, but did you use information from other years? See my major comment 3.

191-192: We answered this in the major comment. We hope this clarifies the method. We added a reference.

260: The negative latent heat flux means in this context sublimation, not melt. What happened to the snow deposited by the event? Was it sublimated or melted? Can you provide both amounts? Looking at figure 6, I would say that sublimation dominated over melt after the event.

We will correct this statement; it is not clear. After the event, the snow melted and a small fraction sublimated. The figure below shows that there is sublimation over the

hydrological year but the rate is lower than the melt. During the event and in the other summer events, no melt is registered but sublimation continues.



FIGURES

Figure 1: A, please delete the rest of the political boundaries, or explain what they are. The text refers only to the Maipo River Basin.

We will edit this Figure.

Figure 3: Please change the red colour of the ERA5 longwave radiation. It is difficult to distinguish from the black lines. Maybe change this plot from hourly to daily time steps? As it is, the hourly data have a lot of noise.

Following the comment of Reviewer 1, we will move this Figure to the Supplementary section. We will keep the hourly time step because is the time step that we used for feeding the model.

Figure 4: Can you indicate the event period here?

We will add a marker to indicate the period of the event.

Figure 5: -> “Time series of the 0°C isotherm around the event”

We will correct this.

Figure 5: What is AWS DGA? So, you didn’t use the Ta sensors along the valley to calculate the isotherm?

We will change this. We used several air temperature sensors as is described in the manuscript.

Figure 5: The number 164.6 mm w.e. is only given here, and it is quite important. Please mention it also in the text.

Ok, thank for noting this omission. We will introduce this information in the text.

Figure 6: Please see my main comment 2.

Figure 8: Can you add another panel showing accumulation and ablation separately? I think that would be very useful to understand whether the cause of the neutral mass balance was the snow accumulation during the event or its effect on surface albedo.

We will add what the reviewer suggested:

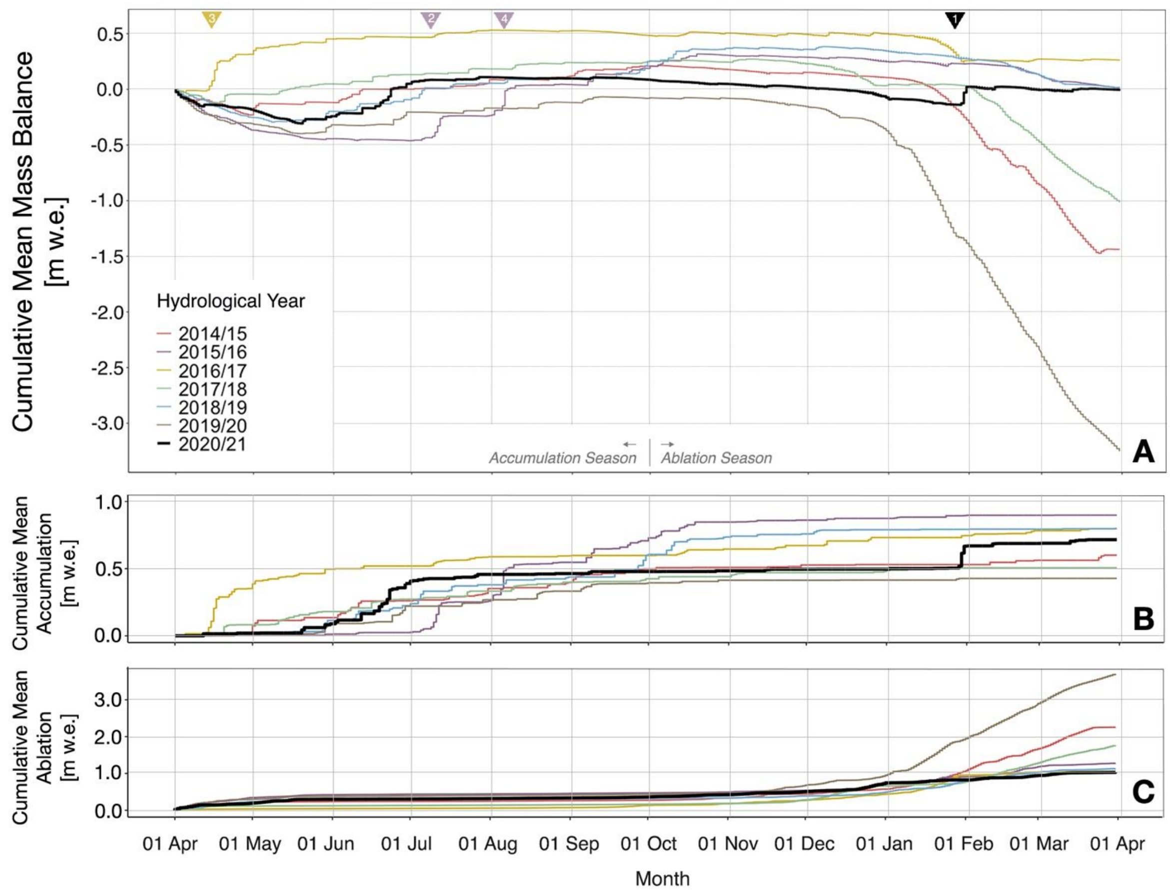


Table 2: Can you add a new column with the average fluxes in the days or weeks after the event? This would make it easier to understand the changes caused by the AR (instead of looking at Figure 6).

We will add a column with the mean values during the event.

SUGGESTED TECHNICAL CORRECTIONS

We are very grateful for the technical corrections by the reviewer. We will introduce all the changes suggested by the Reviewer.

18: add “austral” to “summer”

20: -> “the effects of the AR on the…”

21: Replace “significant” by another term, maybe “massive” or “large”.

25: Introduce the current mega-drought before or maybe just say “a severe drought”. As it is, the sentence assumes that all readers know about the prevailing mega-drought conditions.

35: Delete “during specific periods, such as the hydrological year”

36: -> “there is a typically large interannual variability”

138: -> “strong even for winter events”

150: This sentence is quite orphan. Remove or move to the introduction. Or provide here some more general details.

209: “Pacific coastal grid points” Refer to Figure 2c.

211: Please move “Category 1 being the lowest and …” to line 131 when the categories are first mentioned.

213: -> “by the amount of time” or maybe “duration”

231: “an elevation like January 2021”, which one?

239: “Diurnal cycle” is more precise

250: precise here if the direction of the discrepancy, what is higher and what is lower?

383-385: But this is logical, no? It is the ablation season.

415: “Cortés and Margulis”

425: I think it should be Fig. 4, not 3.

New References

Alvarez-Garreton, C., Boisier, J. P., Garreaud, R., González, J., Rondanelli, R., Gayó, E., and Zambrano-Bigiarini, M.: HESS Opinions: The unsustainable use of groundwater conceals a “Day Zero”, Hydrol. Earth Syst. Sci., 28, 1605–1616, https://doi.org/10.5194/hess-28-1605-2024, 2024.

Box, G. E. P., Jenkins, G. M., Reinsel, G. C., and Ljung. G. M.: Time Series Analysis: Forecasting and Control (5th ed.), Wiley, United States, 720 pp., ISBN 978-1-118-67502-1, 2015