

Response to anonymous referee #3

We thank the referee for their constructive comments, which will certainly help to shape this manuscript into an improved paper. We provide here our responses to each comment and/or question made and how we will modify the manuscript as a result. The referee's comments are in blue, and our response in normal text.

General comments

The study analyzes the control of the present-day climate on the surface mass balance of the Patagonian Icefields. The main goals of the study are clearly formulated, and the study is well structured and written over largest parts. In the Discussion section, a stronger comparison with and discussion of results of other SMB studies in the region could strengthen the findings. Overall, the study adds valuable knowledge to the understanding of the interaction between climate and glacier mass balance in the southern Andes. I have one major comment which needs addressing and revision before publishing the article, together with several minor comments.

Major comment

The main limitation of this study is the fact that there is no spatial analysis for the correlation of SMB with large-scale indices and climate. It is possible that e.g. SAM does have an important impact on the SMB of the southern SPI, however, not on the whole study site. Averaging over such a large area can cause different signals in different regions to equal out. The study site does stretch over a large latitudinal band, and we know from literature that the climate and glaciology of NPI and SPI can show different characteristics and patterns. This is taken into account by calibrating the SMB model for both icefields individually, but then ignored throughout the rest of the paper.

Overall, I think by the spatial averaging a lot of valuable information is lost. I advise to conduct a spatiotemporal analysis instead of averaging over the SPI and NPI in order to gain information about the regional variability of climatic control on the SMB in Patagonia.

We thank the referee for this valuable comment. We will conduct a spatiotemporal analysis and discuss it in a revised version of the manuscript. Specifically, we will perform a principal component analysis (PCA) on the time-lat-lon field of SMB and we will seek for the main modes of variability of the SMB. If there is one leading mode of spatiotemporal variability (accounting for most of the joint variance), we will compare its PC with the time series we have been using so far (spatial average over the NPI and the SPI) in order to ensure that our method give us a time series representative of the variability of most of the icefields' area. If there is more than one leading mode of spatiotemporal variability, we will redo Figs. 6 and 9, and Table 5 considering each mode of variability and we will discuss the results in the manuscript.

Minor comments

L1: "Northern and Southern Patagonian Icefields" should be "Northern and Southern Patagonian Icefield"

We thank the referee for pointing this out. We will modify the line accordingly in a revised version of the manuscript.

L56 & 76 & 482: “dryer” should be “drier”

We thank the referee for this correction. We will fix this typo in a revised version of the manuscript.

L88: The word “scenario” is strongly associated with climate scenarios, I recommend to reformulate

We thank the referee for this recommendation. We will reformulate the sentence in a revised version of the manuscript.

L93: “assess” to “assesses”

We thank the referee for this correction. We will fix this typo in a revised version of the manuscript.

L112-123: The paragraph about the study site is a bit short in my opinion. I would include some brief information about major differences between the two icefields (e.g., SPI many marine terminating glaciers; do we have substantial climatic differences between the two icefields?). A reference to Fig. 2a would make sense here.

We thank the referee for this suggestion. In a revised version of the manuscript we will extend the section about the study area including the topics suggested by the referee.

L125-131: Which exact variables are taken form RecCMv4?

We took the near-surface air temperature, precipitation, and surface downward solar radiation fields from the RegCMv4. We will include this information explicitly in L126-127 in a revised version of the manuscript.

L133: Why are two different versions used for precipitation and temperature?

We used the last versions available of the CR2MET products of precipitation and temperature. As these products are independent, there is no problem in using different versions for each variable.

L132-140: Both datasets, RefCMv4 and CR2MET, are (at least partly) based on ERA-Interim. I miss a comparison with an independent dataset. What about weather station data, or an independent Reanalysis dataset?

As shown in Fig. S1, there are very few stations near the Patagonian Icefields with enough data available for deriving climate statistics to compare with the RegCMv4 within the period 1980-2015. The CR2MET product uses this information in the best possible way and constitutes our best station-based approach in the region. Nonetheless, we will include a comparison between these stations and the RegCMv4 in a revised version of the manuscript.

L150: You used the abbreviation ERA-Interim before. Introduce it at the first mentioning, please.

We thank the referee for pointing this out. We will introduce ERA-Interim at the first mention, as suggested.

L154: Dot is missing at the end of the sentence.

We thank the referee for this correction. We will fix this in a revised version of the manuscript.

L158: This is not clear to me: “Lastly, we spatially unweighted averaged the meteorological forcing and the glaciological over the Patagonian Icefields...”

We thank the referee for warning us about this unclear expression. In this step we computed the spatial average of the meteorological forcing assigning the same weight to each grid point. We will clarify this in a revised version of the manuscript.

L164: The first “DEM” can be removed.

We thank the referee for this suggestion. We will remove the first “DEM” in a revised version of the manuscript.

L183f.: This is not a downscaling of radiation, but simple interpolation.

We thank the referee for pointing this out. We will change the expression accordingly.

L199: I would replace the 10800s in the equation by a variable representing the timestep

We thank the referee for this suggestion. We will modify the equation as suggested in a revised version of the manuscript.

L201: These are not soil. Rather call it type of surface.

We thank the referee for pointing this out. We will use “type of surface” instead of “soil” when referring to snow, firn and ice.

L208: Accurately, the end of summer season would be the 31 March.

We thank the referee for pointing this out. We will refer to April 1st as the start of the autumn season.

L218: Please, use a consistent number of decimal places.

We thank the referee for pointing this out. We will use a consistent number of decimal places in a revised version of the paper.

L221-223: The values for c_0 are very different between NPI and SPI. Why is this the case?

These values reflect the difference in SMB between NPI and SPI having similar sensitivity to near surface temperature.

L227: See comment to L132-140.

Please see our response to the minor comment on L132-140.

L241 & Table1: I recommend using a different abbreviation for the time period here to avoid confusion, as T has been used for temperature before.

We thank the referee for pointing this out. We will use a different abbreviation for the time period in a revised version of the manuscript.

Table 1 and following tables: It is common to put the table captions above the respective table.

We thank the referee for this recommendation. We will put the table captions above the respective table in a revised version of the manuscript.

Table 2: The annual SMB and precipitation value does not exactly add up from winter and summer values. Rounding error?

Yes, winter and summer value do not add exactly in the case of annual SMB and precipitation because of rounding errors.

L286-289: Only mention the significant correlations here: “Among the modeled meteorological variables, the annual SMB is found to have the largest correlation with the annual precipitation ($r = 0.69$), followed by annual insolation ($r = -0.44$) (see Table 3). The same order is also evident in winter. The correlation between the SMB and temperature is only significant in summer.”

We thank the referee for this recommendation. We will modify the paragraph accordingly in a revised version of the manuscript.

L332: The correlation seems to be highest especially over the SPI?

While the map does not show correlation directly, effectively it shows the highest slope of regression over the SPI.

L346: “shows” to “show”

We thank the referee for this correction. We will fix it in a revised version of the manuscript.

Fig. 6b: The grey and white shading is confusing at the first glance, as it seems like there would be two different variables in this plot like it is in panel d. Maybe you can give the shading the same color as the contours to make it clearer.

We thank the referee for this suggestion. We will modify the figure and give the shading the same color as the contours as suggested.

L368f.: Refer to Fig. 9a here first.

We thank the referee for this suggestion. We will refer to Fig. 9a in L368 accordingly.

L392ff.: The low correlation with the ENSO and SAM could be due to the spatial averaging over the whole study site. Consider differentiating into regions.

Please see our reply to the major comment.

L418-426: Discussion and comparison with other SMB studies in southern Patagonia would support your findings. Similar findings have been found before, e.g., at Grey and Tynall Glacier (Weidemann 2018, <https://doi.org/10.3389/feart.2018.00081>)

We thank the referee for this suggestion. We will discuss and compare with other SMB studies as suggested.

L473 & 490: “SBM” to “SMB”

We thank the referee for this correction. We will fix this typo in a revised version of the manuscript.

L476-489: Every paragraph starts with “years of ... SMB are characterized by ...”. Consider reformulating.

We thank the referee for this suggestion. We will rephrase the paragraphs accordingly in a revised version of the manuscript.