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Interactive comment on "Revisiting extreme precipitation amounts over southern South America and implications for the Patagonian Icefields" *by* Tobias Sauter

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Title: Revisiting extreme precipitation amounts over southern South America and implications for the Patagonian Icefields

PAPER SUMMARY AND RECOMMENDATION

Sauter presents an evaluation of the precipitation magnitude across southern South America. The emphasis is given in the implications to the surface mass balance (SMB) of both Icefields. New data is mainly compared with previous SMB models. Based on the data obtained from an Orographic Precipitation Model, the main con-

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clusions are that Patagonia is not the wettest place on Earth and that the previous SMB overestimates the accumulation. The scientific significance is high regarding the lack of information (and observations) of the actual magnitude of the precipitation on the Patagonian Icefields. The scope of the research is clear and prove (based on the used datasets and assumptions), that higher amount of precipitation previously reported are not sustained by the moisture flux over the region, although this conclusion, of course, will continue to be subject of discussion in the future. The manuscript is within the scope of HESS, it is in general well-written. The reason for the study must be well justified in the Introduction. The Methodology section needs to clarify and add some explanations, as well as some dataset and experiments details used for validation/comparison. The Results/Discussion section needs to be strengthened. I think this paper provides interesting data and results to the glaciological and hydroclimatological communities. In my opinion, it must be considered for publication after solving/clarifying some issues (see Major comments) and a careful revision of the text (see Minor comments).

MAJOR COMMENTS

1. Introduction

As one of the main topics is the implication of the precipitation on the mass balance on the Icefields, a detailed review of the previous estimations is necessary, considering also the title of the Manuscript. This is barely mentioned, but a comprehensive revision will be helpful for the reader and also will give a strong justification to the present work, mainly related to the fact that besides all the past efforts, still high uncertainties exist in the precipitation magnitude and/or accumulation rate on the Patagonia Icefields.

In this section, it is mentioned the importance of the atmospheric rivers as a source of moisture on Patagonia (first paragraph), but a previous work (Langhamer et al., 2019) indicated that the main source of moisture for the South Patagonian Icefield is the Pacific Ocean between 30° and 60° S. Please, clarify this.

2. Soundings

It seems that the soundings are used to validate and corrected the WVF from ERA-Interim. Although the information about the WFV trend for both soundings is interesting, it is not used in the analysis. A Figure showing the comparison of the observations with the ERA-Interim data will be useful to understand the bias correction (Page 5, Lines 15-20). Please note that the SSMIS data is not mentioned in the Methodology section as a dataset used for comparison.

3. Spatial differences

It is well established that there are extreme climate gradients on the region, and the results of this work also provide evidence of this, however, in terms of SMB just a mean value is used for each Icefield (NPI and SPI). The author must consider the spatial differences and/or the heterogeneous response of theses glaciers determined by the geodetic method (e.g. Malz et al., 2018; Jaber et al., 2019). Overall, the discussion is related to the glacier shrinkage, despite that, some glaciers show positive (e.g. Pio XI) and stable mass balance.

4. Mass balance uncertainty

The approach to calculating the mass balance is simple but useful to demonstrate the implication of the overestimation of the accumulation rate. However, it must be mentioned other source of uncertainty on SMB estimations. Recent work indicates that the method chosen to estimate the ratio of solid precipitation is also a source of uncertainty in accumulation estimations (Bravo et al., 2019). This even could lead to lower accumulation rate than those mentioned in the manuscript as the method used is quite simplistic.

5. Limitations and nonlinearities

This section presents a comprehensive analysis of the main source of uncertainty, related to the linear nature of the model. This is quite interesting and necessary in a work

of this nature, and the last three lines of this section (Page 8, Lines 11-14) is a perfect summary of this section. However, this analysis should be useful if quantification of the uncertainty is given. This quantification could be obtained from the WRF experiment, which also needs to be mentioned in the Methodology section. This section also uses three of a total of seven Figures to explain the limitations, please check if is really necessary the three Figures.

6. Consistency on percentage

Please clarify the percentage of overestimation regarding previous works. For instance, it is mentioned in Page 6 Lines 15-16 that the maximum precipitation (11.58 +-0.98 m yr-1) represents a reduction of 60% compared to other numerical studies, while in the Conclusions section (Page 8, Lines 21-22) this same value represents a reduction of 30-50%. Please also check the other percentages given.

MINOR COMMENTS:

Please perform a careful revision of the References.

Define in the text acronyms not defined: GPM, SSMIS, WRF, OPM

Just for consistency, use the same units. In the text, the units are in some sections as m yr-1, while other sections and in Table 1 the units are m w.e. yr-1. This could produce some confusion. Please also note that the work of Bravo et al. (2019) is snow accumulation and no total precipitation.

I suggest to include some of the equations that are explained in the Methodology sections in Page 4 lines 3-10.

On Page 2, most of the last paragraph should be on the Methodology section (assumptions and conditions).

Page/Lines:

3/1: Define “DR”

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3/11 “DR-scaling”

3/14: “Langhamer et al. (2018)” is not listed in References

3/ 17: Define “GPM”

3/24: Indicate the vertical precipitation gradient of Schaefer et al. (2013)

3/26-27: “orographic precipitation model (OPM)”

3/28: “Garreaud et al., 2016” is not listed in References

3/33: “the decay”

4/ 11: “derived”

4/13: “remarkably”

4/20: “delivers”

4/27-28: Add period of the average WVF given.

4/29: Add reference to this sentence.

5/12: Define SSMIS

5/17: “suggests”

6/1-2: “Dirección General de Aguas”

7/10: “Southern Annular Mode (SAM)” or “Antarctic Oscillation (AAO)”

7/18: “Given” instead of “In view of”

7/19: Delete “necessary”

8/16: “based on” instead of “on the basis of”

8/20: “based on”

8/26: Delete “clearly”

8/29: “Assuming that changes in the orographically induced precipitation are. . .”

8/31: “per degree of warming”

9/3: Delete “in order”

Figure 1: “show”

Figure 2: Add units to Y-axis

Figure 4: Reference to SPI is “Schaefer et al. (2015)” no “Schaefer et al. (2013)”

Figure 4: Caption indicate that the period is “1975-2000”, however, the number of blue points (annual values) is greater than this period covers. Correct or clarify this. Maybe “1975-2011”?

Figure 4: Complete last line of the caption: “Schaefer et al..”

Table S2: Please indicate which Stations are leeward and which are windward. This will be helpful to fully understand the manuscript on Page 6, Lines 1-4.

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