The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2018-258-RC1, 2019

The Cryosphere Discussions

Interactive comment on "Heterogeneous spatial and temporal pattern of surface elevation change and mass balance of the Patagonian icefields between 2000 and 2016" *by* Wael Abdel Jaber et al.

Anonymous Referee #1

Received and published: 9 January 2019

General comment

This manuscript applies advanced SAR processing techniques in order to derive spatially detailed maps of surface elevation change (SEC) of the Northern and Southern Patagonian icefields, NPI and SPI respectively. The text is well written, the figures are of good quality, the tables are clear and informative, the topic is of high interest and the results are very interesting, confirming previous studies showing as a whole a strong negative ice volume change with high spatial variability. The authors analyse in detail different sources of errors and gives precise estimations of uncertainties for every studied glacier, different data sets and analysed periods. The results are not totally

novel, since the data sets employed in this manuscript were recently used in a paper published by Malz et al., (2018) with some variations in dates, error assessments and study area. Unfortunately, the results are not totally comparable between them since the glacier basins and dates are not the same. These differences preclude a precise estimation of discrepancies, but in general the results are statistically similar. The main contribution of Abdel Jaber et al, is their claimed much smaller uncertainties due to several correction that Malz et al didn't applied. After considering the analysis performed by Abdel Jaber et al, I think the error assessment is much more rigorous, effectively addressing many error sources of the data sets, but it is too ambitious when trying to extrapolate parameters from single stations/glaciers for correcting some issues related to the whole icefields. In those cases, is better to live with higher uncertainties and not adding more doubts as I think were added when using Perito Moreno as model for altitudinal gradients for example.

Thanks to the detailed error analysis, this manuscript provides a state-of-the art estimation of surface elevation change of both Patagonia Icefields. Unfortunately, the last data set of 2015 does not come from the end of ablation season, therefore, the authors applied a seasonal corrections to the derived surface elevation changes in order to provide estimates that correspond to full seasonal cycle. This seems to be a weak point of the study design. I guess this was caused by the availability of TanDEM-X imagery, however, employing a more recent datatake from the end of ablation season (later than 2015/16), would have considerably strengthen the importance of this contribution. Assuming that the surface elevation changes in summers 2011/2012 and 2015/2016 are equal, based on similarity of monthly mean air temperature records in some neighbouring weather stations is very arguable.

The other weak aspects of the manuscript are the assumptions regarding altitudinal gradients only supported by Perito Moreno glacier data. This glacier cannot be considered representative for the entire icefield due to extreme longitudinal gradients of climate and mass balance associated with orographic barrier of the Patagonian Andes.

I would be keen to see maps of systematic error similar to Fig S7 that shows random error. This is especially important for some major outlet glaciers of SPI (Jorge Montt, Pio XI, O'Higgins, Viedma and Upsala) where seasonal correction was in the order of several meters (Fig. S4b).

This work is largely based on the results and methods reported by Abdel Jaber (2016) PhD thesis. In order to avoid undesirable repetitions, I guess the thesis can be quoted only a couple of times, and then assuming that the results are the one obtained in this manuscript.

In synthesis, I think this manuscript is highly valuable and fits very well with the aim and scope of the journal.

Some specific comments:

P1 L20: ... and ..., respectively

P2 L9: any other reference? this is only review

P3 L8-9: You frequently refer to Abdel Jaber (2016), how different is its work from this submission? I presume is roughly speaking the same.

P3 L23-24: Later you refer to Abdel Jaber (2016) as a source for subaqueous ice loss estimates

P5 L15-20: Crippen et al. (2016) provided only a general description of NASADEM, and as far as I now, its performance has not been thoroughly compared with SRTMGL1. This I guess is one of main differences of this work compared to a very similar study by Malz et al. (2018) - how does it impact your final results? Were there really less voids compared to SRTMGL1?

P6 L25: How different were your glacier outlines from those used by Malz et al? The Randolph inventory is known to have problems in many places. Maybe you can discuss about this.

P7 L10: There is a problem when quoting equations along the whole manuscript. Only Eq. 2 is mentioned in the text and some equations are between lines without label numbers, don't helping in the fluent reading process.

You refer here to Eq. (2) well before introducing it (and before Eq. (1))

P8 L20. The temperature and balance altitudinal gradients in the SPI are highly different between east-west margins or northern - southern parts etc. Maybe you can check a recent paper by Bravo et al in JGR (DOI: 10.1029/2018JD028857) and comment on this.

P8 23-36: Can you please clarify this part? For example Perito Moreno and Jorge Montt have very different climatic setting (Lenaerts et al., 2014), I wonder if Perito Moreno is a best choice for a reference in this case.

P8 L30-32: Again, issue of transferability of parameters of Perito Moreno to entire SPI. Why was it not necessary for NPI, because of the day of datatake, I guess?

P8 L36-37; Fig S4: There are sharp boundaries between zones corresponding to different timespans, do they propagate to the final product introducing discontinuities?

P9 L19: Uncertainty bound on glacier-wide density seems to be too low. Cogley (2009) refer to Sapiano et al. (1998) 6% estimate as reasonable. In similar work, Malz et al. (2018) provide three scenarios of different densities, it is their main source of uncertainty for the final results.

P10 L7-10: Please back it up with some reference

P10 L24: Finally, what exactly was the criterion for masking regions prone to penetration? Was it only manually outlined based on expert knowledge?

P11 L8-9: See comment above

P11 L11: Bippus (2007) assumed this lapse-rate for summer season on Perito Moreno, however as far as I know this value was not based on measurements. Additionally, she

accounted for an off-glacier location of AWS, resulting in additional temperature offset. Maybe you can compare your numbers with Bravo et al 2019

P12 L26: Is 0.1 m based on literature?

P13 L1-5: I think that the error linked to the seasonal correction may be underestimated as it does not seem to cover all uncertainties related to the transferability of hypsometric averages shown in Fig. 8 (see previous comments).

P15 L26: It that is true than your seasonal correction should use lower density in accumulation area.

P15 L30: Perito Moreno glacier

P16 L28: Results were recently published in Frontiers - Langhammer et al. (2018)

P16 L37: Again, I doubt that Perito Moreno is representative for entire SPI and SPI, Steufer (2007)

P17 L26: This issue is a critical factor in the whole analysis of the elevation changes in the high plateau of the icefields. We know that the accumulation is extremely high, an in between few days you can have huge accumulation events. I think this high temporal variation of snow fall must be taken into account. See Schwikowski et al 2013 for snow accumulation on the SPI.

P18 9? What analysis? It is missing in methods and results sections. Maybe you wanted to quote Abdel jabber 2012? P18 L25: See comment above P33 Fig.4: Why is there a sharp transition in the terminal part of the glacier on panel a? Frontal retreat I guess?

New references mentioned in this review:

Bravo, C. et al (2019) Air Temperature Characteristics, Distribution and Impact on Modeled Ablation for the South Patagonia Icefield. JGR, DOI: 10.1029/2018JD028857

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Sapiano, J.J., W.D. Harrison and K.A. Echelmeyer. 1998. Elevation, volume and terminus changes of nine glaciers in North America. Journal of Glaciology, 44(146), 119-135.

Schwikowski, M., M. Schläppi, P. Santibañez, A. Rivera and Casassa G. (2013): “Net accumulation rates derived from ice core stable isotope records of Pío XI glacier, Southern Patagonia Icefield”. The Cryosphere 7, 1635-1644. doi.org/10.5194/tc-7-1635-2013

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2018-258, 2018.