EGUSPHERE-2025-3259

Final response, December 18th 2025

Final author comments

Response to RC2

The manuscript presents work in the area in Antarctica with very low accumulation and mainly no ablation. That gives excellent possibility to study ages of different snow layers. Aim is to define how well annual stratigraphy is visible in older snow and how surface features affect to the stratigraphy over the years. In addition, SMP measurements (snow hardness) correlation with age defined based on chemical composition is studied. Also, annual accumulation rates calculated from the trench, ERA5 and earlier snow stake data are compared. For the analysis, 50m long and 1.5m deep trench was made in December 2019, covering snow accumulation approximately from past 20 years.

General comments

Accumulation hiatus could be explained better.

Accumulation hiatus, near zero accumulation or erosion over a given period of time, is a concept that has been studied already, see for instance these manuscripts (Genthon et al., 2016, Picard et al. 2019). We add this definition to paragraph 3.4 as well as the link to these manuscripts to ensure that readers have the same definition than the one we used when they read this manuscript.

The novelty of our method is to describe accumulation hiatus from a final accumulation product (snow pits) in which, by definition, only strictly positive accumulation is recorded. To do so we have extended the definition of hiatus to a snow accumulation less than 3 cm over a given period of time. 3 cm correspond to the smallest accumulation amount we can detect with the trench resolution.
Next we do a spatial analysis of accumulation hiatus based on the dated trench isochrones covering a 50 m distance and a 20 year accumulation record. The vertical distance between two isochrones represents the accumulated snow over that period at the location of the 26 trench profiles. We ask what fraction of profiles are subject to accumulation less than 3 cm of snow for that period of time. Finally, we repeat this computation for all pairs of isochrones, and bin average the results by time period, to obtain the spatial fraction of hiatus as a function of time period. We find that the trench isochrones reproduce well the hiatus that are observed by direct method such as with the RLS.

The have rewritten the first paragraph in the hiatus section 3.4 in order to improve the explanation.

Old version:

> "Fig. 4b shows that the 2012 and 2013 isochrones are in a very narrow range of depths (< 3 cm) around profile P32, indicating a low accumulation at this location for the year 2012. Such occurrences of accumulation below 3 cm are interpreted as near accumulation hiatus (compared to the 8 cm of annual snow accumulation), i.e. periods with negligible accumulation or even erosion at a given location. Considering that the vertical resolution of the alignment is 3 cm, i.e. the lowest depth difference that we can resolve, we refer to periods with smaller amount of snow accumulation as *hiatus*. The hiatus fraction for an

accumulation event is the fraction of profiles with a hiatus. The probability of hiatus for a time scale is the mean hiatus fraction for all accumulation events corresponding to this time scale. The frequency of hiatus should be close to 100 % for a very short time difference, because almost all snow deposits are less than 3 cm, and gradually decreases with the considered time-scale.

Fig. 7 shows the probability of hiatus occurrence as a function of the time scale, up to three year periods, in the trench and in the RLS area. The 19 year record of accumulation in the trench, with 3 cm vertical resolution, equivalent to at least 6-month temporal resolution, is compared to the 2 years time series of the RLS (period 2) with daily resolution. (...)"

New version:

"Annual accumulation hiatus, near zero accumulation or erosion over a year, is frequently observed near Dome C (Genthon et al., 2016, Picard et al. 2019). We investigate whether we can detect it in the reconstructed trench accumulation. In order to describe accumulation hiatus from a final accumulation product (snow pits) in which, by definition, only strictly positive accumulation is recorded, we have extended the definition of hiatus to a snow accumulation less than 3 cm over a given period of time. This 3 cm threshold corresponds to the smallest accumulation amount we can detect with the trench resolution. For example, the 2012 and 2013 isochrones in Fig. 4b are in a very narrow range of depths (< 3 cm) around profile P32, indicating an accumulation hiatus at this location for the year 2012. We consider all pairs of isochrones and compute the fraction of profiles where hiatus are occuring. We bin average this hiatus fraction by the time period separating isochrones in each pair. The same analysis is repeated on the elevation profiles of the RLS data, with a threshold of 3 cm accumulation.

The hiatus fraction as a function of time period for the trench and RLS is shown in Fig. 7. The 19 year record of accumulation in the trench, with 3 cm vertical resolution, equivalent to at least 6-month temporal resolution, is compared to the 2 years time series of the RLS (period 2) with daily resolution. (...)"

The main point and impact of the study could be better clarified in the conclusions.

We acknowledge that the conclusion can gain in conciseness, by highlighting clearly three main points of our study, which were slightly hidden in too vague sentences. The three points are the following:

1) The global consistency of the reconstructed accumulation rate at Dome C with direct observational methods, both in mean values are inter-annual variability, including periods of low accumulation (accumulation hiatus).
2) We highlighted the persistence of a 30 cm high and 10 m long snow dune over a period of 20 years, and further showed the low correlation between topography and snow accumulation. This is a single observation at the location of the trench that would need to be generalized, but for interior sites like Dome C, 30 cm corresponds to more than 3 years of accumulation, so it is significant that it would remain at the same location over an extended period of time.
3) Finally, our results show that the linear approximation of the age scale age scale over 20 years is within a +-1.5 years dating error of the finer age scale based on using older snow pits to obtain absolute dates. This is an encouraging perspective for transposing our approach to the broader study

of replicate cores covering longer time scales, where only linear interpolation between multi-decadal time horizons are available.

We have added a stronger focus on the main points and impacts in the conclusion:

> "Here, we reconstructed the last two decades of snow accumulation at Dome C at annual time scales, by using chemical composition and physical properties of 26 vertical profiles across a transect of 50 m. ~~The dating method is based on using older snow pits to obtain absolute dates.~~ The mean local accumulation rate matches the ones obtained in ERA5 (total precipitation - evaporation), and from a stake farm (GLACIOCLIM, within the spatial uncertainty). The reconstructed accumulation time series shows further similarities with observations, including inter-annual variations that ~~The amplitude of the inter-annual variations of snow accumulation~~ can reach up to 50 % of the total local accumulation, and around 5-10 % chances of annual accumulation hiatus at the profile scale ~~at Dome C.~~
>
> We evaluated the spatial variability of the accumulation at the meter scale. We found that variations of 20 % in the accumulation rate along the transect on average, with a decorrelation length of roughly 1.4 meters. These statistics confirm that snowfalls are not uniformly deposited at Dome C, but instead each event forms patches of accumulation. ~~The measurements suggest around 10 % chances of annual accumulation hiatus at the profile scale.~~ This impacts ice core signal interpretation and contributes to the stratigraphic noise. We argue that for timescale larger than two years, the impact of these random erosion on the accumulation is largely mitigated. ~~and that by combining several profiles, it is possible to evaluate precise local annual accumulation rates.~~
>
> We observed the persistence of a 30 cm dune over the 20 years duration of the trench record. We also found that the holes in the local surface topography are filled only slightly more than the bumps (+15 % at the annual scale) leading to persistence of the topography over many year. ~~We indeed observed the persistence of a 30 cm dune over the 20 years duration of the trench record.~~ This shows that meter- scale topographic features may persist over decades of accumulation. Better understanding of the competing processes leading to the spatial pattern of the surface mass balance are key, as the detection of the influence of climate change on precipitation amounts in Polar Regions remains to be determined. In particular, dating ice cores which is often using volcanic eruptions only happening every several decades could suffer from uncertainties of a few years. ~~Taking into account the accumulation patterns is thus key to reconstruct sub- decadal climatic variations from ice core records in interior sites of the Antarctic Plateau.~~ Yet, our results show that a the linear approximation of the age scale between tie points separated by a few decades is only leading to uncertainties of 1.5 years. This is an encouraging perspective for transposing our approach to the broader study of replicate cores covering longer time scales, where only linear interpolation between multi-decadal time horizons are available."

Please write numbers below 10 as text.

This has been corrected wherever necessary.
Numbers were left as numerals when preceding a unit or amount of time (2 meters , 6 months, 5 years), when indicating a version (version 2).

Please avoid starting sentences with “Figure …”

This has been fixed.

I recommend using the CRediT standard for the author contributions. Now it is not clear if any of the authors participated in the field measurements, for example.

Details on the contribution of all authors are now provided using the CRediT standard.

Specific comments

Figure 1: P0.3 is not marked to the Fig 1a.

This was the result of an inconcistency when mentioning profiles P0.1 and P0.3 whose samples were mixed together. We are now only mentioning P0.3 in the text and showing P0.3 in Fig 1a.

Line 87: Why P0 was not mixed with P0.1 since it is closer than P0.3, right?

We wished to have two complete profiles at a short distance of each other. None of P0, P0.1, P0.3 had big enough snow samples for the analysis. Our choice therefore was to group P0 with a profile 30cm to the left ("P-0.3", not mentioned in the manuscript) and group P0.1 and P0.3 together. Grouping P0.1 with P0 would have left P0.3 incomplete.

Line 63: Change as “Chemical tracers and physical snow properties including snow microstructure (density, specific surface area (SSA) and penetrometry)”.

This has been fixed.

Line 64: Change as “methanesulfonic acid (MSA)”

This has been fixed.

Line 164: Change as “The stakes are measured every year”

This has been fixed.

Figure 5: Colors are difficult to separate and makes figure difficult to read.

The colors in Figure 5 are only meant as a aestetical device and are not essential to the reading of the information in the plot. This is most easily seen by looking at the picture in gray scale (see below). What is interesting is to look at the overall spread of the snow pit age scale, rather than knowing which age scale corresponds to what snow pit, which is the information contained in the color. Overall, we see that the snow pit age scales are well included into the error bars and that they converge towards the same value +/- 1 year at the bottom of the reference profile (corresponding to early 1999).
This is the very reason why colors where chosen similar enough so the figure does not appear

saturated, which would distract the reader, but not completely homogeneous so as to slightly separate the profiles.

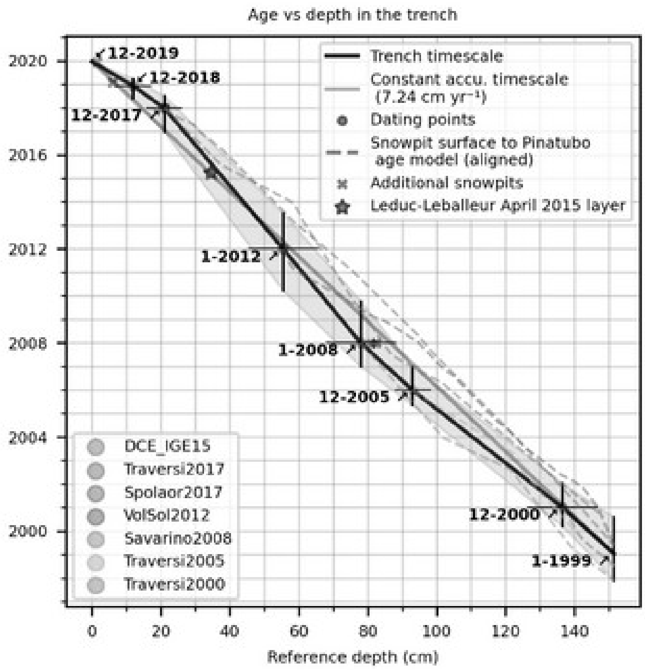

Figure 6b: Figure is very unclear because all lines are top of each other.

Figure 6b is the integration of the accumulation rate time series shown in Figure 6a. The point is exactly to show that they show very little deviations and reach the same values after 15 years of accumulation (2004-2019), so the difference in inter-annual variability seen in Figure 6a actually averages out when looking at total accumulation. As such, it is a validation of the trench accumulation rate reconstruction compared against reanalysis and stake measurements.
It also shows that the stake farm measurements with the classical surface density conversion (320 kg /m3) deviates towards higher total accumulation, while the suggested conversion value of 295 kg reconciles direct observations with the trench analysis and the ERA5 reanalysis.
The alternative of showing the 4 curves on shifted levels would fail to illustrate this important conclusion.

We have detailed the following sentence in the caption of Figure 6b to insist on this point:

> [...] (b) Cumulated accumulation time series. Series have been set to an initial value of 0 mm in January 2004 (first GLACIOCLIM stakes measurements), and RLS initial value is set to match GLACIOCLIM in January 2015. ~~Trench cumulated accumulation follows closely ERA5 net accumulation (precipitation - evaporation). ρsurf = 295 kg m−3 seems to give better agreement between trench and stakes data~~. When overlaid, the accumulation time-series of the trench follows closely that of ERA5 (precipitation - evaporation), and that of GLACIOCLIM with ρsurf = 295 kg m−3, showing a small deviation of less than 20 kg/m^2 (5%) over the period 2004-2019.