We thank referee 1 for the useful comments. The referee's comments are marked in green, while our replies in black.

Paleari et al. present a new way of measuring 10Be in polar snow/ice by using the excess of meltwater from continuous flow analysis (CFA) instead of discrete snow samples in EGRIP S6 firn core. The authors investigate the agreement with other 10Be records from Greenland measured in a "traditional" way. They also use this record to study the 11-year solar cycles as well as the short-term SEP events and stratospheric volcanic eruptions. This new way of measuring 10Be opens new opportunities for the collection of continuous records with less time-consuming sample preparation while saving an important portion of the ice cores for other measurements.

The paper is an introduction study to advertise the opportunities of using 10Be measured by CFA technic to investigate solar cycles and short-term 10Be deposition events. The analyses on the 10Be record are not very deep. On the other hand, the new measurements technic is promising. So, my two main comments, among others, are about the CFA technic that should be more highlighted and the (non-)detection of 10Be short-term events related to SEP or volcanic eruptions. I recommend major revisions before acceptance for publication in CP.

Specific comments:

- *The preparation of the CFA samples is described in section 2.1. In addition, I think it would be beneficial to add the schematic figure summarizing this preparation. Moreover, it would be interesting to know how much time is effectively won when using this technic instead of the classical extraction from ice or snow samples, as well as the quantity of ice.*

We thank the reviewer for the suggestion. For the preparation of the CFA samples we do not need the ion exchange chromatography (IEC) step. Since our equipment is able to support 12 samples at one time, this new preparation allows us to skip about 3 hours of work every 12 samples, as well as saving materials (e.g. columns and chemicals for the extraction of the radionuclides from the columns). More details will be added in the revised manuscript.
Concerning the suggested schematic figure for the preparation, note that only the time-consuming step of filtration through IEC has been removed from our usual procedure pertaining to Greenland ice core samples that typically are larger. A schematic figure of lab preparation of 10Be samples of small sizes with and without IEC can be found in the recently published study from Nguyen et al. (2021). We will make this clearer in the text as well as refer to the figure.

- *I am not completely convinced that 10Be from CFA can be used to detect SEP or volcanic eruptions. As the authors said, "one of the main complications of dealing with CFA systems is the possible smoothing of the signal locked in the ice" (see grey and green curves in figure 3). Moreover, is the temporal resolution of the EGRIP S6 core (yearly) enough for such detection? It should be discussed in the manuscript. Finally, the analysis can be misleading in its present form. The authors just state the years when the residual is more than 1-sigma, and it is difficult to know if these years correspond to some events or if they are due to local effects. To improve the way how are presented the analyses, I suggest replacing the histogram figures (figures 6, 7 and 8), which are not really used in the manuscript, by the standard score records shown in Supplementary Material. In these graphs, the authors could add colored dashed vertical lines corresponding to major volcanic eruptions and SEP events. In this way, it would facilitate the analyses and it would be easier for the readers to see if the standard score peaks correspond or not to these events. I would also suggest coloring the curves if the standard score curve is higher to 1-sigma, 2-sigma…, like for climatological indices.*

We thank the reviewer for contributing to present the results of our analyses more clearly.

a) On the detection of SEP events or volcanic eruptions using CFA samples:

The detection of SEP events using CFA samples was previously assessed in Paleari et al. (2022), where the occurrence of an extreme SEP event from 9125 years BP was detected also in CFA samples from the EGRIP core. Moreover, such extreme events were also detected in 10Be records with lower resolution, such as the GRIP and EDML records, characterized by ~5 years resolution (e.g. O'Hare et al., 2019; Paleari et al., 2022). Therefore, we are confident that the resolution of the CFA record presented in this study is suitable to detect large SEP events (e.g., extreme events detected in 775 CE or 9125 years BP). Since large stratospheric volcanic eruptions can leave a similar imprint in 10Be records in terms of magnitude (e.g. Baroni et al., 2011, 2019), we can assume that, likewise, the resolution of the CFA samples allow detection of the volcanic signal. From Paleari et al. 2022, it can be seen that CFA leads to no significant smoothing of the 10Be peak related to the 9125 years BP event. Furthermore, it was previously assessed that CFA smoothing typically leads to a smoothing of 3-4 months for ice cores with a similar accumulation rate than EGRIP (e.g., Mekhaldi et al., 2017), and therefore does not affect significantly the detectability of a peak expected to last typically 2-3 years as shown in previous studies (e.g., Mekhaldi et al., 2015; O'Hare et al., 2019; Paleari et al., 2022).

As for GLEs that are at least 2 orders of magnitude smaller than extreme paleo-events, they cannot be detected using discrete ice samples at higher resolution than the CFA 10Be record (e.g. Pedro et al., 2011; Zheng et al., 2020; Mekhaldi et al., 2021). Therefore, the paper does not suggest that CFA samples can be used to detected GLEs, but rather that CFA samples preserve a similar signal as discrete ice samples in the context of the detection of the solar 11-year cycle, of large outliers induced by stratospheric volcanic eruptions, and of extreme paleo-events.

These arguments will all be made clearer in the main text.

b) On the residuals analysis:

As suggested by the reviewer we will replace the histograms in the revised version with the figures included in the supplementary material. However, we think the inclusion of vertical lines corresponding to SEP events and volcanic eruptions in the figure may suggest we are making a clear correlation between residuals exceeding 1sigma and SEP events/volcanic eruptions, whereas we cannot do that with our results, and could therefore bias the readers.

- *The comparison of EGRIP S6 with other Greenland ice cores is quite convincing (figures 3 and 4), while it is not so much the case for Antarctica. I would rephrase the sentence "our results indicate that the signal measured in the CFA samples is reproducing the common radionuclide signal in Greenland and Antarctica as well as the discrete firn samples" at lines 218-219. Moreover, how the correlation is improved if instead of "global stack – no EGRIP", a Greenland stack – no EGRIP is used in Figure 5? Do the $_{10}$Be normalized records correspond to 10Be concentrations records (and not flux) for both Greenland and Antarctica? Please precise.*

We thank the reviewer for the suggestion. If we use the Greenland stack instead of the global stack, we obtain a higher correlation (CFA: r= 0.77 (p<0.01); Discrete: r=0.70 (p<0.01)). In order to include this point in the discussion, we will revise Figure 4 to include a comparison with the stacks of Greenland (excluding EGRIP) and Antarctica separately. Similarly, a discussion will be added to the text. Furthermore, we will clarify in the revised version that we are using 10Be concentration records, and not fluxes.

Minor comments and corrections:

- *1$_{st}$ sentence of the abstract: "10Be is produced by the interaction of galactic cosmic rays (GCR) or solar energetic particles (SEP) with the Earth's atmospheric constituents."*
- *Section 2.3: The authors adopted the timescale by Zheng et al., submitted. Because this paper is under review, the readers have no complete information about the timescale of EGRIP.*

We are aware that, at the moment, the details are not enough to assess the timescale of the EGRIP S6 core. However, a detailed assessment is included in the paper by Zheng et al. and it is currently under review.

The timescale for the EGRIP S6 core is constructed by counting the annual layers visible in the CFA dataset of the core using the StratiCounter algorithm (Winstrup et al., 2012). To constrain the annual layer count and align the EGRIP S6 age model with the main core, tie points of the EGRIP-GICC05 age scale (Mojtabavi et al., 2020) were identified in the electrolytic meltwater conductivity records at 21.53, 23.94 and 30.63 m depth and 73, 87 and 125 yrs b2k respectively. As explained in the manuscript, Zheng et al. (in review) proposed adjustments of the chronology based on the correlation between the 10Be record from the S6 core and other 10Be records from Greenland and the theoretical 10Be production rate modeled from neutron monitor data. More details will be added in the revised manuscript.

- *Table 1: highlight in color the years corresponding to SEP or volcanic events. 11-year cycle: I suggest doing some spectral analyses, too.*

We thank the reviewer for the suggestions:

a) Although it could guide the reader, we think that highlighting the years corresponding to SEP or volcanic events could bias the reader. Since we are not able to make a clear correlation between residuals and events, we decided to not modify the table.

b) We will include a new figure in the revised version showing a wavelet analysis of the CFA and discrete data, and of the global stack (excluding the EGRIP S6 10Be records) to better assess the presence of the 11-year cycle in the data – see Fig. 1 below. The spectral analysis of the records highlights the presence of the 11-year cycle in the S6 records, especially so in the period 1900-1960, whereas it shows that by stacking several records it is, as expected, possible to increase the signal to noise ratio and to better detect the 11-year solar cycle.

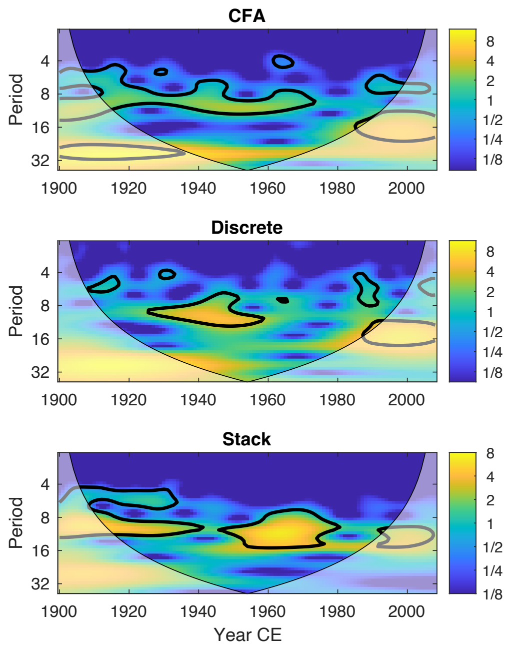

Figure 1. Continuous wavelet power spectrum (Grinsted et al., 2004) of the 10Be concentration records from CFA samples (top panel) and discrete samples (middle panel) from EGRIP S6, and of the global stack (bottom panel) calculated including the records from NGRIP,NEEM, Dye 3, Renland, Das2 , DML, DSS, Vostok and Concordia. The records were smoothed (3-year moving average). The black line denotes 5% significance.

- *Figures in Supplementary Material are not referenced in the main manuscript while they are useful. I suggest replacing the histograms by these figures (see general comment). The histograms can go in supplementary material if the authors want to keep them.*

As suggested by the referee, the histograms will be replaced with the supplementary figures in the revised manuscript.

References

Baroni, M., Bard, E., Petit, J. R., Magand, O., and Bourlès, D.: Volcanic and solar activity, and atmospheric circulation influences on cosmogenic 10Be fallout at Vostok and Concordia (Antarctica) over the last 60years, Geochim. Cosmochim. Acta, 75, 7132–7145, https://doi.org/10.1016/j.gca.2011.09.002, 2011.

Baroni, M., Bard, E., Petit, J. R., and Viseur, S.: Persistent Draining of the Stratospheric 10Be Reservoir After the Samalas Volcanic Eruption (1257 CE), J. Geophys. Res. Atmos., 124, 7082–7097, https://doi.org/10.1029/2018JD029823, 2019.

Grinsted, A., Moore, J. C., and Jevrejeva, S.: Application of the cross wavelet transform and wavelet coherence to geophysical time series A., Nonlinear Process. Geophys., 11, 515–533, https://doi.org/10.5194/npg-11-515-2004, 2004.

Mekhaldi, F., Muscheler, R., Adolphi, F., Aldahan, A., Beer, J., McConnell, J. R., Possnert, G., Sigl, M., Svensson, A., Synal, H. A., Welten, K. C., and Woodruff, T. E.: Multiradionuclide evidence for the solar origin of the cosmic-ray events of 774/5 and 993/4, Nat. Commun., 6, 1–8, https://doi.org/10.1038/ncomms9611, 2015.

Mekhaldi, F., McConnell, J. R., Adolphi, F., Arienzo, M. M., Chellman, N. J., Maselli, O. J., Moy, A. D., Plummer, C. T., Sigl, M., and Muscheler, R.: No Coincident Nitrate Enhancement Events in Polar Ice Cores Following the Largest Known Solar Storms, J. Geophys. Res. Atmos., 122, 11,900-11,913, https://doi.org/10.1002/2017JD027325, 2017.

Mekhaldi, F., Adolphi, F., Herbst, K., and Muscheler, R.: The Signal of Solar Storms Embedded in Cosmogenic Radionuclides: Detectability and Uncertainties, 2,3Journal Geophys. Res. Sp. Phys., 126, https://doi.org/10.1029/2021ja029351, 2021.

Mojtabavi, S., Wilhelms, F., Cook, E., Davies, S. M., Sinnl, G., Skov Jensen, M., Dahl-Jensen, D., Svensson, A., Vinther, B. M., Kipfstuhl, S., Jones, G., Karlsson, N. B., Henrique Faria, S., Gkinis, V., Astrid Kjær, H., Erhardt, T., Berben, S. M. P., Nisancioglu, K. H., Koldtoft, I., and Olander Rasmussen, S.: A first chronology for the East Greenland Ice-core Project (EGRIP) over the Holocene and last glacial termination, Clim. Past, 16, 2359–2380, https://doi.org/10.5194/cp-16-2359-2020, 2020.

Nguyen, L., Paleari, C. I., Müller, S., Christl, M., Mekhaldi, F., Gautschi, P., Mulvaney, R., Rix, J., and Muscheler, R.: The potential for a continuous 10Be record measured on ice chips from a borehole, Results in Geochemistry, 5, 100012, https://doi.org/10.1016/j.ringeo.2021.100012, 2021.

O’Hare, P., Mekhaldi, F., Adolphi, F., Raisbeck, G., Aldahan, A., Anderberg, E., Beer, J., Christl, M., Fahrni, S., Synal, H.-A., Park, J., Possnert, G., Southon, J., Bard, E., and Muscheler, R.: Multiradionuclide evidence for an extreme solar proton event around 2,610 B.P. (∼660 BC), Proc. Natl. Acad. Sci., 116, 201815725, https://doi.org/10.1073/pnas.1815725116, 2019.

Paleari, C. I., Mekhaldi, F., Adolphi, F., Christl, M., Vockenhuber, C., Gautschi, P., Beer, J., Brehm, N., Erhardt, T., Synal, H., Wacker, L., Wilhelms, F., and Muscheler, R.: Cosmogenic radionuclides reveal an extreme solar particle storm near a solar minimum 9125 years BP, Nat. Commun., 13, https://doi.org/10.1038/s41467-021-27891-4, 2022.

Pedro, J. B., Smith, A. M., Simon, K. J., Van Ommen, T. D., and Curran, M. A. J.: High-resolution records of the beryllium-10 solar activity proxy in ice from Law Dome, East Antarctica: Measurement, reproducibility and principal trends, Clim. Past, 7, 707–721, https://doi.org/10.5194/cp-7-707-2011, 2011.

Winstrup, M., Svensson, A. M., Rasmussen, S. O., Winther, O., Steig, E. J., and Axelrod, A. E.: An automated approach for annual layer counting in ice cores, Clim. Past, 8, 1881–1895, https://doi.org/10.5194/cp-8-1881-2012, 2012.

Zheng, M., Adolphi, F., Sjolte, J., Aldahan, A., Possnert, G., Wu, M., Chen, P., and Muscheler, R.: Solar and climate signals revealed by seasonal 10Be data from the NEEM ice core project for the neutron monitor period, Earth Planet. Sci. Lett., 541, 116273, https://doi.org/10.1016/j.epsl.2020.116273, 2020.