Review to: “Atmospheric ^{10}Be from Talos Dome (East Antarctic) ice core records geomagnetic dipole intensity from 170 to 270 ka BP”

Comments from reviewer are in black / answers to the comments are in blue / suggested modified sections are in orange, with the specific modifications in **bold**

Review 1:

The manuscript presents a new ice core record from Talos Dome, Antarctica, covering the period from 170 to 270 ka BP. This 10Be record is highly significant and provides valuable insights into geomagnetic field variations, including one well-defined global excursion and several others of moderate intensity. The study is thorough, containing extensive information on 10Be measurements, as well as climate proxies and ion concentrations, which are used to assess postdepositional effects and accurately estimate the 10Be flux. The resulting signal is consistent with data from the Dome Fuji ice core, sediment archives, and global production reconstructions based on the VADM stack.

We thank the reviewer for their comments, the time dedicated to review, and the very valuable feedbacks they suggested.

It is important to clarify the reference background to which the results are reported. Discuss the possible options in a single section, and rather than reporting multiple values for one event, decide on one reference value. For example, the background, 1.36, 1.44 or 1.56 x10^5 at cm^-2 a^-1, is over which period, mean, or estimated over the running mean, before or after excluding the identified 10Be minima? (Lines 280 to 293, 349 to 350)

Answer

We acknowledge that our discussion on the background Lines 280 to 293 is not clear enough. We want to clarify that the values reported lines 349 and 350 refer to the mean values, including the flux during the geomagnetic excursions. A clear definition of the background Lines 280 to 293 would have prevented this lack of clarity. Following the suggestion made by the reviewer, we add a section in the Result section dedicated to defining the background value “4.3. ^{10}Be background flux”, in addition to subsections “4.1 ^{10}Be concentration and flux” and . “4.2. ^{10}Be minima”. Lines 280-293 we presented to options to define the background, using either a fixed baseline or the mean value on the minimum-removed profile. Although it would have been beneficial to define a clear background value, neither our profile nor our understanding of the polar bias allows to do so. We therefore prefer to highlight this limitation, further work being necessary to refine this question. We also clarify this point in the new 4.3 section.

Revision:

L243: “**4.1. ^{10}Be concentration and flux**”

L263: “**4.2. ^{10}Be minima**”

L280: “**4.3. ^{10}Be background flux**

After removing the 52 identified ^{10}Be minima, rolling averages can be calculated to smooth the record and obtain the first-order variations, which are likely to result. Test 1 ka, 3ka and 5 ka rolling averages

(Figure S1) illustrate the trade-off between noise reduction and signal preservation. Given the mean resolution of our record (300 a) we selected a 3 ka rolling average as a practical compromise. This choice provides stable background trends while preserving the amplitude of GDM-related variations. The resulting 3-ka averaged ^{10}Be flux record can be compared to geomagnetic reconstructions, including the Dome Fuji ice core data (Figure 4, Horiuchi et al., 2016), authigenic ^{10}Be/^{9}Be records from marine sediment cores (Figure 5, Simon et al., 2016) and ^{10}Be production (Figure 5, Poluianov et al., 2016) calculated from RPI-based VADM (Channell et al., 2009). Flux enhancement during geomagnetic excursions or events depends strongly on the choice of background taken as reference. **When discussing paleomagnetism, the background should be defined as the ^{10}Be profile without minima.** Here, we consider either the full 170–270 ka BP interval ^{10}Be flux mean average ($(1.36 \pm 0.26) \times 10^5$ at cm^{-2} a^{-1}) or a fixed baseline of 1.1×10^5 at cm^{-2} a^{-1} as **background**. The latter could be considered as representative of the long-term background ^{10}Be flux, which is close to the minimum values the 3 ka rolling average around 178 ka BP and 223 ka BP. Depending on the chosen baseline, the flux enhancement factors during specific events are as follows: for the 190 ka BP event (IBE), the ^{10}Be flux is 1.59 or 2.08 times the background; for the 205–215 ka BP event (PFE), the increase is 1.24 or 1.62 on average; and for the 240 ka BP event (ME), the peak flux reaches 1.25 or 1.63 times the reference value. **It is evident that defining a clear background value would have been preferable; however, this was not possible due to the limitations inherent in our profile and our understanding of the polar bias. We therefore advocate the necessity of having this dual scenario, mean or fixed values, with further work being necessary to refine this question.**"

L 349: "For the period 170–270 ka BP, the mean 3 ka rolling ^{10}Be flux in TALDICE**, including the background and the geomagnetic events,** is 1.44×10^5 at cm^{-2} a^{-1}, which slightly increases to 1.56×10^5 at cm^{-2} a^{-1} when the identified ^{10}Be minima are excluded."

Line 80: Several geomagnetic excursions are reported (Figure 1), but the caption reads three. It would be beneficial to provide a table, either in the main text or in the Supplementary Material, listing the records plotted, including their references. Additional columns could indicate which excursion is recorded and, potentially, the corresponding age. I assume the authors already have this information, as the studies are discussed in Section 2.

Answer:

We thank the reviewer for this suggestion. A Table has been added in supplementary.

Revision:

L121: "Figure 1: map of sites recording at least one of the geomagnetic excursions discussed in this paper: the **IBE and PFE** excursions (triangles), IBE alone (stars), or PFE alone (circle). **The references are listed in Table S1."**

Table S1: list of studies reporting at the IBE, PFE, and IBE and PFE excursions

Excursions recorded	Latitude	Longitude	Type of archive	Archive name	Source
IBE	43.48	-112.53	Volcano	site E at the Idaho National Engineering Laboratory INEL	Champion et al., 1988
PFE	43.78	-121.53	Sediment	Pringle falls	Herrero-Bervera et al.1989; 1994
IBE PFE	-1.64	159.22	Sediment	Ontong Java plateau ERDC 113p	Taux & Wu, 1990
IBE PFE	0	155.87	Sediment	Ontong Java plateau ERDC 89p	Taux & Wu, 1990
IBE	-3.09	-110.53	Sediment	ODP Sites 848	Valet & Meynadier, 1993
IBE	2.99	-110.5	Sediment	ODP Sites 851	Valet & Meynadier, 1993

IBE	1.01	136.96	Sediment	West Caroline Basin, western equatorial Pacific NP5	Yamazaki & Ioka, 1994
IBE	2	135	Sediment	West Caroline Basin, western equatorial Pacific NGC16	Yamazaki & Ioka, 1994
IBE	4.13	136.27	Sediment	West Caroline Basin, western equatorial Pacific NGC29	Yamazaki & Ioka, 1994
IBE	2	138.01	Sediment	West Caroline Basin, western equatorial Pacific NP7	Yamazaki & Ioka, 1994
IBE	3.8	141.48	Sediment	NP35	Yamazakia et al., 1995
IBE	1.22	160.57	Sediment	NGC36	Yamazakia et al., 1995
IBE	-14.99	175.17	Sediment	NGC38	Yamazakia et al., 1995
IBE	43.52	-30.4	Sediment	SU9008	Weeks et al., 1995
IBE	7.78	77.5	Sediment	KET82-51	Guyodo & Valet 1996
IBE	4.73	103.58	Sediment	DED87-07	Guyodo & Valet 1996
IBE	-2.55	91.33	Sediment	MD84-629	Guyodo & Valet 1996
IBE	-1.42	90.32	Sediment	MD85-668	Guyodo & Valet, 1996
IBE	-1.52	90.7	Sediment	MD85-669	Guyodo & Valet, 1996
IBE	-8.38	112.57	Sediment	MD85-674	Guyodo & Valet, 1996
IBE	9.9	121.53	Sediment	ODP 768A	Guyodo & Valet, 1996
IBE	10.75	121.57	Sediment	ODP 769B	Guyodo & Valet, 1996
IBE	39.37	-26.61	Sediment	SU-92-17	Lehman et al., 1996
IBE	37.79	-27.23	Sediment	SU-92-18	Lehman et al., 1996
IBE	37.3	-27.09	Sediment	SU-92-19	Lehman et al., 1996
IBE	44.68	168.23	Sediment	ODP Site 884	Roberts et al., 1997
IBE PFE	60.4	-23.6	Sediment	ODP Site 983	Channell et al., 1997; Knudsen et al., 2008; Christl et al., 2010
IBE	32.97	-76.28	Sediment	ODP Site 1061	ODP Leg 172 Scientific Party 1998
IBE PFE	32.98	-76.23	Sediment	ODP Site 1062	ODP Leg 172 Scientific Party 1998
IBE PFE	33.68	-57.62	Sediment	ODP Site 1063	ODP Leg 172 Scientific Party 1998; Knudsen et al., 2008; Christl et al., 2010; Channell et al., 2012
IBE	58.21	-48.37	Sediment	HU90-013-013P	Stoner et al., 1998
IBE	61.07	-24.02	Sediment	ODP Site 984	Channell et al., 1999
IBE	-19.7	246.5	Seafloor	East Pacific Rise (EPR)	Gee et al., 2000
IBE	-19.4	246.5	Seafloor	East Pacific Rise (EPR)	Gee et al., 2000
IBE PFE	53.6	108.3	Sediment	Lake Baikal	Oda et al., 2002; Demory et al., 2004
IBE	55.5	-14.7	Sediment	ODP Site 980	Channell & Raymo, 2003
IBE PFE	-40.9	9.9	Sediment	ODP Site 1089	Stoner et al., 2003
IBE PFE	37.8	-10.6	Sediment	MD95-2042	Thouveny et al., 2004; Carcaillet et al., 2004
IBE PFE	40.58	-9.87	Sediment	MD95-2040	Thouveny et al., 2004; Carcaillet et al., 2004
IBE PFE	62.67	-37.46	Sediment	ODP Site 919	Channell et al., 2006
IBE	58.93	-47.12	Sediment	MD99-2242	Laj et al., 2006
IBE	59.08	-31.47	Sediment	MD99-2247	Laj et al., 2006
IBE	19.58	117.63	Sediment	ODP Site 1145	Laj et al., 2006
IBE	16.45	116.27	Sediment	ODP Site 1146	Laj et al., 2006
IBE PFE	57.19	-47.13	Sediment	JPC-18	Evans et al., 2007
IBE PFE	47.6	-57.58	Sediment	JPC-19	Evans et al., 2007
IBE	32.77	130.28	Volcano	Unzen Volcano	Shibuya et al., 2007
IBE PFE	35.6	-106.75	Volcano	Albuquerque Volcanoes, NM	Singer et al., 2008
IBE	-50.2	-45.7	Sediment	IODP Site U1302/03	Channell et al., 2014
IBE	58.24	-45.64	Sediment	IODP Site U1306	Channell et al., 2014
IBE PFE	-10.53	147.22	Sediment	MD05-2930	Simon et al., 2016
IBE PFE	-2.51	144.32	Sediment	MD05-2920	Simon et al., 2016
IBE	-77.5	39.4	Ice core	Dome F	Horiuchi et al., 2016
IBE	2.77	-110.57	Sediment	ODP Site 851	Valet et al., 2020
IBE	39.08	-127.78	Sediment	ODP 1021	Valet et al., 2024

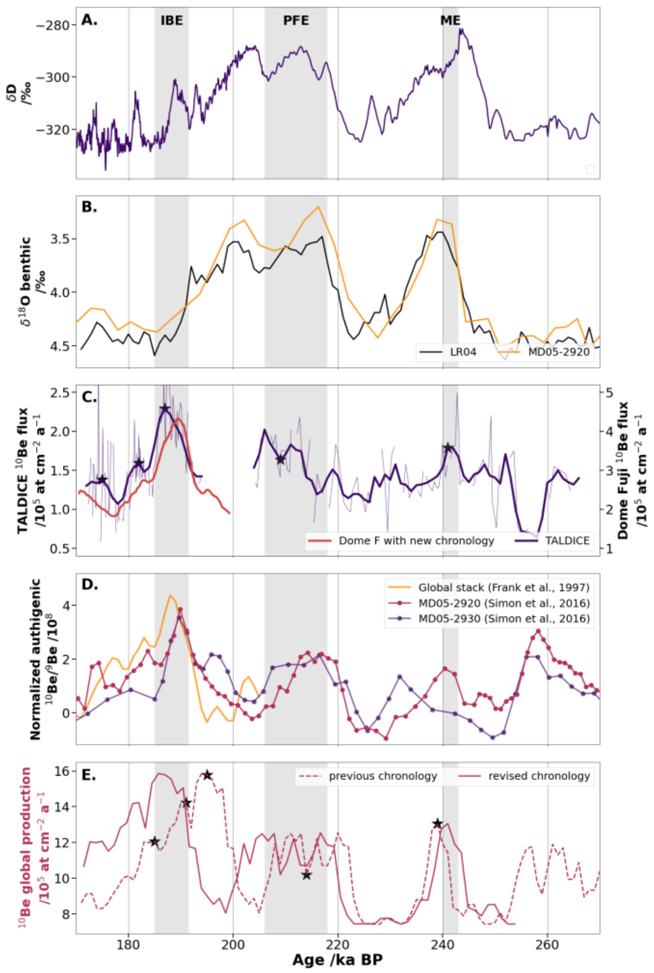
From a point a view of the geomagnetic field, the authors discussed variations derived from the PISO-1500 RPI stack. A global model of IBE exists, though outdated, and built with limited, hemispherically-constrained sediment records (Lanci et al. 2008, doi: 10.1016/j.pepi.2008.06.004), the dynamics of IBE can be compared with the TALDICE record. As well as with the global stacks of Frank et al., 1997 (https://doi.org/10.1016/S0012-821X(97)00070-8)

Answer:

We thank the reviewer for completing our discussion with these records. We have added the global ^{10}Be stack to our Figure 5 (Frank et al., 1997), as the data are available. We also now discuss the comparison with this global record as well as the model from Lanci et al. (2008).

Revision:

Modified figure 5:



L510: "**During IBE, the TALDICE ^{10}Be flux record closely follows variations in oceanic authigenic ^{10}Be/^{9}Be from a global compilation (Frank et al., 1997) (Figure 5). In particular, the timing, duration, and stepped structure of the collapse and subsequent recovery of the GDM are consistent between the ice cores and marine records (Figure 5). For instance, the ≈7 ka plateau of elevated ^{10}Be flux observed in TALDICE has also been observed in Dome F ice core (Horiuchi et al., 2016) and is in agreement with oceanic records (Knudsen et al., 2008). Besides, the good overall agreement**

between the TALDICE and Dome F records with global geomagnetic field model of the IBE (Lanci et al., 2008) further supports the global record of Antarctic ice cores.

Because of this broad **global** agreement, a comparison of ^{10}Be production calculated from RPI-based VADM and authigenic $^{10}Be/^{9}Be$ with ice core ^{10}Be fluxes is possible."

General comment on using brackets when reporting ages and standard deviation on the age? Why? If it is the journal rule ok, otherwise the text will be cleaner without, and removing them improves readability in my opinion (throughout the whole text). The same comment applies to the values of the 10Be/9Be ratio, 10Be half-life (e.g., line 187), and all other numbers in brackets.

Answer:

We thank the reviewer for this comment. However, we prefer to follow the IUPAC writing (https://old.iupac.org/publications/books/gbook/green_book_2ed.pdf, page 83) when reporting values as: *(value ± std) unit*.

Revision:

No modification

Minor comments and questions:

Line 30: Add a reference for the first sentence. E.g., Bono et al., 2022 (doi: 10.1029/2022GL100898)

We modified accordingly

Line 34: the geodynamo

We modified accordingly

Line 38: I wouldn't say 'occasionally conflicting', rather 'with high uncertainties'

We modified accordingly

Line 46: Add 'e.g.', in front of references, as these are examples.

We modified accordingly

Line 47: decreases in plural and (recovery) in the brackets in singular. I understood what the sentence says, but it can be clearer.

We clarified this sentence.

Revision:

L47: "In both excursions and full reversals, **the dipole moment decreases prior to the VGP migration, while the recovery of field intensity occurs after the return to a stable polarity state, either in the original or in the reversed polarity**"

Line 48: (ref)?

Sorry for the mistake. We should have added the reference.

Revision:

L47: "In both excursions and full reversals, **the dipole moment decreases prior to the VGP migration, while the recovery of field intensity occurs after the return to a stable polarity state, either in the original or in the reversed polarity (Valet et al., 2005; Laj et al., 2006).**"

Line 49: another word for migration?

We prefer to remain consistent and use VGP migration

Line 51: We don't know if the IBE is probably the strongest. By which criteria? It is probably among the strongest.

We thank the reviewer for raising this lack of precision. We now clarify this referring to geomagnetic intensity reconstruction.

Revision:

L51: "The Iceland Basin Excursion (IBE, naming and dating of the event is discussed in section 2.1), dated to approximately 190 ka BP, is probably the strongest excursion during the Bruhnes chron (< 780 ka BP) **based on GDM intensity reconstruction** (Simon et al., 2016)"

Line 53: reduction in % with respect to what? Present-day values?

We thank the reviewer for raising this lack of precision. We now clarify this referring to the background value.

Revision:

L53: "**Dipole intensity reduction has been estimated between 70 % (Yamamoto et al., 2010) and 80 % (Simon et al., 2020) relative to the pre-event background dipole moment.**"

Line 59: Better make two sentences. It is produced in the atmosphere … 10Be mainly results …

We have now separated the two blocks.

Revision:

L59: "**Atmospheric** ^{10}Be mainly results from spallation reactions between galactic cosmic rays and atmospheric oxygen and nitrogen atoms (Poluianov et al., 2016). **Between 60 and 66 % of its atmospheric production occurs in the stratosphere** (Golubenko et al., 2022; Poluianov et al., 2016; Zheng et al., 2024)"

Line 59: too many brackets: .. in the stratosphere, from 60% to 66% (refs)

We corrected this as mentioned in the preceding answer.

Line 64: remove the comma before that

We modified accordingly

Line 65: studies = records

We modified accordingly

Line 73: avoid double brackets, e.g., … events such as the Laschamps, ~41 ka BP (ref) and

We modified accordingly

Line 74: The Pringle Falls also named Mamaku or Jamaica? As written so far, Pringle Falls and Mamaku are two separate events?

We thank the reviewer for raising this inconsistency. We agree with the reviewer on this point, although it is also true that this inconsistency is present in the literature. We now refer to the section 2, that discusses the names of these excursions.

Revision:

L74: "respectively the IBE and the **two** Pringle Falls **excursions** also named Mamaku or Jamaica **(see section 2 for a literature review on the naming of the events),**"

Line 77: add reference for the sedimentary, as it is given for the other record used for comparison from Dome Fuji.

We added the references.

Revision:

L77: "**(Horiuchi et al., 2016; Simon et al., 2016; Frank et al., 1997)**"

Line 111: Stoner et al., 1998 is not in the References

We thank you for this attention.

Line 113: remove 'on'

We modified accordingly

Line 125: an RPI

We modified accordingly

Line 338: PISO-1500

We modified accordingly

Line 141/142: Reference only once, as it is the same.

We modified accordingly

Line 155: Section name: ‘Material, methods and chronology’, as the chronology is a Subsection in this Section

We modified accordingly

Line 165/175: Only suggestion: Can these long links be removed from the main text and added in the Acknowledgment section, where the institutes and facilities are listed anyway again?

We modified accordingly

Line 167/168: repetition with Line 178 about the cutting/melting.

We thank the reviewer for raising this point. We removed the second mention

Line 173: … developed by Raisbeck et al., 2006 and Baroni et al., 2011. Cite without the brackets, and avoid repetition.

We modified accordingly

Line 177: remove ‘the’ in front of the number of samples. The number is introduced for the first time here.

We modified accordingly

Line 177: Why is the standard deviation reported like this? If it is important to report that this is one standard deviation, then: 121+-10 g (1 \sigma).

We modified accordingly

Line 184: in a crucible

We modified accordingly

Line 187: The ratio is unitless, right? On this line, and the rest of the text

Indeed, the ratio is unitless, which is why we wrote at at^{-1}

Line 198: then shared for analysis ..., Please clarify whether ‘shared’ means that different measurements were performed in different laboratories, or that the same measurements were carried out on the same samples for inter-laboratory comparison.

We thank the reviewer for pointing out this ambiguity. The text has been revised to clarify that the samples were distributed among the laboratories to accelerate the analytical work. Each laboratory analyzed a distinct subset of samples, and no inter-laboratory comparison was performed.

Revision:

L198: “The discrete samples were then **distributed** for analysis among four different **laboratories for analysis**: University of Florence (Italy), BAS (Cambridge, United-Kingdom), IGE (ex-LGGE, Grenoble, France), and AWI (Bremerhaven, Germany). **No inter-laboratory comparison was performed, and each laboratory analyzed a distinct subset of samples.**”

Line 200: What is MSA?

We thank the reviewer for raising this point. We now clarify that MSA is methane sulfonic acid

Line 209: The AICC2023 chronology (Bouchet et al., 2023) was used to date

We modified accordingly

Line 210: Make a new sentence 'The mean snow accumulation is 5.5 cm a-1', and move it to Line 212 after the range of accumulation rates is listed, and before the sentence starting with 'On average, …'

We modified accordingly

Revision:

L210: "The AICC2023 chronology **(Bouchet et al., 2023)** was used to date the ice**,** spanning from (172.3 ± 1.9) ka BP to (275.7 ± 1.8) ka BP. Our record covers several transitions from glacial to interglacial periods, from Marine Isotope Stage (MIS) 6.4 to 8.4 (Railsback et al., 2015). **Therefore, the annual snow accumulation rate, provided by the AICC2023 chronology, ranges between (4.3 ± 0.8) cm a^{-1} and (8.1 ± 1.5) cm a^{-1} with a mean value of 5.5 cm a^{-1}.** On average, the ≈20 cm resolution corresponds to ≈300 years (min = 60 a; max = 1,375 a)."

Line 233: Maybe not refer to Figure 5 here because the figure comes much later.

We corrected this mistake and changed it to Figure 1.

Line 240: moving is more commonly used than rolling

We agree that the term 'moving average' is more commonly used. In our case, however, the averaging window is defined in time (3 ka) rather than by a fixed number of data points, due to irregular sampling. This results in a variable number of samples within each window, for which the term 'rolling average' is more appropriate.

Line 234: Why 0.2 in Eq. 1?

We thank the reviewer for pointing this lack of precision. The coefficient 0.2 in Equation 1 corresponds to the ±20 % relative uncertainty on snow accumulation rates associated with the AICC2023 chronology. We have clarified this explicitly in the text to avoid any ambiguity.

Revision:

L234: "Rather than applying the full absolute uncertainty of the accumulation rate, **we use the 20 % accumulation rate uncertainty from AICC2023 as a relative uncertainty (0.2) applied to deviations from the mean accumulation rate**"

Line 235: The paragraph starting here should be moved later when the comparison is discussed

We understand the reviewer's suggestion to move this paragraph closer to the comparison section. However, this paragraph does not present a comparison itself, but describes a methodological update applied to the Dome Fuji ^{10}Be record prior to any comparison. Specifically, we recalculated the ^{10}Be flux using the updated DF2021 chronology and associated accumulation rates. We therefore consider it more appropriate to keep this description in the Methods section, as it documents how the external dataset was processed before comparison with the TALDICE record. Nevertheless, to improve clarity, we have slightly rephrased the paragraph to emphasize that it describes a methodological update of the Dome Fuji record rather than the comparison itself.

Revision:

L235: "**Prior to comparison with the TALDICE record, the Dome Fuji ^{10}Be fluxes (Horiuchi et al., 2016) were recalculated using the more recent accumulation rate.**"

Line 240: the sentence to be clearer, e.g., '3 ka rolling average of the standard deviation'. Suggestion: These 10Be minima were identified when the concentration fell below the mean minus one standard deviation, both calculated using a 3 ka moving window. (If this correctly explains how the minima were identified)

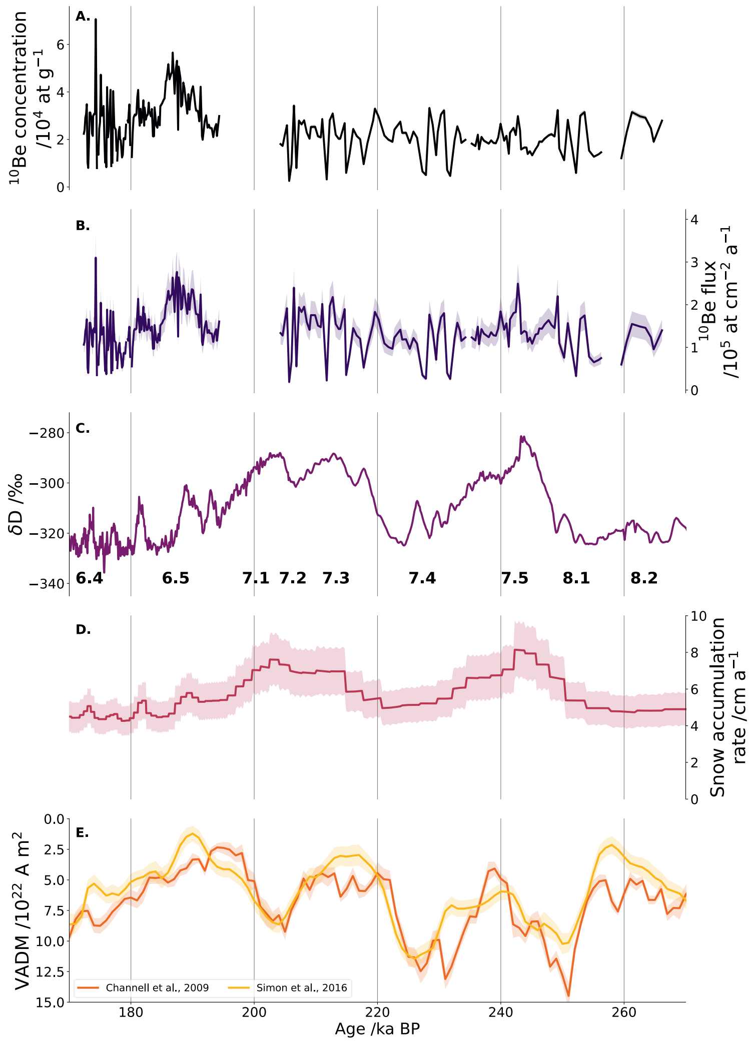
We thank the reviewer for this rephrasing and modified accordingly.

Line 280: rolling again? If you decide to change it in the first place, change it accordingly

No modification to be consistent

Line 245: Add the MIS periods mentioned here on top of Fig. 2?

We thank the reviewer for this suggestion and we modified accordingly



Line 246: Refer to Fig. 2D

We thank the reviewer for this suggestion and we modified accordingly

Line 281: Testing 1 ka, 3 ka …

We modified accordingly

Line 284: To avoid figure reference and citation together. Suggestion: 'The resulting 3-ka averaged 10Be flux record can be compared to geomagnetic reconstructions, including the Dome Fuji ice core data (Horiuchi et al., 2016) in Figure 4, and authigenic 10Be/9Be records from marine sediment cores (Simon et al., 2016), and the 10Be production (Poluianov et al., 2016) calculated from RPI-based VADM (Channell et al., 2009) in Figure 5.

We modified accordingly

Line 288: too many brackets

We modified accordingly

Revision:

L288: “Here, we consider either the full 170–270 ka BP interval ^{10}Be flux mean average **of** (1.36 ± 0.26) × 10^5 at cm^{-2} a^{-1} or a fixed baseline of 1.1 × 10^5 at cm^{-2} a^{-1} as reference values.”

Line 289: After the discussion on the baseline, decide on one and report the enhancement factors with respect to the selected one. Maybe also add the enhancement with respect to the present-day values?

As said in one previous answer we conserve the discussion with the two scenario. We add, as a general idea, the contemporary flow value.

Revision:

L289: “Depending on the chosen baseline, the flux enhancement factors during specific events are as follows: for the 190 ka BP event (IBE), the ^{10}Be flux is 1.59 or 2.08 times the background; for the 205–215 ka BP event (PFE), the increase is 1.24 or 1.62 on average; and for the 240 ka BP event (ME), the peak flux reaches 1.25 or 1.63 times the reference value. **As a general idea, the flux enhancement factor for IBE represents 1.5 times the modern value of c. 1.64 10^5 at cm^{-2} a^{-1} at Dome C (Jouzel et al., 2026).”**

Line 340: running median.

To be consistent with the naming rolling mean average, we prefer to use the rolling median naming.

Line 340: ‘similar to’ not ‘similar than’. rolling mean average? Suggestion: ‘During glacial periods, the median method results in 10Be fluxes similar to those obtained using a running mean (Figure S2).’

We thank you for raising this mistake.

“Rolling mean average” allows to clarify between the different types of averages. To be consistent, we have now modified all mentions of “rolling mean” to “rolling mean average”.

Line 341: I thought the running median and mean are both calculated on the minima identification results, or not? The sentence is confusing

We thank the reviewer for raising this lack of clarity. The median is calculated based on the total 10Be signal, including 10Be minima. Raisbeck et al., (2006) suggested that the median should be used to consider the effect of extrema. In Figure S2, both the mean, including minima, and the no-minima mean are presented.

Considering the minima for calculating the mean slightly increase the 10Be flux. The difference between the median and the no-minima mean is lower than the difference between the mean and the no-minima mean. Nevertheless, the median value is still 6 % lower than the no-minima mean value. Therefore, we argue that the no-minima is a more robust method for investigating the VADM. We modified the sentences to better explain this point.

Revision:

L341: “However, the median method results in similar ^{10}Be fluxes to those based on a rolling mean average (Figure S2). On average, the method based on minima identification results in +10 % ^{10}Be flux compared to the median method (Figure S2).”

Line 353: … age models, AICC2023 for TALDICE (Bouchet et al., 2023) and the Dome Fuji DFO-2006 chronology (Kawamura et al., 2007).

We modified accordingly

Line 359: over which period?

We thank the reviewer for raising this lack of clarity.

Revision:

L341: "While the mean ^{10}Be flux in TALDICE is 1.56 × 10^5 at cm^{-2} a^{-1} **over 170–190 ka BP** (accounting for the minima)"

Line 363: .. over the last millennium, between 1000 and 1885 CE, where the …; and only 'CE' not 'a CE'

We modified accordingly

Line 366: remove brackets around Supplementary material, separate with a comma.

We modified accordingly

Line 367: remove brackets of the citation, separate with a comma.

We modified accordingly

Line 368: list the solar minima intervals

We thank the reviewer for this suggestion, which we integrated in the paper.

Revision:

L368: "with the occurrence of solar minima during this interval **(Wolf, 1280 – 1350 CE; Spörer, 1420 – 1570 CE; Maunder 1645 – 1715 CE; Dalton 1790 – 1830 CE, Steinhilber et al., 2012).**"

Line 384: … in an Antarctic ice core over the period from 170 to 270 ka BP.

We thank the reviewer for raising this lack of clarity. We wanted to be more general to remind the different flux enhancement of different excursions over the Bruhnes chron.

Revision:

L384: "stands out as one of the most prominent geomagnetic events **during the Bruhnes chron (Simon et al., 2016)"**

Line 385-389: needs to make clear that this interpretation is based on 10Be,

We thank the reviewer for the suggestion and we clarified this.

Revision:

L385: "Such ^{10}**Be-based** enhancement factors place IBE among the strongest known geomagnetic excursions of the last 1 Ma, comparable to the Laschamps event as measured in ^{10}**Be in** East Antarctic cores (Raisbeck et al., 2017) or **authigenic** ^{10}**Be from** oceanic cores (Simon et al., 2020), with no equivalent recorded between 200 and 800 ka BP (Cauquoin, 2013), and approaching the amplitude of the Bruhnes–Matuyama transition (Raisbeck et al., 2006; Simon et al., 2020)."

Line 386: It is difficult to say 'slightly higher' because it depends a lot on the reference background, as the authors already discussed. I agree with 'comparable'.

We modified accordingly

Line 407: (Figure 4) not (Figures 2, 4 and 5)

We modified accordingly

Line 410: mirrors? I would use another verb. 'Mirrors' as 'reflects' in terms of slow decrease during the M/B reversal and rapid decrease in excursions, or as 'reproduces, resembles', the same behavior? My understanding is the first one, but it could be misinterpreted

We thank the reviewer for pointing out this potential ambiguity. We originally used 'mirrors' in the sense of a temporal mirror image (i.e., opposite asymmetry), but we agree that this wording could be misinterpreted. The sentence has been revised to explicitly describe the time-reversed relationship between excursion and reversal intensity patterns

Revision:

L410: "Interestingly, this asymmetric pattern **is opposite, in a temporal sense, to that** observed for polarity reversals (e.g., Valet and Meynadier, 1993; Valet et al., 2005): **reversals are characterized by** a slow decrease of the dipole moment in the initial polarity followed by an abrupt recovery of the dipole moment in the new opposite polarity. After long and intensive debates (Kok and Tauxe, 1996; Mazaud, 1996; Meynadier et al., 1998; Meynadier and Valet, 1996), the hypothesis was recently tested on authigenic $^{10}Be/^{9}Be$ records reconstructed from sediment cores (Simon et al., 2018; Valet et al., 2024, 2025) which suggested that the asymmetric patterns were not convincingly reproduced for any of the reversals of the last 4 Ma."

Line 415-417: Great point!

Thank you

Line 418: remove the four brackets in this line, and in the paragraph

We thank the reviewer for this comment. However, as mentioned earlier we prefer to follow the IUPAC writing (https://old.iupac.org/publications/books/gbook/green_book_2ed.pdf, page 83) when reporting values as: *(value ± std) unit*.

Line 422, 1) the ages come with large uncertainties, 2) do we expect excursions to occur at the same time globally, considering the geomagnetic field dynamics?

We agree that age estimates associated with geomagnetic excursions carry large uncertainties, which are explicitly reported in the manuscript. In addition, excursions related to a collapse of the geomagnetic dipole moment are expected to be globally synchronous. This is supported by cosmogenic nuclide records showing coherent ^{10}Be increases in both Greenland and Antarctic ice cores. We have clarified this point in the text and now emphasize that the dispersion of reported ages likely reflects the prolonged duration of the event and chronological uncertainties rather than true diachronism of the geomagnetic signal.

Revision:

L418: "Regarding the timing, the IBE flux maximum forms a plateau between (192.07 ± 1.41) ka BP and (185.56 ± 1.44) ka BP, suggesting a ≈7 ka interval of extremely low magnetic field strength. This age is in general agreement with previous estimates from sedimentary and volcanic archives. For instance, the age aligns well with the K–Ar dating of transitional lava flows from the Snake River Plain at (188 ± 8) ka BP (Champion et al., 1988), and with excursion ages inferred from high-resolution marine sediment cores in the Ontong Java Plateau (≈190 ka BP; Tauxe and Wu, 1990) and the eastern equatorial Pacific (Valet and Meynadier, 1993). It is also consistent with authigenic $^{10}Be/^{9}Be$ records from Portuguese margin cores (Carcaillet et al., 2004). Slightly older ages, such as the (197 ± 17) ka BP have been reported though for the Unzen lava flow in Japan (Shibuya et al., 2007). **It should be noted that age uncertainties associated with both volcanic and sedimentary records are large, often of the same order as the reported differences between archives. Moreover, geomagnetic excursions associated with a collapse of the geomagnetic dipole moment are expected to be globally synchronous, as supported by cosmogenic nuclide records showing coherent ^{10}Be increases in both Greenland and Antarctic ice cores (Raisbeck et al., 2017). In this context, the spread in reported ages likely reflects** the prolonged duration of the event, as indicated by the ≈7 ka plateau in ^{10}Be flux, which complicates the definition of a single "event age", **combined with age uncertainties, rather than a true diachronism of the geomagnetic signal**."

Line 449: in agreement with PISO-1500 variations

We modified accordingly

Line 450: Isn't it the case that for excursions, i.e., enhancements, the only variations that should be interpreted are those in the flux, not in the concentration? What does it mean if the others are not expressed in the concentration?

We agree that for geomagnetic excursions, variations in ^{10}Be flux are generally the most appropriate to interpret in terms of geomagnetic field intensity, whereas concentrations can be strongly affected by accumulation changes. This is precisely why we explicitly discuss the fact that the PFE and ME are only expressed in the flux record and not clearly in concentrations. We consider whether such signals could result from accumulation-related artifacts or age-model effects, and argue that this is unlikely based on (i) the occurrence of these events during interstadial periods with high accumulation rates, (ii) the partial control of ^{10}Be concentrations by climate proxies (Na^+), and (iii) the robustness of the AICC2023 chronology over this interval. We have clarified this reasoning in the text.

Revision:

L450: "**Variations in ^{10}Be flux are more directly representative of changes in cosmogenic production, unlike ^{10}Be concentrations which are strongly modulated by snow accumulation. In this context, it is noteworthy that, unlike the IBE, the PFE and ME** are not clearly expressed in ^{10}Be concentrations, and only emerge in the ^{10}Be flux (i.e., once considering snow accumulation rate variations and considering ^{10}Be minima). This raises the possibility of **whether these low-amplitude signals could be artifacts**

related to accumulation-rate variations or age-model uncertainties. Nevertheless, both events occur during interstadial periods (MIS 7.3 for PFE and MIS 7.5 for ME) marked by elevated accumulation rates, approximately 8 cm a^{-1} (Figure 2), thus supporting the consideration of snow accumulation rate variations. This is further corroborated by the correlation between the concentrations of Na^+ and ^{10}Be (R^2 = 0.23, after the removal of the minima, Figure S3) which indicates that about 23 % of ^{10}Be concentration is explained by climate-driven variations in ^{10}Be deposition. Moreover, the robustness of the AICC2023 chronology over this interval, supported by a dense network of chronostratigraphic markers (Bouchet et al., 2023), strengthens the reliability of the flux signals. While confirmation from additional ice cores is required, the present evidence supports the occurrence of two distinct moderate geomagnetic excursions (PFE and ME), enriching the geomagnetic field history during MIS 7. **This observation further emphasizes that relying solely on ^{10}Be concentrations may lead to biased interpretations of ^{10}Be production when glacial and interglacial periods alternate, and that both ^{10}Be concentrations and snow accumulation rates should be reported to allow robust geomagnetic interpretations.**"

Line 463: interstadial stages of MIS 7 (7.1 for IBE, ..), Line 400: interglacial MIS 7.1? I believe my confusion here comes because I don't have expertise in paleo(climatology). Please explain: interstadial vs interglacial in terms of short/long, warm/cold, between/within glacial period. I think it is important to know the climate conditions when these excursions happened.

We thank the reviewer for pointing out that the distinction between interstadial and interglacial terminology may not be obvious outside the paleoclimate community. In ice core and marine isotope stratigraphy, MIS 7 is a complex stage composed of several relatively warm substages (7.1, 7.3, 7.5), commonly referred to as interstadials rather than full interglacials. We have clarified this terminology in the manuscript to better explain the climatic context in which these excursions occurred.

Revision:

L463: "In particular, the occurrence of the three excursions during **warm** interstadial **sub**stages of MIS 7 (7.1 for IBE, 7.3 for PFE, and 7.5 for ME)**, i.e. relatively warm intervals within MIS7,** raises the question of a climate-dependent polar bias."

Line 509: add the age of the Mid-Pleistocene Transition

We thank the reviewer for raising this point, which is included.

Revision:

L509: "Mid-Plesitocene Transition **(1.2 – 0.9 Ma, Fischer et al., 2013; Parrenin et al., 2017; Wolff et al., 2022)**"

Line 511: Using the VADM reconstruction PISO-1500 (Channell et al., 2009)

We modified accordingly

Line 520: This study presents a high-resolution 10Be flux record from the East Antarctic TALDICE ice core, covering the interval from 170 to 270 ka BP, and evaluates the reliability of 10Be as a paleomagnetic proxy and as a tool for synchronizing the chronologies of different proxy archives. (or something along these lines, so the three following points are summarized, not only the first two)

We modified accordingly

Line 545: .. offer great possibility for cross-checking the chronologies ...

We modified accordingly

Feedback on the figures:

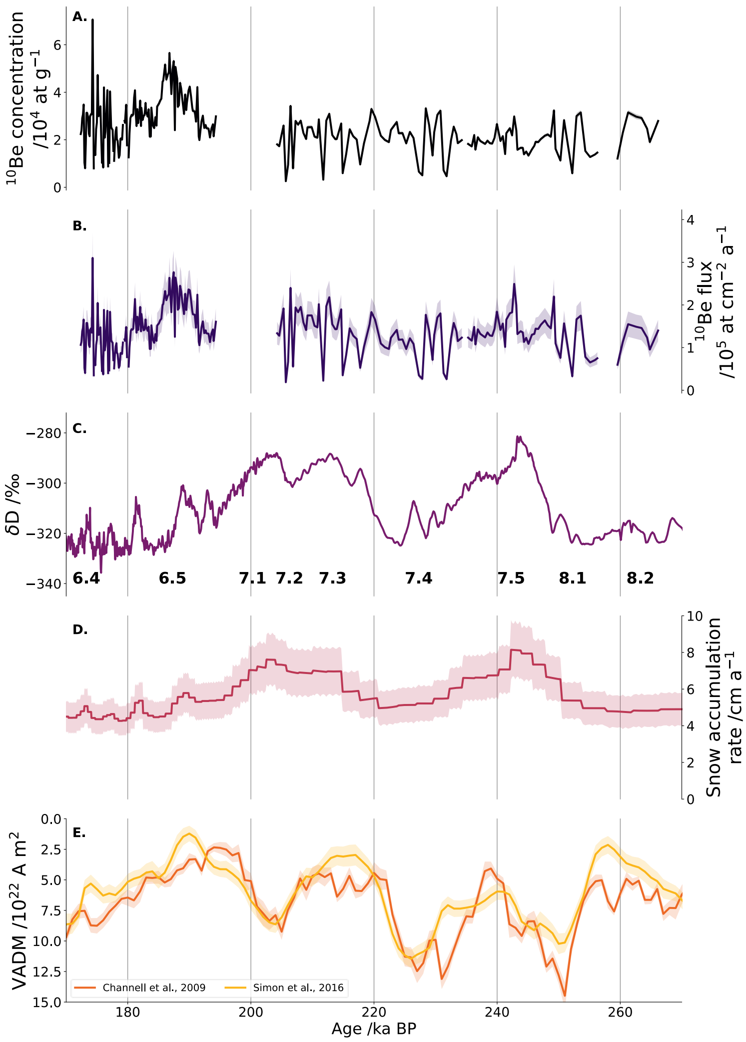
Figure 1: Capital letter in the caption. Expand the caption. The three excursions, which one?

We revised the caption as follow:

*"**Figure 1: M**ap of sites **found in literature** recording at least one of the geomagnetic excursions discussed in this paper: the three excursions (**IBE, PFE and ME**, triangles), IBE alone (stars), or PFE alone (circle). **The references are listed in Table S1**"*

Figure 2 caption: shaded in black? Are these visible? Explain \deltaD. I found the notations for the subfigures in the brackets confusing. It is much clearer to have: A) …. B) …. etc, as it is started, then continue for C), D), and add E). Write the name of the RPI stack. Y-axis is reversed. Note the MIS stages at the top

Be concentration uncertainties are small, which is why we cannot see the shaded black areas. We clarified in caption that the uncertainty is <3.6 %. MIS has been added.



*"**Figure 2: A)** TALDICE ^{10}Be concentration (10^4 at g^{-1}) with the concentration uncertainty **(shaded black, 3.6 % on average). B) ^{10}Be** flux (10^5 at cm^{-2} a^{-1}) with the uncertainty (shaded purple) **which accounts for** the concentration uncertainty and the variation of the accumulation (see section 4). **C)** Climate variations are recorded in TALDICE with δD **water isotopes** (‰; Stenni et al., 2011)**, from which Marine isotope stage can be listed (6.4 to 8.3; Railsback et al., 2015)**. **D)** Snow accumulation rate (cm a^{-1}) is retrieved from the AICC2023 chronology (Bouchet et al., 2023). **E)** Virtual Axial Dipole Moment (VADM, A m^2) is estimated from Relative Paleointensity (**PISO-1500;** Channell et al., 2009) (orange) or from authigenic $^{10}Be/^9Be$ (Simon et al., 2016). Note that the **y-**axis is reversed."*

Figure 3: Capital letter in the caption. Shaded orange and grey, do these overlap? In total, they should be 52, or 52 orange only? Note down in the caption which ones are removed in the analysis? List the major ion concentration (…).

We thank the reviewer for these comments. We corrected the caption and clarified the definition and counting of minima, including the fact that minima are identified at the ^{10}Be sampling resolution (≈20 cm), so that low-concentration intervals extending over 40 cm are counted as two minima. We also clarified the meaning of the orange and grey shaded areas and corrected the total number of minima retained in the analysis. We also realized that we have made a mistake. Only 40 minima are identified in the section 1470 – 1531 m. The 52 minima mentioned in the previous version included other sections that have been removed from the manuscript, in order to mainly focus on the 170-270 ka BP period. Figure 3 correctly showed the section with the 40 minima. We corrected the section 4.2.

*"**Figure 3: M**inima in ^{10}Be concentration (black **line**) **identified at the measurement resolution (≈20 cm) are highlighted by shaded areas. Orange shading indicates ^{10}Be minima that are concomitant with macima in major ion concentrations, whereas grey shading indicates minima without concomitant major ion maxima.** The resolutions are the measurement resolution, i.e. ≈20 cm for ^{10}Be. **Because minima are defined at the ^{10}Be sampling resolution, a low-concentration interval extending over 40 cm is counted as two distinct minima. Only the 40 minima identified within the 1470–1531 m depth interval (corresponding to 170–270 ka BP) and retained for the present analysis are shown.** The major ion **(Na^+, Cl^-, MSA, SO_4^{2-}, Ca^{2+}, Mg^{2+}, NO_3^-, and H^+)** concentration profiles are in high resolution (8 cm). Acidity profile (H^+) is calculated from an ionic balance (see section 3.2.2)."*

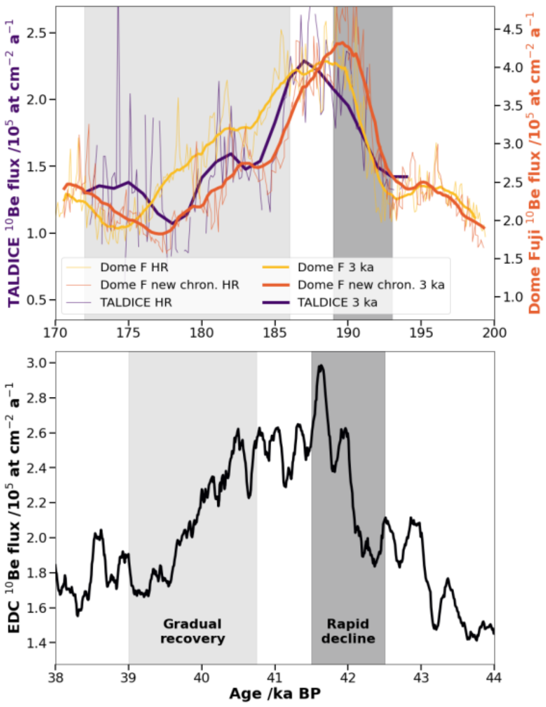
L263: "**4.2. ^{10}Be minima**

A total of **40** minima in ^{10}Be concentration were identified across the TALDICE record studied in this work, which appear to coincide with maxima in the concentrations of major ions (Figure 3). This association is statistically significant (permutation test's *p*-value = 0.0001), though no direct quantitative relationship can be established. The major ions involved originate from a variety of sources, including oceanic sea spray (Na^+, Cl^-, Mg^{2+}, MSA, SO_4^{2-}), crustal dust (Ca^{2+}, Mg^{2+}), and volcanic (SO_4^{2-}) sources. In addition to ion concentration peaks, many of the ^{10}Be minima are also associated with decreases in the Cl^-/Na^+ ratio which is typically used to study changes in the relative contributions of marine aerosols or alterations in transport processes (Legrand et al., 2017).

To test whether the identified ^{10}Be concentration minima preferentially occur under particular conditions, we compared their distribution against δD and [Ca^{2+}]. Of the **40** minima identified, **31** occurred during glacial intervals (δD < -300 ‰), which is proportional to the fraction of the record spent in glacial conditions (**77** %). A χ^2 test confirms no significant increase in the number of minima during glacials (p = **1.00**), and δD values at ^{10}Be minima are statistically indistinguishable from non-minima levels (Mann-Whitney U test, p = **0.889**). In contrast, [Ca^{2+}] concentrations are systematically higher at ^{10}Be minima. While median [Ca^{2+}] is only slightly elevated at minima compared to the background (Mann–Whitney U p = **0.53**), contingency tests using thresholds show strong enrichment: for example, **32** % of ^{10}Be minima exceed 15 ppb Ca^{2+} compared to **13** % of the background (**χ^2 = 8.0, p = 0.005**), and **7** ^{10}Be minima exceed 30 ppb compared to only **9** out of **221** non-minima samples (**χ^2 = 8.4, p = 0.005**). This suggests that short-lived ^{10}Be minima preferentially coincide with dust-rich conditions."

Figure 4: Capital letter in the caption. Which line is purple? .. the snow accumulation rate. Also, rather than the vertical lines showing the x-axis major ticks, add minor x-axis ticks only to the x-axis, and add vertical lines that distinguish the periods of rapid decline and the three-step recovery (and four arrows showing the decline and recoveries). I would suggest adding another panel showing the Laschamps excursion, as there is an extended discussion on it (with similar vertical lines).

We thank the reviewer for these comments. We have revised the Figure 4, now including the Laschamps excursion record from EDC (Raisbeck et al., 2017) and some highlighted areas to better distinguish periods of rapid decline from those of gradual recovery.



*"**Figure 4: C**omparison of Dome Fuji (**high resolution and 3 ka rolling mean average,** yellow, Horiuchi et al., 2016) and TALDICE (purple, this study) ^{10}Be flux records for IBE. The revised Dome Fuji record is also presented based on chronology revision, which modifies snow accumulation rate (orange, Oyabu et al., 2022). **The dark (resp. light) grey shaded area represents the period of rapid decline (resp. slow recovery) of the GDM. For comparison, the same periods can be identified during the Laschamps excursion in the ^{10}Be flux record from EPICA Dome C ice core (Raisbeck et al., 2017)**"*

Figure 5: Note the IBE, PFE and ME in the figure on top of the grey bars. Denote the subfigures A,B,C... and add these to the main text when referring to the subfigures. The timing of the stars in TALDICE is also different in MD05-2920, but the sediment record wasn't considered for defining the shifts, right? Are the stars from TALDICE directly applied to the 10Be global production? I found the star around 210 ka very difficult to uniquely identify.

Regarding the stars, we are sorry if having the stars on the MD05-2920 core led to confusion. Indeed, as correctly understood by the reviewer, the stars only enable the alignment of the RPI-based ^{10}Be production record with the TALDICE one. Besides, we agree with the reviewer that the ca. 210 ka BP star is difficult to precisely assign. We clarify in the document the higher uncertainty on this matching.

Revision:

L429-430: "These well-resolved features are also mirrored in ocean sediment records (Black stars in Figure 5) and could serve as valuable tie points for synchronizing paleoclimate archives across different media. **In contrast, the feature tentatively identified around c. 210 ka BP is less well constrained and should be regarded as having a higher uncertainty in its assignment."**

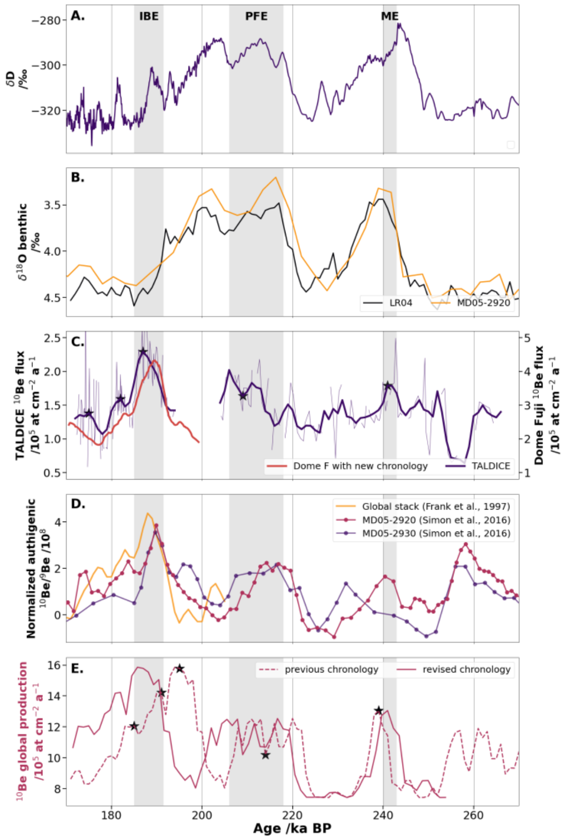


Figure 5**: Comparison of ^{10}Be and climate records from ice cores and marine sediments over 170–270 ka BP with: **A.** TALDICE δD (/‰), **B.** benthic δ^{18}O (/‰) from LR04 stack (Lisiecki and Raymo, 2005) and MD05-2920 (Tachikawa et al., 2014), **C.** TALDICE and Dome Fuji ^{10}Be (in purple and red respectively, /at cm^{-2} a^{-1}), **D.** authigenic ^{10}Be/^{9}Be from **global stack reconstruction (yellow, Frank et al., 1997), MD05-2920 (red), and MD05-2932 (purple) (Simon et al., 2016),** and **E.** the ^{10}Be global production (/at cm^{-2} a^{-1}; Poluianov et al., 2016) calculated from RPI-based VADM (Channell et al., 2009). Grey bars highlight the main geomagnetic excursions discussed in the text (IBE, PFE, ME). Timing of identifiable geomagnetic features (black stars in TALDICE and RPI-based VADM) is used to obtain a revised chronology of RPI-based VADM used for calculating the ^{10}Be production**, noting though a lower confidence on the star around 210 ka BP."