

Interactive comment on “Direct North-South synchronization of abrupt climate change recordin ice cores using beryllium 10” by G. M. Raisbeck et al.

G. M. Raisbeck et al.

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General comment

Replies are in bold

The paper of Raisbeck et al. presents a new attempt of the direct synchronization between Greenland and Antarctic ice cores using Be-10 isotope record. This is a rather promising approach since it can provide a much higher accuracy as compared to the synchronization via methane concentration. If this method could indeed provide an accuracy of ca. 100 years or even better, this would be very important for a better understanding the mechanisms of abrupt glacial climate change. I believe, this is an interesting paper but the description of the most crucial aspect of the paper - synchro-

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nization of two ice core records - is too laconic and requires further clarifications.

The authors write in the abstract that they match the Be-10 peak from the EPICA core with the same peak in the GRIP ice core. Unclear is what they meant under the term “peak”. If this is the whole Laschamp excursion, then this peak is too broad to allow accurate matching. In fact, as it follows from the paper, the authors selected two centennial scale excursions in Be-10 flux (“A” and “B”) in one record and match them with two similar peaks in another one. Although Figure 2 looks reasonably convincing, the question remains how robust (objective) is the method of matching of two Be-10 records which contain numerous centennial scale fluctuations. The authors only mentioned that this is “the best match between” two wiggly curves. I would like to ask the authors to clarify whether the “best match” was found using some objective criteria (e.g. maximum of correlation) or just by a careful visual inspection.

The two 10Be tie points were chosen by visual inspection, and two new exterior tie

points by a procedure that is now described in the text. The two 10Be curves were then matched

using the Analyseries program (Pailiard et al., 1996). We are unaware of any totally

objective method of correlating two irregular curves which does not require the choice of at

least one initial tie point, and some assumptions about how much squeezing and stretching

is allowed when optimizing the correlation between the remainder of the curves.

My understanding is, though it is not explicitly stated in the paper, that after matching “A and “B” events between two records, the whole Antarctic time scale was linearly shifted by 815 years without any other attempt to synchronize the records using an-

other Be-10 wiggles. The result of this match shown in Figure 2 is somewhat surprising to me. While for the record younger than 42.5 Ka BP the correlation between two Be-10 records is rather good and the thermal seesaw model agrees well with the observation, the older part of the record shows no obvious correlation between Be-10 records and the simulated event AIM-11 lags the real one by ca. 500 yr. Since I cannot see the reason why the model does not work for AIM-11, I would rather assume that two “synchronized” records around 44 Ka BP are already out of phase by half of millennium. This problem might be resolved by matching Be-10 peak in GRIP record at 44.2 with EDC peak at 43.6 Ka BP.

The reviewer is right that initially the Antarctic curve was simply shifted linearly. We now choose two

other exterior tie points based on methane, as described in the text. The effect is indeed to significantly

improve the correlation of the minor 10Be peak at ~44 ky, and the agreement of the model at AIM 11.

This, however, would imply that the GRIP and EDC time scales in the interval between 44 and 42 Ka BP differ by more than 25%. Is it possible and can it be explained by changes in accumulation rate or other problems related to the dating of EDC? A more general question is how confident the authors are that the individual centennial scale Be-10 excursions in an individual ice core always represent a global scale event and can be matched with the bipolar counterpart? The last question, how realistic in the view of these problems is the author's suggestion (in “Perspectives”) that this method “potentially permits a correlation on a time scale of better than 20 years”?

While we are quite confident that the two 10Be tie points we have chosen are robust, we agree with

the reviewer that the correlation of all the centennial scale 10Be variations will

be possible only

when a more complete and higher resolution profile for Greenland is used. We now have such

a profile at NGRIP which we believe will fulfil this requirement.

Specific comments

Page 760, line 10. "The Be-10 peak straddles the middle one of these events".

Please specify which peak is meant here - one of many centennial ones, or the whole Laschamp events. In the latter case, the peak straddles all three AIM events.

We now specify that it is the most prominent part of the ^{10}Be peak which straddles the middle climatic event (AIM 10).

Page 760, lines 21-29. I found the comparison of the results presented in the paper with early studies somewhat confusing, especially, mentioning of 1500 lead of Antarctic temperature since the latter is clearly not the case for AIM 10. Instead, it would be rather straightforward to say that the new results confirm early Bluniers's and EPICA findings that the maxima of Antarctic warmings coincide with the onsets of DO events.

Blunier et al came to two conclusions regarding large DO events; (1) that Antarctic warming preceded these events by 2-3 ky. (2) The maximum in the Antarctic temperature coincided with the onset of the DO events. The present paper shows that, within the precision obtained here (~ 200 years), the second conclusion also holds for the smaller DO events, while the Antarctic warming precedes the onset of the DO events by a much shorter time, as predicted by the bipolar seasaw model.

Page 761, line 23. The choice of $\tau=2200$ years requires some justification because in the previous work it has been shown that the best fit of the thermal bipolar seesaw model to the data is obtained for the time scale of ca. 1000 yr.

We now clarify that the choice between a tau of 2200 and 1200 is not obvious in the phase agreement, which is the most relevant parameter.

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