Clim. Past Discuss., 8, C581–C586, 2012
www.clim-past-discuss.net/8/C581/2012/

Climate of the Past Discussions

Interactive comment on "On the gas-ice depth difference (△depth) along the EPICA Dome C ice core" *by* F. Parrenin et al.

F. Parrenin et al.

parrenin@ujf-grenoble.fr

Received and published: 19 June 2012

Review of Parrenin et al "Delta Depth in EDC. . .."

original text is plain, answer is bold

This is an important, useful paper that summarizes four different approaches to the difficult problem of constructing accurate gas chronologies, owing to the inherent problem of the gas age-ice age difference in Antarctic ice core records. The authors compare a classical approach of modeling with three observation-based methods. In brief, they find that the modeling approach has some shortcomings. This result will be important for the ice core community and should be published with some major revisions.

There seems to be a mistake in the formula used for the δ15N approach (see below),

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

and the authors have neglected the crucial effect of thermal fractionation in the firn on δ15N. Both of these issues could, and likely do, have substantial impacts on the conclusions and so must be rectified in any revised version.

There has been a typesetting mistake in the published version of equation 15 but the original manuscript as well as the calculations are correct. The formula will be corrected in the revised version.

We did take into account the thermal fractionation altough only with temperature gradient assumed to be constant through time. But indeed this temperature gradient varies by more than our confidence interval of 0.003°C. So we now use simulations by the Goujon et al. [2003] model, to estimate the temperature difference in the firn and to correct the δ15N data from the thermal fractionation.

Also, it seems highly unlikely that the authors' assumption can be correct there was no convective zone in the glacial periods, based on findings elsewhere in Antarctica. For example, at Taylor Dome the d15N went to near zero during the last glacial period. The fact that the authors have neglected the possible role of convection constitutes a major issue that must be resolved.

The zero convective zone is a work hypothesis. The fact that we find a good agreement for TI between the 15N approach and the other approaches (seesaw, synchro to EDML and TALDICE) suggests that there is indeed a zero or small convective zone at EDC during this time period. This is relatively clearly written in the d15N section. As a further proof, we attach a figure similar to figure 8 of the manuscript but zoomed on Termination I and with an assumed 20 m convective zone. One can see that the 15N approach does not agree anymore with the synchro to EDML and TALDICE methods and with the seesaw method.

Finally, the authors state that "it has never been demonstrated" that d40Ar is a gas phase temperature proxy. This is not quite accurate – Severinghaus et al., 2003 GCA, Severinghaus and Brook, 1999, and Severinghaus et al. 1998 did show that d40Ar

CPD

8, C581–C586, 2012

responds to temperature. However, it also responds to gravitational settling so the interpretation of d40Ar in terms of temperature change is not straightforward. Caillon et al (2003) did explain this clearly, I believe. Goujon et al. (2003) did show that part of the Vostok d40Ar signal at Terminations is due to temperature, although it is difficult to say whether it constitutes half or two-thirds of the amplitude.

Sentence reformulated to: 'However, Caillon et al. [2003] based their conclusions on the assumption that at Vostok, δ40Ar varies in phase with temperature, which has never been demonstrated.' The 3 papers you mention study the thermal effect in Greenland. The last paper also study the gravitational effect at Siple but interpret its variations as accumulation variations. At Vostok, Caillon et al. [2003] find a d40Ar record that correlate relatively well with the deuterium record. They invoke a varying convective zone (related to temperature) to explain these d40Ar variations. However, all this is not a firm proof that d40Ar responds in phase with temperature. It might happen, for example, that LID is related to the impurity content, as proposed by Hörhold et al. [2012]. If this is true, all the interpretation (on varying convective zone) and conclusion (on CO2-AT phasing) by Caillon et al. [2003] may be wrong.

Detailed comments: P 1097 1. Gravitational acceleration should be 9.825 for Antarctica, not 9.81

Corrected.

p 1098 2. equation 15 has a mistake, I think: δ15N can be expressed as the sum of two terms, the gravitational and thermal components:

This is a typesetting mistake by the editorial office that we did not see during the checking phase. The original manuscript is correct (same equation as your last one) and so are the calculations.

3. line 13 is confusing – perhaps you meant to say "Note that we have evidence for a

CPD
8, C581–C586, 2012

large convective zone at present at some sites ”?

Yes, it is what we meant. Sentence corrected.

4. line 14 – this assumption, of a constant ΔT, seems unnecessary. Goujon et al (2003) calculated ΔT, at Vostok, through glacial cycles. Why not do it at EDC? They found it to be rather larger during the glacials, when a lower accumulation rate plus the transient cooling at the surface created a very substantial ΔT, with negative sign. They found up to -4 C at 25 ka, the neglect of which would create an error of 0.05 per mil in the gravitational signal, corresponding to a 10 m error in inferred firn depth. This effect would make your δ15N-based Δdepth systematically larger during glacials, if accounted for. So it is a bias, not just a source of uncertainty.

See remark above. Note that from Figure 4a of Goujon et al. [2003], the firn temperature gradient at 25 ka is about 2-2.5°C, not 4°C.

5. line 21 – this gradient uncertainty, of <0.003 K m-1, corresponds to a value of 0.3 K for a diffusive column 100 m thick. This seems much too small given the above.

See anwer above.

P 1104 6. line 6 “antiphase” not anthiphase

Corrected.

p 1105

7. line 15 – “come from” not comes from

Corrected.

p 1106 8. line 1 – “is the existence of non-laminar flow effects.”

Corrected.

9. line 5 – “past variation of ice thickness”

CPD

8, C581–C586, 2012

Corrected.

10. line 22 ”. . .firn densification model correctly estimated Δage at Vostok during Termination III.”

Corrected.

p 1107 11. line 2 – Termination II (upper case when it is a specific one)

Corrected.

12. line 9 – “as is the case”

Corrected.

p 1109 13. line 23 – “can help improve the EDC. . .”

Corrected.

We wish to warmly thank the reviewer for his careful and expert review.

Interactive comment on Clim. Past Discuss., 8, 1089, 2012.

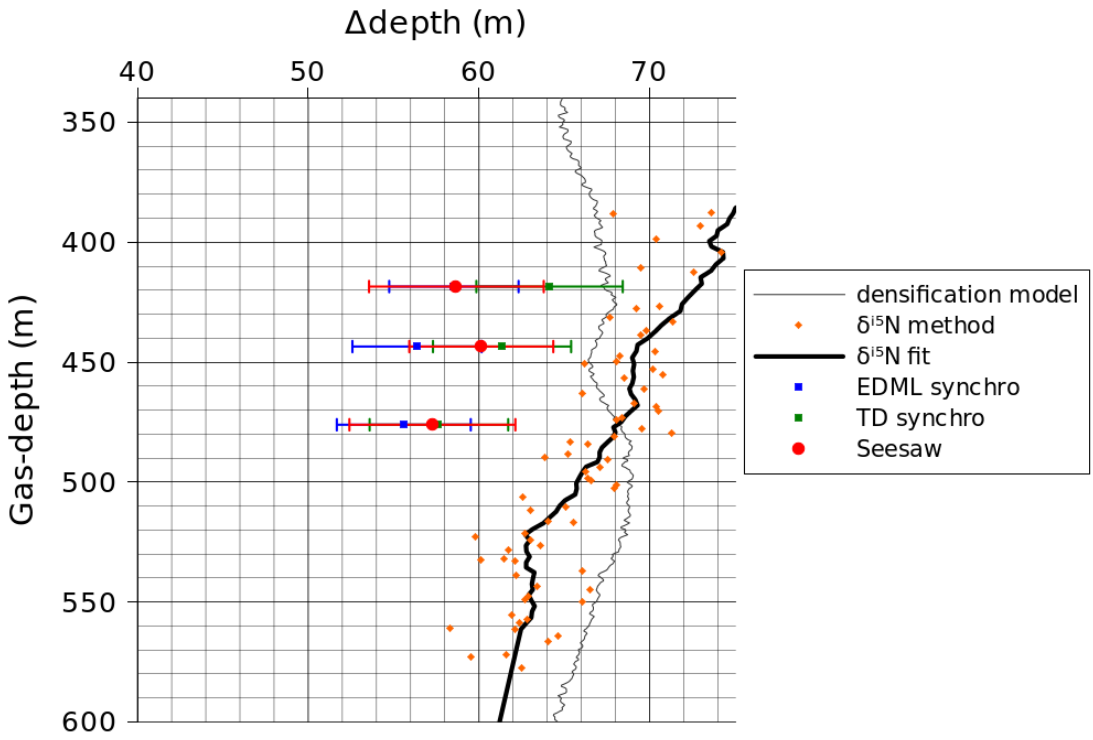

Fig. 1.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper