Dear Editor,

We have now carefully revised the manuscript in view of the constructive and helpful editorial and reviewer comments as outlined in detail below and the paper is now ready to resubmit. In addition to the reviewer comments, we also included comments by colleagues, leading to another co-author listed on the revised version of the manuscript.

Regards Hubertus Fischer

C. Barbante (Editor)

The paper has been reviewed by two competent colleagues and I am sharing all of them comments, in particular those relating to the possible distortion of the record near the bedrock.

We have revised the text to expand on the discussion of potential flow disturbances at the bottom of the ice sheet (see replies to the reviewer comments below for details).

We also spotted an error in the model for the Dome C site, where the oldest stratified ice was assumed to be at 35 m above bedrock instead of 70 m. We reran the model excercise leading to Figure 1, replaced Figure 1 and changed the values for the geothermal heat flux at Dome C in the text. Note, that the absolute value of the derived geothermal heat flux is somewhat model dependent. We now stress this more clearly in the text. Changing the value at Dome C, however, had no relevance for the other exercises performed and the conclusions of our study.

Anonymous Referee #1

I would like to see more discussion of the possibility of distortion of the record near the bed. I am particularly concerned that the goal requires using ice that is within 100 m of the bed, a zone that is typically disrupted by ice flow. Although they discuss how to minimize the likelihood of this occurring, I feel this is a large and unpredictable risk that needs more emphasis.

We expanded the discussion on this point at several locations of the text. Clearly, we cannot give an ultimate answer, where undisturbed ice is found, based on current knowledge, but we stress that the presite survey for the site selection of any Oldest Ice ice core has to take special care to find out, whether the ice is not disturbed before drilling the core. The following text has been added or modified in the manuscript:

Abstract „ For example for the geothermal heat flux and accumulation conditions at Dome C, an ice thickness lower than but close to about 2500 m would be required to find 1.5 My old ice, i.e. more than 700 m less than at the current EPICA Dome C drill site. Within this constraint, the resolution of an Oldest Ice record and the distance of such old ice to the bedrock should be maximized to avoid ice flow disturbances, for example by finding locations with minimum geothermal heat flux. As the geothermal heat flux is largely unknown for the EAIS, this parameter has to be carefully determined beforehand."

Page 14: In none of the model solutions in Fig. 2 can we find 1.5 million year old ice above 100 m from the bedrock and even to find such old ice 50 m above bedrock, one has to stay within a narrow ice thickness window of 2100-2500 m of ice equivalent. These observations become critical as disturbances of bottom ice are regularly observed in deep ice cores. Even at Dome C, which is located on a dome and which is subject to some bottom melting today, the bottom 70 m appear to be subject to disturbances of the ice, showing a clear lack of glacial/interglacial cycles. A potential lateral movement of the dome position over time may contribute to these disturbances.

Page 18: In the discussion above we have neglected any horizontal flow of the ice other than the implicit divergence imposed by the decreasing w as the bed is approached. Apart from its influence on

the age profile in the ice, horizontal flow is especially worrying as it imposes the risk of flow disturbances. As illustrated by the Vostok (Raynaud et al., 2005;Parrenin et al., 2001), EPICA Dronning Maud Land (EDML) (Ruth et al., 2007;EPICA community members, 2006) and NEEM (NEEM community members, 2013) ice cores, which are all located several hundred kilometers downstream of the initial site of snow deposition for deep, old ice, such flow disturbances are a common phenomenon in the bottom of these ice cores and can affect a few hundred meters of ice at the bottom. To initiate such flow disturbances both strong bedrock undulations as well as the occurrence of bottom melting at any upstream location may contribute. In case of ice frozen to bedrock, the bottom drag leads to strong shear deformation, increasing the chance of flow disturbances, especially if the rheology of the ice changes in the core from glacial to interglacial ice (NEEM community members, 2013). In the case of an upstream switch from frozen to liquid based ice, such a slip/stick situation may be also favorable for overturning of ice layers leading to folds (Wolovick et al., 2012). Moreover, downstream refreezing of melt water that was formed upstream, as suggested by (Bell et al., 2011) based on ice radar measurements, can further compromise the age of the ice at the bottom. This may be especially important in regions of high horizontal flow and pronounced bedrock topography. Importantly, our model above does not take into account the bedrock topography. Future more refined modeling efforts have to take advantage of the new high-resolution bedrock topography (Fretwell et al., 2013) and other ongoing or future radar campaigns.

Page 20: Note that the selection of a dome position alone is also not sufficient to find old, well-stratified ice as illustrated by the flow disturbances encountered at GRIP and GISP2 in Greenland (Grootes et al., 1993). Only sites in the vicinity (about 50-100 km) of a dome or saddle, where ice thickness is low enough and where bedrock topography is reasonably smooth appear to be good candidates. Accordingly, reasonably flat subglacial highlands with a rather limited maximum ice thickness would provide ideal conditions for an Oldest Ice ice core. As shown above, ice thickness should not exceed 2500 m, if we assume the same geothermal conditions as at Dome C. To complicate things further, dome and ice divide locations may also have moved by tens of kilometers over time despite their forcing by bedrock undulations. Thus, a more detailed reconnaissance of dome and potentially saddle positions is essential to get high resolution information on bedrock topography, ice thickness, internal radar layer stratigraphy and the temperature at the base of the ice.

Also I would stress the need for the record to be replicated from a second site before it will be widely accepted. It should be expected that ice from three sites will be required to meet the goal of reproducing the record because it is likely one of the sites will not be usable due to stratigraphic distortions

We fully agree and this has now been explicitly stated in the text on page 27

A technical correction on page 2791 line 16 is that the wording in the following phrase "water is refreezing downstream of the hydraulic head" does not use the term head correctly, but the meaning is clear.

The wording has been changed

J. Jouzel (Referee)

Page 2773 : Line 24 EPICA communitymembers, 2006 should be replaced by EPICA community members, 2004

Done

Page 2774
line 4 to 6 : with CO2 leading the climate change in the Northern Hemisphere but being in phase (Parrenin et al., 2013) or slightly lagging the warming in the SouthernOcean region (Pedro et al., 2012; Shakun et al., 2012). This sentence is written implicitly assuming that the results recently

published for the last Termination (the three articles cited refer to it) systematically apply to all terminations of the last 8 glacial cycles. This may not the case and in any event is not at all firmly documented. This needs rewriting.

The respective text has been changed to clarify this and the latest study by Abe-Ouchi is now discussed in the manuscript.

Page 2776, line 10. I suggest to slightly extend this paragraph (for example mention that some basal melting can help to get undisturbed sequences: : :).

The problem of flow disturbances has now been more extensively discussed in the text (see above). We are grateful for the comment on a small amount of basal melting by the reviewer. However, even a small amount of basal melting can lead to significant ice loss and limits the age of the ice as shown for example in Figure 4. Moreover, a small amount of melting today may mean no melting or much more melting in the past as ice thickness and accumulation rate vary with time. In the first case such a temporal stick/slip variation may lead to disturbances and refreezing of water at the bottom, in the latter part, the old ice is gone. Accordingly, we feel that is is safer to stay away from such conditions and state this in the manuscript.

Page 2782 line 14 : EPICA Community Membres 2004 (not 2006 ?)

Checked and the reference is correct

Page 2787 line 14 : I suggest to specify : present-day accumulation rates (as previous cited figures relate to long-term average values)

Changed accordingly