Clim. Past Discuss., 10, C1648–C1651, 2014
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Climate of the Past Discussions



# *Interactive comment on* "The WAIS-Divide deep ice core WD2014 chronology – Part 2: Methane synchronization (68–31 ka BP) and the gas age-ice age difference" *by* C. Buizert et al.

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Received and published: 3 October 2014

General comment

Buizert et al. present a chronology for the deep part of the West Antarctic Ice Sheet (WIAS)-Divide ice core (WAIS-D) which is based on stratigraphic matching to Greenland ice cores using atmospheric methane. The paper gives a detailed description of the method and its uncertainty including a sensitivity study for the gas age-ice age estimates. The authors discuss the characteristic features of the WAIS-D core and point to the potential of the small WAIS-D dage for precise investigations of inter-hemispheric climate relationships and phasing issues.

Overall it is a well written paper with appropriate introduction and description of the methods. The reader can easily follow the mathematical exercises and the interpretation of the results. The ice core and climate-of-the past scientific community will definitely benefit from the content of the paper. Their approach is innovative and illuminates some interesting aspects concerning our understanding of the proxy-parameter in ice cores. One aspect here might be the relationship between the water isotopes and the temperature and accumulation rate. The WAIS-D core shows us that there is no simple relationship and that even for dating ice cores additional information is needed (borehole temperatures, inverse methods). Another interesting issue that is discussed in some detail is the role of impurities for firn densification at WAIS-D.

Specific comment

By reading the paper one gets the impression that dating of the deep part of WAIS-D is solved and quite robust even for the estimates of temperature and accumulation rate. Most convincing is in this context Figure 1 where the overlap between the estimates of two different methods for the accumulation rate, d15N and Dage is plotted. However, one parameter in the whole dating procedure is not shown: the thinning on which their approach based on (and the comparing model outputs of the Parrenin Ddepth method as well). In the supplement of the cited publication of WAIS-Divide Project Members (Nature, 2013) I found some data to infer the thinning function at least for half of the time interval in the overlap period (14-23ka BP). Attached to that review you will find a graph displaying the thinning function versus normalized depth (depth divided by total core length). The thinning factor during the glacial period is surprisingly very high in comparison to the earlier Holocene (almost 0.2 difference!, purple curve) or in comparison to the ideal case of constant thinning rate (blue dotted line) or even in comparison to the EDC thinning (red curve) of the same depth. I am not an expert but it seems that it is important to discuss why the thinning (higher thinning factor) of older/deeper ice is much less than younger/shallower ice. I would rather expect the opposite trend that the thinning is higher (lower thinning factor) in deeper ice and



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especially in glacial ice than in Holocene ice due to the proposed softness of impurity loaded ice. On the other hand the results of the sensitivity study of the authors about the impurity effect on densification respectively accumulation rate (Figure 4, blue curve) show that in the Glacial period the accumulation rate would be enhanced by a factor of roughly 1.7 to fulfill the constrains for d15N and temperature. If we assume that there is a impurity effect during the Glacial at WAIS-D (what is negated by the authors so far) the thinning function would be changed to a much more continuously decreasing function (in the attached figure shown as green line) with depth what in my opinion is much more expected and similar to derived thinning functions of other deep ice cores and even to the ideal case. By including the impurity effect in the densification model one would change the glacial accumulation rate by the factor of about 1.7 (if one rely on the temperature reconstruction) and would only slightly change dage by about 200 years (see Figure 4,upper and lower panel). These changes would have not much influence on the chronology at all. I am sure that the authors could give more arguments for the flow model that they use for calculating the thinning function. I would suggest that they could add a short discussion about the reliability of the flow model for that deep part of the ice sheet. Or do we see here the impurity effect in the WAIS-D deep ice core?

Technical comment

Figure1: Unit of the axis label should be Acc rate (m ice a-1) instead of Acc rate (m a-1).

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Interactive comment on Clim. Past Discuss., 10, 3537, 2014.





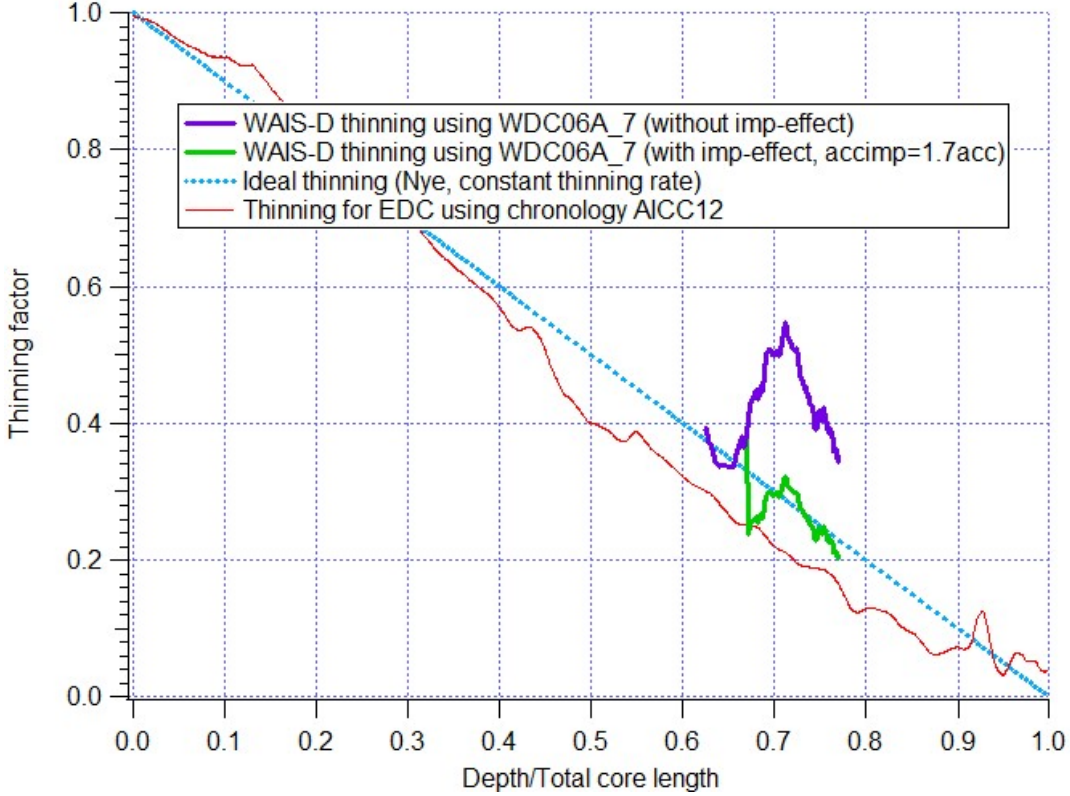


**Fig. 1.** Thinning function of WAIS-D ice core



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