

## ***Interactive comment on “A 60 000 year Greenland stratigraphic ice core chronology” by K. K. Andersen et al.***

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NGRIP new chronology review

A new ice core chronology in the palaeoclimatologist community is of first importance as it often becomes the reference for a lot of archives where climatic events are well marked and where the absolute dating is difficult to obtain. It is also of first importance for the archives where absolute dating is available like on speleothems and where we can check the coherence of independent chronologies. Another key point in this study is that it concerns a period beyond the  $^{14}\text{C}$  method in which the timing of climatic events is still debatable.

The comparison with absolute dated records, speleothems and magnetic field events

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fits well which give confidence in this new chronology. I have however raised some important points about the counting method and the comparison with speleothems that could be more discussed in the paper.

p. 1239 : while in fig. 2 the annual layer counting appears relatively easy to perform (stadial preceding GI14), it is much less trivial in fig. 1 which is however within GI14 itself: when the grey scale curve displays a small peak compared to its neighbour, then it is reasonable to count  $1/2 \pm 1/2$  as seen at about 2343.3 m; but other examples of uncertain annual layers are not so obvious: for example near 2343.6m a layer is marked as uncertain despite the fact that the grey scale curve shows, at this place, a pronounced peak; similarly, at 2343.5, the peak is as high as the former one but is also marked as uncertain. The information given by the Conductivity and the Sodium seems, here, not very useful as individual annual layers do not appear clearly. A more detailed recall of the counting method would be useful in order to be more convincing.

The visual stratigraphy (and the ECM) appears to be the most accurate measurement for layer counting, but we observe that several double peaks in these records are counted a single year (i.e. 2343.25; 2343.27; 2343.4); this might result in an underestimation of the ages. This should be discussed more.

p. 1240 and fig.3: because the former NGRIP ss09sea chronology has been widely used, it seems important to show the difference with GICC05 on a time scale and not only on fig.4 graph. Then, we will be able to observe that the difference between both NGRIP chronologies becomes noticeable before and after GIS8, and that for the GIS12 onset, which is among the most important events of this period and which has been recorded in many archives, the new GICC05 chronology is about 500 years younger.

p. 1241 : Comparison with cave records –

It seems important to be a little bit more cautious when comparing Greenland ice core and speleothem records: are we sure that Greenland  $\delta^{18}O$  changes and speleothem proxy are synchronous ? Is the Asian monsoon intensity, recorded in

the Hulu Cave speleothems, perfectly synchronized with the temperature changes in Greenland? All these questions have a sense in regard to the bipolar seesaw mechanism that is observed between South and North ice records and where offsets of more than 1ka can be observed for glacial events (Barbante et al., 2006) (EPICA community members). The shape of the transitions can be very different between the Greenland records and speleothem ones depending on its geographical location and of the mechanism that drives the isotopic composition of the calcite – it is not obvious to find accurate tied points to correlate in both records. For example, if you look at the last deglaciation in Borneo you will observe a smooth and regular trend that began earlier than the abrupt NGRIP Bølling-Allerød transition and that displays neither the Bølling-Allerød cooling trend nor the Younger-Dryas event. All this raises the complexity of the relationship between the North Atlantic and Pacific climates (Partin et al., 2007)). See also the different pattern during the Last Deglaciation between Greenland and stalagmites from France and North Africa (Genty et al., 2006).

It is interesting to note that the Villars cave record which is the closest to Greenland and which is the longest one in a single stalagmite (31-82 ka), fits very well with this new chronology, better than the Hulu record for the GI12 period, which corresponds to among the most pronounced climatic changes in Europe during MIS3. A second stalagmite from Villars had confirmed the chronology and the isotopic changes of this period (i.e. the GIS12 onset is at  $46.6 \text{ ka} \pm 0.5$ ; (Genty et al., 2005)), this should be addressed and, despite the more confused shape of the Villars isotopic records between GIS9 and GIS11, the GI12 onset is clear, well dated on very fast growing stalagmites, this looks like another confirmation of this new NGRIP chronology (keeping in mind that the isotopic records,  $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$  of speleothem and  $\delta^{18}\text{O}$  of ice core, are synchronous in the error margins). It is true also that for this key period the Hulu Cave is constrained by less dated points and that its growth rate is much smaller.

In Fig. 6, it would be useful to add, as for the Hulu record, the U-Th dated points for the Kleegruben Cave record so we can have an idea of the possible accordion effect.

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For this later record, you should discuss more in detail why there is such a discrepancy with the GICC05 chronology for the GI12 transition : more than 1ka (> than the estimated errors) and of the same order as observed with the Socotra record for GI11 onset. This makes the warming in the speleothem record occur during a very cold period in NGRIP .

Comparison with cosmogenic records and tephra horizons bring complementary pieces that support this chronology. The conclusion could be amended in light of the above comments. This is a very nice work of first importance for all palaeoclimatologists.

Detailed comments :

p. 1237 : Eemian, *sensu stricto* should be used for the vegetation changes, OIS 5e may be better here;

p. 1239 : It is not clear what the difference is between ECM and conductivity records

Figures 1 and 2 : units are missing for ECM and Visual stratigraphy

p. 1240 : "... 1.5cm thick. . ."; "... 2.5 cm thick.."

p. 1242 : the two Hulu Cave stalagmites that concern this period (MSL and MSD) are about 40 and 45 cm long, not two meters.

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