Comment on cp-2021-176

Frédéric Parrenin (Referee)

Referee comment on "Comprehensive uncertainty estimation of the timing of Greenland warmings in the Greenland ice core records" by Eirik Myrvoll-Nilsen et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-176-RC2, 2022

In this article, the authors propose a the structure of the age density in the layer-counted GICC05 chronology for NorthGRIP.

They model the structure of the age density (the number of layer per depth unit) as the sum of a 2nd-order polynomial term (representing the layer thinning due to ice flow), a d18O-related term, and a depth-related term that is unique to each stadial or interstadial interval.

The rest of the residuals is described as noise, which is best characterized by a AR(1) or AR(2) process.

It is then discuss whether there could be a systematic bias in the Maximum Counting Error (MCE), but no clear conclusion is drawn in this section.

Later, in an application section, the depths of the DO transitions are determined using a statistical framework, and the age uncertainties are derived from the depth uncertainties and from the age uncertainties previously derived.

The paper is well written, and the application of statistical tools is rigorous, as far as I could understand, but I have a few comments which could help to make the paper more relevant.

General comments:

1. The title is misleading, since here you really focus on NorthGRIP/GICC05, with its particular uncertainty structure. I would therefore use a more specific title. Moreover, the part related to the determination of the DO transitions is not mentionned in the title, while it is an interesting application.

2. The paper pretend to model the GICC05 uncertainty, but I think it rather models the GICC05 age density. It is the first interest of this paper, to try to explain the GICC05 age density as far as possible with mathematical regressions, and to have an as small as possible residual term.

3. The modeling of the thinning process as an additive 2nd-order polynome is questionable. First, the thinning function is not additive, but rather multiplicative. The analysis should therefore be applied to the log of the age density, so that multiplicative terms become additive terms. Second, there are more appropriate formulation of the thinning function, the like Lliboutry profile (see for example Parrenin et al., The Cryosphere, 2017). Although here I am not sure it will make a big difference, since the difference with a 2nd order polynome is important only in the very bottom section.

4. The depth-related term in the age density is an interesting observation, but there is no physical explanation for it. It could be interesting to discuss some hypotheses.

5. The modeling of the stochastic residuals with AR(1) or AR(2) processes is questionable, since the age density is calculated every 5 cm (if I understood correctly). Therefore, an AR(1) process does not represent the same time memory in the top or bottom parts of the records.

6. The residuals are described as a gaussian process, but it seems from Fig. 2b that the standard deviation is not constant but rather depth dependent. This is not really discussed as far as I understood.

7. Regarding biases, when I read the abstract I got interested because I thought that such bias would be estimated. This could be the case by using a more accurate (in absolute ages) and independent chronology, like the U-Th dating of the Hulu cave speleothem record. But this is not the case here. I don't really see which message we get from this section on the biases, since there is no clear quantification at the end.

8. Regarding the identification of the DO transitions, it only appears as an application of the uncertainty quantification method, while I agree with Anders Svensson it has an strong interest by itself, in particular for the stacking of these transitions. Maybe giving more focus on this aspect could make the paper more relevant. I also agree with Anders Svensson on the interest of applying this method to other Greenland cores, other datasets or older time periods.

Specific comments:

l. 245: "of the GICC05 chronology"

l. 246 "over counted or missed." (missing dot)

fig. 6 legend, 2nd line: "linear ramp"