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Interactive comment on "A complete representation of uncertainties in layer-counted paleoclimatic archives" *by* Niklas Boers et al.

Anonymous Referee #1

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In this paper a probabilistic representation of uncertainties in the dating of layer-counted paleoclimatic records is presented. The model is based on a Bayesian approach to obtain the probability of a given value of the proxy x at the past time t, expressed as a conditional probability $p(x|t)$. This is an unusual representation, since the dating problem is usually expressed in terms of the uncertainty in time (date) t as a function of the depth in the record z; $p(t|z)$. By Bayes theorem these are connected, and one is obtained from the other by the standard technique of ignoring the prior distributions (flat priors), and by invoking the conditional probability density of the proxy conditioned on the depth $p(x|z)$. From the mathematical point of view this is all formally correct and consistent, but from a physical point of view it is surprising that $p(x|z)$, which represents the measurement error on the proxy x in the record at depth

z, should contain much information on the dating uncertainty for the depth z. Anyway, when presenting results the relevant probability $p(t|z)$ is indeed in focus. The main results are presented in Figure 2 (NGRIP) and Figure 4 (Suigetsu lake), where $p(x|z)$ actually does not play a role.

I will focus on the ice core record, which I am most familiar with. Here the dating uncertainty is estimated by (Andersen et al., 2006) by reporting the maximum counting errors (MCE) in the annual layer counting ($t_i = i$), as a function of depth z_i. Three models for the probability density $p(t|z_i)$ are applied: Normal distribution $\mathcal{N}(i, \sqrt{MCE(i)})$ for uncorrelated counting errors, $\mathcal{N}(i, MCE(i))$ for correlated counting errors and $\mathcal{U}(i - MCE(i), i + MCE(i))$ for strongly correlated errors. The results for the latter two are very similar, which is reassuring, since it is difficult to argue for one over the other.

I have two main concerns: Firstly, the results are presented in terms of the record $\hat{x}(t) = \int xp(x|t)dx$. This curve has very little to do with the real proxy record. Especially as the increasing uncertainty with age smears the record. In this particular record with jumps between two states at a time scale of a few thousand years comparable to the dating uncertainty, the statistical mean becomes meaningless. This is also noted by the authors. The problem is reflected in the (very) small insert in Figure 2D, where at a certain time the probability density becomes bimodal. Secondly, the usefulness of the representation in terms of the blue lines representing the dating uncertainty in Figures 2C and D should also be explained. To me it seem that just two figures with time scales corresponding to the upper and lower edges of the blue MCE bands in Figure 1 B .

I can recommend publication.

Minor points:

A discussion on a possible skewness in the distribution $p(t|z)$ could be added: One should expect that the probability of missing an annual "peak" (local maximum) it the curve (say, due to diffusion, or voids in the record.) is different from the probability in detecting an extra peak or shoulder in the record not representing an annual maximum. (say, due to an anomalous seasonal cycle).

P2L2: The phrase "Varves" is usually only associated with rock or clay sedimentary annual layers, not tree rings or ice cores.

P2L9: The dating uncertainty does not by itself do much to create artificial abruptness in transitions. Such artifacts are more related to disturbances in the record (voids, foldings etc.)

P5L16: The factor $\frac{1}{2}$ in the last formula beats me. Consider using dz_i og Δz_i rather than r_i, also in formula in Figure 1. It would help readability.

P5L19: chose → chosen

P7L10: It is very difficult to see the substantial differences between Fig 2, C and D.

Figure 1 A: I propose to make a 3D figure (see my sketch).

Figure 1 B: Explain the change in slope at 1500 m (transition from Holocene to glacial ice).

Figure 2: Use same scale (y-axis) in A as in B-D. (same for Fig 4 A and B).

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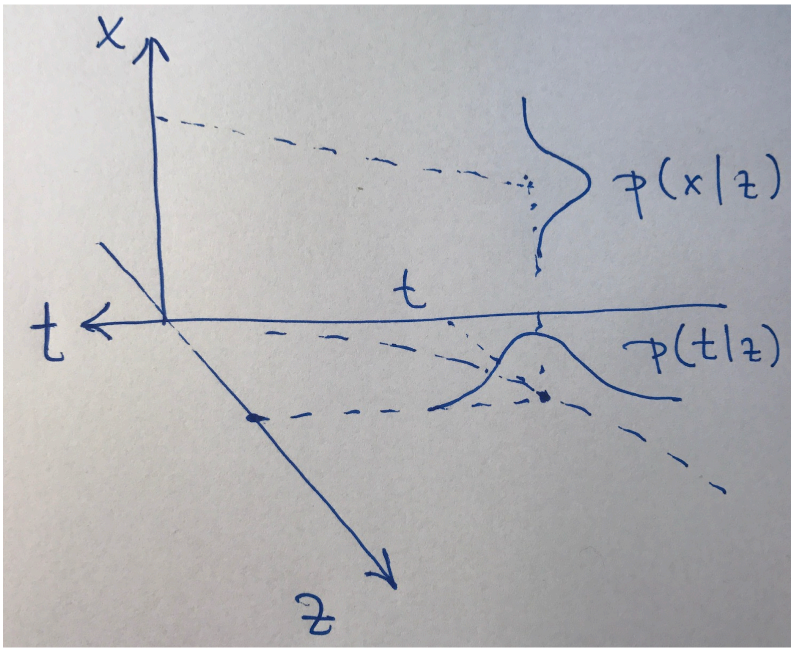

Fig. 1.