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

Niklas Boers et al.

boers@pik-potsdam.de

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We thank the reviewer for her/his positive evaluation of our manuscript. Regarding your two main points:

1. We agree that a representation of the temporal evolution of uncertainties in terms of $\hat{x}$ is misleading, and our main point is that the sequence of probability density functions $p(x|t)$ themselves should in fact be the focus of representing this evolution. This point is already mentioned in the manuscript, but in the revised version, we will emphasize it even further.
2. The blue shadings in Fig. 2 indicate the probability densities $p(x|t)$ for each t, and not $p(t|z)$; this is also noted in the color bar label. The densities $p(x|t)$ are

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the final results of our approach to represent the record as probability densities (over the proxy values x) for different, error-free ages t. The dating uncertainty distribution $p(t|z)$ is used in the derivation of $p(x|t)$ via Eq. (1). Furthermore, the increase of dating uncertainties towards the past, which is apparent in Fig. 1B, is reflected in the increasing spread of $p(x|t)$ the further one goes into the past in Figs. 2C and 2D. This result is not trivial: it is a consequence of the Bayesian approach we employ. We will clarify this point further in the revised version.

Regarding the minor points in the Review:

For each annual layer, it is indeed possible that the uncertainty distributions are skewed, just as Referee #1 points out. In the original study (Andersen et al., QSR, 2006) reporting the chronology employed herein, uncertain layers are counted as $1/2 \pm 1/2$, thereby assuming a symmetric distribution. This counting should be adjusted in cases where the probability to miss a layer and the probability to count a false layer are not identical. The maximum counting error would then generally not be the same for negative and positive values, and the overall uncertainty distribution $p(t|z)$, which would be accordingly skewed, should be used when computing $p(x|t)$.

We would like to emphasize here that any functional form for $p(t|z)$ can be used in our approach. We thank the reviewer for pointing this out, and will add a corresponding sentence in the revised manuscript.

P2L2: We will correct this in the revised manuscript.

P2L9: We agree with the reviewer that in our approach to represent dating uncertainties, abrupt transitions that actually exist in the proxy evolution will be typically smoothed out in accordance with the uncertain dating, rather than being artificially amplified. However, in traditional proxy record representations, proxy values

are shown at specific time points. Ignoring the uncertainties of these time points may lead to situations where transitions appear much sharper than is actually supported by the data themselves when the dating uncertainties are considered.

P5L16: The Riemann sum, which is used to approximate the integral in this discrete setting, is defined using $r_i = (z_{i+1} - z_{i-1})/2$. This is the average of the two increments above and below the depth z_i, which the reviewer refers to as Δz_i: Setting $\Delta z_i := z_{i+1} - z_i$, we have $r_i = (z_{i+1} - z_{i-1})/2 = ((z_{i+1} - z_i) + (z_i - z_{i-1}))/2 = (\Delta z_i + \Delta z_{i-1})/2$. Taking this average is the standard approach when approximating a (continuous) integral by a discrete sum. It provides a better approximation than taking only the previous (or the following) increment. We will clarify this in the revised version.

P5L19: Thank you, this will be corrected.

P7L10: Please refer to our author comment AC1. We had, due to a typo, in fact uploaded an erroneous version of Fig. 2. In the figure attached to AC1, which will also be used in the revised version, small-scale differences between Fig. 2C and Fig. 2D are clearly visible.

Figure 1A: We had also thought about a 3D figure for the sketch of our method, and we appreciate the reviewer's effort in suggesting one. Figure 1 attached to this comment would be a possible 3D version of the sketch. However, it is actually misleading to use 3D cartesian coordinates because the z-axis is integrated over, and does thus play a different role than the x- and t-axes. In order to avoid confusion, we would therefore like to keep the original 2D version.

Figure 1B: As the reviewer notes correctly, this change in slope occurs at the transition from glacial to interglacial conditions, and reflects the substantial increase in dating uncertainties at this point, due to changing accumulation rates and increasing pressure in the ice. We will add a corresponding sentence in the revision.

Figure 2: We thank the reviewer for pointing this out to us and will use identical y-axes in the revised version of our study.

If the editor agrees, we will revise our manuscript in accordance with the reviewer's comments and our responses above.

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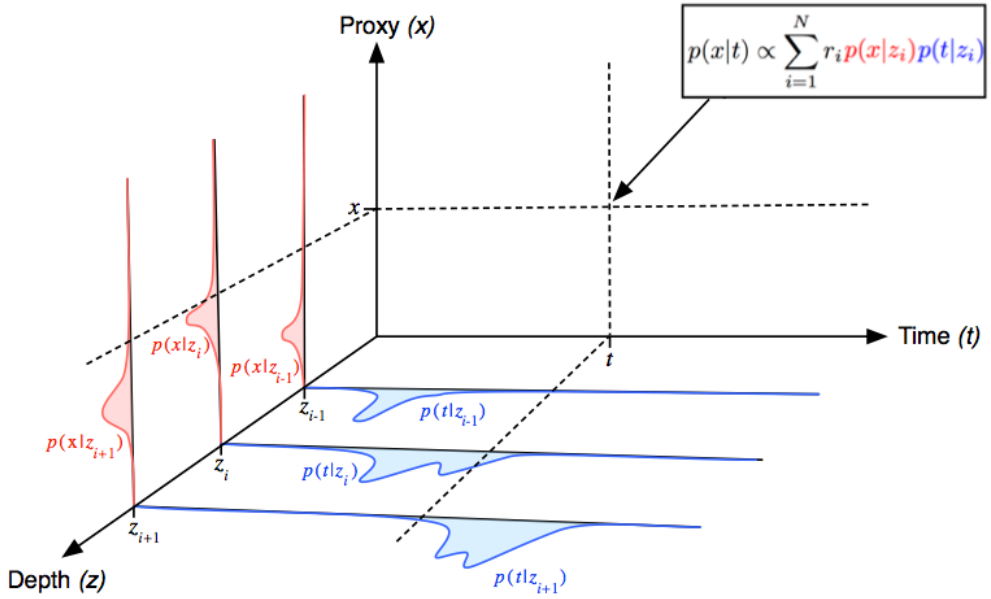

Fig. 1.

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