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Climate of the Past
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Discussions

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

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We thank the reviewer for the thorough evaluation of our manuscript. Regarding her/his specific comments:

> We agree that, realistically, the probability of missing an annual layer is generally not identical to counting a false one. However, for both the NGRIP and the Suigetsu datasets, the reported dating uncertainties are based on the assumption of symmetric counting errors. It would be interesting to repeat the annual layer counting for these records, taking into account that the error distributions are most likely not symmetric. Non-symmetric errors would lead to different maximum counting errors for negative and positive values, and hence to the overall

(i.e., cumulative) dating uncertainty distributions $p(t|z)$ being skewed. This skewness of $p(t|z)$ could then be used when applying our method in just the same way, as pointed out by Referee #1. Ideally, the correct $p(t|z)$ would be reported alongside with the record itself; our formalism can treat arbitrary dating uncertainty distributions, and its specific characteristics will be propagated to the final $p(x|t)$. We will add a corresponding comment in the revised version of the manuscript.

nes 15-16: We agree with the reviewer. A tephra layer would indeed reset the MCE back to zero, which would be reflected in very narrow dating uncertainty distributions $p(t|z)$ around such a layer. The spread in the derived $p(x|t)$ would decrease accordingly in Figs. 2C, 2D, 4B and 4D. We will add a sentence on this point in the revision.

bs line 10: We apologize for the incorrect usage of "calibration curve," and will replace it by "comparison curve" throughout the revised version. We will also change our suggestion to actually use the Suigetsu record as a calibration curve, since we do agree that IntCal should be used for such a purpose. In the revised manuscript, we would still show how to use our Bayesian method to derive the overall uncertainties of the radiocarbon ages — including the errors from the layer-counting process — and propose that this could also be done for the IntCal calibration curve.

ne 31&33: In fact, we use the notation Δ^{14}C for the "inferred level of radiocarbon in the atmosphere," given in **per mil**, as deviations from the reference value of 1950, in the same way as in the associated reference (Bronk Ramsey et al., Science, 2012). We agree that, to infer these values, information about timing needs to be included. For the time interval under study, the Suigetsu chronology is derived from the varve-counting process, and this temporal information is used to infer past levels of atmospheric radiocarbon (i.e. Δ^{14}C), as deviation from the 1950 reference value. Thus, this record consists of inferred Δ^{14}C values, associated

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with corresponding sediment depth values and ages, including age uncertainties. This is all the information we need in order to apply our Bayesian approach to derive $p(x|t)$, as shown in Fig. 4B.

line 20-22: We agree with the reviewer that several studies have presented approaches to visualize dating uncertainties of paleoclimatic proxies. We already cited two studies by M. Blaauw (2010 & 1012), but will also include the 2007 reference in the revised version. In the revised manuscript, we will also note more explicitly that the idea of directly visualizing dating uncertainties is not new. However, we would like to emphasize that, to the best of our knowledge, visualization of proxy record uncertainties (in the style of Blaauw et al., 2007) is not widely used in the geoscientific community that deals with layer-counted proxy archives. With our proposed approach, we are not only able to visualise the proxy record uncertainties, but also to *quantify* them in a mathematically precise sense: $p(x|t)$ yields the best estimation of x at time t, given the observed data and their uncertainties. Therefore, the derived $p(x|t)$ series can also be used for further, quantitative analyses.

p2 line 3: The reviewer is right, we will correct this in the revision.

p2 line 19: By “bifurcation parameters”, we refer to the estimated parameters of an energy-balance model in the corresponding reference. We will rephrase the sentence accordingly.

p5 line 14: A Riemann sum is the standard technique for approximating a (continuous) integral, given discrete values of the function to be integrated. We will clarify this in the revised manuscript and provide a standard, first-year calculus reference.

p5 line 19: Thank you, this will be corrected in the revised version.

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

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