Reply to Reviewer #2

of the manuscript

Estimating the timescale-dependent uncertainty of paleoclimate records—a spectral approach. Part I: Theoretical concept

by Torben Kunz,Andrew M. Dolman, and Thomas Laepple,
submitted to *Climate of the Past* (https://doi.org/10.5194/cp-2019-150).

In the following, the original comments by the reviewer are shown in black, our replies in blue, and citations from the manuscript are shown on a gray background with changes in red:

1) General comments

The manuscript addresses the estimation of the uncertainty of proxy-based reconstructions taking into account that uncertainties are potentially serially correlated. I think that the study of the uncertainties of climate proxy reconstructions is extremely relevant for the investigation of the climate of the past.

The approach described in the manuscript does not take into account calibration errors and dating uncertainties, which seems to be an obvious limitation of the method. However the option of preferring analytic solutions rather than more complex formulations that could easily become untreatable is somewhat justified in the text (section 5).

In my opinion the manuscript is solid and scientifically sound, and I only have some minor corrections to suggest.

We appreciate the helpful and constructive comments and suggestions of the reviewer. Below the specific comments are addressed point by point.

2) Specific comments

1. page 2, line 55: maybe it would be useful and illustrative to compare the results of numerical simulations with the results obtained using the analytic approach described in the manuscript.

(a) In order to verify our analytic results, we performed extensive sets of numerical simulations of exactly the same model as described by the analytic approach. By doing so we were able to bring analytic and numerical solutions into perfect agreement, with different settings of the various model parameters. This was an important step for achieving full confidence in our analytic results.

(b) Apart from this, one may conduct a more general comparison, in an application-oriented context, between (i) the reconstruction uncertainties obtained by the approach presented in this study, and (ii) the uncertainties obtained from alternative approaches like, for example, different proxy forward models or more simplistic approaches ignoring any serial correlation of reconstruction errors. However, such methodological comparisons should be made in a systematic manner and can be expected to become rather comprehensive, providing interesting material for future studies.

2. page 3, line 3: "representation of smoothing by bioturbation", please rephrase / clarify.

   We rephrased this to clarify the meaning of the sentence on lines 62-63:

   ~~The representation of smoothing by bioturbation~~ The fact that archive smoothing is represented by bioturbation limits the validity of the method in its current form [. . .]

3. Figure 1: since the stochastic signal and the deterministic seasonal signal are discussed first than the archive formation and sampling effects, maybe move Fig. 1a) to the last graph.

   It is true that the order of the panels in Fig. 1 differs from the order they are mentioned in the text, where they appear in the order (b), (c), (a), (d). However, first, it would not be meaningful to show the panels in this order because it makes more sense to have panels (b), (c) and (d) together, and, second, the PDF shown in (a) is, in some sense, a more abstract quantity than the timeseries, and like an operator that acts on what is shown beneath it in panels (b)-(d). Therefore, we leave this unchanged.

4. maybe change the title of section 2.5 to "Reconstruction uncertainty", the term "versus" doesn't seem to be the most accurate here

   We agree it is not the most intuitive section title. We changed it to make it consistent with the title of section 2.4:

   ~~2.5 Reconstruction error versus uncertainty~~

   2.5 Definition of reconstruction uncertainty

3) Typos

1. line 22 & line 37: typo (indispensible)

   Corrected.

2. line 117: equaivalently

   Corrected.