Clim. Past Discuss.,
https://doi.org/10.5194/cp-2019-153-AC1, 2020

Climate of the Past Discussions

Interactive comment on "Estimating the timescale-dependent uncertainty of paleoclimate records – a spectral approach. Part II: Application and interpretation" *by* Andrew M. Dolman et al.

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Received and published: 25 September 2020

Extracts of referee's comments appear in italics

Dear Referee,

Thank you for taking the time to review our work and for your positive comments and suggestions.

My general suggestion is that the authors explore how different assumptions on the characteristics of the climate fluctuations affect their results. I do not think it is necessary to do this systematically, but it should be straight forward to plug in a few examples. For instance, different power laws and maybe the spectrum with two characteristic time scales (the spectrum of a two-box model driven by white noise).

We agree that the manuscript would benefit from some exploration of how changes to the assumed power-spectrum of climate affect the estimated time-scale dependent errors.

In brief: if the power of the high-frequency portion of the spectrum (about which we know something from the instrumental record) is held constant, while the slope at lower frequencies is made steeper, this increases the error components due to bioturbation - the smoothing effect and also the amount of climate variation redistributed as white noise. There is however some interaction with the parameter tau_b, which controls the amount or depth of sediment mixing and therefore the timescales integrated by the bioturbation filter. The deeper the mixing, the larger the effect of varying the power-spectrum slope. If the power at high frequencies is not keep constant, e.g. if using just a pure power-law spectrum, where changing the slope also effects power at high frequencies, then this interaction with tau_b gets more complicated, as a shallower slope can mean more power at high frequencies.

We will add a section exploring these effects either as part of the main manuscript or as a supplemental section.

It would also be interesting to see a discussion of the applicability of the method beyond the Holocene climate.

Regarding the application of this method beyond the Holocene. Many of the error components, such as the bioturbation smoothing and seasonal aliasing, should remain approximately correct; however if we include glacial-interglacial cycles there will be

larger variations in both the sedimentation rate and the seasonality of the signal carriers (e.g. foraminifera). For the seasonal cycle of the climate, the amplitude of the seasonal cycle and the precession driven modulation of the seasonal cycle will vary with the longer inclination and eccentricity orbital cycles – although the proportional changes are relatively small.

For the assumed stochastic climate spectrum, the key issue is the assumption of stationarity. If multiple glacial cycles are included then one could argue that the spectrum is again stationary and still dominated by a power-law type variation. It becomes more difficult to justify if just one glacial-interglacial is included. In summary, we would argue that current approach also works beyond the Holocene, albeit less accurately than within the Holocene. Nonetheless it is a significant improvement over assuming independent errors. We propose to discuss these issues in the manuscript.

Minor comments:

The authors state that "Currently the temporal covariance structure of proxy uncertainties is largely ignored in the literature". This is true, but there are a few papers. For instance this one: Nilsen et al., Assessing the performance of the BARCAST climate field reconstruction technique for a climate with long-range memory, Climate of the Past, 2018.

We will add references to the existing literature paper that does consider the temporal covariance in proxy errors.

On line 24: "The power-spectrum of a proxy error contains all the information required to derive timescale dependent uncertainties." My comment is that, yes this is true, if you only consider second-order statistics. In principle, there can be other sources of uncertainty; for instance, changes in the fluctuation level over time.

This statement should be qualified by the necessary assumption of stationarity, which we make clear in our companion part I article, but we should also make clear here in part II.

Line 18: calcite should not be in italics, same on line 19, 21, 28, and in Table 1.

We will fix this error.

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