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## Comment on cp-2020-164

Paula Reimer (Referee)

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Referee comment on "On the tuning of plateaus in atmospheric and oceanic  $^{14}\text{C}$  records to derive calendar chronologies of deep-sea cores and records of  $^{14}\text{C}$  marine reservoir age changes" by Edouard Bard and Timothy J. Heaton, *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2020-164-RC1>, 2021

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The manuscript by Bard and Heaton provides a much-needed and well-presented assessment of the Plateau Tuning (PT) method developed by Sarnthein et al. in numerous publications and most recently synthesized in *Climate of the Past* (Sarnthein et al. 2020). The PT method has been used, primarily by Sarnthein and colleagues, to create a time scale for marine sediments at the same time as determining the radiocarbon offset (or marine reservoir age - MRA) between planktonic foraminifera and the atmosphere.

Bard and Heaton present and discuss the implications of a number of paleoclimatic and paleoceanographic assumptions inherent to the PT method. Among these assumptions, one of the most problematic is that the MRA must be constant for an extended period in order to define the plateau. A constant MRA during plateaus is very unlikely if the cause of the large MRA values reported by Sarnthein et al. is hypothesized to be due to carbon cycle changes. In addition, for the plateau method to work, the atmospheric  $^{14}\text{C}/^{12}\text{C}$  level must change rapidly from one plateau to the next as can be more readily seen when the plateau records are converted to  $\Delta^{14}\text{C}$ . These changes are an order of magnitude larger than any documented production rate changes in the dendrochronologically-dated tree-ring  $^{14}\text{C}$  records. Another troublesome side-effect of the PT method is the large variation in sediment accumulation rate required to produce the plateaus. In some cases the sediment accumulation must drop to zero which implies a hiatus, but Sarnthein et al. don't provide independent evidence from the marine cores themselves.

The main statistical concern for the PT technique is whether plateaus can be identified in the Lake Suigetsu terrestrial macrofossil data, which Sarnthein et al. (2020) have chosen, and in the marine record being tuned. The Lake Suigetsu data is rather sparse and has large uncertainty for many of the points due to small macrofossil size. The marine records, in addition to not having a calendar time scale, are also sparsely dated. Bard and Heaton perform a simulation of the statistical method previously used by the group (Sarnthein et al. 2015) to define plateaus (although the *Climate of the Past* 2020 paper relies on 'visual inspection' to identify plateaus) in the atmospheric and marine records.

The PT simulations use  $^{14}\text{C}$  measurements from IntCal20, based on dendrochronologically-dated tree-rings from 12-13.9 cal kyr BP, and randomly selected to provide the approximate resolution of the Lake Suigetsu data with the uncertainty increased to match that dataset. Likewise, for the marine simulation, they use the same tree-ring dataset randomly selected to match the high resolution Cariaco basin record with a constant MRA

of 400 years which is a best-case scenario. They calculate the gradient in  $^{14}\text{C}$  yrs per calendar year and define a plateau as any period where the gradient falls below  $0.5 \text{ }^{14}\text{C}$  yrs/cal yrs. The gradient threshold of 0.5 is more conservative than the 1:1 ratio which Sarnthein et al. 2015 used which produced longer plateaus but this shouldn't alter the conclusion of the simulation. As it is, three simulations of the atmospheric record produced a different number of plateaus which didn't match in time. Likewise, the simulated marine plateaus couldn't be matched to the atmospheric ones. It is clear that the statistical gradient PT method doesn't work but one could not expect a 'visual inspection' to be any better and certainly not as objective.

Bard and Heaton also created a Lake Suigetsu only curve using the same statistical methods used for the IntCal20 curve construction. They then show that the duration of many of the plateaus proposed by Sarnthein et al. 2020 exceed the 95% probability interval around the Lake Suigetsu curve as well as the IntCal20 curve.

As Bard and Heaton correctly note, at present, the only truly independently dated atmospheric  $^{14}\text{C}$  data older than the current known age tree-ring records (i.e., Lake Suigetsu) is simply too noisy and of insufficient resolution for plateaus to be robustly identified. The IntCal20 curve does not have sufficient resolution for the PT method either. And without independent chronologies and accumulation rates, marine data is even less suitable for use in the PT method.

Specific comments and minor corrections

Line 141-143: 'Consequently, the total duration of  $^{14}\text{C}$  plateaus represent 82% of the time spent between 14 and 29 cal kyr BP, whereas during the remaining 18% of the time, the radiocarbon clock was running almost 5 times too fast'. This concept needs clarification for most readers to follow.

Line 561: Define what is meant by gradient (i.e  $^{14}\text{C}$  yr per cal yr).

Line 572-3: 'Fig. 5d shows the gradient estimates overlain with the suggested gradient threshold of  $0.5 \text{ }^{14}\text{C}$  yr/cal yr'. Explain why a gradient of 0.5 was used.

Line 591-2: 'we remove the calendar age information that aids  $^{14}\text{C}$  yr/cal yr gradient calculation.' Add that this was done in order to simulate the marine records used by Sarnthein et al. which have no calendar age information

Paragraph 3.7: Move the following sentence to the start of the paragraph, or re-word, so that the reader knows that IntCal20 is used to simulate the marine record: 'We create our simulated pseudo-marine cores to span 12-13.9 cal kyr BP, again using IntCal20 as our true atmospheric  $^{14}\text{C}$  baseline'

Figure 6b: It would be useful to have the gradient threshold marked on this figure to see where potential plateaus might exist.