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Comment on cp-2020-164

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Community comment on "On the tuning of plateaus in atmospheric and oceanic ^{14}C records to derive calendar chronologies of deep-sea cores and records of ^{14}C marine reservoir age changes" by Edouard Bard and Timothy J. Heaton, Clim. Past Discuss., https://doi.org/10.5194/cp-2020-164-CC5, 2021

Comment on cp-2020-164 "On the tuning of plateaus in atmospheric and oceanic ^{14}C records to derive calendar chronologies of deep-sea cores and records of ^{14}C marine reservoir age changes" by Edouard Bard and Timothy J. Heaton

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To our knowledge, Bard & Heaton provide the first thorough and independent discussion of the so-called Plateau Tuning method presented in a number of papers by Michael Sarnthein and colleagues over the past ~15 years and particularly in a recent CP "review" paper (Sarnthein et al., 2020).

As discussed by both referees (Paula Reimer and an Anonymous Referee), Bard & Heaton provide a critical assessment of the Plateau Tuning method. We mostly agree to these assessments and we therefore do not want to further discuss the principal errors and limitation as well as statistical issues of the Plateau Tuning method.

Since we both recovered and investigated sediment cores from the Chilean margin and adjacent South Pacific over the last two decades, we would like to comment and provide some more details on the controversial results on sediment records from this region as presented in Sarnthein et al. (2020) and correctly noted by Bard & Heaton. Some of these statements are repeated in CC1 by Michael Sarnthein.

Our comment primarily refers to the Plateau Tuning results of sediment core PS97/137 and some of the hypothetic implications for the sedimentary setting and paleoceanographic implications (e.g. the derived reservoir ages). Since these results are part of a manuscript in preparation, we here provide some of the background information necessary to assess the Plateau Tuning attempt and reservoir age record of PS97/137.

Site PS97/137 is located at the upper continental margin, ~30 nm off the entrance to the Strait of Magellan at a water depth of ~1100 m. PS97/137 lies within a few miles from site

MD07/3128 that provided excellent high-resolution paleoceanographic records (e.g., Caniupán et al, 2011; Lamy et al. 2015.). Both sites are within a small-scale sediment depo-center ("sediment drift") with an up to ~700 m thick sediment sequence that has been chosen for IODP drilling during Expedition 383 (Site U1542; Lamy et al., 2019). Sediments are foraminifera oozes during the Holocene underlain by glacial, primarily siliciclastic sediments with low carbonate and biogenic opal contents. These low biogenic contents are primarily due to dilution by enhanced terrigenous sediment supply from the glaciated hinterland, absence of sediment trapping in the fjords, and reduced winnowing by the overlying Cape Horn Current.

Physical properties and geochemical data allow to splice PS97/137 into the well-dated record of MD07/3128 suggesting that the here investigated part of PS97/137 covers the past ~25 ka. The latest published age model of MD07/3128 (Lamy et al., 2015) was based on 8 radiocarbon dates for the interval covered by PS97/137 using the reservoir ages derived at the Chile margin further north (MD07-3088; Siani et al., 2013). Sedimentation rates are below 10 cm/ka during the Holocene, ~15 cm/kyr during Termination 1 and in the order of ~1 m/kyr during the Last Glacial Maximum. As such, these highly variable sedimentation-rates are generally complicating the assignments of individual plateaus (assuming that these exist). This complication likely applies also to some of the earlier published Plateau Tuning results from low-latitude continental margin sites (e.g., GeoB3910, Balmer et al. 2016) with highly variable sedimentation-rates (Arz et al., 1998; Arz et al., 1999).

Ultimately, this is reflected in inconsistent Plateau Tuning results for PS97/137 in the submitted and published version of Sarnthein et al. (2020) as correctly noted by Bard and Heaton (submitted). We note that high reservoir ages (e.g., 1000 ^{14}C yrs as based on the most recent Plateau Tuning) are not substantially higher than the 800 yrs we assumed for MD07/3128 based on the Siani et al. (2013) study. However, Sarnthein et al. (2020 and supplements to CC1) derive various hiatuses in their Plateau Tuning records, not only at our but also at other high resolution continental margin sites. Though we cannot strictly exclude hiatuses at the "sediment drift" site PS97/137, we do not expect to find significant gaps in the sedimentation during glacial periods characterized by reduced bottom currents and strong terrestrial sediment input (Lamy et al., 2015). Therefore, at least for the southern Chilean Margin, we do not find solid evidence nor see any reason to conclude: (citing CC1 by Michael Sarnthein: Though widely not appreciated by paleoceanographers, hiatuses appear to be a feature actually widespread at high-sedimentation rate sites in the deep sea – One may assume: The higher the rates the more extreme they may be subject to changes in depositional regime"). This conclusion is at least counterintuitive and needs more in-depth investigations and supporting evidence.

Finally, regarding PS97/137, Michael Sarnthein (supplements to CC1) states "PS97-137 off Southern Chile (Ku¨ssner et al., 2020): A rough count of sediment laminations has fairly well confirmed the length of a PT-derived paired 14C plateau for the LGM". Since the lamination texture is still under debate and in neighboring cores (MD07/3128, IODP U1542) this feature is not present, more thorough investigations than "rough counting" is required.

As mentioned above, we are strongly in favor of assessing the Plateau Tuning method independently and generally concur with this critical discussion of the Plateau Tuning method by Bard & Heaton, who provide an important separate assessment for those who seek in-depth information on the applicability, reliability and limitations of the Plateau Tuning method. Further independent studies on well suited high resolution, continuous sediment records are in our opinion still required to put the Plateau Tuning method on the touchstone.

References:

Arz, H. W., J. Pätzold, and G. Wefer, 1998. Correlated millennial-scale changes in surface hydrography and terrigenous sediment yield inferred from last-glacial marine deposits off northeastern Brazil. Quaternary Research 50, 157-166.

Arz, H. W., Pätzold, J. & Wefer, G., 1999. Climatic changes during the last deglaciation recorded in sediment cores from the Northeast Brazilian Continental Margin. Geo Marine Letters, 19: 209-218.

Balmer, S., Sarnthein, M., Mudelsee, M., Grootes, P.M., 2016. Refined modeling and C-14 plateau tuning reveal consistent patterns of glacial and deglacial C-14 reservoir ages of surface waters in low-latitude Atlantic. Paleoceanography 31, 1030-1040.

Caniupán, M., Lamy, F., Lange, C.B., Kaiser, J., Arz, H., Kilian, R., Urrea, O.B., Aracena, C., Hebbeln, D., Kissel, C., Laj, C., Mollenhauer, G., Tiedemann, R., 2011. Millennial-scale sea surface temperature and Patagonian Ice Sheet changes off southernmost Chile (53 degrees S) over the past similar to 60 kyr. Paleoceanography 26, PA3221.

Lamy, F., Arz, H.W., Kilian, R., Lange, C.B., Lembke-Jene, L., Wengler, M., Kaiser, J., Baeza-Urrea, O., Hall, I.R., Harada, N., Tiedemann, R., 2015. Glacial reduction and millennial-scale variations in Drake Passage throughflow. P Natl Acad Sci USA 112, 13496-13501.

Lamy, F., 2016. The expedition PS97 of the research vessel POLARSTERN to the Drake Passage in 2016. Reports on polar and marine research. Bremerhaven, Germany. https://doi.org/10.2312/BzPM_0702_2016

Lamy, F., Winckler, G., Alvarez Zarikian, C.A., and the Expedition 383 Scientists, 2019. Expedition 383 Preliminary Report: Dynamics of the Pacific Antarctic Circumpolar Current.International Ocean Discovery Program. https://doi.org/10.14379/iodp.pr.383.2019.

Sarnthein, M., Kussner, K., Grootes, P.M., Ausin, B., Eglinton, T., Muglia, J., Muscheler, R., Schlolaut, G., 2020. Plateaus and jumps in the atmospheric radiocarbon record - potential origin and value as global age markers for glacial-to-deglacial paleoceanography, a synthesis. Clim Past 16, 2547-2571.

Siani, G., Michel, E., De Pol-Holz, R., DeVries, T., Lamy, F., Carel, M., Isguder, G., Dewilde, F., Lourantou, A., 2013. Carbon isotope records reveal precise timing of enhanced Southern Ocean upwelling during the last deglaciation. Nature Communications 4.