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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-CC6, 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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Precise dating of marine cores is a tricky problem even during the period covered by ^{14}C dating because of varying ^{14}C reservoir age (MRA) of the surface ocean (i.e. Bard et al., 1988, Bard et al., 94, Siani et al., 2001; Bondevick et al., 2006; Austin et al., 2011 ; Skinner et al., 2014). It is now well admitted that even in subtropical surface waters the MRA will change, at least because of varying atmospheric CO_2 (Galbraith et al., 2015). Thus any new approach that would help to establish precise marine core chronology would be most welcome. Hence, transposing the "wiggle–matching technique" to marine cores could be a nice idea. However Bard and Heaton indicate in this paper that, until now, atmospheric ^{14}C wiggles are precisely determined only before 12.6 kyrs (Intcal 20, Reimer et al., 2020). Furthermore, as Bard and Heaton highlight, marine sediment cores are generally not varved and many mechanisms, such as varying MRA, bioturbation, might create wiggles in their ^{14}C record that do not have any atmospheric ^{14}C plateau counterpart. Thus "wiggle-matching" for marine sediment cores could only be a further constrain to other chronology/sedimentation rate determinations for high sedimentation rate cores with a ~100 years resolution ^{14}C record.

Unfortunately the only rigorous determination of past surface ocean MRA requires to measure the ^{14}C difference between atmospheric and a marine record. This can be achieved for well identified common horizons like a volcanic ash layer on land and in marine sediments. This approach is certainly not trivial, it requires the comparison of the tephra chemistry (including very often major and trace elements geochemical signatures) and requires other constrains based on a thorough stratigraphy framework of both marine and continental archives.

Sarnthein et al., (2020) present the results of MRA with the marine plateau technique for core MD07-3088 in the South-East Pacific, a core that we studied previously. This core presents high sedimentation rate, ~60cm/kyrs during the Holocene and deglaciation and ~300cm/kyrs during the last glacial maximum, depending from a peculiar sedimentary dynamics via the terrigenous contribution from the nearby fjords and from the closeness of the Patagonian ice sheet to the study site during the last glacial period (Davies et al., 2020). Few tephra horizons were determined within this core (Siani et al., 2013; Haddam et al., 2018), and chemically and stratigraphically connected to land dated eruption of the Hudson Volcano. Thus for the deglaciation part, this core benefit from a determination of four independent surface water MRA with a 100-150 yrs error on the age determination. Sarnthein et al., (2020) present in the supplementary material a curve of the MRA for this core from 22 to 10.5 kyrs. The plateau tuning does not require any hiatuses in this core but sediment rate changes up to a factor of 25 that is the result of considering large plateau and not comparing the full wiggles observed in the intcal20 calibration curve as highlighted by Bard and Heaton (wiggles from 10 to 17 cal kyrs "plateaus pre boreal to plateau 2b"). Sarnthein et al., (2020) recognize that the MRA could change within a plateau as they associated two different MRA for this core within the plateau 1 period. For the deglaciation part of this high sedimentation rate core with a high resolution ^{14}C curve, it could be interesting to realize a real wiggle-matching exercise using an ocean circulation model, to take into account the different shape of the marine and atmospheric curves and test different MRA changes, to check if this technique could add any valuable constrain on the MRA changes. For the glacial part of the core (~17-22 kyrs), that has no other constrains from tephra layers, and for which the benthic and planktonic isotopic curve do not show any variations within stage 2, the choice of the possible wiggles is widely open, if the wiggles were clearly determined in intcal20 calibration curve. Thus the MRA cannot be precisely defined, the errors could be two to three times the MRA changes for this core.

Up to now there are only few determination of MRA, benefiting either of ^{14}C dated marine shell with known collection age date, volcanic eruption for which tephra are dated on land and in marine cores. A common practice is to use tuning of climatic records between continental and marine archives, like rapid changes in temperature (Austin et al., 2011). It is important to be aware of the assumptions under such exercise and to assign corresponding errors on the chronology obtained for marine records. Such technique however will mask possible nonsynchronous climate changes and precludes studying the climate dynamics on the centennial to pluri-decennal time scale (Mekhaldi et al., 2020).

Whatever the method proposed to assign reliable and precise chronology for marine records, it is needed to assess its applications and limitations with a rigorous theoritical and experimental study. Bard and Heaton provides a careful study of the different assumptions underlying the "plateau technique" that is of great importance for paleoceanographic community.

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