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Plateaus and jumps in the atmospheric radiocarbon record – potential origin and value as global age markers for glacial-to-deglacial paleoceanography, a synthesis

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SUPPLEMENTARY TEXT. Uncertainties of age control

Rough estimates of uncertainty and aspects of analytical quality were published by Sarnthein et al. (2007, 2015). We now focus on uncertainties tied to the calendar age definition for each ^{14}C plateau boundary both in the Suigetsu atmospheric and the various marine sediment records (Table 1). To recap, an age/sediment section is formally defined as containing a '^{14}C plateau', when ^{14}C ages show almost constant values with an overall gradient of <0.3 to <0.5 ^{14}C yr per cal. yr (based on visual description and/or statistical estimates by means of the 1st derivative of all downcore changes in the ^{14}C age – calendar age relationship; Sarnthein et al., 2015) and a variance of less than ±100 to ±300 ^{14}C yr, and up to 500 ^{14}C yr prior to 25 cal. ka. Here ^{14}C ages form a plateau-shaped scatter band with up to 10% outliers, that extends over more than 300 cal. yr in the Suigetsu record and/or equivalent sections of marine sediment depth (following rules defined by Sarnthein et al., 2007).

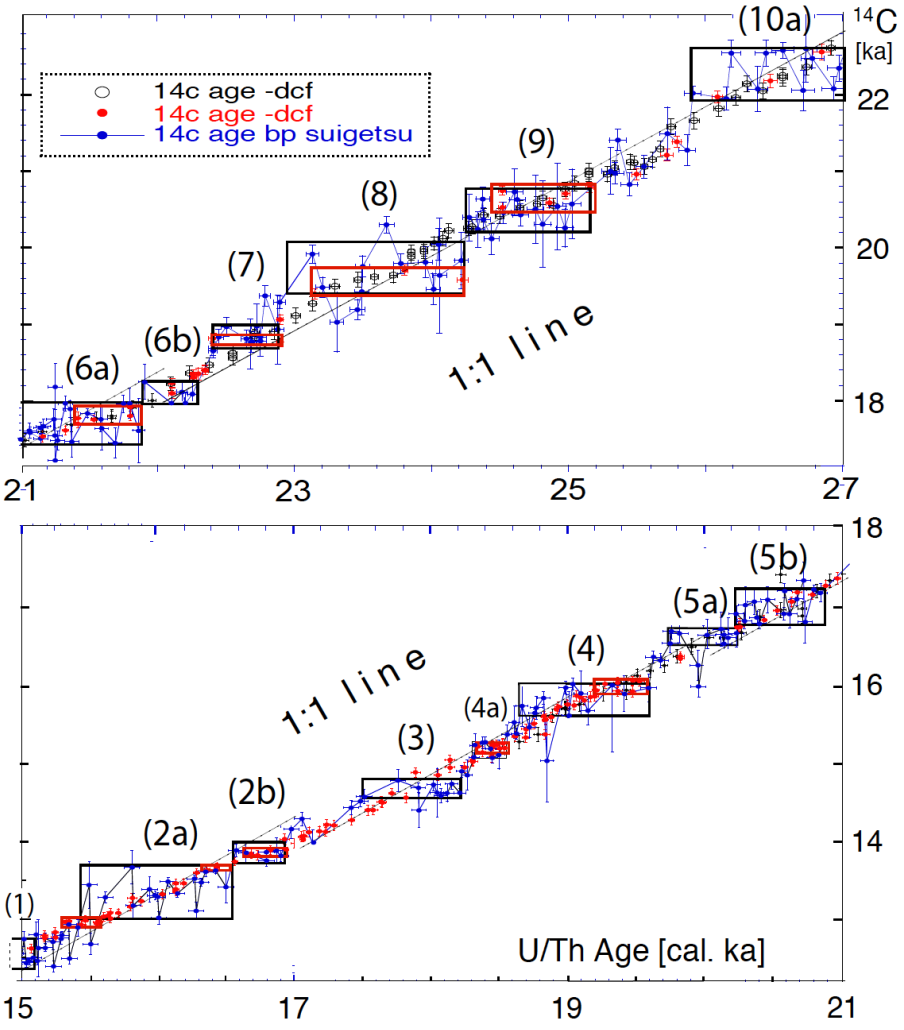
On visual inspection a plateau boundary is assigned to the break point between the low to zero or reversed slope of a ^{14}C plateau and the normally high regression slope of the ^{14}C concentration jump that separates two consecutive plateaus (Figs. 1 and S1). More precisely, a boundary marks the point, where the ^{14}C curve exceeds the scatter band of the plateau either crossing the upper or lower envelope line. Thus, the boundary is chosen about halfway between the last ^{14}C age within a plateau band and the next following age outside the scatter band (Figs. 1 and 2). On the U/Th-based model age scale (Bronk Ramsey et al., 2012) most ^{14}C dates of the Lake Suigetsu section are spaced at intervals of <10–60 yr from 10 to 15 cal. ka and 20–140 yr between 15 and 29 cal. ka (Fig. 1). Thus the uncertainty of a plateau boundary age assigned halfway

between two ^{14}C ages nearby inside and outside a plateau's scatter band would, on average, amount to ±10–±70 cal. yr.

In principle, the calendar age uncertainties of marine ^{14}C plateau boundaries are treated likewise: After being tuned to those in the Suigetsu ^{14}C record, the uncertainties are deduced for the position of all plateaus of a suite within the uncertainty envelope of the U/Th model-based age calibration. Hence the estimates of total age uncertainty present the propagated error of the calibrated age of a Suigetsu plateau boundary plus that of the pertinent plateau in the marine record, where variable depth spacing of ^{14}C ages is converted into average time spans.

SUPPLEMENTARY FIGURES

– Fig. S1. Individual atmospheric ^{14}C ages and error bars of Lake Suigetsu plant macrofossils vs. U/Th-based model age of 15–21 (bottom) and 21–27 (top) cal. ka (blue dots; Bronk Ramsey et al., 2012). ^{14}C plateaus longer than 250 yr are outlined by a suite of labeled horizontal boxes that envelop scatter bands of largely constant ^{14}C ages. Red dots and black circles in Fig. 1a display ^{14}C ages of Hulu stalagmites. Similar to ^{14}C ages of Suigetsu also those of Hulu Cave reveal a suite of ^{14}C plateaus (red boxes) tentatively assigned in this figure, plateaus that are shorter than Suigetsu-based plateaus and occupy slightly different age ranges. The 1:1 line reflects gradient of one ^{14}C yr / cal. yr.



– Fig. S2. Centennial-to-millennial-scale temporal and spatial variations in planktic (pla.) reservoir (res.) and (raw = uncorrected) apparent (app.) benthic ^{14}C ventilation (vent.) ages recorded at 18/20 key sites in the Atlantic (S2a, b, e), Pacific (S2c, d), and Indian (S2e). Site locations are given in Fig. 7. Stratigraphic units are marked on top of each diagram: Younger Dryas (YD), Bølling-Allerød (B/A) Heinrich Stadial 1 (HS-1), Last Glacial Maximum (LGM), and Heinrich Stadial 2 (HS-2).

Origin and various features characteristic of ^{14}C records: About 50% of all planktic and ('raw') benthic ^{14}C records were already published in Sarnthein et al. (2015). However, the cal. age of all records originally based on microscopy-based varve counts was now converted into U/Th-based model ages (Bronk-Ramsey et al., 2012). Planktic ^{14}C

reservoir ages of Core GIK23074 are now supplemented by benthic ventilation ages. Planktic ^{14}C reservoir ages of SHAK06-5K are detailed in Ausin et al. (2019 and under review). Benthic ventilation ages plotted for SHAK06-5K are matched from neighbor core MD99-2334K (Skinner et al., 2014) the stratigraphy and ^{14}C reservoir ages of which are closely correlated by means of narrow-spaced suites of ^{14}C ages. To show an example, 'raw' benthic ventilation ages in Core MD08-3180 are recalculated into 'actual' ventilation ages (Balmer and Sarnthein, 2018) that incorporate past changes in atmospheric ^{14}C concentration between the time of deep-water formation and the local growth of benthic foraminifers. South Atlantic ^{14}C records GeoB3910, GeoB1711-4, and KNR-159-5-36 (data slightly supplemented) are from Balmer et al. (2016), now however, with cal. ages converted into U/Th based model ages. The same applies to MD07-3076, where the continuous planktic and benthic ^{14}C records are from Skinner et al. (2010), corroborated by three blue bars reflecting the extent of planktic ^{14}C plateaus tuned to atmospheric plateaus no. 1, 2b, and 4. South Pacific ^{14}C records PS75-104, SO213-76, MD07-3088, and PS97-137-1 are from Küssner et al. (2018 and under review; data stored at PANGAEA). Planktic and benthic ^{14}C records of neighbor cores GIK17940 and SO50-37, PS75-104 and SO213-84, and ODP893A and MD02-2503 each are plotted on joint graphs, paired records that are obtained from small-scale sea regions with a common level of planktic ^{14}C reservoir age. Benthic ^{14}C ages of SO50-37 and SO213-84 are from Ronge et al. (2016), those of MD07-3088 from Siani et al. (2013).

Fig. S2a. NORTH ATLANTIC AND NORDIC SEA SITES

WEST and CENTER —— —— *EAST*

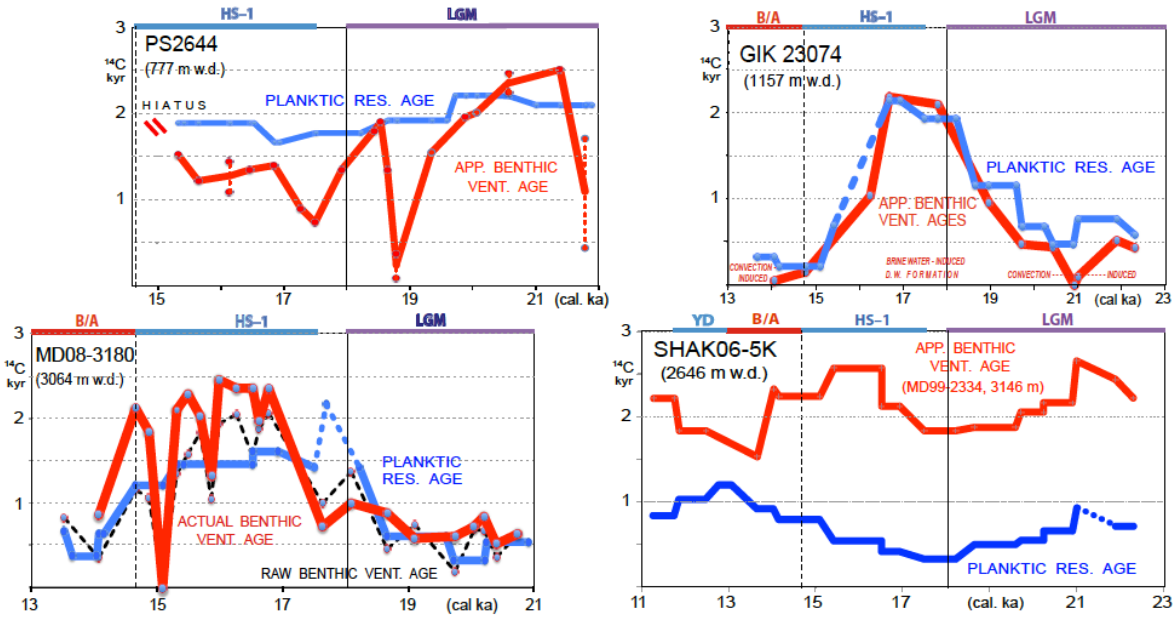


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Fig. S2b. SOUTH ATLANTIC SITES

WEST —— —— *CENTER and EAST*

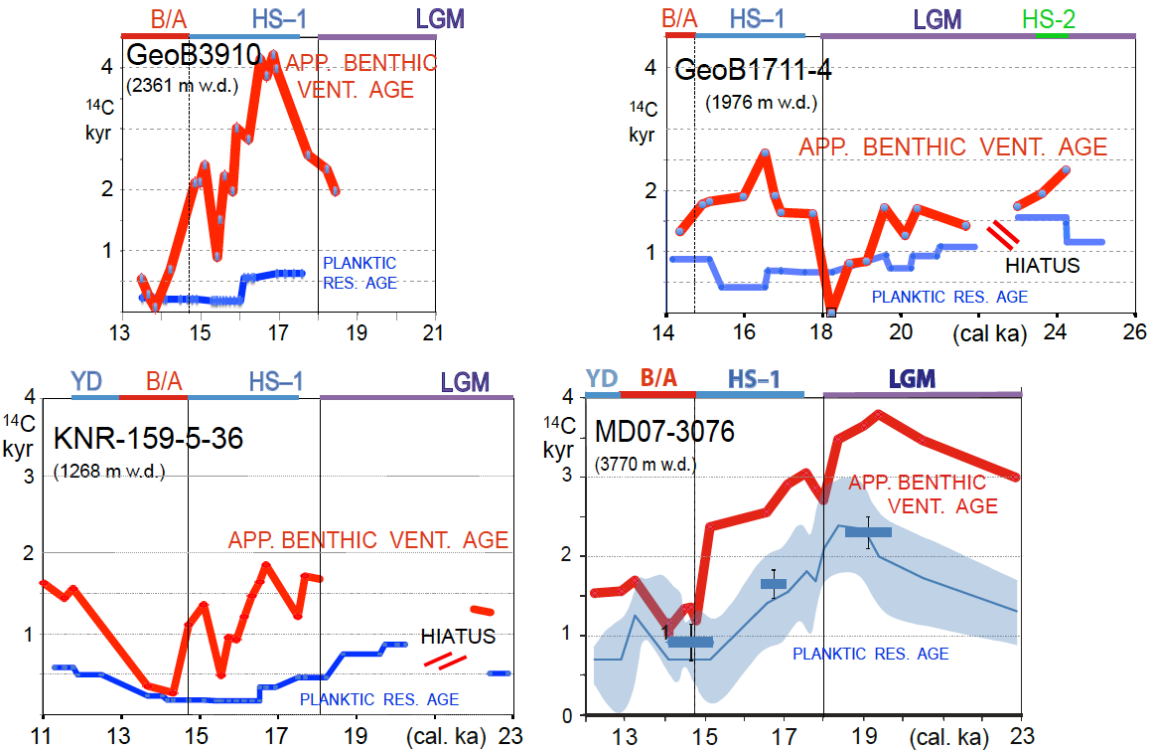

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Fig. S2c. SOUTH PACIFIC SITES

WEST — — *EAST*

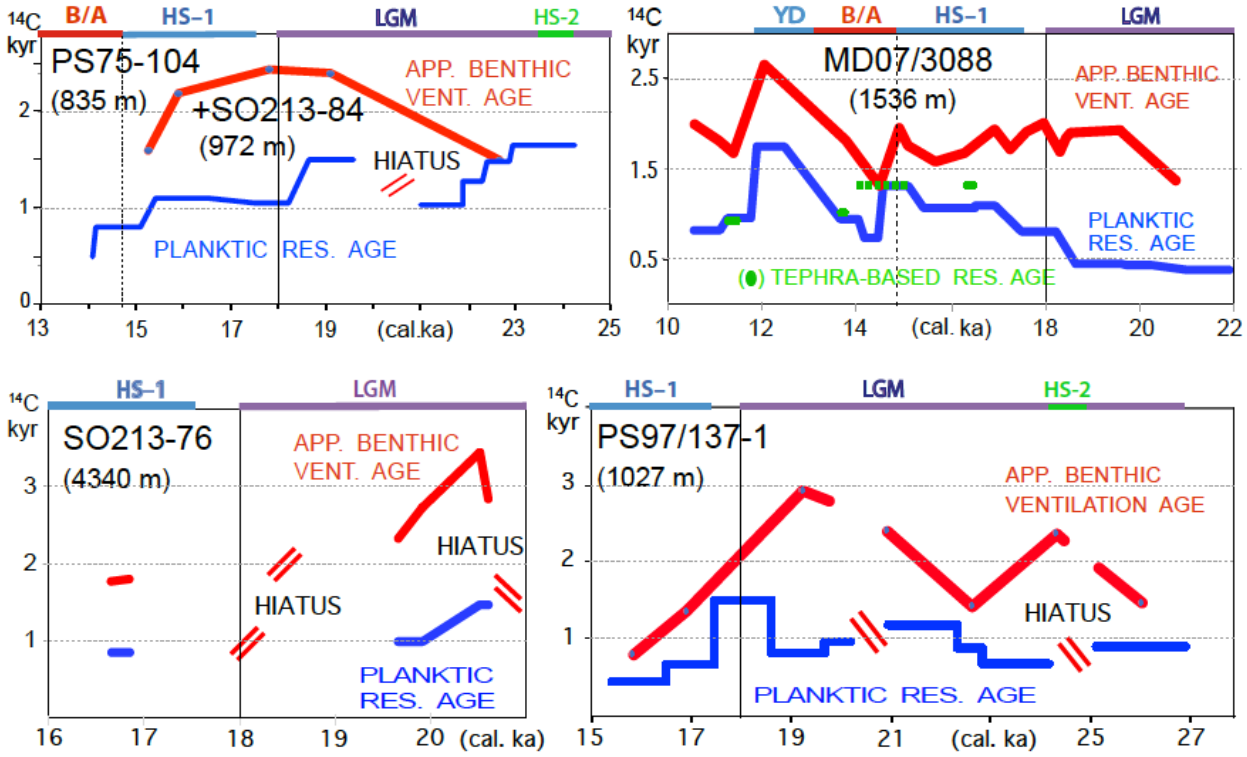

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Fig. S2d. NORTH PACIFIC SITES

WEST and SOUTH CHINA SEA — — *EAST*

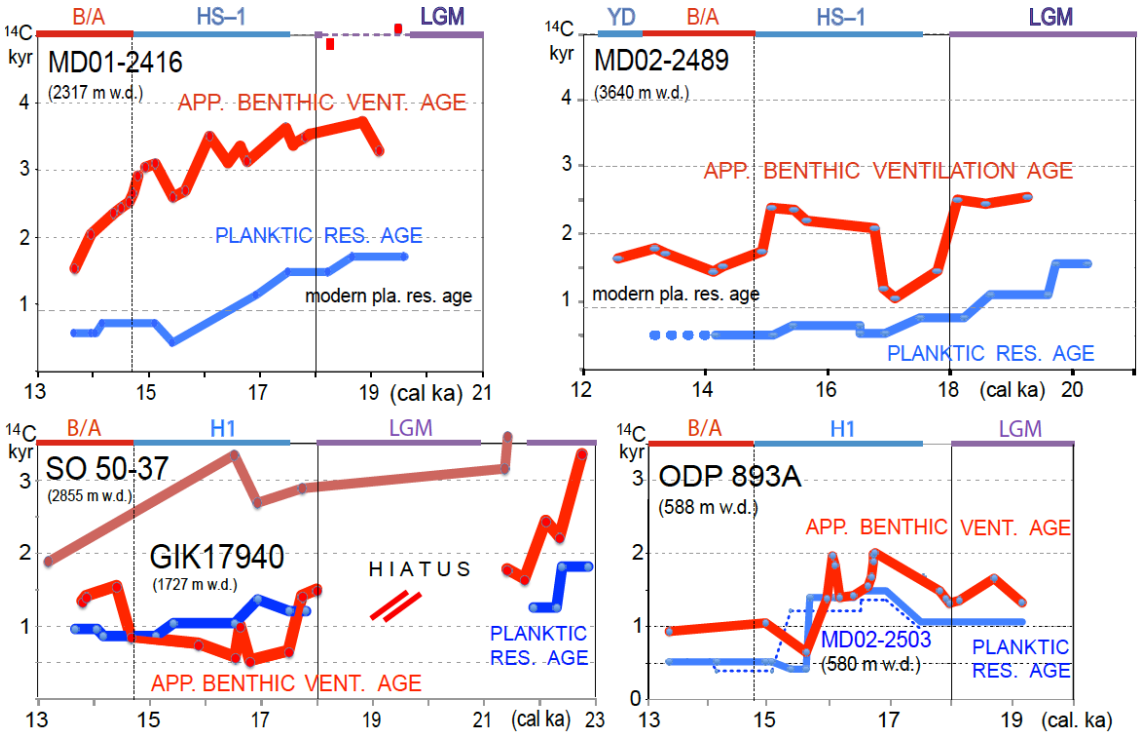

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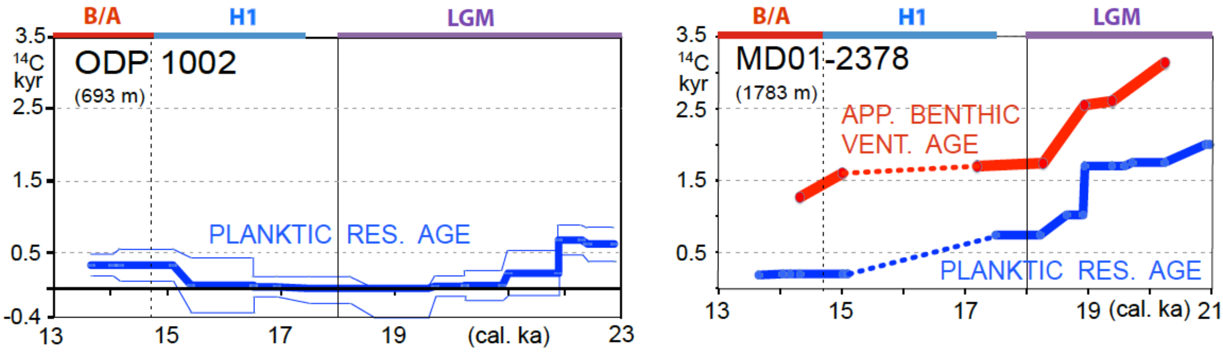
Fig. S2e. SITES in the EQUATORIAL OCEAN

CARIACO BASIN — — *SOUTHERN TIMOR SEA*



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