

Supplementary Information for:

Forced changes in Atlantic overturning are distinctly fingerprinted by South Atlantic western boundary transports

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- **Supplementary Figure 1 (Fig. S1)** - The SBL and AMOC across latitude and depth
- **Supplementary Discussion 1** - Interpretation of Figure S1
- **Supplementary Figure 2 (Fig. S2)** - Model-proxy comparisons for the AMOC and NBUC evolution
- **Supplementary Discussion 2** - Interpretation of Figure S2

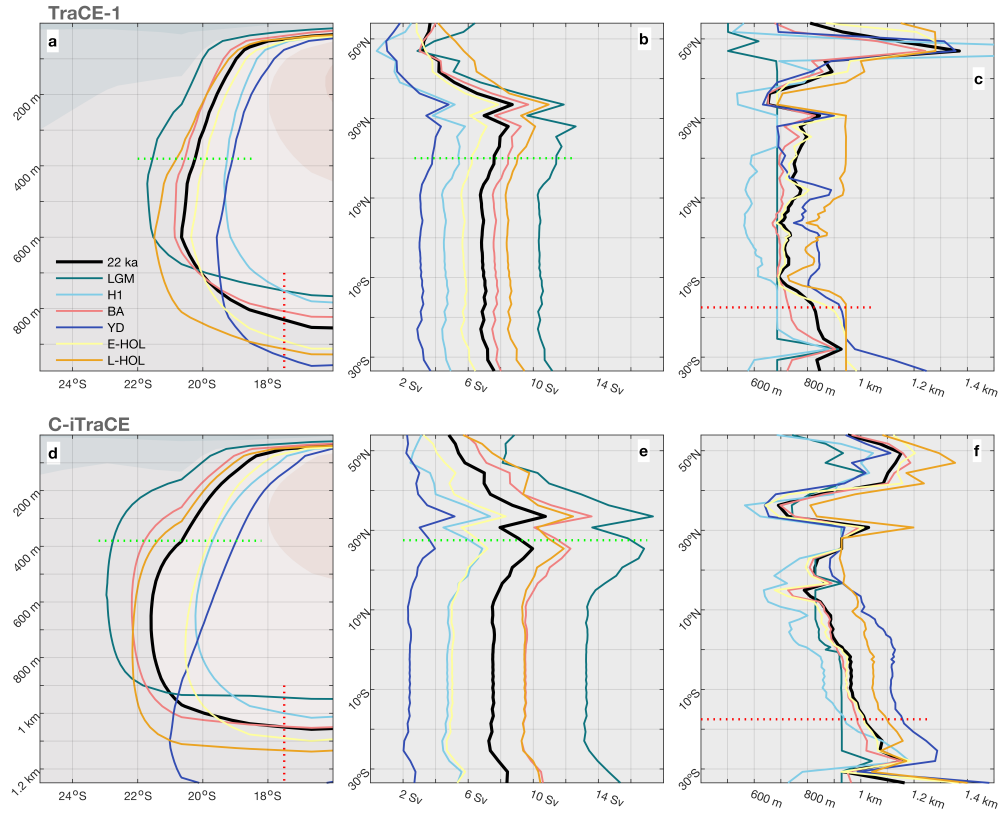


Figure S1: sSEC bifurcation vertical profile (a / d), where background colors represent past-22 kyr mean meridional velocities averaged over the western boundary layer (red denotes northward velocities, while blue denotes southward velocities – as in Fig. 3d of the original manuscript); and meridional profile of the maximum AMOC strength (b / e) and corresponding depth (c / f) – referenced to Fig. 1a of the original manuscript. Black thick contours represent the past-22 kyr mean, while colored filled contours represent the time-mean associated with each main climatic period of the last deglaciation. Dashed green and pink lines indicate the regions over which the SBL best tracks changes in AMOC strength and depth, respectively. Top / lower panels display results from TraCE / C-iTraCE. LGM = Last Glacial Maximum; H1 = Heinrich Event 1; BA = Bølling–Allerød; YD = Younger Dryas; E-HOL = Early Holocene; L-HOL = Late Holocene.

1 Supplementary Discussion

The vertical profile of the SBL (Fig. S1a, d) is shown alongside meridional profiles of the maximum AMOC streamfunction (Fig. S1b, e) and its associated depth (Fig. S1c, f) – for the past 22 kyr (black contour), divided into its main climatic periods (colored contours). When the AMOC strengthens, the northward transport along its upper limb and the NBUC increases, shifting the sSEC bifurcation to the south, and vice-versa. Thus, the SBL itself indirectly tracks changes in AMOC strength, as indicated by green dashed lines. As the lower base of the sSEC bifurcation is associated with the NBUC depth, the maximum SBL depth also tracks changes in the depth of the AMOC upper limb, especially over its portion near the SBL, as indicated by pink dashed lines.

The AMOC strength across climatic periods varies consistently along latitudes, overall, being characterized by proportional deviations from its mean value at each latitude – which is consistent with the idea of meridionally coherent deglacial AMOC changes. The analogous temporal variation of the AMOC depth, in turn, is rather inconsistent across latitudes, especially in TraCE, implying that while the SBL serves as a good indicator for variations in the full latitudinal-scale AMOC strength, the maximum SBL depth seems somewhat constrained to represent variations in the AMOC upper limb depth over its latitudes near the SBL. As discussed by Liu (2023)¹, AMOC strength and depth seem to be controlled by different forcing factors, not increasing/decreasing consistently. While the AMOC evolution in TraCE reflects a linear superposition of its response to all individual external forcings (similar to global temperature), the AMOC depth, in turn, responds non-linearly to the transient evolution of the full set of forcings¹. Taking this into consideration, the SBL could also be useful as an indicator of variations in AMOC depth and geometry, apart from AMOC strength, even though it is likely restricted to represent the AMOC depth over the subtropical South Atlantic.

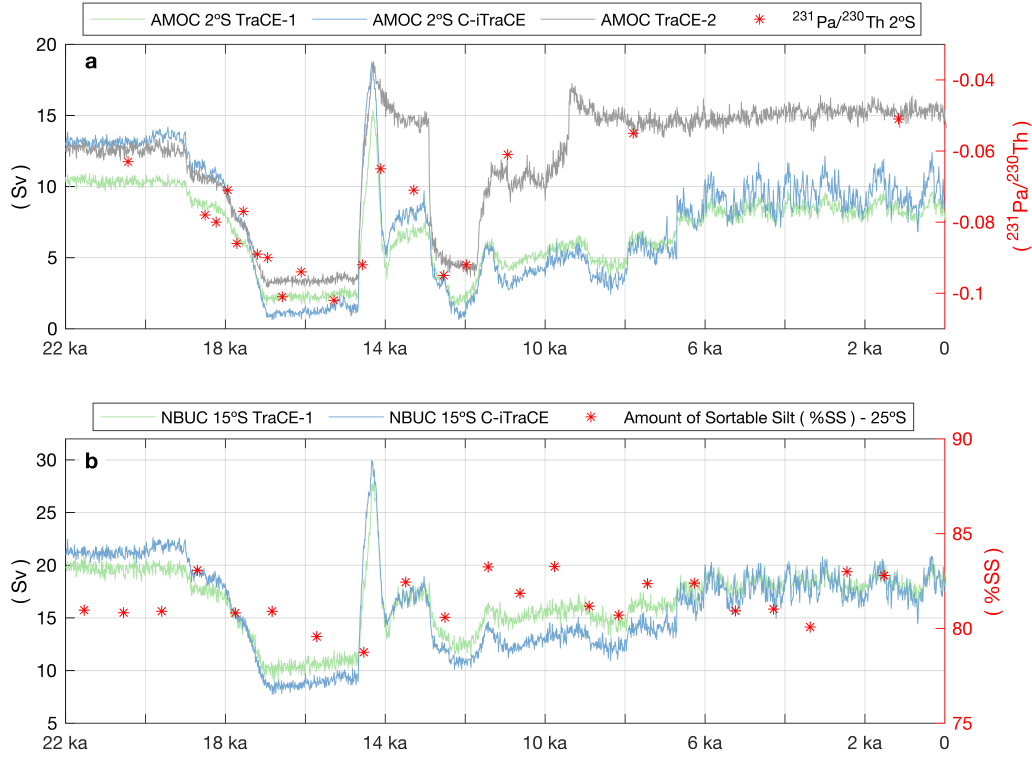


Figure S2: **(a)** Decadal evolution of the AMOC at 2°S from TraCE-1 (green) and C-iTraCE (blue), and of the Northern Hemisphere AMOC from TraCE-2 (gray), compared against $^{231}\text{Pa}/^{230}\text{Th}$ records from core GeoB16202-2, located at 1.91°S, at the Brazilian margin². **(b)** Decadal evolution of the NBUC at 15°S from TraCE-1 (green) and C-iTraCE (blue), compared against records of the amount of sortable silt (%SS) in core NAP63, located at 24.84°S, at the Brazilian margin³.

2 Supplementary Discussion

The protactinium/thorium ratio ($^{231}\text{Pa}/^{230}\text{Th}$) has been shown to exhibit the best performance in constraining the AMOC strength⁴. This is because sedimentary $^{231}\text{Pa}/^{230}\text{Th}$ is suggested to record a depth-integrated, large-scale lateral transport signal that reflects aspects of the overall circulation of the overlying water column^{5,6}. Comparing the modeled Southern Hemisphere AMOC with available $^{231}\text{Pa}/^{230}\text{Th}$ records from a core located at the Brazilian margin, at approximately 2°S^{2,5}, yields satisfactory agreement (Figure S2a). This agreement supports a meridionally coherent evolution of the AMOC over the last deglaciation, as simulated by TraCE and C-iTraCE, and as independently indicated by consistent $^{231}\text{Pa}/^{230}\text{Th}$ signals across different latitudes in the Atlantic basin⁵. In turn, the high correspondence between AMOC and NBUC evolution identified in our results is supported by a satisfactory agreement between the modeled NBUC and sortable silt records (Figure S2b) derived from a core also located at the Brazilian margin, used to infer the flow speed of the Intermediate Western Boundary Current (IWBC)³, which is analogous to the NBUC at intermediate depths⁷.

Supplementary References

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