



Supplement of

Water masses in the Atlantic Ocean: water mass ages and ventilation

Mian Liu and Toste Tanhua

Correspondence to: Mian Liu (2023000069@xmut.edu.cn)

The copyright of individual parts of the supplement might differ from the article licence.

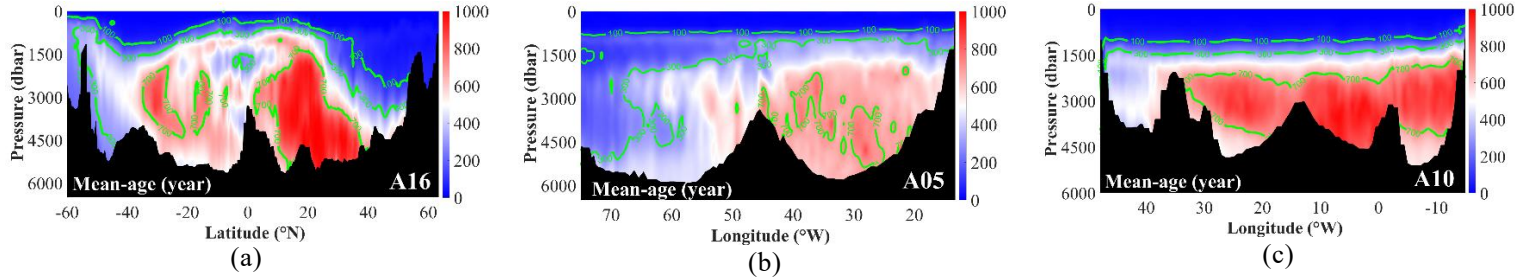


Figure S1. Mean-ages along the three selected WOCE/GO-SHIP sections
(Corresponding to **Fig. 5** in the main text)

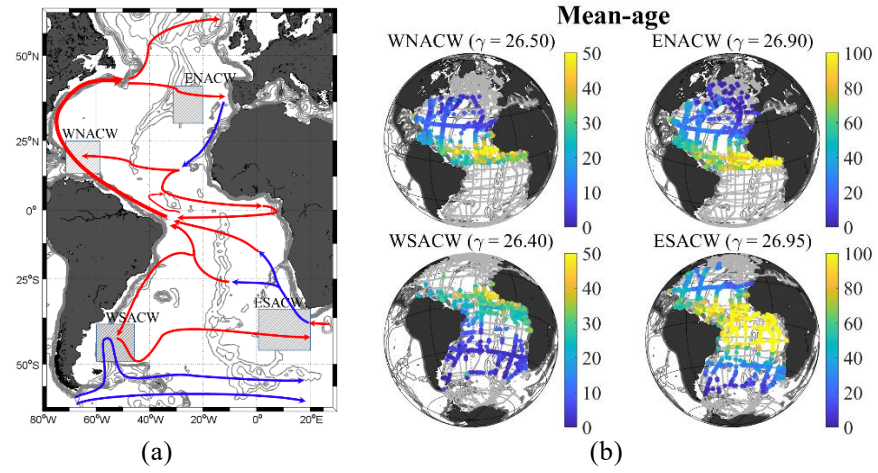
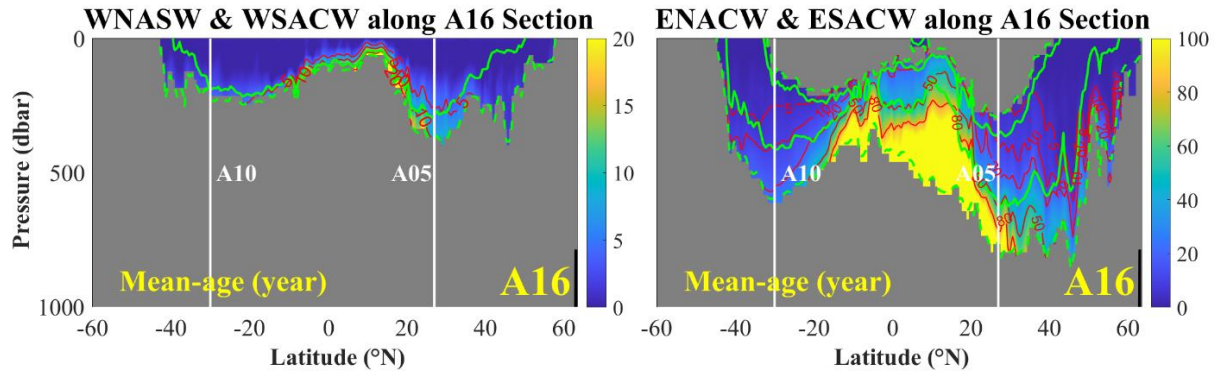
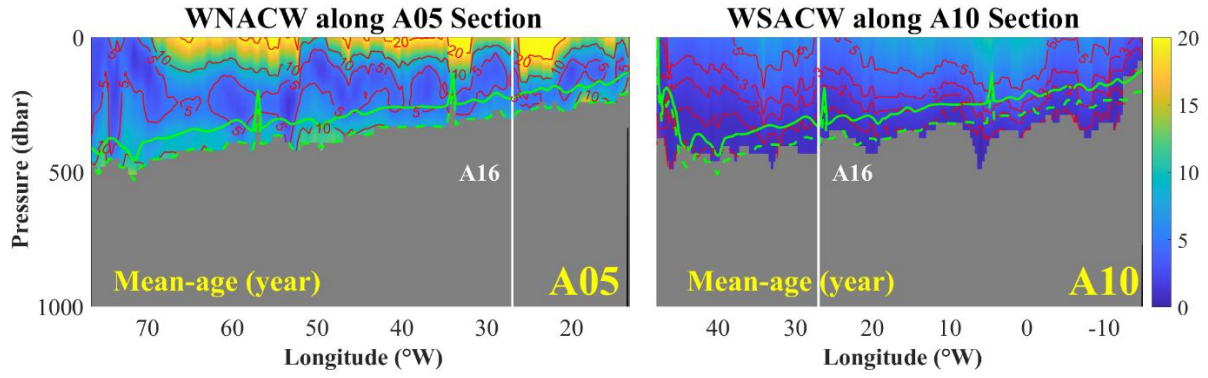


Figure S2. Mean-ages of central water masses in the Atlantic Ocean.

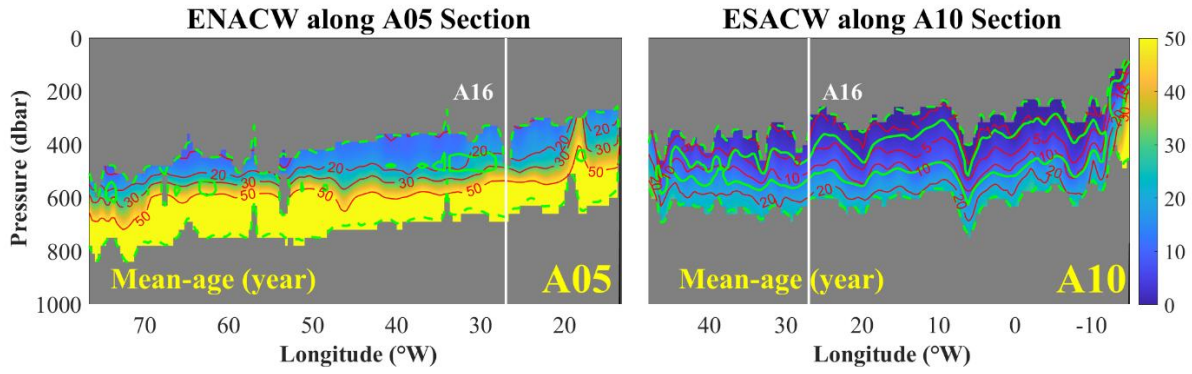
- (a) The main currents in the upper layer with warm (red) and cold (blue) currents and the approximate formation areas (rectangular shadows) of central water masses.
- (b) Mean-ages of central water masses at their core neutral densities (kg m^{-3}). The colored dots show the ages in each station. The grey dots show all the GLODAPv2 stations that have less than 20% contribution of the water mass in question or lack of transient-tracer data.
(Corresponding to **Fig. 6** in the main text)



(a)



(b)



(c)

Figure S3. The mean-ages (years) of central waters along the three sections for the upper 1500 dbar. The solid green isolines show the 50% fractions of water masses and the dashed green lines show the 20 % fractions. The grey color indicates areas with less than 20% contribution from central waters. White vertical lines show cross overs with other sections.

(Corresponding to **Fig. 7** in the main text)

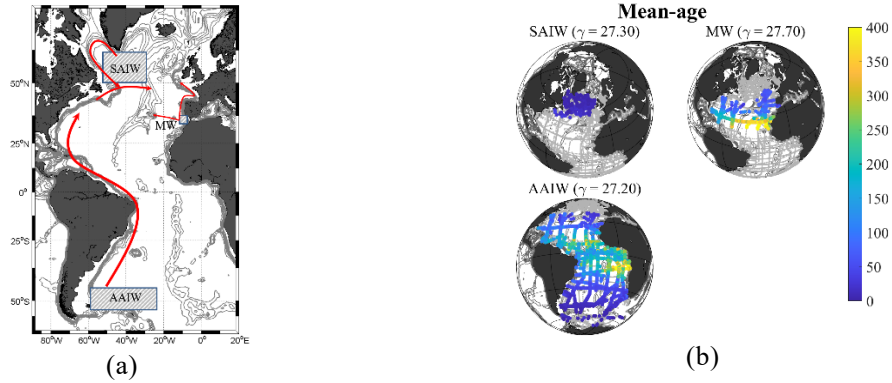


Figure S4. Mean-ages of intermediate water masses in the Atlantic Ocean.

- (a) Main currents in the intermediate layer. The currents (arrows) and the formation areas (rectangular shadows) of water masses in the intermediate layer.
- (b) The mean-ages of intermediate water masses at their core neutral densities (kg m^{-3}). The colored dots show the ages in each station. The grey dots show all the GLODAPv2 stations that have less than 20% contribution of the water mass in question or lack of transient-tracer data.

(Corresponding to **Fig. 8** in the main text)

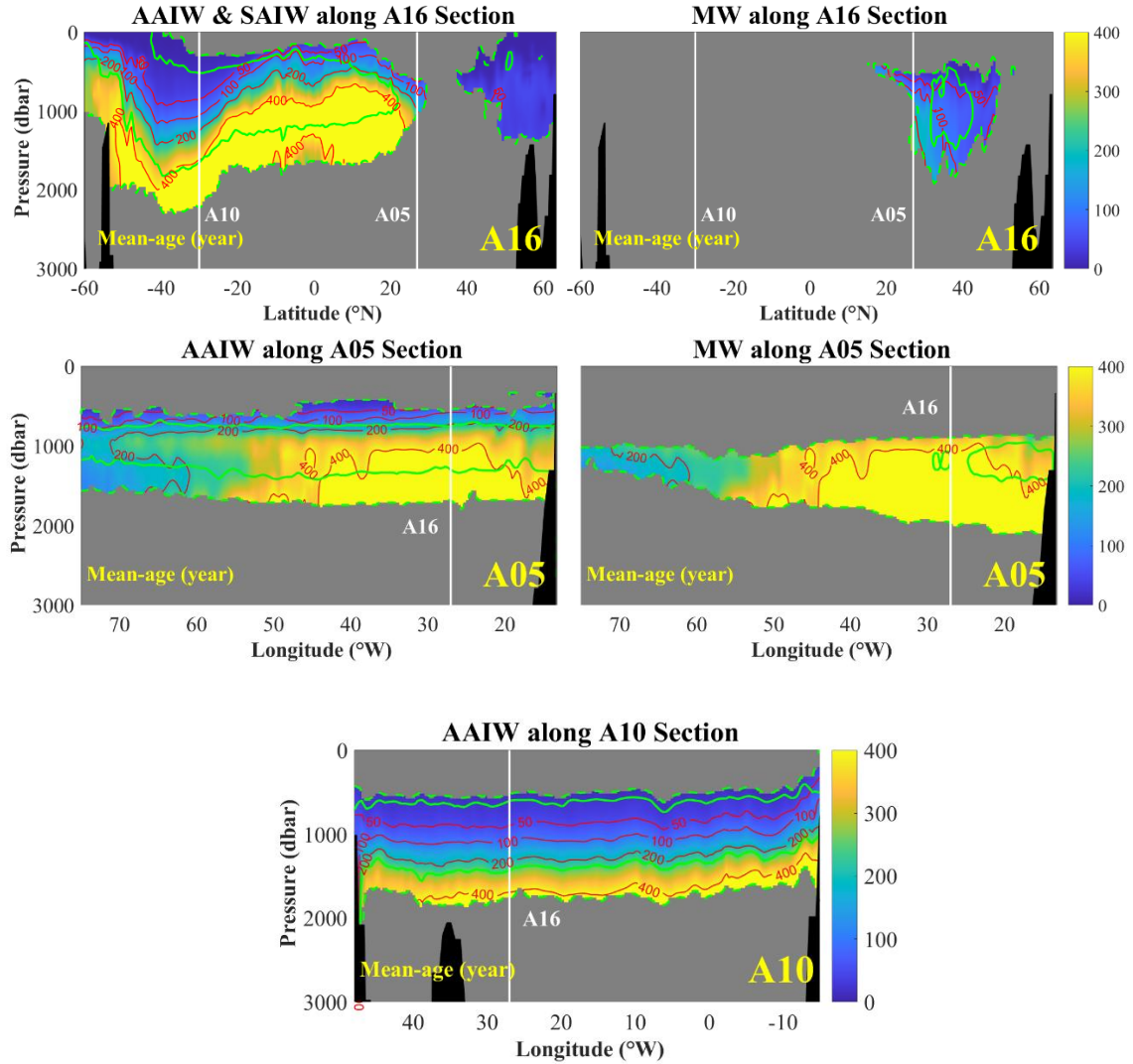


Figure S5. Mean-ages (years) of intermediate water masses along the three sections for the upper 4000 dbar. The solid green isolines show the 50% fractions of water masses and the dashed green lines show the 20 % fractions. The grey blank indicates less than 20% contribution from intermediate water mass. White vertical lines show cross overs with other sections.

(Corresponding to **Fig. 9** in the main text)

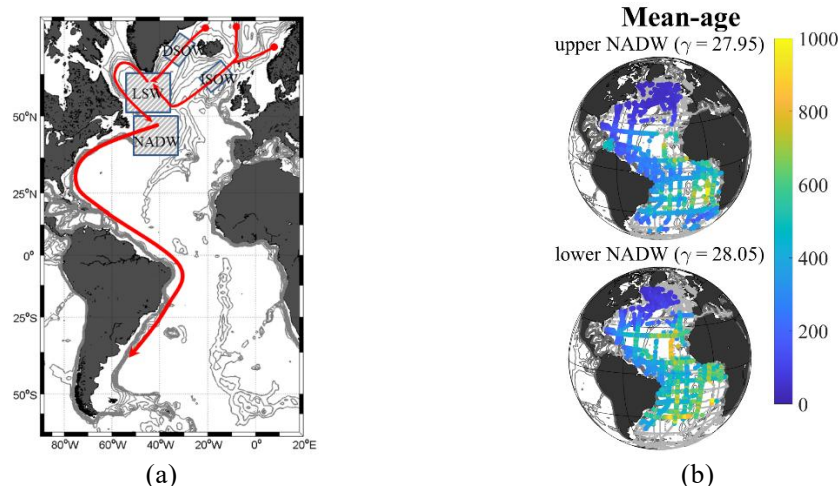


Figure S6. Mean-ages of upper and lower NADW in the Atlantic Ocean.

(a) Main currents in the deep and overflow layer. The currents (arrows) and the formation areas (rectangular shadows) of water masses in the deep and overflow layer.

(b) The mean-ages (years) of upper and lower NADW at their core neutral densities (kg m^{-3}). The colored dots show the ages in each station. The grey dots show all the GLODAPv2 stations that have less than 20% contribution of the water mass in question or lack of transient-tracer data.

(Corresponding to **Fig. 10** in the main text)

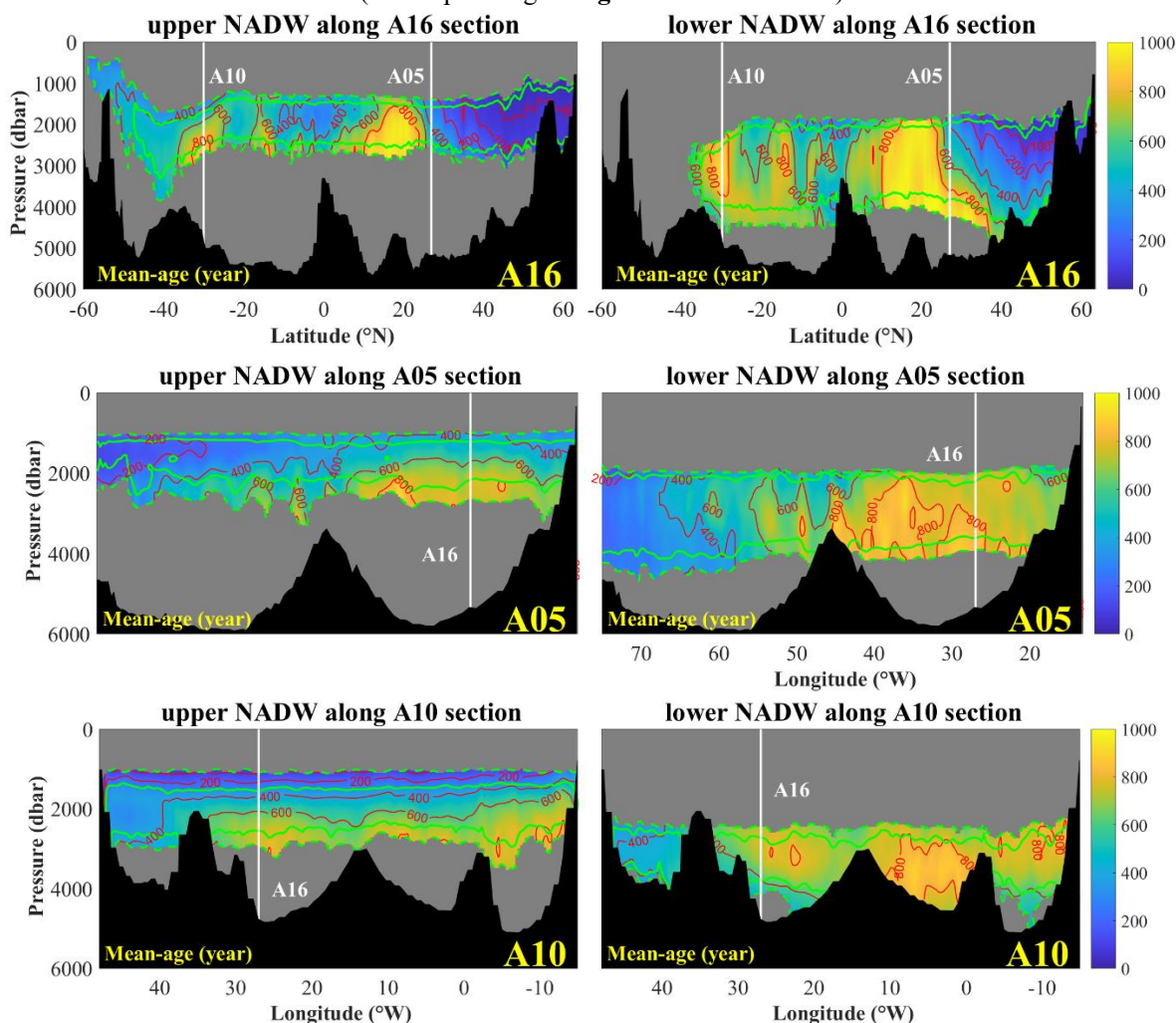


Figure S7. Mean-ages (years) of upper and lower NADW along the A16 (a), A05 (b) and A10 (c) section lines. The green contour lines show fractions of water masses in 50 % and the dashed green lines show the 20 % fractions. The grey blank indicates less than 20% contribution from NADW. The white vertical lines show cross overs with other section lines.

(Corresponding to **Fig. 11** in the main text)

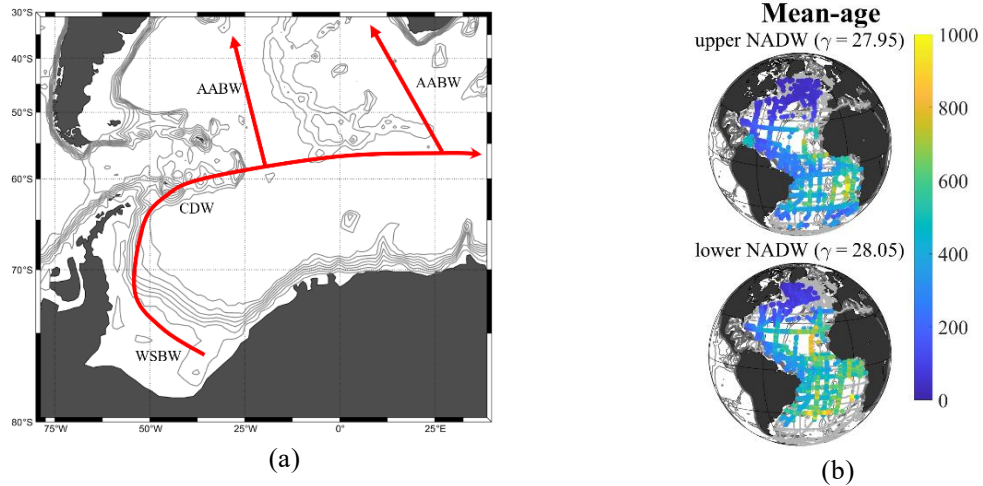


Figure S8. Mean-ages of bottom water masses in the Atlantic Ocean.

(a) Main currents in the bottom layer. The currents (arrows) and the formation areas (rectangular shadows) of water masses in the deep and overflow layer.

(b) The mean-ages (years) of bottom water masses at their core neutral densities (kg m^{-3}). The colored dots show the ages in each station. The grey dots show all the GLODAPv2 stations that have less than 20% contribution of the water mass in question or lack of transient-tracer data.

(Corresponding to Fig. 12 in the main text)

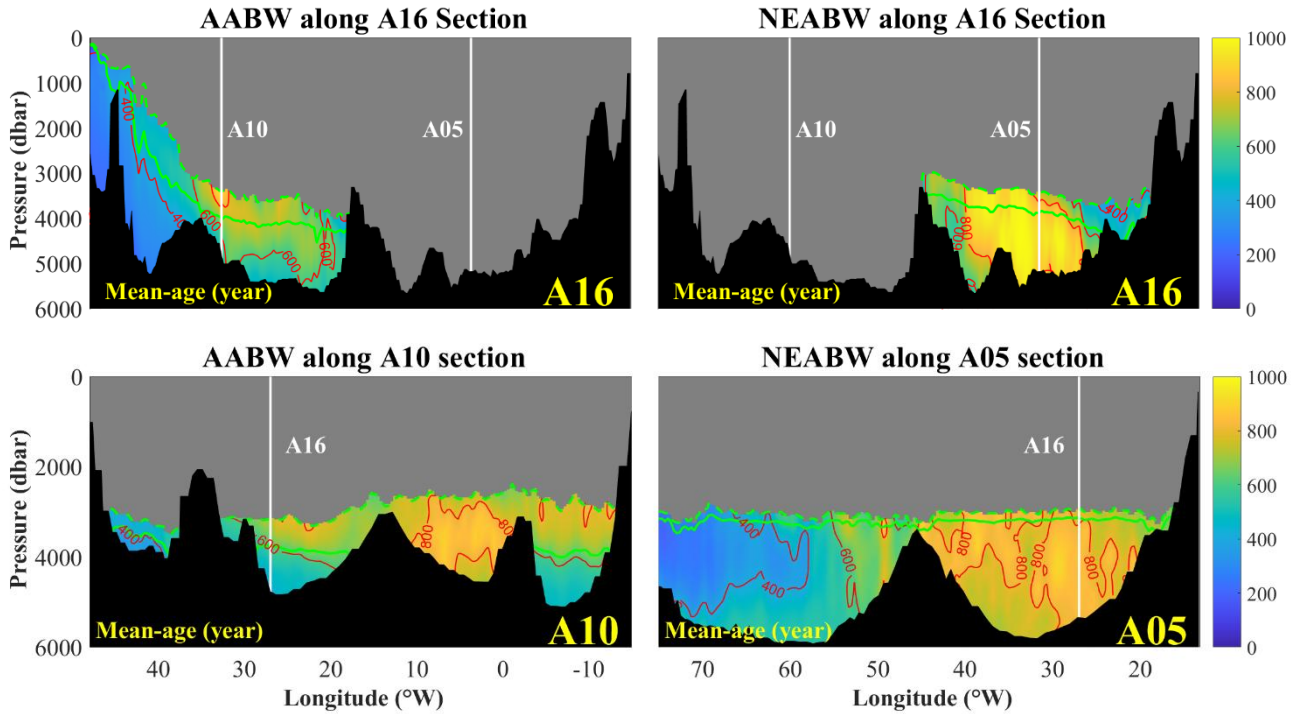


Figure S9. Mean-ages of AABW and NEABW along the A16 (a), A05 and A10 (b) section lines.

The green contour lines show fractions of water masses in 50 and the dashed green lines show the 20 % fractions. The grey blank indicates less than 20% contribution from bottom water masses. The white vertical lines show cross overs with other section lines.

(Corresponding to Fig. 13 in the main text)

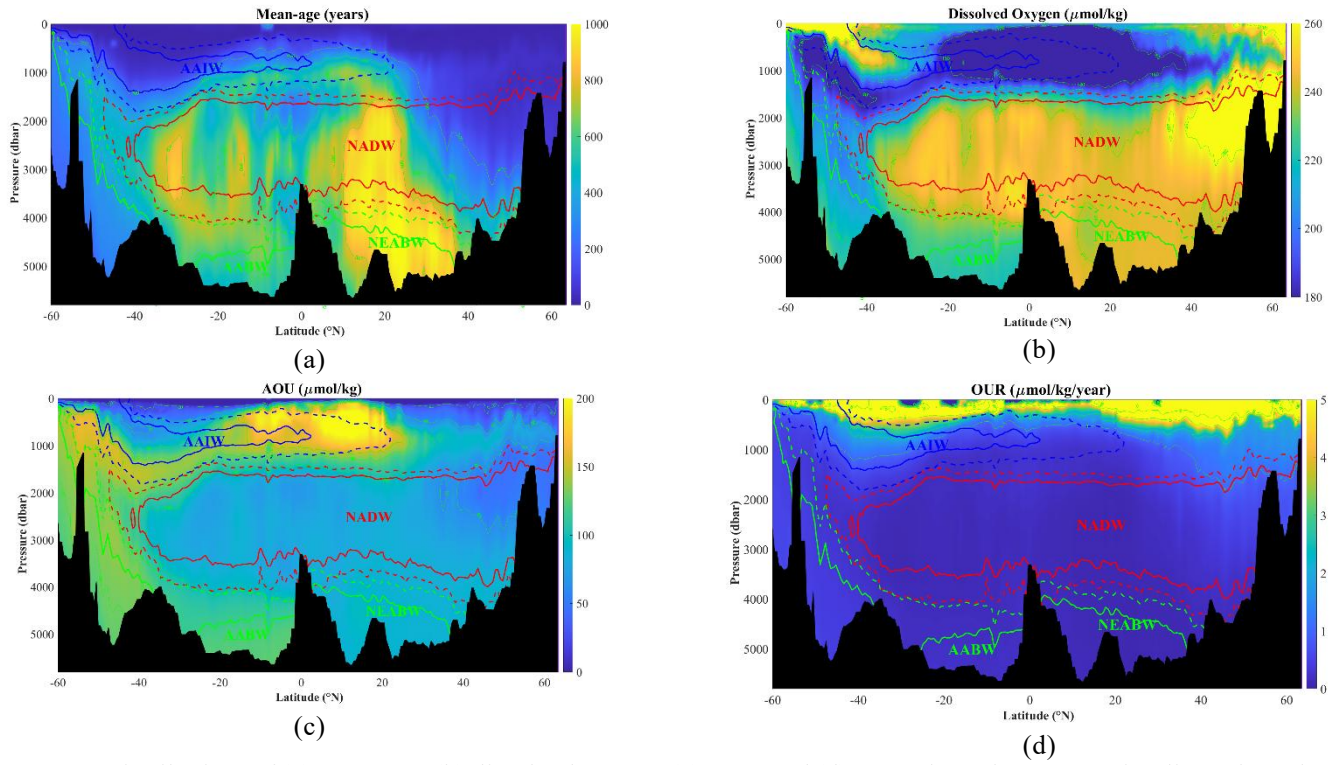


Figure S10. Distributions of (a) mean-age, (b) dissolved oxygen, (c) AOU and (d) OUR along the A16 section line. The color solid lines show the fractions of 80% in each water mass and the dashed lines show the fractions of 50%.

Note: OUR is calculated from **mean-age**. (Corresponding to **Fig. 15** in the main text)

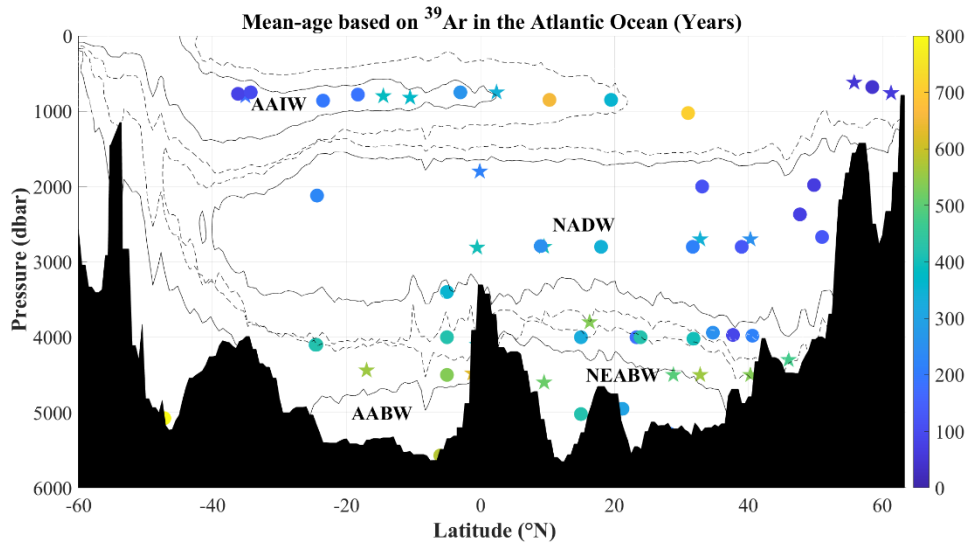


Figure S11. Mean-ages of the wide-spread water masses estimated by ^{39}Ar in the Atlantic Ocean. The circle dots show the data in the west, while the stars show the data in the east Atlantic Ocean. The solid isolines show the 80% fractions of water masses and the dashed lines show the 50 % fractions. (Corresponding to **Fig. 17** in the main text)

Table S1. Complete comparison of water mass mean- and mode-ages estimated from CFC-12/SF₆ and ³⁹Ar for paired Atlantic stations.

Water Masses	Age Type (years)	Tracer	Location	Latitude/Longitude Range	Neutral Density (kg m ⁻³)	Age ± Uncertainty (years)
AAIW	Mean-age	CFC-12 & SF ₆	West	35–45 °S, 60–20 °W	27.15–27.25	70 ± 10
			East	35–45 °S, 20 °W–10 °E	27.15–27.25	200 ± 25
		³⁹ Ar	West	35–45 °S, 60–20 °W	27.15–27.25	150 ± 20
			East	35–45 °S, 20 °W–10 °E	27.15–27.25	175 ± 20
		CFC-12 & SF ₆	West	15–25 °S, 40–20 °W	27.20–27.30	300 ± 35
			East	15–25°S, 20 °W–10 °E	27.20–27.30	500 ± 60
		³⁹ Ar	West	15–25 °S, 40–20 °W	27.20–27.30	300 ± 40
			East	15–25 °S, 20 °W–10 °E	27.20–27.30	500 ± 60
	Mode-age	CFC-12 & SF ₆	West	35–45 °S, 60–20 °W	27.15–27.25	10 ± 2
			East	35–45 °S, 20 °W–10 °E	27.15–27.25	30 ± 4
		³⁹ Ar	West	35–45°S, 60–20°W	27.15–27.25	30 ± 5

			East	35–45 °S, 20 °W–10 °E	27.15–27.25	35 ± 5
			West	15–25 °S, 40–20 °W	27.20–27.30	49 ± 6
		CFC-12 & SF ₆	East	15–25°S, 20°W–10°E	27.20–27.30	80 ± 12
			West	15–25 °S, 40–20 °W	27.20–27.30	60 ± 10
		³⁹ Ar	East	15–25 °S, 20 °W–10 °E	27.20–27.30	90 ± 15
NADW	Mean-age	CFC-12 & SF ₆	West (A05)	15–25 °N, 70–40 °W	27.95–28.05	200 ± 30
			East (A05)	15–25°N, 40–10°W	27.95–28.05	600 ± 80
		³⁹ Ar	West	15–25 °N, 70–40 °W	27.95–28.05	130 ± 20
			East	15–25 °N, 40–10 °W	27.95–28.05	400 ± 50
	Mode-age	CFC-12 & SF ₆	West (A05)	15–25 °N, 70–40 °W	27.95–28.05	40 ± 6
			East (A05)	15–25 °N, 40–10 °W	27.95–28.05	100 ± 15
		³⁹ Ar	West	15–25 °N, 70–40 °W	27.95–28.05	40 ± 6
			East	15–25 °N, 40–10 °W	27.95–28.05	80 ± 12
			West (A10)	25–35 °S, 50–30 °W	>28.10	400 ± 50

AABW & NEABW	Mean-age	CFC-12 & SF ₆	East (A10)	25–35 °S, 10 °W–10 °E	>28.10	600 ± 80
		³⁹ Ar	West	25–35 °S, 50–30 °W	>28.10	500 ± 60
			East	25–35 °S, 10 °W–10 °E	>28.10	600 ± 70
	Mode-age	CFC-12 & SF ₆	West (A10)	25–35 °S, 50–30 °W	>28.10	50 ± 8
			East (A10)	25–35 °S, 10 °W–10 °E	>28.10	100 ± 15
		³⁹ Ar	West	25–35 °S, 50–30 °W	>28.10	90 ± 12
			East	25–35 °S, 10 °W–10 °E	>28.10	110 ± 15

Uncertainties: CFC-12/SF₆ from mixing ratio sensitivity ($\Delta/\Gamma = 0.8\text{--}1.2$); ³⁹Ar from measurement statistics (1 σ). West = west of Mid-Atlantic Ridge (MAR); East = east of MAR. Neutral density ranges follow Liu and Tanhua (2021). Note: ³⁹Ar data from Rodriguez (1993); CFC-12/SF₆ data from GLODAPv2 (2000s–2010s). Temporal mismatch and steady-state assumption apply.