

How can age and oxygen become decoupled?

Age and oxygen are typically expected to be strongly negatively correlated in the ocean interior (ventilated regions?). Under what conditions does this negative relationship break down, and even reverse?

Results - Model Age-Oxygen Relationship:

ESM2Mc model output along Line W suggests a region in the ocean interior where this relationship is reversed (Figure 1). Scatter analysis of age and oxygen in this region (distance averaged between 600–900 km) indicates that this positive correlation area occurs when there is a larger gradient in age than oxygen (Figure 2). This suggests that the positive correlation could be due isopycnal heave.

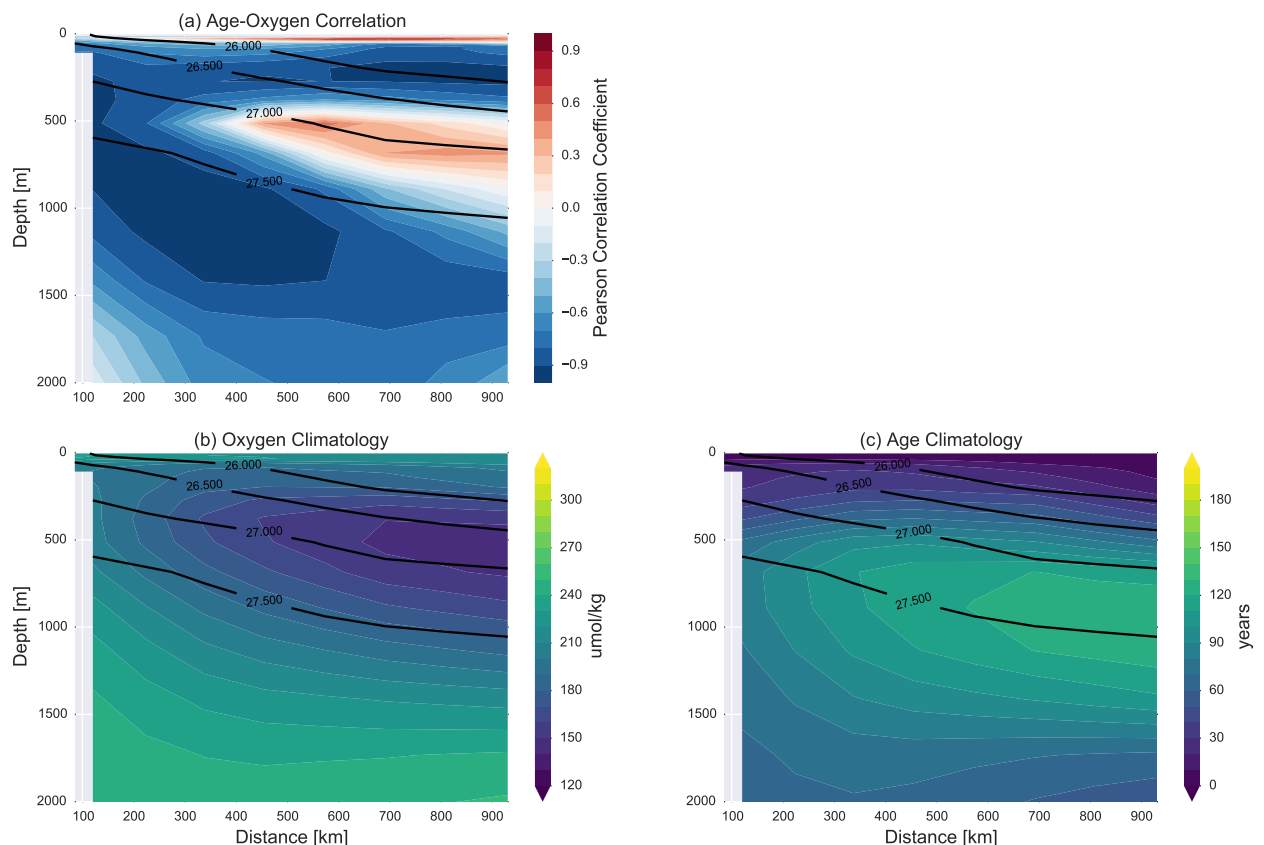


Figure 1: (a) Pearson correlation coefficient for age vs oxygen interpolated to Line W. (b) oxygen climatology and (c) age climatology on Line W.

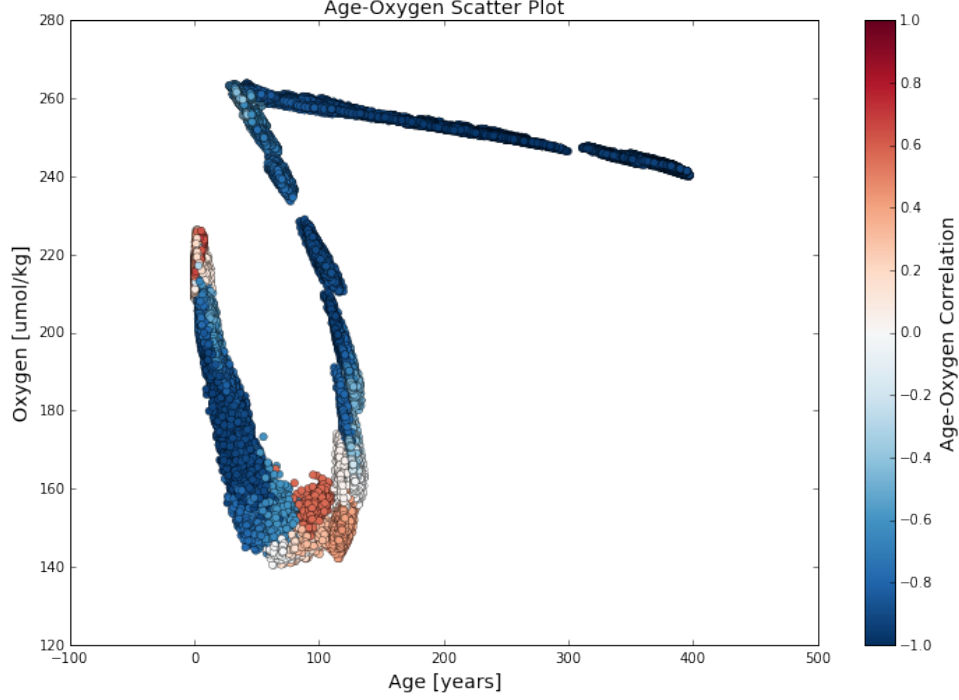


Figure 2: Scatter plot of age and oxygen averaged between distances 600–900 km. Colors indicate correlation coefficient.

To explore why there is a positive correlation in this region at this depth, we partition the correlation between age and oxygen into two terms: the correlation on a constant density surface ($\gamma_n = 27.0$) and the correlation due to the vertical displacement of the density surface (heave). These two terms are referred to as ‘no heave’ and ‘pure heave’ respectively.

To calculate these two terms first the correlation between age and oxygen is calculated on the average depth of the $\gamma_n = 27.0$ density surface:

$$r_{\text{total}} = \text{corr}(\text{age}, \text{o}_2) \Big|_{\gamma_n=27.0} \quad (1)$$

Next the no heave term is calculated by taking the correlation of age and oxygen interpolated to the $\gamma_n = 27.0$ surface at each time-step.

$$r_{\text{no heave}} = \text{corr}(\text{age}|_{\gamma_n=27.0}, \text{o}_2|_{\gamma_n=27.0}) \quad (2)$$

Finally the pure heave term is calculated as the difference between the total correlation and the no heave correlation.

$$r_{\text{pure heave}} = r_{\text{total}} - r_{\text{no heave}} \quad (3)$$

Figure 3 shows that the positive correlation region at the end of Line W is entirely do to the localized vertical displacement of the isopycnal surfaces.

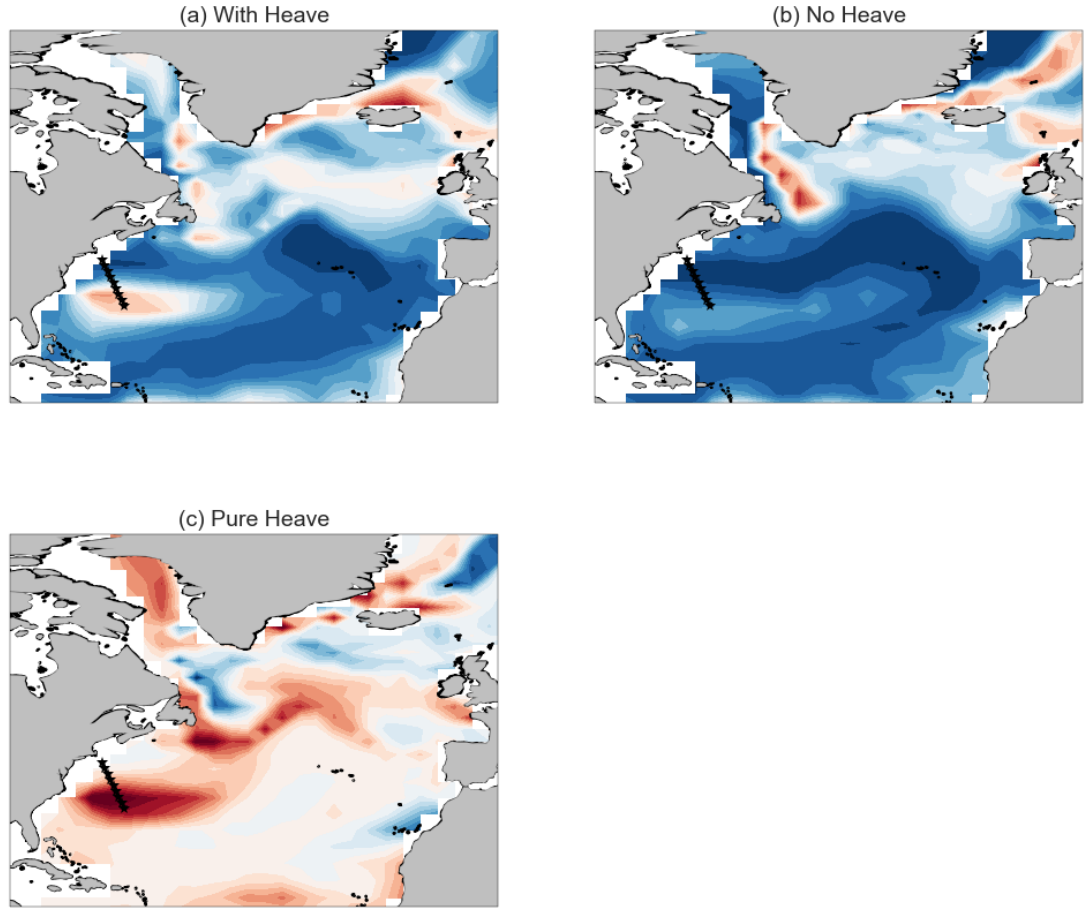


Figure 3: Correlation coefficient between age and oxygen on neutral density $\gamma_n = 27.0$. (a) shows the correlation on the average depth of the isopycnal, (b) shows the correlation with the effects of isopycnal heave removed, and (c) shows the difference between these two, i.e. the impact of isopycnal heave on the correlation.