Benthic-planktonic radiocarbon age as ocean ventilation proxy: the impact of air-sea exchange.

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The assessment of past ocean ventilation changes often relies on the difference between radiocarbon ages of co-existing benthic and planktonic species (B-P ages). However, several factors limit the potential of the B-P ages method in this purpose. The radiocarbon distribution in the ocean is controlled by atmospheric 14C level, by air-sea exchange rate, by mixing in the ocean interior, as well as, by water mass pathways. The complex interplay between these processes may result in significant departures of the B-P ages from the actual ventilation timescale.

Here we examine the sensitivity of B-P ages to circulation and air-sea processes in 3-D OGCMs by means of idealized radioactive tracers. The equations describing the evolution of such tracers are established in the framework of The Constituent-oriented Age and Residence time Theory (CART, www.climate.be/cart). Theoretical developments yield that for a given radioactive decay rate the difference between the ventilation age and the radio-age increases with decreasing air-sea exchange rate.

The long time needed for radiocarbon exchange with the atmosphere result in B-P ages overestimating the true ventilation time. This bias may reach several hundred years in numerical experiments with 3-D OGCMs.

Further, B-P age biases, that is the difference between radiocarbon and ventilation B-P ages, are not uniform. They exhibit marked vertical and horizontal structures, even when homogeneous boundary conditions are applied at the surface.

This behavior is a direct consequence of the finite air-sea exchange rate. Indeed contributions of remote areas (with larger ages) to the tracer age increase as this rate decreases.