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How well do benthic-planktonic radiocarbon age approximate ocean ventilation?

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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 C14 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. Taking advantage of partial ages (Mouchet et al., 2016) we investigate the reasons for such significant departures. These ages allow to evidence how contributions from distant ocean regions to the local ventilation increase as the air-sea exchange rate decreases.
We further examine the role of atmospheric evolution of radiocarbon concentrations over the last 40 kyr and different OGCMs circulation in shaping these differences.
B-P age biases depend in a non-linear way on the air-sea exchange and circulation rates while heterogeneity in the air-sea exchange rate only plays a secondary role.
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