Project: **975**

Project title: **OCTANT**

Principal investigator: **Anne Mouchet and Uwe Mikolajewicz**

Report period: **2021-11-01 to 2022-10-31**

1 Project Overview

The main objective of OCTANT is investigating to what extent the temporal evolution of the ocean circulation during abrupt events may be inferred from deep-sea cores. In that purpose we implemented in MPIOM isotopic ratios commonly measured in sediment cores as well as several age tracers allowing tracking water masses and their role in ventilation. By means of transient simulations from the end of the last glacial maximum (LGM) to the present day we investigate the relevance of radiocarbon as a proxy for deep ocean ventilation changes. In parallel we develop tracer methods aimed at assessing water mass fractions and ventilation pathways.

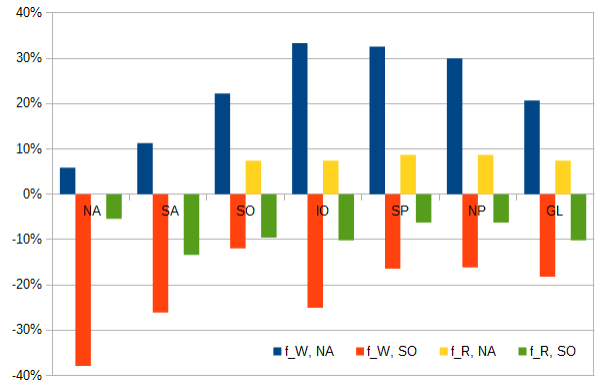
2 Report on work performed

The work performed for this project has consisted in paper redaction and analysis of already performed experiments. Some computing time was used for sensitivity experiments and post processing.

The work performed includes

1. Revision of the paper “Investigating the effect of surface equilibration on radiocarbon ages in the deep ocean” by Mouchet A., Mikolajewicz, U., and Deleersnijder, E. submitted to Earth and Planetary Sciences Letters.
   This paper examines the use and limitation of radiocarbon as a proxy for the ventilation of the deep ocean. One key finding is that the representation of mixing processes in the model, and the consecutive change in water mass pathways, has a larger impact on the water mass and age fractions than on the radiocarbon-like tracer fractions (Fig. 1).
   Water mass fractions exhibit significant differences between experiments with different mixing schemes (Fig. 1, left). In contrast, the changes for the radiocarbon-like tracer, though of the same sign, are much less dramatic. Further, the later do not necessarily record the actual ventilation changes or their proportion: concentration and age fractions of the radiocarbon-like tracer do not report any change in the deep Atlantic Ocean basins for the water with origin in the NA surface, in contrast to the ventilation (or water) tracer.
   For the same circulation the impact of a decrease in air-sea exchange rate by about 20% (Fig. 2) is of similar magnitude for the radiocarbon-like tracer with origin in the NA than the changes obtained when water trajectories differ. In this case, the fractions for the radiocarbon-like tracer from the SO are less affected by the modification in the air-sea exchange rate. This is probably explained by the small time spent by water masses at the surface of the Southern Ocean.
   Hence the radiocarbon-like tracer is ambiguous in reporting the reasons of changes.

2. Redaction of a paper “Diagnosing deep ocean ventilation pathways by means of partial ages” by Mouchet A., Deleersnijder, E, Delhez E., and Six K.
   Partial ages [1] allow investigating where water masses spend most of their time in the deep ocean. These locations (where age is built) do not coincide with those where oldest water are found (where age is stored).
   Additionally, dividing the partial age relative to a specific region by the average time spent in that region allows obtaining a ‘return’ coefficient, i.e., a measure of the probability for the water to transit again through that region.
   These concepts are applied to the global ocean and to the Pacific Ocean where a throughout investigation of the impact of model resolution is performed.



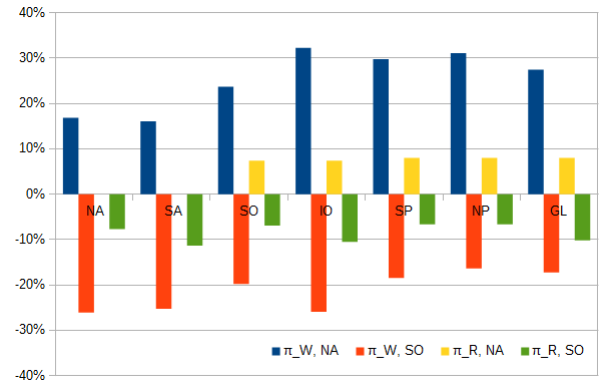


Fig. 1 Relative differences between experiments with different circulation for characteristics of water with origin in the surface North Atlantic (NA) and in the Southern Ocean (SO). Values obtained in the deep ocean basins (X-axis) for the ventilation tracer (blue and orange) and for the radiocarbon-like tracer (green and yellow).

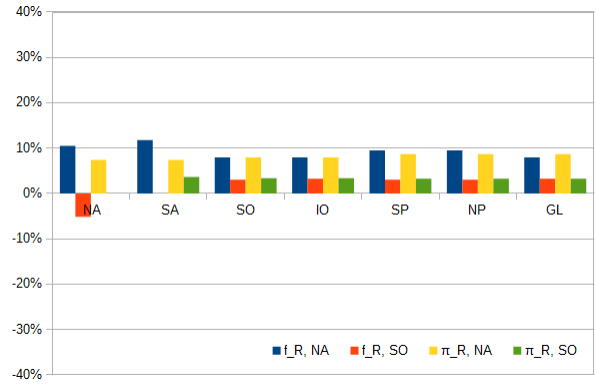


Fig. 2 Relative differences in mixing ratios and age fractions for the radiocarbon-like tracer when the air-sea exchange rate is reduced by 20%.

References

[1] Mouchet, A., Cornaton, F., Deleersnijder, E., Delhez E. Partial ages: diagnosing transport processes by means of multiple clocks. *Ocean Dynamics* **66,** 367–386, doi: 10.1007/s10236-016-0922-6, 2016.