Project: **975**

Project title: **OCTANT**

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

Report period: **2019-01-01 to 2019-12-31**

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 sediment 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.

Activities during 2019 covered several aspects: technical developments, theoretical investigations, assessment and analysis of available transient experiments, and paper redaction.

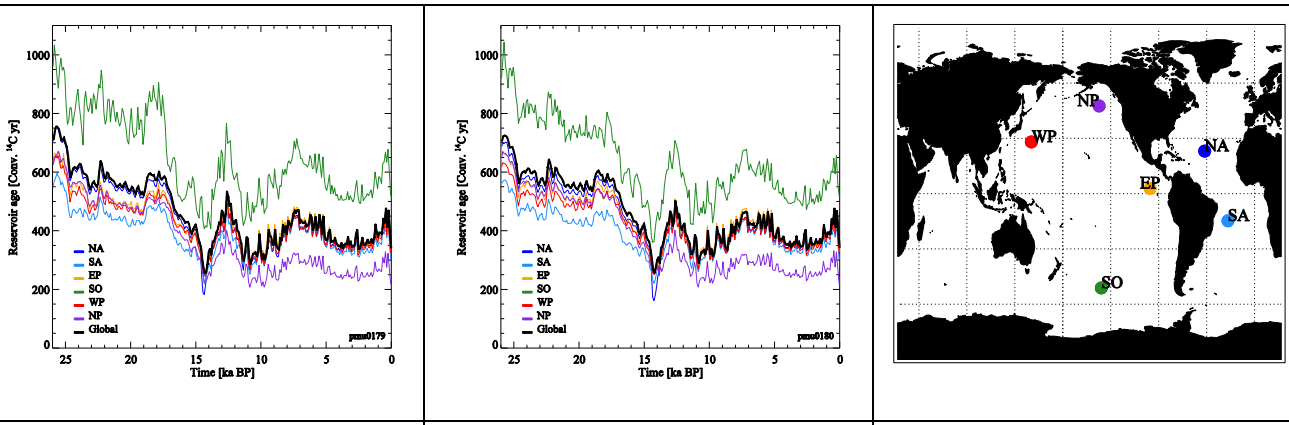
2 Report on work performed in 2018

Reports of the previous years mentioned that we have been confronted to a conservation problem with MPIOM. There were no indications that this problem would also expose tracers with strong restoring at the sea-surface. However, while preparing a publication on the age tracers we discovered severe inconsistencies. Theoretical developments and model studies indeed show that the age of a radioactive tracer is always less or equal to the age of a non-radioactive tracer subject to the same boundary conditions [1]. This was not the case in experiments with the 'bugged' model version. With the corrected version the property is verified. We therefore had to re-launch all the related experiments. The related publication [2] will be submitted during November 2019.

RESERVOIR AGE

The isotopic depletion of surface water with respect to the atmosphere is usually reported as the Marine Reservoir Age (MRA). Accurate knowledge of this age and its past evolution is essential for dating sediment cores hence for the reconstruction of the timing of deep ocean events. As of today, the MRAs span a range from 400 yr in subtropical gyres to more than 1000 yr in polar areas [3].
In each deglaciation experiment the MRA is routinely computed (Fig. 1). It exhibits a large spatial variability, but also a strong dependency on the climate state, especially on the replacement time of surface water, which is here illustrated by the strength of the Atlantic meridional overturning circulation (AMOC, Fig. 2 left). The experiment exhibiting the lowest AMOC (g310013) is characterized by larger MRAs. Regional changes, probably consecutive to differing ventilation rates, also affect the relative evolution of regional MRA with time; for example, the EP and NP curves in 'g310012' and 'g130013' behave in a different way (Fig. 1).

In the past there is evidence that MRAs were more elevated [3, 4]; however, they are poorly constrained. As a consequence for the construction of the past atmospheric signal, a constant MRA is considered for periods older than 13.9 kyr BP [4]. The average MRA resulting from our experiments is in qualitative agreement with the reconstructed marine curve [4]. It should be noted that many of the records used in that reconstruction come from coastal areas which are not well represented in coarse resolution models. This could explain part of the discrepancy. The uncertainty reproduced in right panel of Fig. 2 is that due to the four climate reconstructions. According to our experiments the MRA increased significantly in the past; this is in agreement with other studies [e.g., 3]. One may then question the assumption used in INTCAL13 of a constant (and rather low) MRA reservoir ages before 13.9 cal kyr BP.
This topic is being further investigated and assessed.



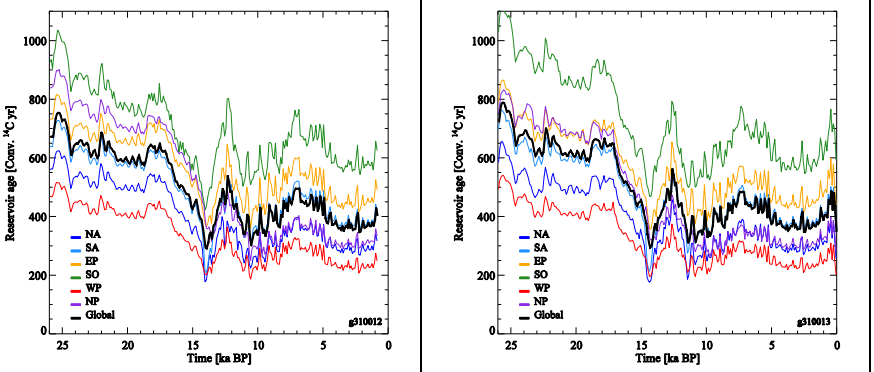


Fig. 1 Marine Reservoir Age (MRA) over the last 26 ka for different realizations with MPI-ESM. The position of the local curves is given on the map above. The mean global MRA (black) is computed over the upper 75 m.

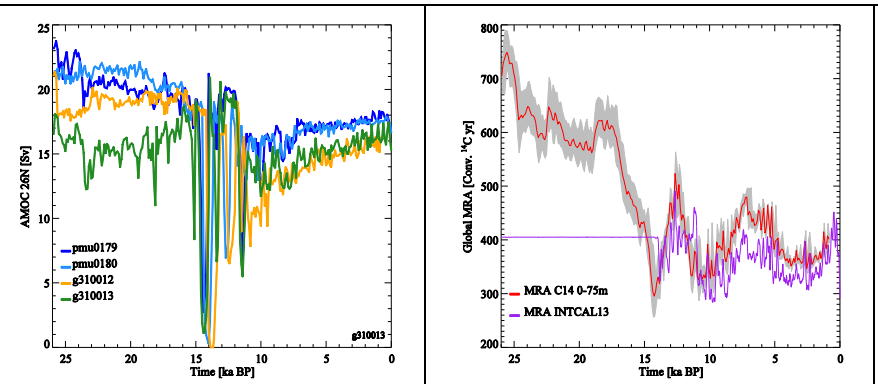


Fig. 2 Meridional overturning circulation at 26N for the four experiments above (left). Global MRA averaged for the four experiments above (right). The grey shaded area gives the experiments' range. MRA from INTCAL13 [4] is also reproduced (purple).

[1] Delhez, E., Deleersnijder, E., Mouchet, A., Beckers, J.-M., 2003. A note on the age of radioactive tracers. Journal of Marine Systems 38, 277-286.

[2] Mouchet A., Mikolajewicz, U., Beckers, J.-M., Delhez, E.J.M., Deleersnijder, E., 2019. Ocean ventilation pathways as reported by radiocarbon. To be submitted to Earth and Planetary Sciences Letters.

[3] Butzin, M., Köhler, P., and Lohmann, G., 2017, Marine radiocarbon reservoir age simulations for the past 50,000 years, Geophys. Res. Lett., 44, 8473–8480, doi:10.1002/2017GL074688.

[4] Reimer, P. J., et al. (2013), IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP, Radiocarbon, 55, 1869–1887, doi:10.2458/azu_js_rc.55.16947.