Changes in the Greenland Sea deep convection since the last glacial – first results

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Abstract

The deep convection is one of the key processes in the ocean circulation. It is responsible for the formation of deep water masses and crucial for the ventilation of the deep ocean. It is also important for the Earth's climate as the deep water masses can store large amounts of excess heat and carbon from the atmosphere. One of the regions where deep open-ocean convection takes place is the Greenland Sea. The intensity of this process changes over time but the exact course of its evolution remains largely unknown. We reconstructed the evolution of the Greenland Sea deep convection since the last glacial using radiocarbon ventilation ages obtained by calculating the offset of radiocarbon-dated benthic foraminifera from the contemporaneous planktic species and the atmosphere. To obtain a more realistic age model of core PS1878, we recalibrated the available planktic radiocarbon dates using reservoir ages reported by Thornalley et al. (2015). The primary results show extremely high ventilation ages (up to ~10,000 years) during Heinrich Stadial 1 (HS1) indicating that the deep convection was almost completely absent during that time. Situation changed completely during the Bølling-Allerød (BA) interstadial, when the ventilation ages decreased significantly, indicating a full recovery of the convection process after the ice age. The recovery was interrupted in the Younger Dryas (YD), the coldest phase of the deglaciation. The deep convection process intensified again in the early Holocene to reach a maximum in the middle Holocene. Finally, after around 3,000 years BP the intensity of the deep convection decreased to its present-day level. Additionally, our results confirm large differences of radiocarbon ages derived from various benthic species.

Age model

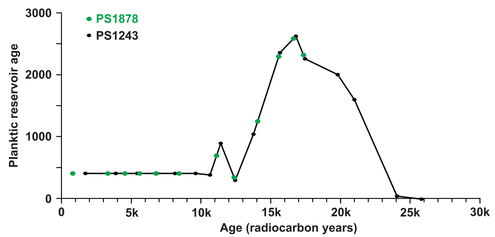


Fig. 1. The obvious shortcoming of the age model of core PS1878 (Telesiński et al. 2015) was that a reservoir age of 400 years was used over the entire record. To improve the age model, we used reservoir ages (green dots) interpolated from Thornalley et al. 2015 (black dots). Additionally, the age model was supplemented by three new AMS ^{14}C datings.

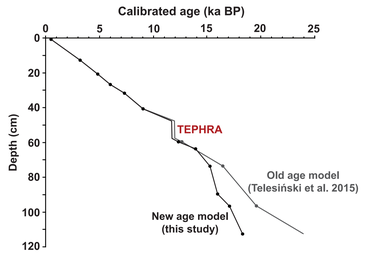


Fig. 2. The new age model of core PS1878 (black) using variable reservoir ages yielded generally younger ages and higher sedimentation rates in the pre-Holocene part of the record than the old age model (grey).

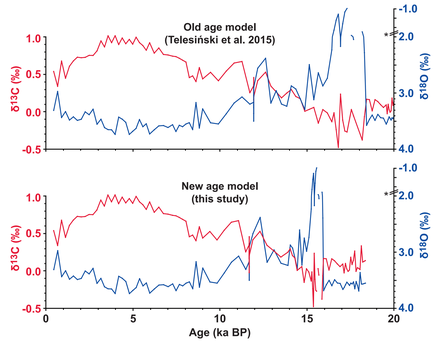
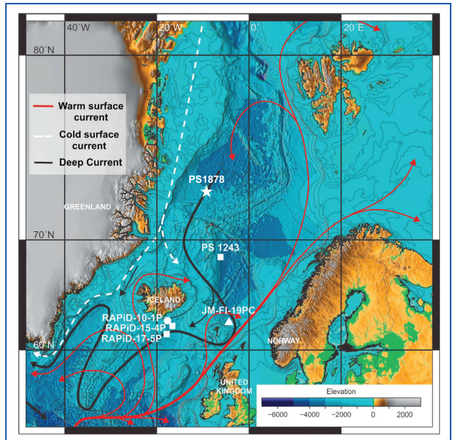


Fig. 3. The most prominent change in the planktic stable isotope record of core PS1878 caused by the new age model is the younger age and shorter duration of the extremely light $\delta^{18}O$ peak caused by a freshwater outburst (Telesiński et al. 2014). A shorter (<1000 years vs. ~2000 years) duration of a freshwater event seems much more reasonable. $\delta^{18}O$ data were corrected for ice volume (Fairbanks 1989).
* Note the change in the $\delta^{18}O$ scale.

Study Area



Map of the major surface and bottom water currents in the northern North Atlantic and the Nordic Seas (modified after Ezat et al. 2017). Core PS1878 (Telesiński et al. 2014; this study) is marked with a star. Other cores (Ezat et al. 2017; Thornalley et al. 2015) are also indicated.

Results and discussion

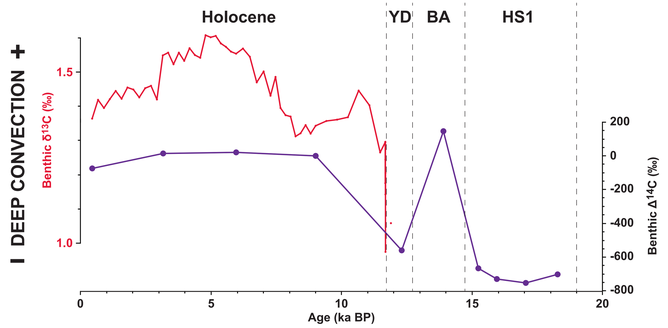


Fig. 4. Telesiński et al. 2015 reconstructed the deep convection in the Greenland Sea using benthic $\delta^{13}C$ record. However, due to the insufficient abundance of benthic foraminiferal species suitable for stable isotope measurements and the uncertainty concerning the carbon cycle during the last glacial termination, the reconstruction was limited to middle and late Holocene. The reconstruction of the radiocarbon ventilation ages (RVA) allows extending the history of the Greenland Sea deep convection further back in time. The RVA (here expressed as seawater radiocarbon ratios - $\Delta^{14}C$) confirm high convection rates over the Holocene with a maximum between 7 and 3 ka BP. They also suggest that the intensity of deep convection was high during the BA and low during the YD and HS1.

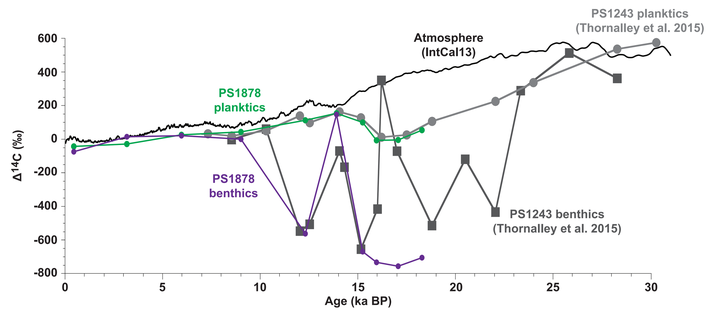


Fig. 5. Our $\Delta^{14}C$ data fit well with those from the deep Norwegian Sea (PS1243, Thornalley et al. 2015) indicating that both sites were bathed by the same water mass, at least since ~15 ka BP.

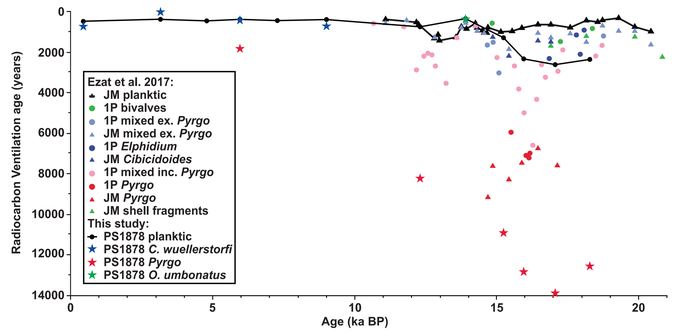


Fig. 6. The reconstruction of PS1878 RVA confirms large differences between various benthic species. RVA yielded from dating of *Pyrgo spp.* are larger than those derived from non-miliolid species, even in the Holocene. The pre-Holocene *Pyrgo* RVA from PS1878 are significantly larger than those reported by Ezat et al. (2017). More species-specific radiocarbon dates are necessary, especially from the late glacial-early Holocene interval, to specify whether the RVA changes result solely from circulation changes or are biased due to taphonomic or vital processes.

References:
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