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Long-lived radionuclides (^{129}I and ^{236}U) as water mass tracers in the North Atlantic and Fram Strait

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Water mass transport and transformation processes in the North Atlantic Ocean play a crucial role in the Atlantic meridional overturning circulation (AMOC). In this context, circulation processes leading to the transport of substances or properties such as heat or greenhouse gases from the sea surface to the ocean interior (e.g. by dense-water formation) are of special interest. These processes are known to be closely linked to water mass transport in the Nordic Seas and to the water exchange between the North Atlantic and the Arctic Ocean through Fram Strait. In order to understand the natural variability of the water circulation and how it will respond to anthropogenic climate forcing, chemical tracers are suitable tools to complement hydrographic measurements and models. Amongst them, the long-lived artificial radionuclides ^{129}I ($T_{1/2} \approx$ 15.7 Myr) and ^{236}U ($T_{1/2} \approx$ 23.4 Myr) have been introduced into the marine environment as part of the global atmospheric deposition of nuclear weapon test fallout (mainly ^{236}U) and as a timely varying, point-like release from two nuclear fuel reprocessing plants in western Europe (mainly ^{129}I). Due to the quite recent introduction of these tracers (since the 1950s), the upper water column in the North Atlantic and the Arctic Ocean contains relatively high amounts of ^{129}I and ^{236}U that evolve in time due to the varying historical releases from reprocessing plants. Thus, the combination of both radionuclides provides a tool to investigate water mass transport pathways and to estimate time scales of circulation. Here we combine ^{129}I and ^{236}U results from the Fram Strait (2016 and preliminary results from 2018) and the OVIDE section (2014 and 2018) to study the water circulation between the Arctic Ocean, the Nordic Seas and the subpolar North Atlantic. We find high concentrations of ^{129}I and ^{236}U as well as high ^{129}I/^{236}U ratios in the surface waters outflowing the Arctic Ocean (concentrations about twice as high as in the inflowing Atlantic waters in the West Spitzbergen Current) which are being transported southwards along the coast of Greenland by the East Greenland Current (EGC). These high concentrations are further observed in the deep overflow waters in the Labrador and Irminger Seas due the influence of waters entering through the Greenland-Iceland passage. The presence of ^{129}I has notably increased in time in both the Fram Strait and most of the OVIDE section, showing the potential of this tracer for future oceanographic studies. Finally, the combination of these results with earlier observations allows to understand transport pathways and transit times of Atlantic Waters into the North Atlantic Ocean. We find both a short loop through the Nordic Seas (8-10 yrs transit time) and a longer loop through the Arctic Eurasian Basin (16-18 yrs transit time).