**Exploring Anthropogenic Radioisotopes as Tracers in Oceanic and Climatic Studies**

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The global ocean is a reservoir for radionuclides, both natural occurring and anthropogenic. The anthropogenic radioisotopes predominantly originate from fallout from historical atmospheric nuclear weapons tests, discharges from nuclear reprocessing plants and releases following accidents at nuclear facilities. In recent years, the application of long-lived anthropogenic radionuclides, such as Tc-99, I-129, U-233 and U-236 as tracers in the marine environment has been increasingly adopted. Due to their conservative behaviour, long residence time and unique fingerprint of their isotopic ratios, these tracers are particularly promising in studying the water mass movement and mixing, tracking ocean circulation pathways and transit times, quantifying water mass composition and estimating pollutant and nutrient dynamics.

The anthropogenic radioisotopes with constrain source terms and release histories also offer a novel perspective for assessing the model-simulated transport and transformation of specific water masses. For example, the well-documented discharges of anthropogenic radioisotopes from the European reprocessing plants, along with their measurements in the Nordic Seas and the Arctic Ocean, supplemented by model simulations, provide quantitative estimates of the advective and diffusive properties of transport pathways and time scales of the Atlantic water to the polar waters.

This paper aims to provide a holistic overview of our series research on exploring anthropogenic radioisotopes (e.g., Tc-99, I-129, U-233 and U-236) in the Baltic Sea, the Arctic Ocean and the Pacific Ocean, in coupling with Earth system models (ESM) for oceanic and climate studies.