Title: Characterizing the Transport of the Atlantic Water in the Nordic Seas and Arctic Ocean by Radioactive Tracers

Partners: (NERSC) Yanchun He[glb], Annette Samuelsen[hzd]; (**NORCE)** Emil Jeansson[cbn], Bjørg Risebrobakken[glb]; (**UiB)** Marius Årthun[plr], Elin Darelius[plr]; (**DTU**, external partner): Jixin Qiao.

Objectives:

1) Characterize the advective and diffusive properties of the Atlantic Water in the subarctic and Arctic Ocean using radioactive tracers from nuclear fuel reprocessing plants.

2) Establish a modeling protocol to facilitate the use of radioactive tracers as a model validation benchmark.

Description of the activity

Anthropogenic radioisotopes (e.g. ^{129}I, ^{236}U, ^{99}Tc) have been discharged to coastal waters from the European nuclear fuel reprocessing plants since the 1960s. The northward-flowing Atlantic Water (AW) entrains and mixes with the contaminated coastal waters. The AW is thereby imprinted by the unique reprocessing tracer signature through its way northward into the Arctic Ocean (AO) and back southward to the deep North Atlantic. Initialized from earlier BVF support, the spreading of radioisotopes as pollutants in the marine environments are simulated (Fig. 1), with improved discharge histories and are validated against observations collected and compiled at DTU. The simulated and observed reprocessing tracers also open huge potentials in climate studies. One application is on ocean connectivity. Here we propose a blue-sky research to explore the application of the 1D advective-diffusive model [Haine & Hall, 2002[1]] on the observed radioactive tracers to derive the transit-time distribution of the AW in the subarctic and Arctic Ocean (hereafter, the TTD method). We will apply this method, for the first time, on our compiled radioactive tracer pair, ^{129}I/^{99}Tc, other than the previously studied ^{129}I/^{236}U pair, with improved reconstruction of input functions based on our previous simulation. The outcomes of the project will particularly characterize the advective and diffusive horizontal transport features of AW into the AO and back southward to the deep North Atlantic, complementing ventilation rates estimates from the gas tracers SF_6 and CFCs. The project aligns well with BCCR's strategic areas and will boost collaborations across three (plus one external) partner institutions and four research themes of BCCR.

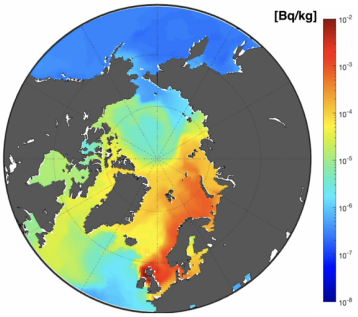

Fig. 1, Simulated Tc-99 concentration in 2000 by NorESM

Timeline: Start in April 2024. **M1**) Prepare observational datasets and input functions by model simulations for the TTD method; **M2**) Calculate the transit times of AW by TTD constrained by different radioactive tracer pairs; **M3**) Compare the derived TTD with tracer age products in the GLODAPv2 dataset and with directly simulated transit-times by Eulerian (output of Nordic collaboration project with DTU and others) and Lagrangian tracer modelings (output of NFR ArMOC); **M4**) Final report.

Outcomes: 1) Determine flow pathways, and the advective and diffusive properties of the AW in the Nordic Seas and the Arctic Ocean, and their decadal changes in the 1990s-2010s. The outcomes could potentially provide bases in future proposals to disentangle natural regime shifts from the anthropogenic impact in the Arctic; **2)** A protocol for conducting simulation of reprocessing radioisotopes with input data, observations for validation and program interfaces, will be initialized. This will facilitate the use of reprocessing tracers as a model validation benchmark for the ocean modeling community.

Budget: Y. He (2 PMs, 279 kNOK), E. Jeansson (1 PM, 168 kNOK), Others (in-kind). Total: 447 kNOK.

[1] Haine & Hall. A generalized transport theory: water-mass composition and age. JPO. (2002).