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Ra isotopes as a tracer of sediment-water column exchange in the North Sea

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Quantifying the benthic flux of short-lived radium isotopes (224Ra and 223Ra) provides information regarding the extent, and the dominant processes governing sediment-water column exchange in the North Sea. For this purpose we employed three independent measurement techniques including sediment incubation chambers, water column inventories, and a surface mass-balance. Incubation results from 11 stations indicate significant spatial variability in Radium efflux throughout the North Sea, as well as a strong dependence on the stirring rate of the overlying water column. Both inventory and mass-balance methods yield consistently higher benthic fluxes for the Southern North Sea than incubation-based estimates due to the inability of the laboratory incubations to recreate the in-situ mixing conditions present in the well-mixed Southern North Sea. Furthermore, fluxes in the Southern North Sea are higher than those previously reported in other regions, likely due to high rates of sediment irrigation induced by strong tidal and wind mixing near the interface of permeable sandy sediments. The seasonality of distributions and the magnitudes of both benthic and coastal Ra fluxes are further examined by applying Ra as a passive tracer in the 3-dimensional hydrodynamics of the ECOSMO model. Finally, flux estimates combined with direct measurements of porewater Ra activities yield volume fluxes [L m-2 d-1], which when further applied to porewater concentrations of carbon or nutrient species, can provide important information regarding the role of sediments in North Sea biogeochemistry.