

Combining beryllium and thorium isotope analysis to quantify the atmospheric fluxes of trace elements from sea ice melting to the ocean

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Understanding and quantifying the fluxes of chemical elements across the atmosphere-ocean-continent interfaces, transported by different vectors (wet and dry deposition, river discharge, sediment resuspension), is a key objective to better represent the role of the ocean in climate models and constrain ocean biogeochemical cycles. Assessment of these fluxes is especially critical in areas that significantly contribute to cool the Earth's climate and undergo rapid climate-driven changes, such as the Arctic Ocean. In polar regions, sea ice is a particularly dynamic vector of chemical elements of different origins that remains poorly constrained. When seawater freezes and turns into sea ice, it becomes a natural barrier between the ocean and the atmosphere, that can intercept a significant amount of atmospheric elements. But it also traps chemical elements of seawater during its formation, which are released into the water column when the ice melts. Building on geochemical approaches developed in the last decade using thorium (^{230}Th - ^{232}Th) or beryllium (^7Be , ^9Be - ^{10}Be) isotopes to quantify lithogenic or atmospheric fluxes to the ocean, we present a new multi-tracer approach combining this set of isotopes to constrain the atmospheric lithogenic flux added to the ocean by sea ice melting. This includes a novel application of the cosmogenic nuclide ^{10}Be to quantify atmospheric deposition in sea ice. First, we present a successful chromatographic method for the separation of Th and Be, with yields > 90% and low blanks (< 0.25%). Using this method, we characterise the first concentration profiles of ^{10}Be and ^{232}Th in Arctic sea ice (from cores collected in July 2022 close to the North Pole). The results demonstrate a strong atmospheric contribution in ^{10}Be in the upper sea ice layer (0-18 cm) but a much lower contribution of atmospheric ^{232}Th in this same layer, suggesting the involvement of other ^{232}Th sources in the upper sea ice. Based on these initial results, we can estimate the atmospheric flux of ^{10}Be and ^{232}Th added to the ocean by sea ice melting. Our results demonstrate that ^{10}Be is a promising tracer to quantify and discriminate atmospheric fluxes to the ocean through sea ice melting.