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Sorting and degradation of permafrost-derived organic carbon during across-shelf transport in the Laptev and East Siberian shelves

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The flux of permafrost-derived organic carbon to the vast Siberian marginal seas has been receiving growing attention because its magnitude is expected to considerably increase due to changes in both river discharge and coastal permafrost stability. To what extent this relocated terrigenous organic carbon (TerrOC) pool will affect climate and biogeochemistry is currently unknown but it will largely depend on its reactivity in the marine environment. This study seeks an improved mechanistic understanding of TerrOC cycling during across-shelf transport in the vast East Siberian Arctic Seas (ESAS). Surface sediments were collected in both river-dominated and coastal erosion-dominated regions as well as at increasing distances from the shore. The organic composition in different density, size and settling velocity fractions was characterized using bulk parameters (δ13C and Δ14C) and terrigenous biomarkers including CuO-derived reaction products (lignin phenols and cutin acids) and solvent extractable HMW lipids (n-alkanoic acids, n-alkanols and n-alkanes).
Key insights were gained by understanding how different TerrOC pools, operationally defined at bulk and molecular level, are distributed among different density, size and settling velocity fractions and how they change over the margin in relative concentration and composition. Our results show that the partitioning and mobility of TerrOC pools is intimately linked to density and size of particles. A large fraction of TerrOC entering the margin is associated with large, lignin-rich plant fragments which are hydrodynamically retained in coastal sediments. The across-shelf transport of TerrOC occurs primarily in the form of mineral-bound OC through the preferential mobilization of fine lithogenic particles rich in HMW lipids. Despite the mineral-association, noticeable decrease of TerrOC was observed at molecular and bulk level which indicates extensive degradation during transport across the margin. Altogether our results indicate that, considering the susceptibility of TerrOC towards degradation during transport, the expected increase of river runoff and coastal erosion in the Siberian region followed by TerrOC mobilization across the shelf will likely represent a positive feedback to climate (e.g., increased pCO_2) and it will affect the Arctic biogeochemistry (e.g., ocean acidification).