Modern and Holocene fluxes of sediment and organic matter into the Arctic Ocean

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Warming in the Arctic is expected to be roughly twice as high as the global mean. Sea ice extent is declining dramatically over the last years and favors accelerating coastal erosion. With erosion rates as high as 25 m yr^{-1}, the release of organic carbon and nutrients from permafrost coasts has dramatic impacts on the global carbon cycle, on nearshore food webs and local communities which are still relying on marine biological resources for food security.

During the Holocene, the delivery of sediments, nutrients, particulate organic carbon (POC) and dissolved organic carbon (DOC) varied in response to temperature and relative sea level changes. Phases of increased material input could serve as an analogue for future erosion scenarios. In the past, changing inputs of sediments, carbon, and nutrients may have altered the biogeochemical setting on the upper arctic shelves and may have impacted the global carbon cycle.

Recent flux estimates of sediment and POC from coastal erosion into the Arctic Ocean are 430 Tg yr−1 sediment and 4.9-14 Tg yr−1 POC, which is comparable to if not higher than riverine fluxes (Wegner et al., 2016). However, the fate of sediments and organic carbon once eroded from the cliff remains largely unknown (Stein and Macdonald 2004) and the release of DOC from melting ground ice in permafrost cliffs has not been considered yet (Fritz et al. 2015).

Material supply over the Holocene is difficult to quantify as it depends on erosion of a coastline whose original configuration is unknown. For example, large parts of the circum-arctic shelves were subaerially exposed during the last glacial maximum (LGM) and became flooded rapidly. Consequently, erosion of coastal permafrost deposits was probably stronger in the early Holocene than today and released more sediments, nutrients and carbon. In the middle Holocene sediment fluxes in the Laptev Sea for example were more variable than today, partly due to rising sea level, spatially and temporally variable flooding of bathymetric features, and coastline adjustments. With coastline retreat, the depocenters moved further southward and thereby successively reducing accumulation rates in the distal shelf areas. In other parts of the Arctic, however, glacio-isostatic rebound was significant so that global transgression was outpaced and therefore reduced shoreline retreat. Even after the modern sea-level highstand was approached around 5,000 cal BP, there is evidence that the depositional system on the shelves took time to stabilize (Bauch et al., 2001).

There are almost infinite possibilities to combine external factors determining the long-term pace of coastal erosion (e.g. climate variation, relative sea-level changes) with internal factors determining the vulnerability to coastal erosion (e.g. morphology, ground-ice content). Only a few of them can be directly measured or reconstructed throughout the Holocene. For the other factors, we need a conceptual model to start with. It is still unclear how much of the formerly dry shelf areas became subject to cliff and shoreface erosion or if they were simply flooded. The most reasonable assumption, though not quantitatively differentiated, is a combination of both processes. One the one hand, erosional discordances between late glacial terrestrial deposits and Holocene marine sediments indicate erosion. One the other hand, submarine permafrost from the LGM, which has not been eroded, is widespread too, and thus indicates preservation of terrestrial Pleistocene deposits after flooding.

In summary, quantitative estimates of erosion rates along Arctic coasts throughout the Holocene are still sparse and need substantial improvement to clarify the fate of terrigenous material in the Arctic Ocean. This is urgently needed to predict the potential impact of increasing erosion on the global climate, on regional ecosystem services and on local communities.

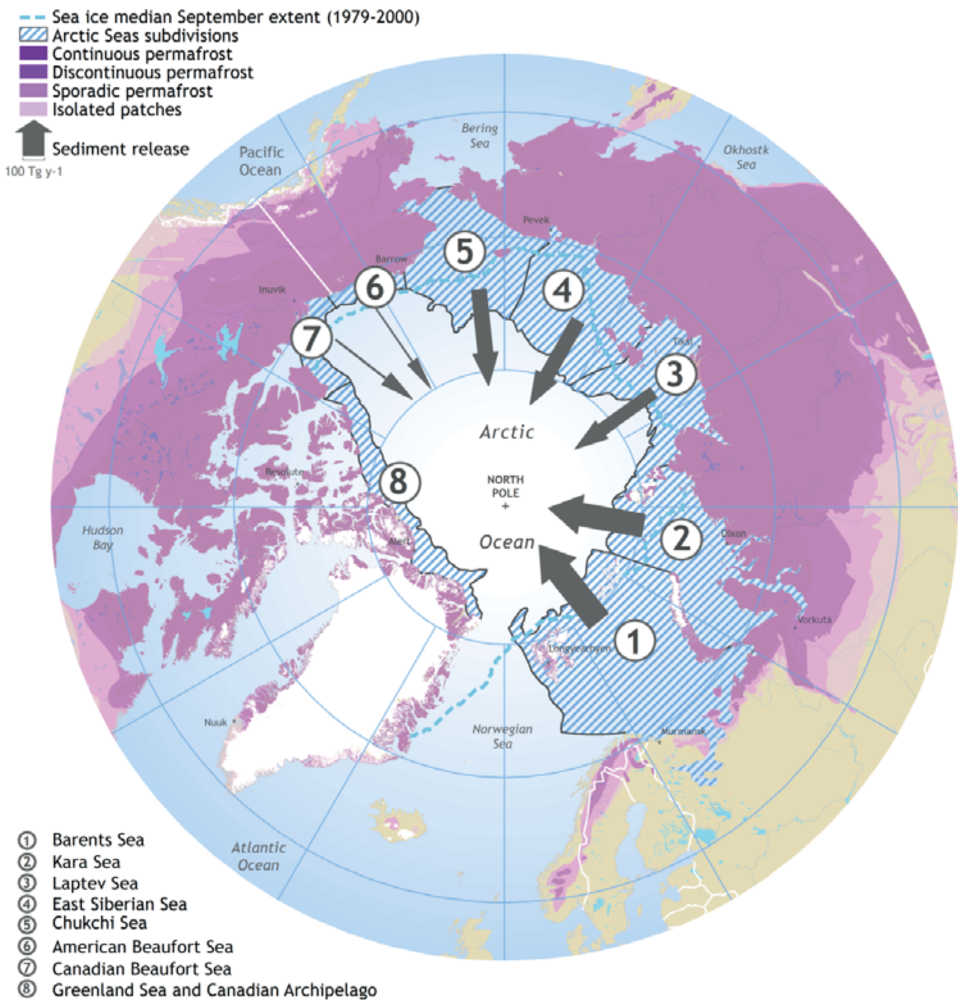

Figure 1: Modern sediment contribution (Tg y-1) from coastal erosion into the Arctic Ocean divided by marginal sea areas (Wegner et al., 2016)

References:

Bauch, H.A., Kassens, H., Naidina, O.D., Kunz-Pirrung, M. & Thiede, J. 2001. Composition and flux of Holocene sediments on the eastern Laptev Sea shelf, Arctic Siberia. *Quaternary Research* 55, 344-351.

Fritz, M., Opel, T., Tanski, G., Herzschuh, U., Meyer, H., Eulenburg, A. & Lantuit, H. 2015. Dissolved organic carbon (DOC) in Arctic ground ice. *The Cryosphere* 9, 737-752.

Stein, R. & Macdonald, R.W. 2004. Organic carbon budget: Arctic Ocean vs. global ocean. In: R. Stein, R.W. Macdonald, (eds.) *The Organic Carbon Cycle in the Arctic Ocean*. Springer. Berlin. pp. 315-322.

Wegner, C., Bennett, K.E., de Vernal, A., Forwick, M., Fritz, M., Heikkilä, M., łacka, M., Lantuit, H., Laska, M., Moskalik, M., O'Regan, M., Pawłowska, J., Promińska, A., Rachold, V., Vonk, J.E., Werner, K., 2016. Variability in transport of terrigenous material on the shelves and the deep Arctic Ocean during the Holocene. *Polar Research*.