Biogeochemical processes in Arctic rivers and the land-ocean interface

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Ongoing climate change in the Arctic is warming soils, thawing permafrost and liberating ancient carbon to inland waters. The potential for newly mobilised permafrost deposits to drive a positive feedback upon climate will depend on its geochemical composition and associated biological and photochemical reactivity within river waters, and during transport along the land-ocean interface. The sources, fluxes and fate of organic carbon (OC) in Arctic rivers are however poorly constrained. Here we examine these processes in the Kolyma River Basin, the largest arctic watershed entirely underlain by continuous permafrost. Aquatic OC composition was measured using techniques ranging from simple optical properties (absorbance and fluorescence) to high-resolution mass spectrometry (FTICR-MS). We developed relationships between optical measurements and dissolved OC (DOC) concentration and composition, enabling us to trace the temporal and spatial variability of OC flux and its quality. Collecting waters across the Kolyma network, we measure radiocarbon (^{14}C) and stable isotopes (^{13}C) on DOC to determine the age and source of DOC fueling microbial demand and photochemical losses. Permafrost-derived OC subsidised a significant proportion (13-43%) of microbial carbon utilisation across headwaters, and caused permafrost-derived OC to be preferentially removed with increasing water residence time. Permafrost OC initially contained a unique molecular FTICR-MS signature which shifted towards a more classic riverine DOC signature during microbial utilisation. Understanding the response of high-latitude river systems to future change and increasing permafrost-derived OC will require integrative studies combining OC geochemistry with measures of carbon reactivity and transformation.