

Modeling the Loading of Terrestrial Dissolved Organic Carbon to Rivers Across the Western Arctic

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Project PI: Michael A. Rawlins BER Program: TES

Project: University Project

The quantity and quality of river discharge exported by Arctic rivers is responding to overarching influences of hydrological cycle intensification and permafrost thaw, with potential implications for the magnitude, timing, and forms of biological production occurring along Arctic coastal zones. Measurements and numerical modeling of nutrient export from Arctic rivers in recent years have supported advances in our understanding of biogeochemical cycling in Arctic coastal waters. In turn, mechanistic understanding of physical processes operating within high latitude watersheds will lead to improved predictions of the impacts of climate change on regional water and carbon exports. A permafrost hydrology model with explicit representation of soil freeze/thaw dynamics, soil organic carbon content with depth, and dissolved organic carbon (DOC) leaching in runoff was used to investigate loading of riverine DOC for the Yukon and Mackenzie Rivers, and watersheds spanning the region between them, over the period 1981- 2010. Model calibration and validation is made through multi-parameter sensitivity analysis using observational records of river discharge and riverine DOC concentrations and export.

Terrestrial DOC loading is approximately 3407 Gg C yr⁻¹, with 24.1% of the total coming from the medium and small rivers with outlets between the mouths of the Yukon and Mackenzie Rivers. The model simulations capture the observed variability in riverine DOC export dynamics and reflect the timing and magnitude of the observed DOC concentrations and stream discharge, though loading for the Mackenzie River is overestimated due to a positive bias in river discharge relative to observed annual totals. Most notably the modeling captures the characteristically high DOC concentrations observed during the spring freshet and relatively lower concentrations that arise through flow from deeper soil horizons as thaws progresses. Spatial estimates of DOC area yield and riverine DOC loading reflect the overarching influences of runoff yield, the proportion of subsurface/surface runoff, and soil organic carbon content. The model simulations point to a strong influence from DOC export on the magnitude, timing, and forms of biological production across the region's coastal zones. The synthesis of data and modeling helps to advance understanding of how climate warming manifested through water cycle intensification and permafrost degradation is likely to impact terrestrial water and carbon exports to Arctic coastal areas.