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Early Melt Season Variability of Fast Ice Degradation Due to Small Arctic Riverine Heat Fluxes

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Abstract : In order to determine the importance of small-system riverine heat flux on regional landfast sea ice breakup, our study explores the annual spring freshet of the Sagavanirktok River from 2014-2019. Seasonal heat cycling ultimately serves as the driving mechanism behind the freshet; however, as an emerging area of study, the extent to which inland thermodynamics influence coastal tundra geomorphology and connected landfast sea ice has not been extensively investigated in relation to small-scale Arctic river systems. The Sagavanirktok River is a small-to-midsized river system that flows south-to-north on the Alaskan North Slope from the Brooks mountain range to the Beaufort Sea at Prudhoe Bay. Seasonal warming in the spring rapidly melts snow and ice in a northwards progression from the Brooks Range and transitional tundra highlands towards the coast and when coupled with seasonal precipitation, results in a pulsed freshet that propagates through the Sagavanirktok River. The concentrated presence of newly exposed vegetation in the transitional tundra region due to spring melting results in higher absorption of solar radiation due to a lower albedo relative to snow-covered tundra and/or landfast sea ice. This results in spring flood runoff that advances over impermeable early-season permafrost soils with elevated temperatures relative to landfast sea ice and sub-ice flow. We examine the extent to which interannual temporal variability influences the onset and magnitude of river discharge by analyzing field measurements from the United States Geological Survey (USGS) river and meteorological observation sites. Rapid influx of heat to the Arctic Ocean via riverine systems results in a noticeable decay of landfast sea ice independent of ice breakup seaward of the shear zone. Utilizing MODIS imagery from NASA’s Terra satellite, interannual variability of river discharge is visualized, allowing for optical validation that the discharge flow is interacting with landfast sea ice. Thermal erosion experienced by sediment fast ice at the arrival of warm overflow preconditions the ice regime for rapid thawing. We investigate the extent to which interannual heat flux from the Sagavanirktok River’s freshet significantly influences the onset of local landfast sea ice breakup. The early-season warming of atmospheric temperatures is evidenced by the presence of storms which introduce liquid, rather than frozen, precipitation into the system. The resultant decreased albedo of the transitional tundra supports the positive relationship between early-season precipitation events, inland thermodynamic cycling, and degradation of landfast sea ice. Early removal of landfast sea ice increases coastal erosion in these regions and has implications for coastline geomorphology which stress industrial, ecological, and humanitarian infrastructure.

Keywords : Albedo, freshet, landfast sea ice, riverine heat flux, seasonal heat cycling
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