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Ultra-high resolution assessment of potential impacts of vegetation shadows on satellite-derived spectral signals from small thermokarst lakes in the boreal forest-tundra transition zone (subarctic Canada)

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Warming of the circumpolar north is accelerating permafrost thaw, with implications for landscapes, hydrology, ecosystems and the global carbon cycle. In subarctic Canada, abrupt permafrost thaw is creating widespread thermokarst lakes. Little attention has been given to small waterbodies with area less than 10,000 m^2, yet these are biogeochemically more active than larger lakes. Additionally, the landscapes where they develop show intense shrubification and terrestrialization processes, with increases in area and height of shrub and tree communities. Tall vegetation that is colonizing waterbody margins can cast shadows that impact productivity, thermal regime and the water spectral signal, which in satellite data generates pixels with mixed signatures between sunlit and shaded surfaces. We undertook UAV surveys using optical and multispectral sensors at long-term monitoring sites of the Center for Northern Studies (CEN) in subarctic Canada, from the sporadic (SAS/KWAK) to the discontinuous (BGR) permafrost zones in the boreal forest-tundra transition zone. This ultra-high spatial resolution data enabled spectral characterization and 3D reconstruction of the study areas. Ultra-high resolution digital surface models were produced to model shadowing at satellite overpass time (WorldView, PlanetScope and Sentinel-2). We then analyzed the impacts of surrounding vegetation and cast shadows on lake surface spectral reflectance derived from satellite imagery. Ultra-high resolution UAV data allows generating accurate shadow models and can be used to improve the assessment of errors and accuracy of satellite data analysis. Particularly, we identify different spectral signal impacts of cast shadows according to lake color, which highlight the need for special attention of this issue onto lakes with more turbidity.

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