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Lichens and mosses moisture content assessment in the Hudson Bay Lowlands through hyperspectral remote sensing technology

T. Neta(1), **Q. Cheng(1,2)**, R. Bello(1), B. Hu(1,2)

(1) Geography Department, York University, Toronto, Ontario, Canada, (2) Department of Earth and Space Sciences and Engineering, York University, Toronto, Ontario, Canada (talineta@gmail.com)

The Hudson Bay Lowlands (HBL), the second largest contiguous peatland worldwide, is characterized by polygonal peat plateau, tundra, moss and lichen covers, wetlands, and sparse forest. Changes in moisture conditions as a result of climate change will have a remarkable impact on the local vegetation composition of the HBL. This will also influence the exchange of greenhouse gases (i.e. CO_2, CH_4) between the surface (both terrestrial and open water) and the atmosphere. For better understanding of changes in this northern peatland regime as a result of climate change, accurate estimates of moisture content are required. Lichens and mosses are sensitive indicators of northern peatlands moisture. Previous studies have been conducted either in field conditions, where weather and accuracy restrictions exist, or under laboratory setting, where the natural moisture conditions of the samples were not preserved. The current study conducts spectral reflectance measurements of lichens and mosses in laboratory conditions, while maintaining the natural moisture conditions of the plant samples. A ground-based hyperspectral spectrometer has been used to measure spectral reflectance of four representative subarctic lichen and moss species. The mosses are *Tomenthypnum nitens* and *Dicranum elongatum* and the lichens are *Cladina stellaris* and *Cladina rangiferina*. The lichen and moss samples have been returned to the field consistently, once spectral measurements were conducted in laboratory setting, to represent the peatlands natural moisture conditions. The data were collected during the 2006 and 2007 summers, southwest of the Churchill Northern Studies Centre (CNSC;

58.73˚N, 93.79˚W), Churchill, Manitoba vicinity. Lichen and moss canopy moisture content measurements were made by using weighing lysimeters. This was validated by hyperspectral optical to near-infrared (400-1100 nm) data in 2006, and optical to middle-infrared (400-2400 nm) records in 2007. The potential of spectral reflectance indices was examined as well, in order to evaluate the plants moisture content. For the data obtained in August 2006, variations in spectral signatures as a result of changes in moisture content are distinctive in the NIR (near-infrared) band. For all species, moisture variability is significantly greater in 2007 versus 2006. Consequently, changes in the 2007 reflectance data of *Dicranum elongatum* and *Cladina stellaris* were seen in the entire spectrum (400-2400 nm). For *Cladina rangiferina*, greater moisture variability did not significantly influence the spectral reflectance observed in the visible range (400-700 nm), though these changes were fairly clear for the NIR and MIR (middle-infrared) region (740 to 2400 nm). For *Tomenthypnum nitens*, changes in moisture content levels impact the spectral reflectance in the MIR region only (1100-2400 nm). For all species, two water absorption signatures are centered at approximately 1490 and 1980 nm, which are fairly clear for both high and low moisture content levels, however, when the plants moisture content is reduced, these water absorption signatures result in higher reflectance values. A third water absorption signature, centered at approximately 1200 nm, is noticeable when the moisture content is high, yet is not clear once moisture content is reduced. For all species, a flattening of the overall reflectance occurs in the MIR portion of the spectrum, as a result of high moisture content values. The data obtained in August 2006 display significant relationship among the *WBI* (water band index; $R_{920}/minR_{(960-1000)}$) values and the moisture content of *Tomenthypnum nitens* (r = 0.84), *Dicranum elongatum* (r = 0.75), *Cladina stellaris* (r = 0.70), and *Cladina rangiferina* (r = 0.71). For the 2007 data, increased plant moisture content was accompanied by increased values of the spectral indices *NDII (normalized difference infrared index;* $(R_{820} - R_{1600})/(R_{820} + R_{1600})$) and *NDWI (normalized difference water index;* $(R_{860} - R_{1240})/(R_{860} + R_{1240})$).For the spectral indices *MSI (moisture stress index;* $avgR_{1550-1750}/avgR_{760-800}$)and *Simple ratio* ($R_{1600}/R_{820}$) increased plant canopy moisture content resulted in reduced values (R represents reflectance values in nm). The *NDII* spectral index was found to be most successful in identifying plant canopy moisture content for all species (average r are 0.72, 0.76, 0.81, and 0.76 for *Dicranum elongatum*, *Tomenthypnum nitens*, *Cladina stellaris* and *Cladina rangiferina*, respectively). It is likely that the great variations in the reflectance values of all species among the 820 nm and 1600 nm wavelength range are the cause for the better relationships achieved by the *NDII*. In addition to moisture content, further factors may affect the spectral reflectance; pigmentation, non-homogeneity of the plant samples, chlorophyll levels, pollution, plants biomass, and other factors. Various levels of moisture at the canopy, center and bottom of the plant, might influence the spectral reflectance as well. The plant canopy moisture content may be different from the entire plant moisture content calculated, and thus, misrepresent the entire sample moisture content. Therefore, correlation coefficients among spectral reflectance indices and plants moisture content are not as significant as they could have been by using controlled laboratory conditions, where samples are hydrated and dehydrated artificially. In addition, all of the above indices have not been tested previously on the above moss and lichen species. Therefore, development of further species specific indices is planned to be made in future studies, to yield better relationships with these plants moisture content.