A COMPARISON OF SATELLITE DERIVED VERSUS *IN-SITU* CHLOROPHYLL VALUES ON TWO MANITOBA GREAT LAKES

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INTRODUCTION

Millions of dollars are spent each year in Canada on protecting waterways from urban and agricultural pollutants, including excess nutrients and keeping fisheries healthy. Increasingly limited funding of federal and provincial agencies charged with environmental protection has led to reduced temporal and spatial water quality monitoring in Manitoba, so that lake management is increasingly based on insufficient data.

The waters of Lakes Winnipegosis and Manitoba are Case II waters, meaning their optical properties are influenced not only by phytoplankton (chlorophyll-a) but also by total suspended sediments (TSS) and coloured dissolved organic matter (CDOM). Large areas in these lakes are very shallow, so that either bottom reflectance (depths vary from 2 - 9 meters) or submersed vegetation add more complexity, making it difficult to monitor chlorophyll-a and TSS with both precision and accuracy. In other large lakes in the Canadian prairies (e.g. Lake Winnipeg and Lake of the Woods), local calibration using *in situ* data has been useful for retrieval of these parameters.

METHODS

In the open water seasons in 2016 to 2017, surface and bottom water quality samples were taken at 43 stations throughout Lakes Manitoba, Winnipegosis and Waterhen. Sites were sampled three times per year (spring, summer and fall) to capture a variety of open water conditions. At selected sites, a field spectrometer (ASD fieldSpec Pro) was used to measure surface reflectance over the spectral range used by ocean colour satellites.

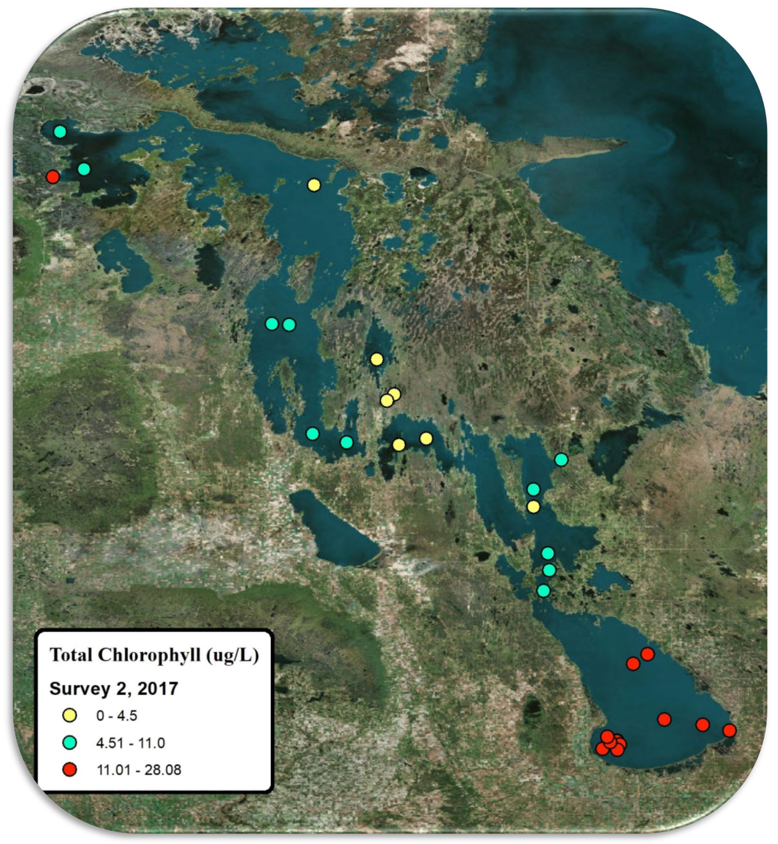

Figure 1. 2017 sample sites showing total chlorophyll (µg L^{-1})

METHODS

Matched water samples for chlorophyll (chl), total suspended solids (TSS), coloured dissolved organic matter (CDOM) and major algal groups (by microscopy) were analyzed . SNAP software (Eurosat MERIS and OLCI analysis software) was used to calculate surface reflectance data and physical products - αpig (algal pigments), chl concentrations and suspended particulate matter (spm) from matched Sentinel-3 OLCI images. This data was compared with *in situ* chlorophyll and TSS as a preliminary investigation of the suitability of OLCI for optical monitoring in these great lakes.

Temperature values within the algorithm were inputted to reflect the actual temperature on the sample dates for which good satellite images occurred. Salinity was changed to 0.5 psu to reflect freshwater.

Surface water samples are also subsampled into 20 ml glass scintillation vials and preserved with Acid Lugols for algal identification and quantification. A subset of surface water samples are settled using a 2 ml settling chamber, and counted using a Leitz diavert inverted microscope.

RESULTS

Total chlorophyll concentration (µg L^{-1}) in Lakes Manitoba and Winnipegosis is highest during the summer months. Values are similar, and range from 0.5 – 34 µg L^{-1} in Lake Manitoba to 2.3 – 24.5 µg L^{-1} in Lake Winnipegosis. For simplicity, chlorophyll concentrations are shown in ranges as per the trophic status calculations of Canfield et al. (1983), which uses chlorophyll among other water quality indicators to asses the trophic status of a lake. Based on chlorophyll concentrations only, 4.5 to 11 µg L^{-1} indicates mesotrophy and above 11 µg L^{-1} indicates eutrophy.

Algal biomass during the summer in both lakes is dominated by either cyanobacteria or chlorophytes. In Lake Manitoba, cyanophyte species dominate (56 – 92% of ug/L biomass) and are made up of a mixture of filamentous blue-greens (ex. *Aphanizomenon gracile*, *Planktolyngbya limnetica* and *undulata* or colonies such as *Woronichinia klingae*. These algae do not appear to form the same surface mats that are common on Lake Winnipeg, but this may be due to the shallower lake depths and whole lake mixing that occurs on Lakes Manitoba and Winnipegosis. Figure 2 illustrates a transect of algal samples collected in the south end of Lake Manitoba (red dots, Figure 1) on August 12, 2017. This sample set was taken at the same time the ASD was used.

RESULTS

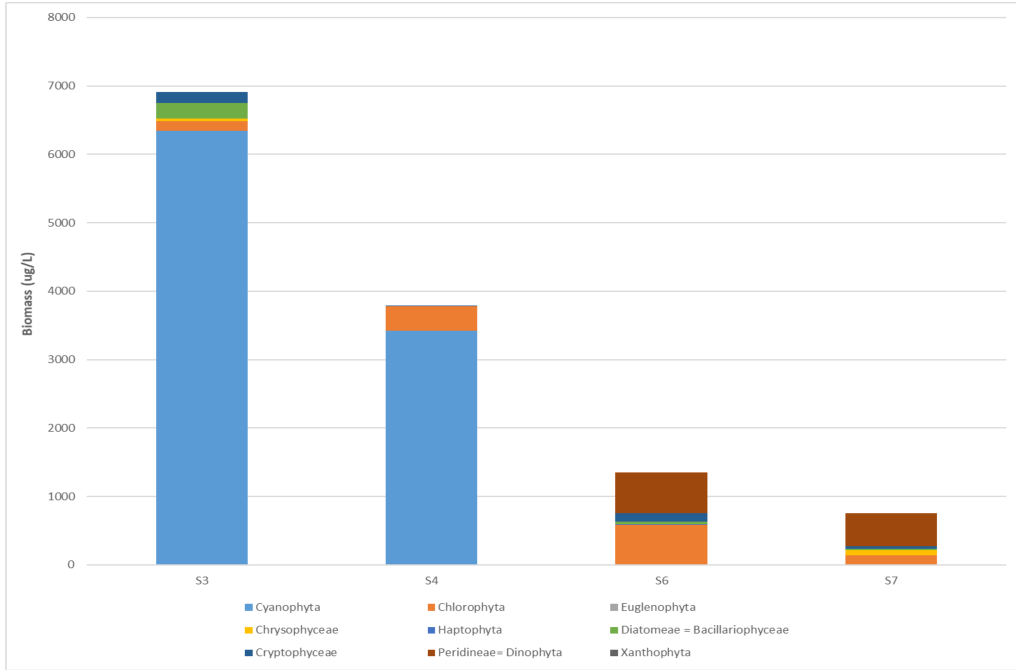

Figure 2. 2017 sample sites showing total chlorophyll (µg L^{-1})

A comparison of OLCI surface chlorophyll concentrations and *in-situ* results for specific dates on the lakes does not show an accurate calculation of chlorophyll by the default OLCI water quality processing algorithm. Figure 3 shows a Sentinel-3 satellite image from August 11, 2017, with the OLCI calculated chlorophyll values ranging from 0.0 to 6.7 µg L^{-1} .

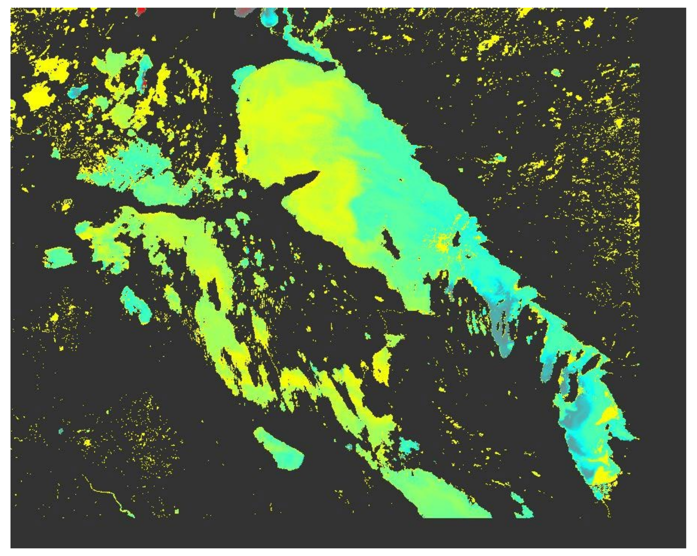

Figure 3a. Aug.12, 2017 OLCI satellite image showing total chlorophyll (µg L^{-1}). Yellow colour = 0 – 4.5 µg L^{-1}, green shows 4.5 – 6 µg L^{-1}.

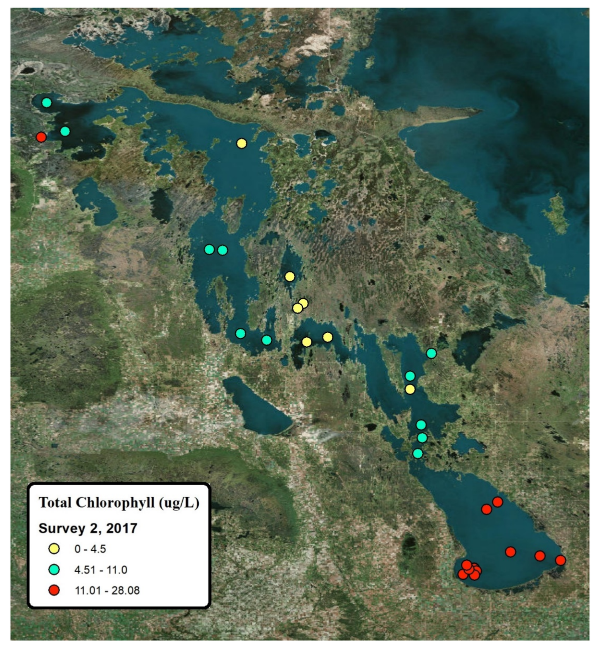

Figure 3b. *In-situ* total chlorophyll values (µg L^{-1}).

SUMMARY

Preliminary analysis shows more work and *in-situ* analysis should be conducted on these three Manitoba lakes to be able to use remote sensing as a long term monitoring tool.

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