Advances in remote sensing of inland water quality and vegetation dynamics by means of Sentinel-2A and Landsat-8 data. Application in an Arctic river basin (Nunavik, Canada)

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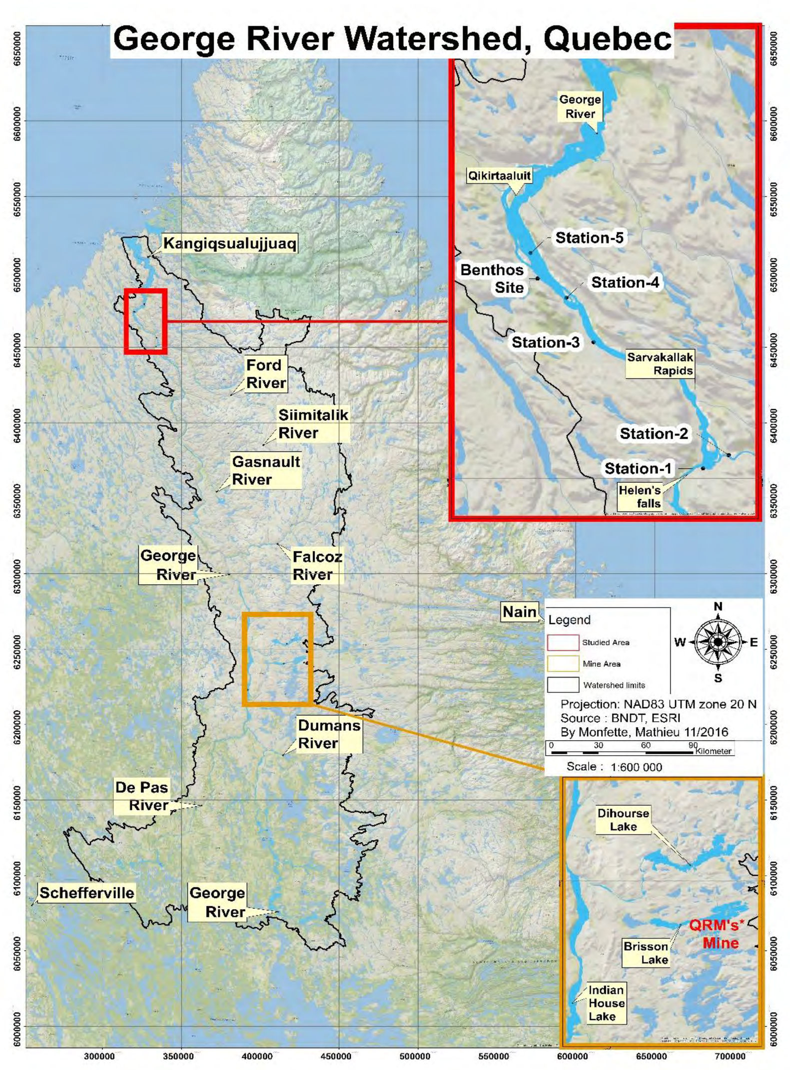
CONTEXT

This study is focused on the George River watershed in Nunavik, northern Quebec (Canada). The river drains an area of approximately 42 000 km2, and flows 565 km across the Taiga Shield from its headwards at Lake Janniere to it's outlet on Ungava Bay. Our local study site (N 58º10'/ W 65º50') is situated to the south of Kangiqsualujjuat; the easternmost Inuit village in Nunavik. Few studies have investigated hydrologic processes and vegetation dynamics over such a large northern river basin.



GOAL and METHODOLOGY

Objective 1: Investigate the utility of remote sensing for assessing water quality and vegetation dynamics across this vast northern watershed.

(i) Relate water quality properties measured along a 35km segment of the George River (e.g., chlorophyll-a, alkalinity, turbidity, suspended sediment concentration (SSC), and water color);

(ii) Spatiotemporal patterns observed in satellite multispectral data (i.e., Landsat-8; Sentinel-2A)

Objective 2: Evaluating riparian vegetation dynamics over a 30-year period (1986 to 2016) across the George River watershed. Here, two sets of Landsat images are used for the 1986 (Landsat-5) and 2016 (Landsat-8) time periods, and are merged with a DEM (25m) provided by the Quebec Government.

This poster summarizes methods and preliminary results obtained from our initial 2016 site visit within the collaborative "Aquabio" project (OHMi).

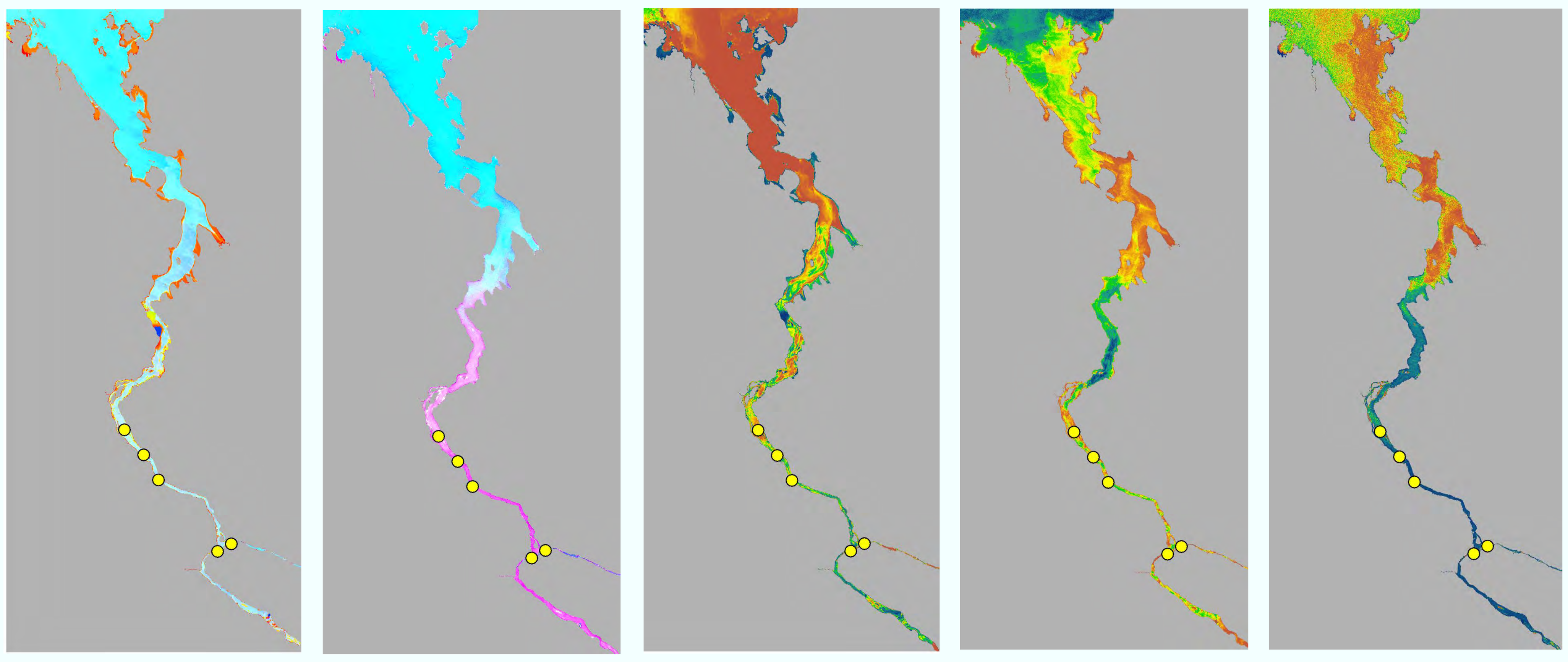
WATER QUALITY ANALYSIS

Chlorophyll: used as an indicator of change in the productivity of the river; changes indicate an enrichment of nutrients or of pollutants.
Turbidity: important optical metric of water quality, can strongly affect reflectance by reducing transmission of light through the water column. Turbidity relates to suspended sediment load, which in turn is influenced by river discharge. It may assist in identifying changes in the hydrological regime of the George River.
After geometric (DEM) and atmospheric (ATCOR/PCI) correction, spectral algorithms from the literature are applied on Sentinel-2A (07/07/2016, high tide) and Landsat-8 (27/07/2016, low tide) visible and near-infrared bands, to relate satellite data with measurements obtained during field surveys.

PARAMETER	SOURCE	L8 BANDS (MM)	S2 BANDS (MM)
CHL-A	Giardino et al., 2001	0.480-0.655	0.490-0.665
	Torbick et al., 2008	e^[0.655/0.480]	e^[0.665/0.485]
	Shafique et al., 2003	0.865/0.655	0.705/0.665
TURBIDITY (SSC)	Yamagata et al., 1988	0.655+0.865	0.665+0.842
	Shafique et al., 2003	none	0.710-0.740

Land Camp, July 2016

Laboratory analysis of water samples at fieldwork stations (yellow dots) indicate low chlorophyll-a concentration (0.1 to 0.9 µg/L) and alkalinity (CaCO3) values ranging from 2.8 to 5.13mg/L.



(A) (B) (C) (D) (E)

Figure 1: Chlorophyll (Giardino+Torbik+Shafique) for L8 (A) and S2A (B) ; Turbidity (Yamagata) for L8 (C) and S2A (D) ; Turbidity S2A (Shafique) (E).

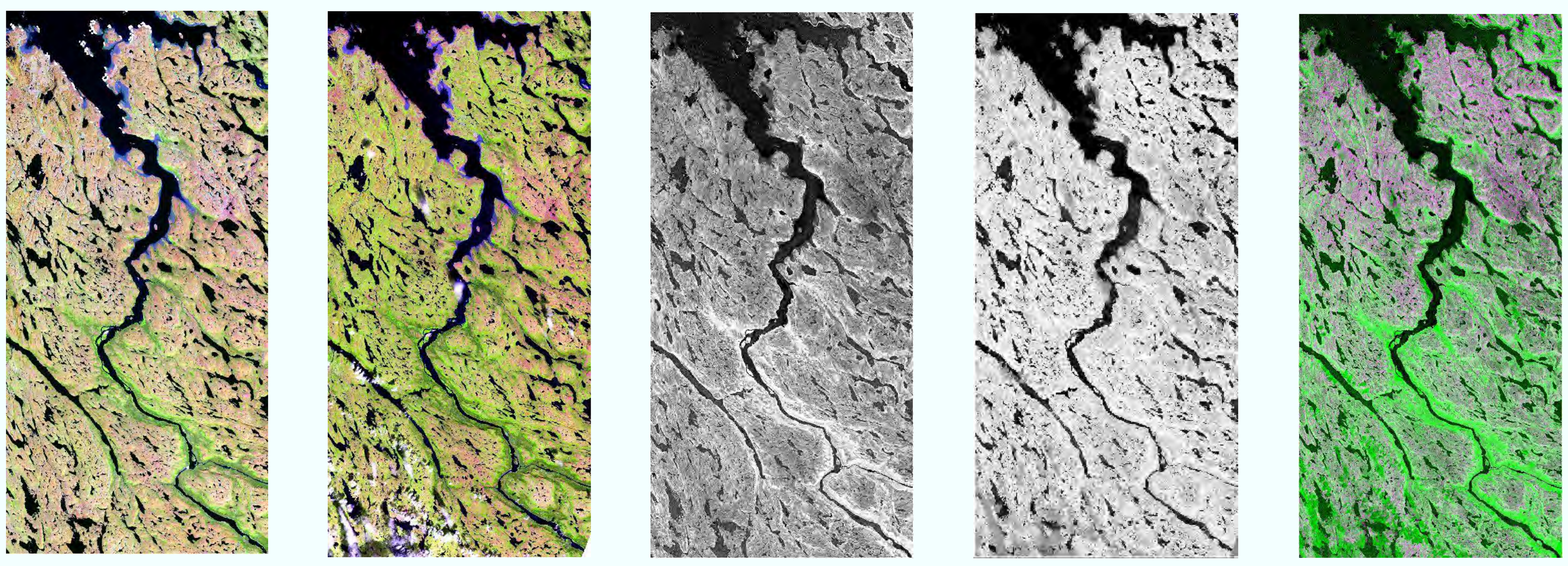
Our analysis highlights the advantage of Sentinel-2A, over Landsat-8, as the additional bands (i.e. Red Edge B5 and B6 channels) are more optimal for water quality monitoring. The additional bands allow us to benefit from previous studies relating water quality to multispectral imagery obtained from aerial surveys.

VEGETATION DYNAMICS

Recent increase in arctic vegetation is well documented using remote sensing approaches at continental and regional scale (Ju and Masek 2016). Here, normalized difference vegetation index (NDVI) are calculated for each 1986-2016 referenced dataset and their comparison exposes a significant increase of the vegetated surfaces over 30 years; a finding confirmed with historical ground photos and the local Inuit community living in Nunavik. Most notable are an increase by more than 10% of continuous cover and a reduction from 45% to 30% of shrubless/treeless sites (Tremblay et al., 2012).

1988 2008

Kangiqsualujjuaq area (George River, 58º42' N, 65º59' W)
modified from Tremblay et al. 2012



(A) (B) (C) (D) (E)

Figure 2: (A) Landsat-5 18.07.1986 ; (B) Landsat-8 27.07.2016 ; (C) 1986 NDVI; (D) 2016 NDVI; (E) 1986-2016 NDVI difference (green color). UTM20, 15 m resolution.

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