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)

* Jean-Pierre DEDIEU[1,2], Mathieu MONFETTE[3], Jan FRANSSEN[3], Thora M. HERRMANN[3], Justine-Anne ROWELL[4], Esther LEVESQUE[2,5], José GERIN-LAJOIE[2,5]

1. Univ. Grenoble Alpes, CNRS/IGE, F-38000 Grenoble, France. jean-pierre.dedieu@univ-grenoble-alpes.fr
2. Centre d'Etudes Nordiques, Univ. Laval, 2405 rue de la Terrasse, Québec, Canada,G1V 0A6
3. Univ. de Montréal, Dép. Géographie C.P. 6128, Montréal, Canada,H3C 3J7
4. Univ. de Montréal, Dép. Chimie C.P. 6128, Montréal, Canada,H3C 3J7
5. Univ. de Québec à Trois-Rivières, Dép. Sc. Environnement, C.P. 500, Trois-Rivières, Canada, G9A 5H7

* **Corresponding Author**

ABSTRACT

The continental hydrological cycle of Arctic regions is one of the least understood components of the earth's climate system. Fundamental knowledge from the fields of meteorology, geomorphology, hydrology and ecology are needed to address our lack of knowledge about the impact of climate change at multiple spatial scales (i.e., from local to global). Developments in remote sensing have made possible to visualize processes dynamics over large areas. In particular, considerable advances in optical sensors technology (high spatial and temporal resolution) now allow us to track anthropogenic impact on the Arctic environment and changes in the physical properties of its components at broad spatial scales. Here, we propose a case study of remote sensing application to continental hydrology to: (i) estimate the quality of inland waters, and (ii) track the recent evolution of riparian vegetation.

The study area is located in Nunavik, northern Québec (Canada), and concerns the George River catchment (565 km length, 41 700 km²). The local study site (N 58° 10'/ W 65° 50') is situated at the south of the easternmost Inuit village of Nunavik, Kangiqsualujjuaq (Ungava Bay); about 100 km to the west of the Torngat Mountains and the Labrador border. A fieldwork campaign for water quality measurements was conducted during summer 2016 with simultaneous remote sensing acquisition, part of a participatory program (OHMi/Nunavik) including Québec / France partnership and in collaboration with the Inuit community (Aquabio project). Community concerns over a rare earth elements (REE) mining project planned in the George River basin motivated this summer science land camp, associating the Youth of the Kangiqsualujjuaq municipality. This work will contribute to establishing current and historical conditions in this Arctic environment as a reference for future evolution.

The first objective focuses on water quality and will involve: (i) measurements of the water properties in the George River along a 35 km stretch of the river: aquatic productivity (chlorophyll-A), alkalinity,…; and (ii) remote sensing estimation of turbidity, suspended sediment concentration (SSC), and water color using multispectral data. The fieldwork results and laboratory analyses characterize the George River as having clear and soft water (neutral pH, low nutrients). These data are compared to the remote sensing multispectral information. For this purpose, two optical images of Sentinel-2A (MSI instrument/10m) and Landsat-8 (OLI instrument/15m) are used for comparison at fine scale, respectively from 07/07 and 27/07 2016. Different spectral algorithms based on visible/near-infrared ratios derived from the literature are applied to the data for quantifying their performance versus laboratory analyses of the *in situ* measurements. It is observed that for both sensors, the Blue band 1 (443 µm) is sensitive to the colored dissolved organic matter (CDOM) and increases the signal absorption, instead of the Green channel (550 µm) highly suitable for an estimation of the chlorophyll-A concentration. Furthermore, the specific Sentinel 2A "Red edge" strait channels B5 (705 µm) and B6 (740 µm) could better perform to retrieve water turbidity/SSC than the larger Red and NIR bands of the Landsat-8 platform, likely due to the low sediment concentration at our measurements sites.

The second objective focuses on evaluating riparian vegetation dynamics over a 30-year period (1985 to 2015) over the entire George River catchment, merged with a DEM (10m) provided by the Quebec Government. Two sets of Landsat images are used under mosaicking for the 1985 (Landsat-5) and 2015 (Landsat-8) time periods. Normalized difference vegetation index (NDVI) are calculated for each referenced dataset and their comparison exposes a significant increase of the vegetated surfaces; a finding confirmed with historical ground photos and interviews with members of the local community. These results highlight the recent and startling pace of environmental changes occurring in this Arctic region over the last 30 years.