Environmental study of the George River watershed (Nunavik, Québec)

Impacts of climate and societal changes

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(Photo M. Monfette, 2017)

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CENTRE D'ÉTUDES NORDIQUES
CEN Centre for Northern Studies

LabEx DRIIHM · CNRS · Investissements d'avenir · OHMI Nunavik Tukisigasuaqatigit · IGE · Université de Montréal · UQTR Savoir. Surprendre.

International Symposium of LabEx DRIIHM
Inter-Disciplinary Research Facility on Human-Environment Interactions - ANR-11-LABX-0010
October 7th-9th, 2019 – ENS Lyon (France)

OUTLINE

Background

- A climate change and societal evolution context
- Research in Nunavik digest

Scientific application and results

- Water quality and chemistry (contaminants)
- Ecological study (Arctic greening)
- Interactive mapping (CBEM)

Motivation

- OHMI-Nunavik and Imalirijiit project design

Conclusions and outlook

- Take home message

Background

❖ Climate trends

- *A worrying context for Arctic and Subarctic regions*:

Since 2000, Arctic surface air T° increased at more than double the global average. Winter (January-March) near-surface temperature positive anomalies of **+6°C** (relative to 1981-2010) recorded in the central Arctic during both 2016 and 2018.

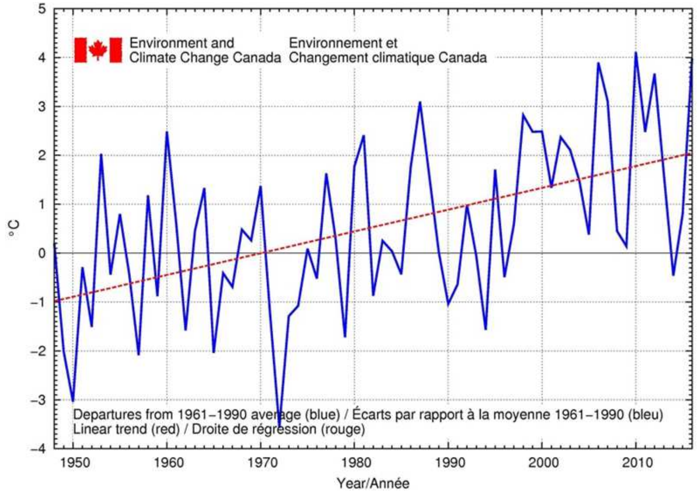
➡ Tomorrow (2050): **+4-7°C** mean annual year T° in the Arctic

Source: **Summary Report, Ocean and Cryosphere in a Changing Climate (SROCC), IPCC, Sept 2019.** ***https://report.ipcc.ch/srocc/pdf/SROCC_FinalDraft_FullReport.pdf***

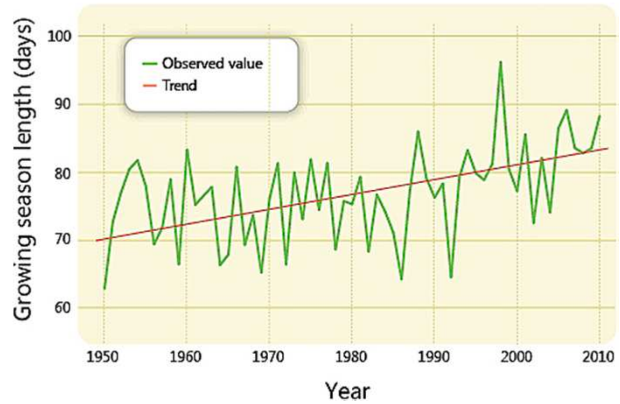
- *Changes, consequences and impacts*:

Projections indicate: decrease of **snow** cover duration impacting hydrology budget, ground-ice loss and **permafrost** degradation, **sea**-level rise, **ecosystems** changes impacting on livelihoods (local population).

Source: **Canada's Changing Climate Report (CCCR), Sept 2019.** ***https://changingclimate.ca/CCCR2019/***



Winter pan-Canadian temperatures, long-term-trend 1948-2016



Growing season, long-term-trend 1950-2010 (Natural Resources Canada)

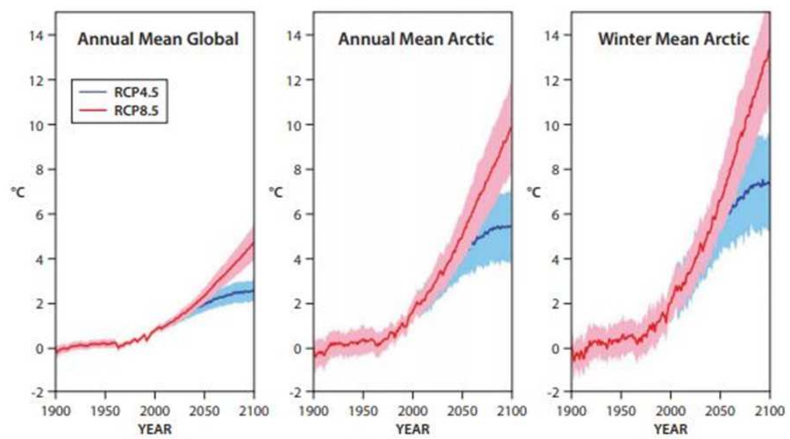
Background

❖ Societal evolution

- *Climate change key impacts*:

- Snow cover and frozen ground change mechanisms affect local people <u>because they have lives and culture strongly linked to the cryosphere</u>.

- Landscape species evolution or salinity increasing in fresh water will impact on settlement trends and other human dimensions (food, traditionnal culture).



Projected changes in global and Arctic Temperatures *(CCCR, 2019)*

- *Active awareness and strategy of local population*:

Inuit Tapiriit Kanatami (ITK), 1971, non-governmental organization, and the National Inuit Strategy on Research (NISR) document, 2018:

- ”Climate action in Inuit Nunangat must be based on an Inuit vision of our resilience in the face of our rapidly changing environment.”
- “Collaborative working relationships between Inuit knowledge and outside partners are necessary for transformative climate action in Inuit Nunangat.”

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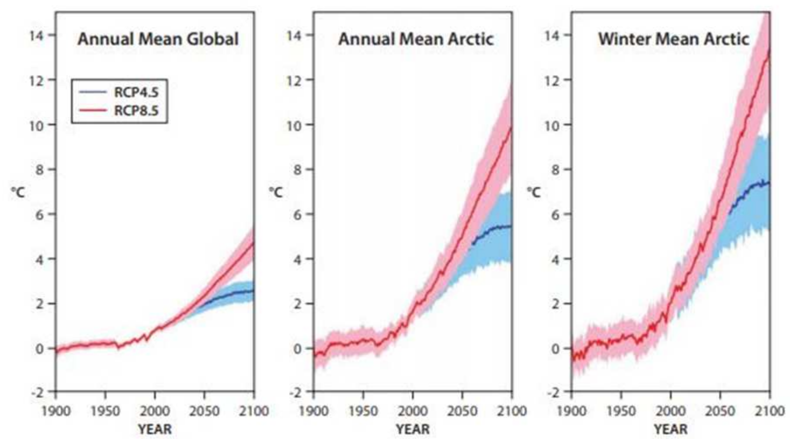

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The five interconnected Inuit climate priorities

Background

❖ Research in Nunavik

A consistent body of Canadian Institutions and multidisciplinary scientific projects

NUNAVIK:
450 000 km^2
13 000 h, 14 villages,
The northern part of Quebec province above the 55th N parallel

The founding act =
Baie James and Northern Quebec Convention (CBJNQ), 1975.

- KATIVIK Regional Government (KRG), 1978, https://www.krg.ca/en-CA/
- MAKIVIK Corporation and CRN, 1978, https://www.makivik.org/fr/gouvernement-du-nunavik/

- Centre d'Études Nordiques (CÉN), 1961, http://www.cen.ulaval.ca/
- Institut Nordique du Québec (INQ), 2018, https://inq.ulaval.ca/

- ArcticNet network, http://www.arcticnet.ulaval.ca
- Sentinelle Nord program, https://sentinellenord.ulaval.ca/fr/accueil
- Polar Knowledge program, https://www.canada.ca/en/polar-knowledge.html

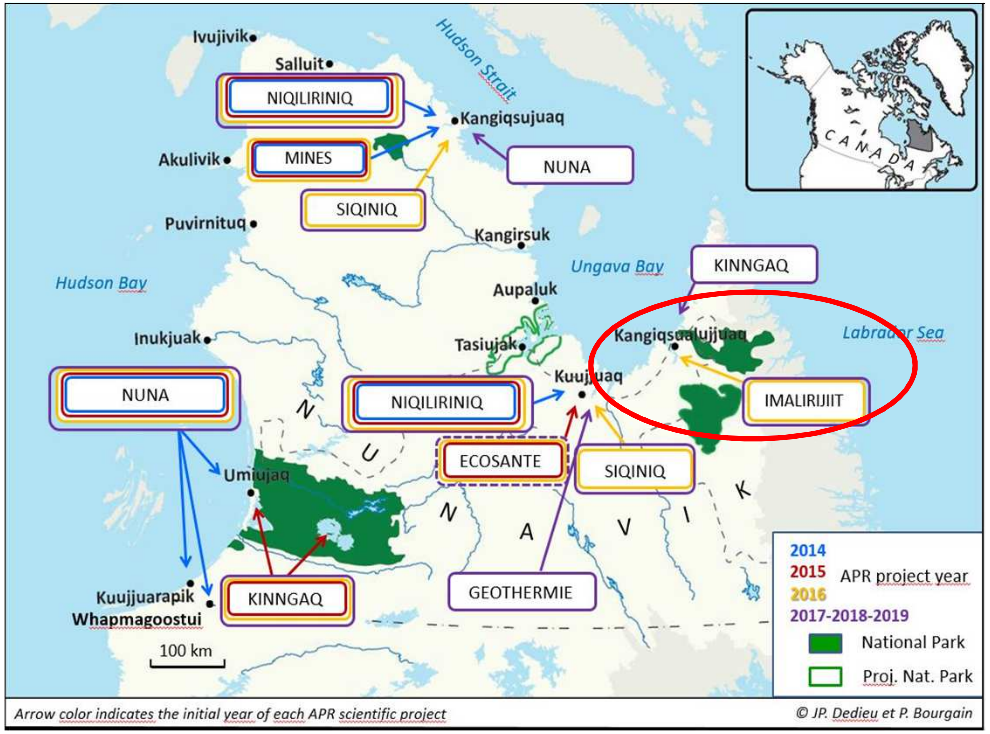
Motivation

❖ **OHMI-Nunavik** (2012)

Contextual originality of the Observatory:

- A France-Québec international collaboration set on a quadripartite collaboration between CNRS (Fr), KRG, Makivik and CEN (Can) = Memorandum of Understanding 2016-2017 & 2017-2018.

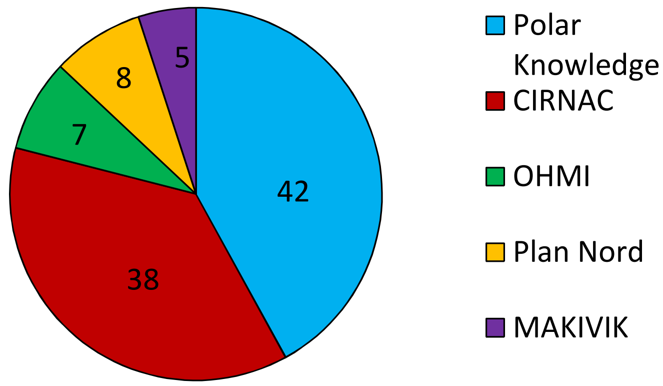
- A pluridisciplinary panel of scientific projects inter-related and dedicated to fundamental & human science.



Motivation

❖ **The IMALIRIJIIT project** (*Aquabio*)

« Those Who Study Water » Genesis :



Imalirijiit 2018-2019 fundings (%)

(CIRNAC : Indigenous Community-Based Climate Monitoring Program)

- 2015: local consultation over all Nunavik villages for a collaborative research with University-affiliated researchers set on the local population prior needs (J. Gérin-Lajoie, UTQR).
  - Positive answer and interest of the Kangiqsualujjuaq municipality (H. Snowball) for the George River watershed.

- 2016: setting-up of a long-term community-based environmental monitoring (CBEM) approach.
  - Prior objective: to determine the basic quality conditions along the George River, to the likely establishment of a mining project targering the extraction of rare earth elements (REE) in this watershed.

- 2016-2019: four years of intensive measurements collecting baseline data (water chemistry, ecological study, interactive mapping) with joint-commitment of researchers (permanent, students) and community members.
  - Design: summer Science Camps and multi programs funding => Interdisciplinary project.

Application site

❖ **George River**
Watershed: ~ 42000 km² River: ~ 600km in length

❖ **Climate** Subarctic to Arctic
450 – 800 mm total precipitation (~ 45 % as snow)

❖ **Geology** Thin soils over till or bedrock

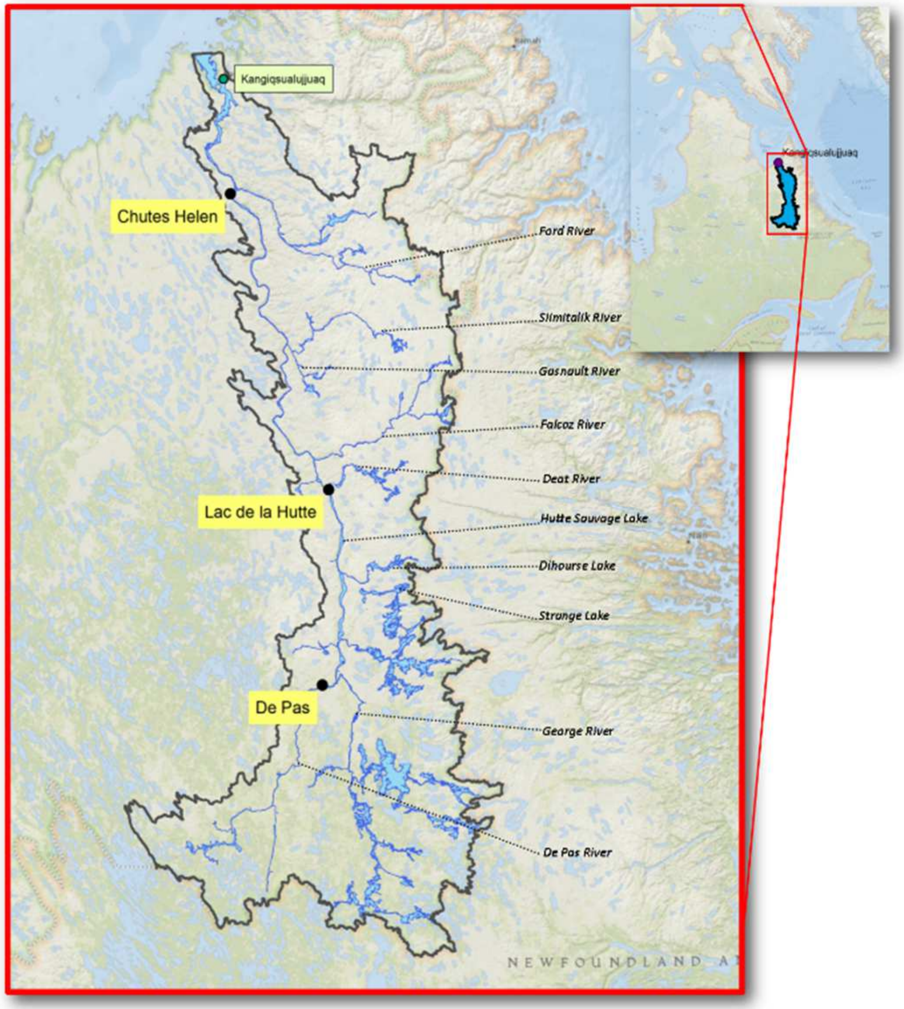
❖ **Kangiqsualujjuaq**
Population : 942 (2016), Youth 0-19 : 395 (2016)

Researchers and community members collaboration on fieldwork (Youths and Elders)

Water quality analysis (2016)

Vegetation analysis (2018)

George river watershed
Northern Quebec, Canada



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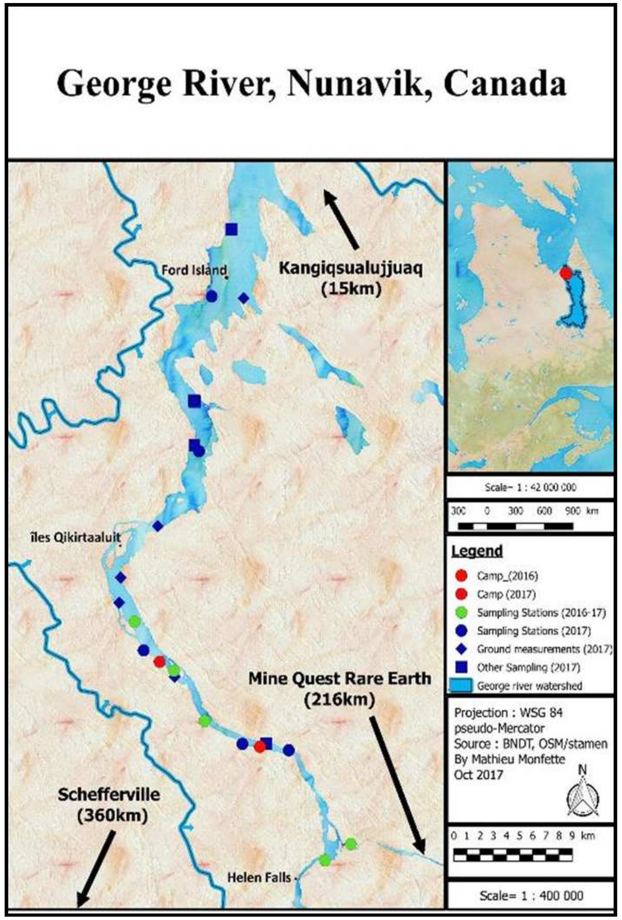
Scientific Application

1. Water quality and chemistry (contaminants)

❖ Context and Objective

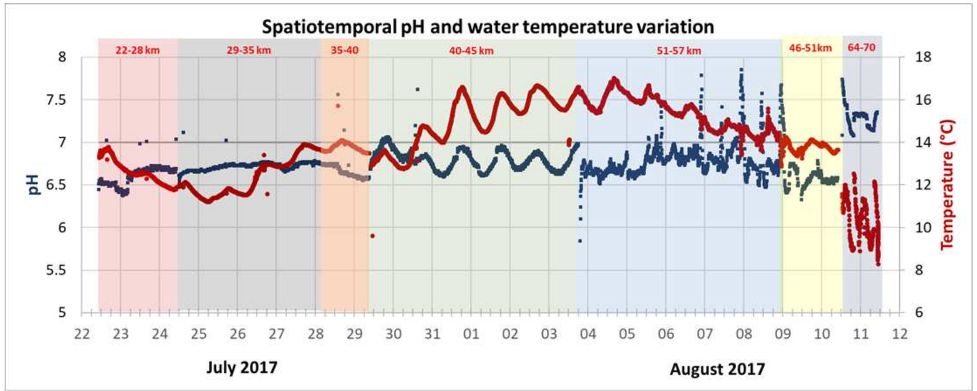
- Need of **understanding** and effective **management** of river systems requires knowledge across the full range of **spatial** and **temporal scales**.
- This knowledge is **vital** for understanding how climate change **impact freshwater ecosystems**.
- Need for development and testing of **methods**, i.e. Remote Sensing, to determine **biogeochemical water quality** parameters in **northern river** systems.
- Establish **baseline water quality** conditions in the **George River watershed** ahead of planned mineral extraction project (trace metal concentration)

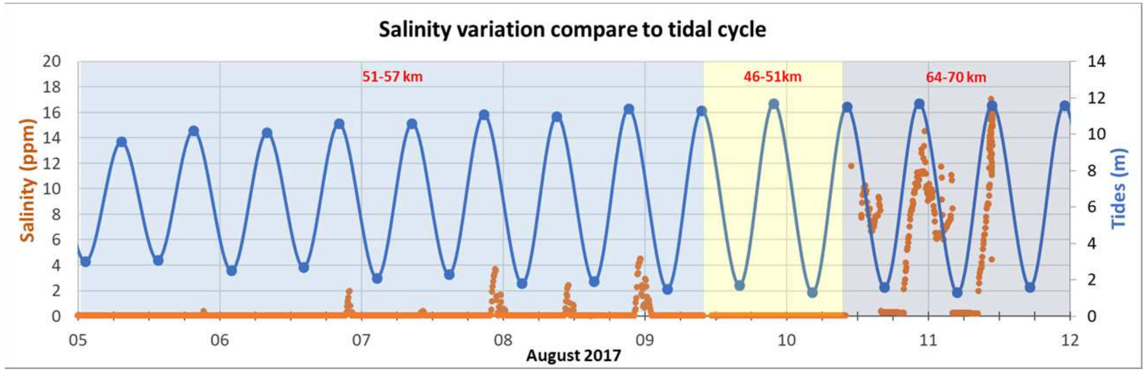


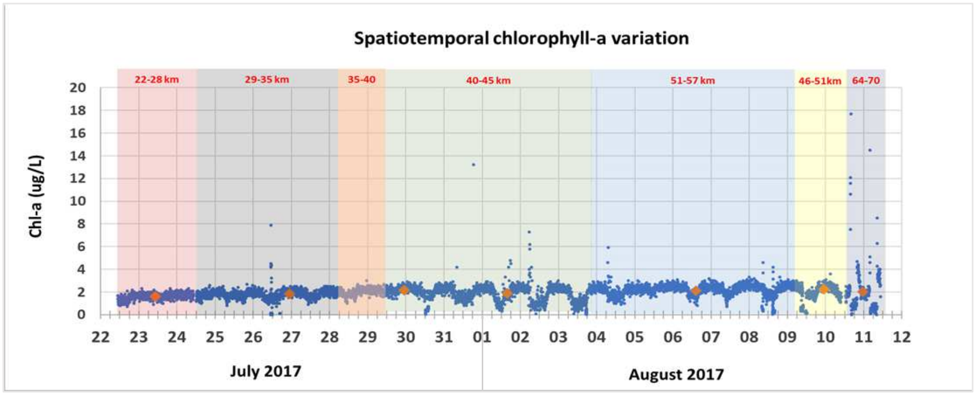
In-situ measurements location

1. Water quality and chemistry (contaminants)

❖ A/ Water quality Results







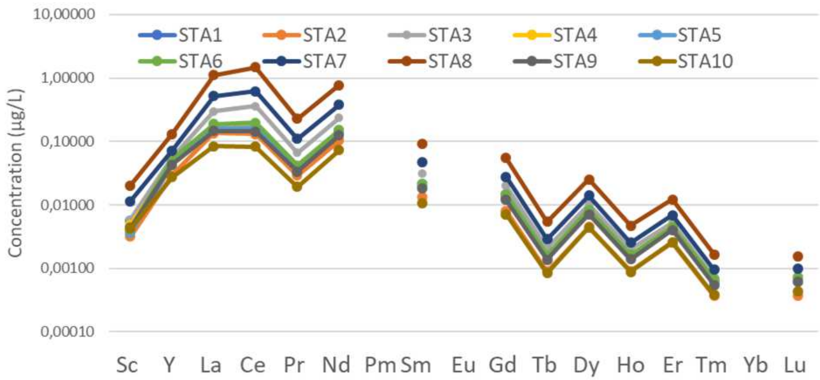
<u>Report</u> :
from both In-situ measurements and remote sensing, data indicate very low values of Chl-a, neutral pH => pure water profile (oligotrophic).

Montfette et al. (EGU 2018). Gérin-Lajoie et al. Ecoscience, 2018.

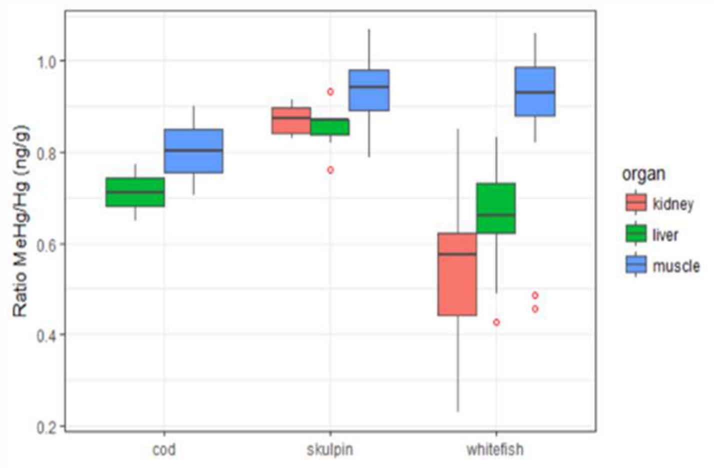
Scientific Application

1. Water quality and chemistry (contaminants)

❖ B/ Contaminants analysis Results



Rare Earth Elements concentration (µg/L) measured in water surface for 10 sites (2017)



Mercury level (ratio MeHg/Hg, ng/g) for three fish species (E. Grant, 2017)

In-situ measurements (2018)

<u>Report</u> :
from water and food chain measurements, data indicate very low values of trace metal: REE, MethylHg, Hg => non contaminated water.

MacMillan (SETAC 2019). Gérin-Lajoie et al. Ecoscience, 2018.

Scientific Application

2. Ecological study (Arctic greening)

❖ Context and Objective

- **Recent climate change** in Arctic and Subarctic regions has an indisputable impact on ecosystems and plant species distribution, documented by literature.

- **Estimate the plant species dynamics** over a 30-year time period (1985-2015) over the George River basin and track their local evolution patterns, by means of in situ observations and optical remote sensing.

- **Evaluate the capability of spectral indices** derived from visible and infra-red wavelengths for relations used to quantify vegetation properties, as the Normalized Difference Vegetation Index (**NDVI**) and the Normalized Anthocyanins Reflectance Index (**NARI**).

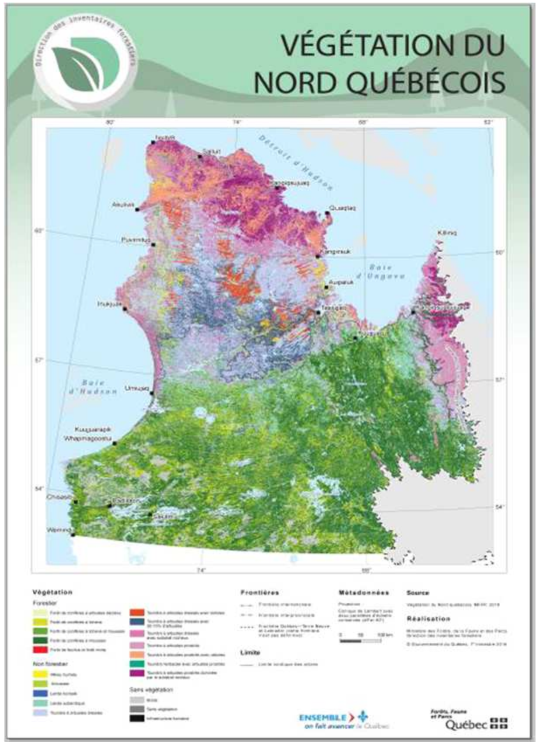
  Because shrubs surface increasing **impact on the local communities'** resources: less Ericaceae (berries).

Kangirsualujjuaq, 1988 and 2008.
(Tremblay et al. 2012)

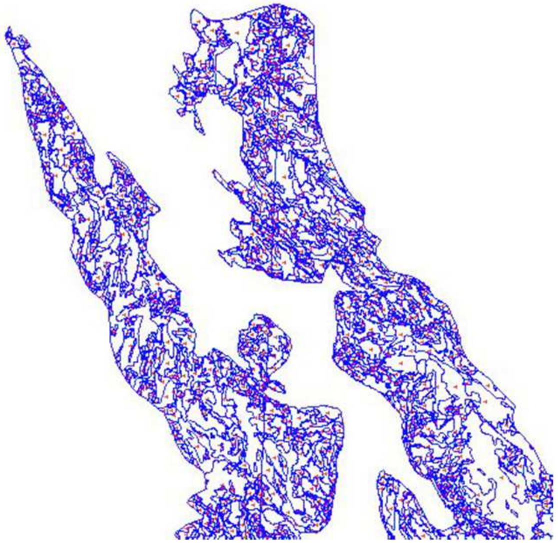
Scientific Application

2. Ecological study (Arctic greening)

❖ **Methodology:** A/ Referenced Vegetation Mapping



MRNFP Vegetation Map, 2018



Shape files extraction and centroïd calculation
for remote sensing output values overlay

Vegetation dominant types
Arctic vegetation
Sub-arctic vegetation
Boreal forest
Wetlands
Rocks and Sparse vegetation

Five land cover types
synthetic classification

Scientific Application

2. Ecological study (Arctic greening)

❖ **Methodology:** B/ Ground-thruth measurements

Transects by helicopter, 2018

A

B

C

D

A) Lichen-spruce woodland (*Cladonia* sp.)
B) Sparse moss-spruce, shrubs and lichens (*Stereocaulon* sp.)
C) Black spruce (green), larch (without needles), shrubs and lichens
D) Decideous shrubs, herbs, mosses, lichens and spruce recruits (green)

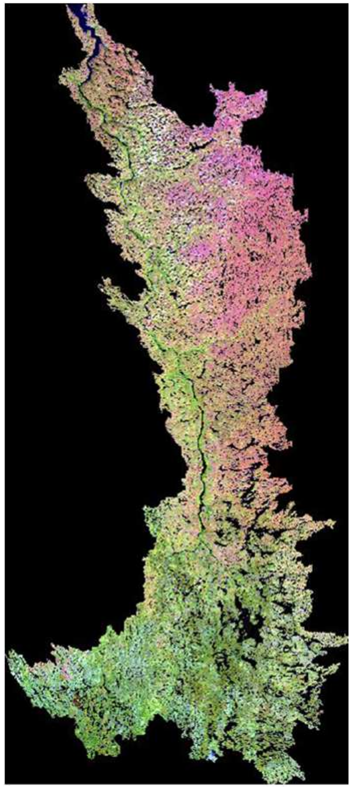
Scientific Application

2. Ecological study (Arctic greening)

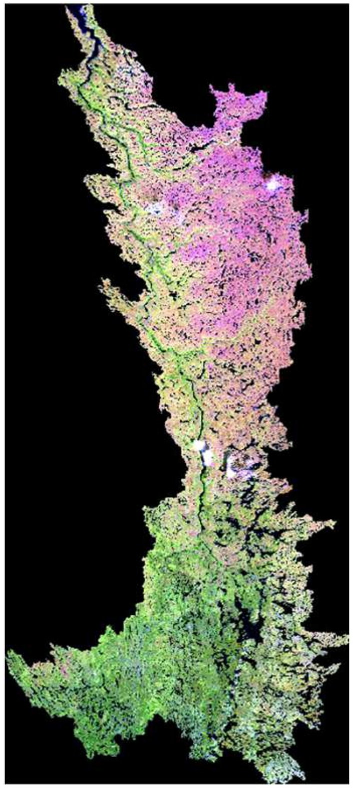
❖ **Methodology**

C/ Remote Sensing

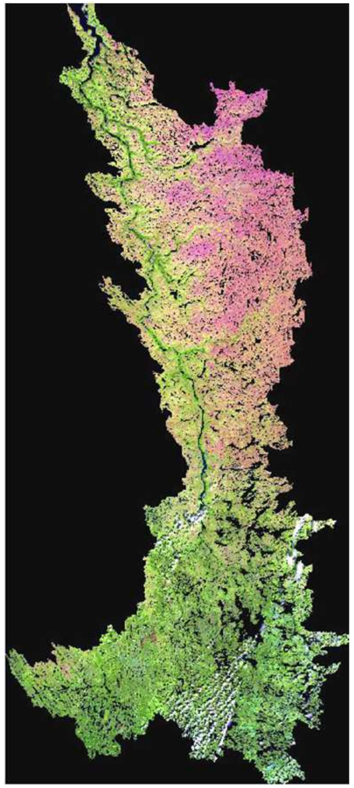
Landsat visible and infra-red composite images mosaic (~ 8 tiles per summertime period)
green : dense vegetation, magenta-orange : sparce vegetation, dark : water bodies, white: clouds



Landsat-5, 1985



Landsat-7, 2000



Landsat-8, 2015

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Scientific Application

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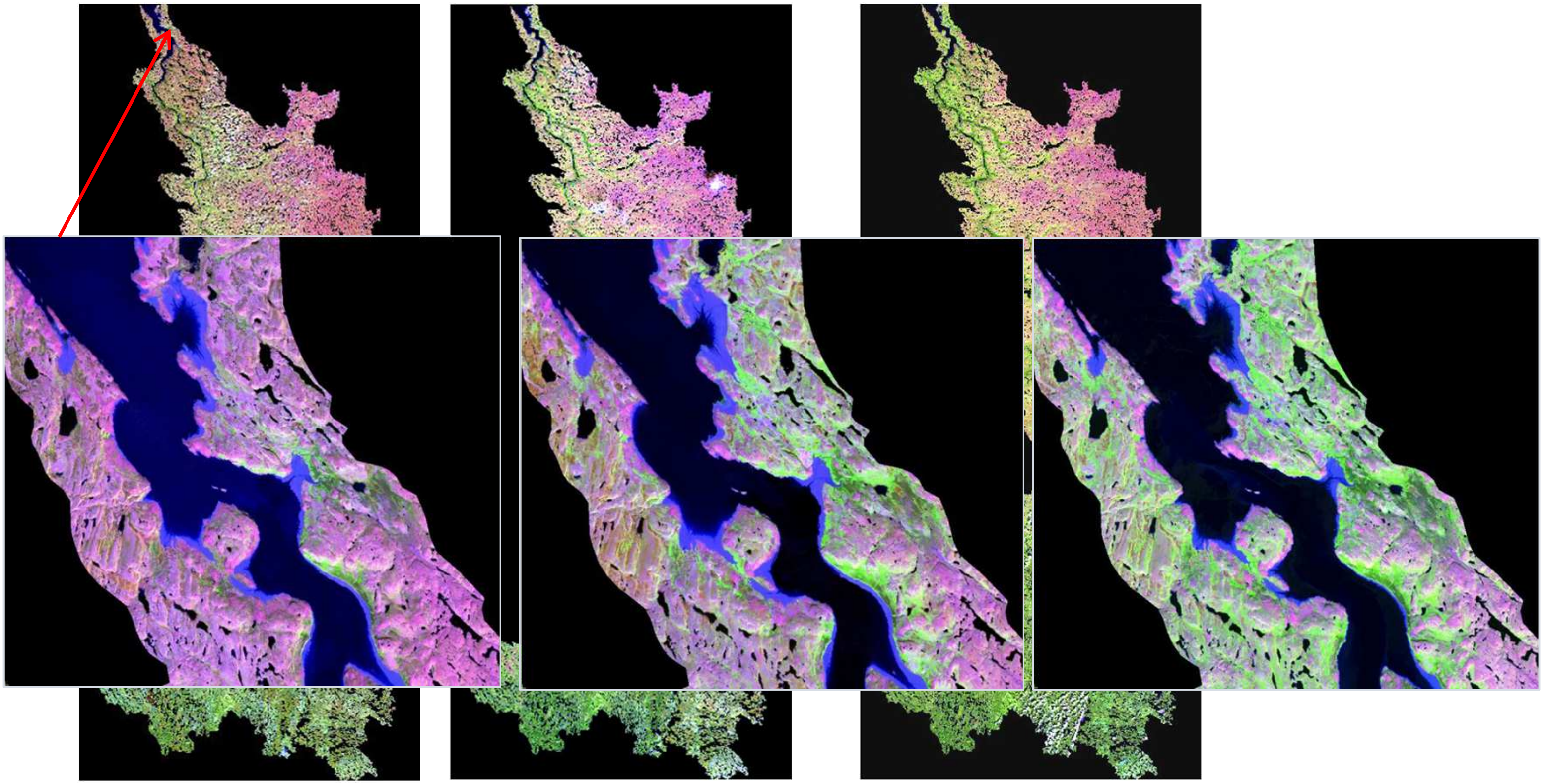
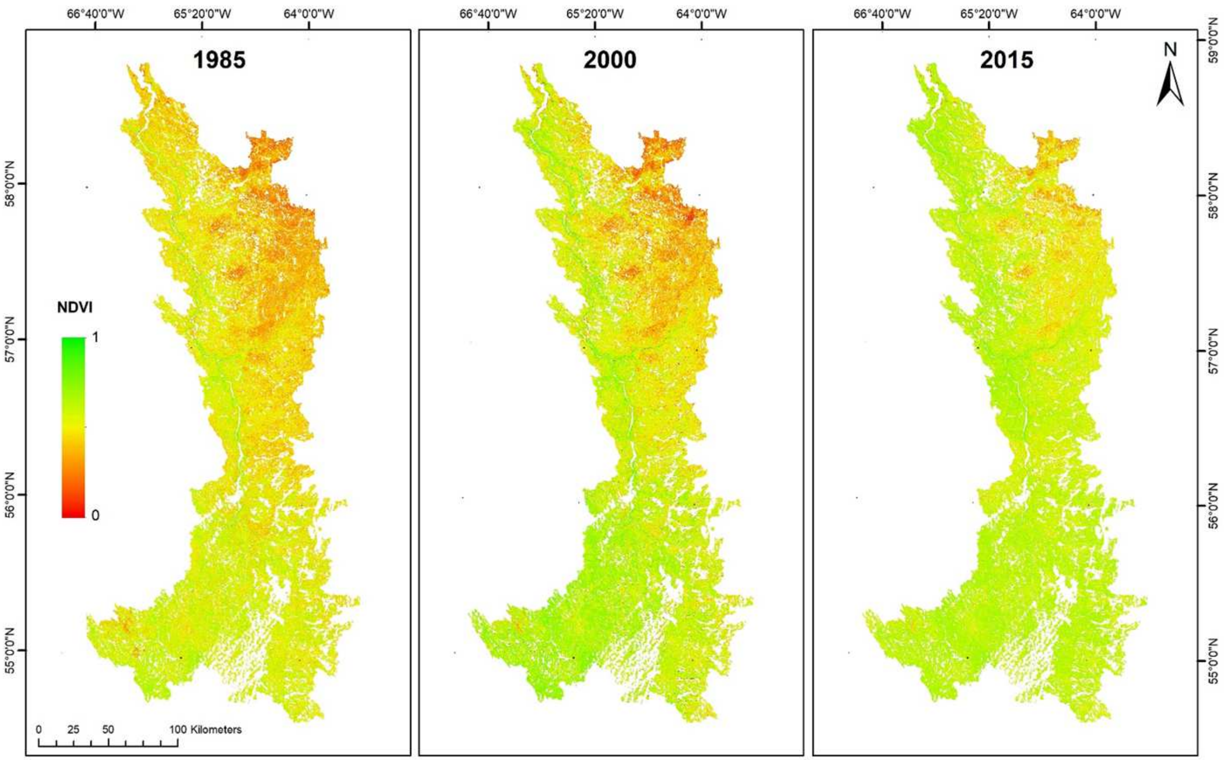


Landsat-5, 1985 Landsat-7, 2000 Landsat-8, 2015

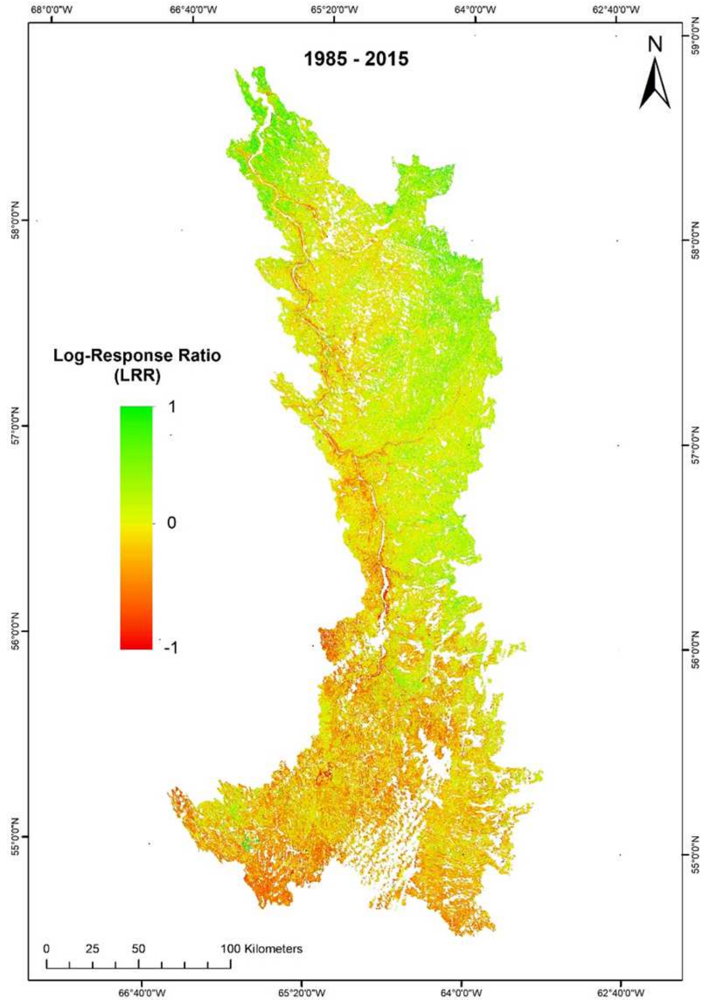
Scientific Application

2. Ecological study (Arctic greening)

❖ Results



Normalized Vegetation Index (NDVI) values



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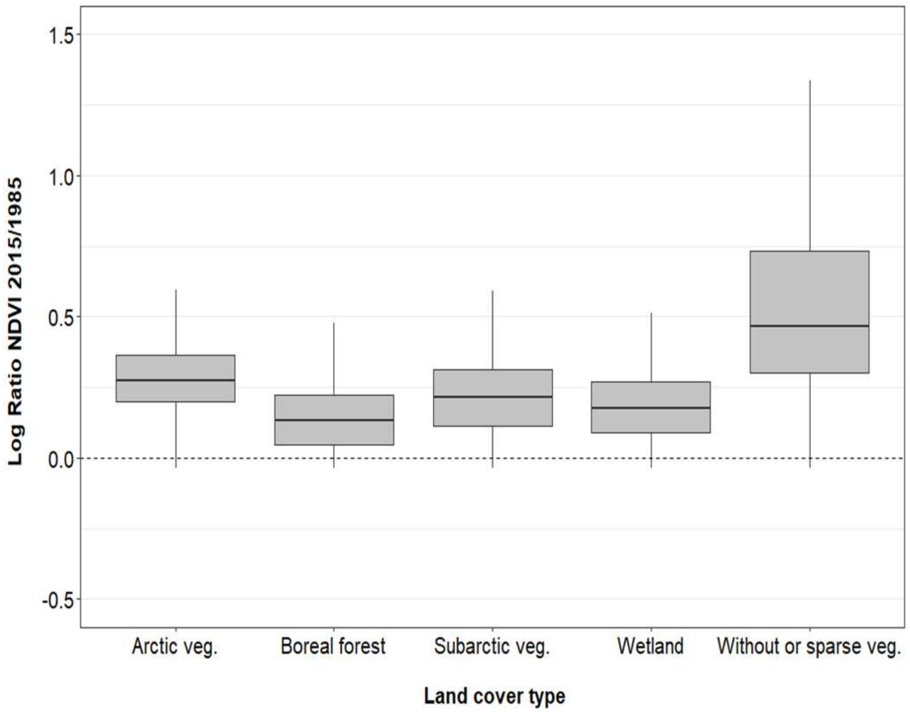


Boxplot of LRR values 1985-2015 comparison for the five vegetation dominant types

Report :
Arctic and subarctic greening affect prior the sparce vegetated areas over a 30-year time period with shrubs and birch tree densification.
Impact is serious in respect of the local food resource decrease for Inuit population (less berries).

Houset et al. (EGU 2019). Dedieu et al. for Remote Sensing, 2020.

Scientific Application

2. Ecological study (Arctic greening)

❖ **Work under progress:** NARI index application (A. Bayle, 2019-2020) helpful to monitor resources for the local communities.

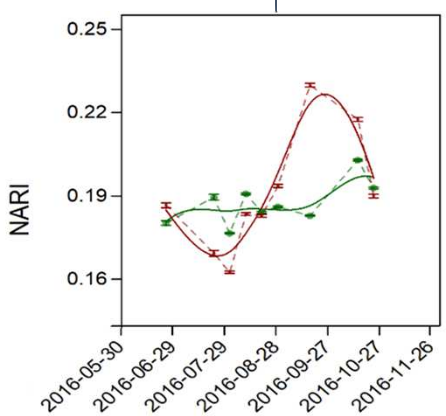
Innovative method to map shrublands dominated by Ericaceae

Some species are undergoing leaves reddening during late-fall

It is the result of anthocyanin accumulation (red pigments) in leaves

Remote sensing of anthocyanin accumulation in leaves during late-fall using Green and Red-edge bands from Sentinel-2 (Index : Normalized Anthocyanin Reflectance Index, NARI)

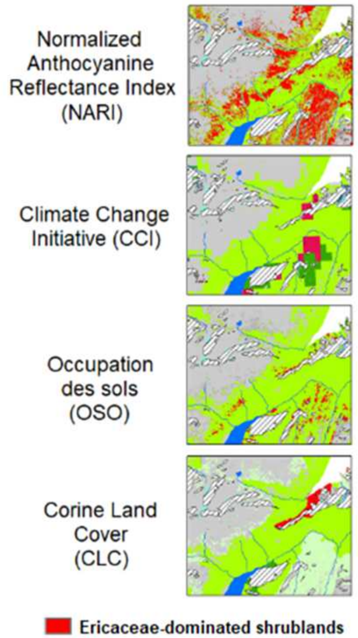
Result : Progressiv increases of NARI for
Method : Binarization of linear model slope NARI ~ Day of the year



Red : Ericaceae-dominated shrublands
Green : Grasslands productives

Mapping of Ericaceae-dominated shrublands (red) according to NARI model (top) and 3 widely-used Land Cover products

Results :
Kappa = **0.86** vs Ground-truth data
=> Estimated surfaces : x10 versus other Land Cover databases (CCI, OSO, CLC) with Kappa ≤ 0,10

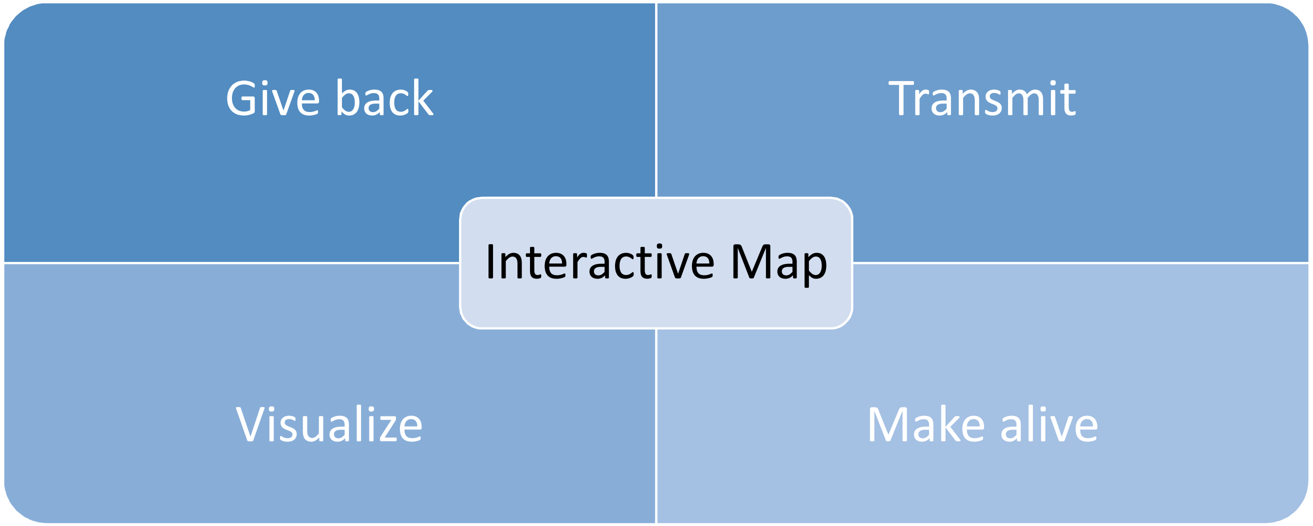


Scientific Application

3. Interactive mapping (CBEM approach)

❖ Context and Objective

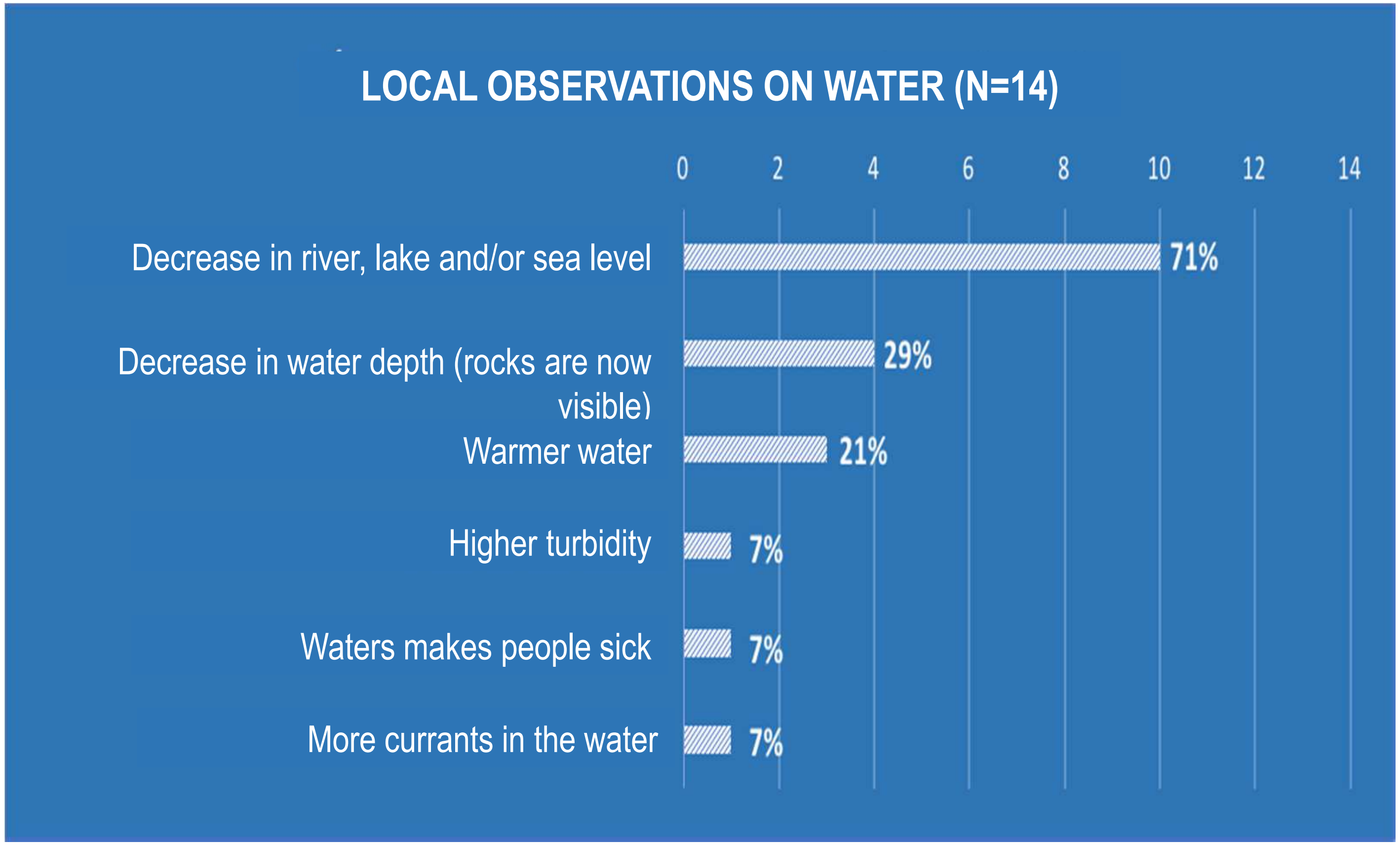
What are the best tools to represent the data measured in the territory and the local knowledge collected, in order **to share information** with the community and to locally train resources?



Scientific Application

3. Interactive mapping (CBEM approach)

❖ Inuit knowledge of observed changes in the George River watershed



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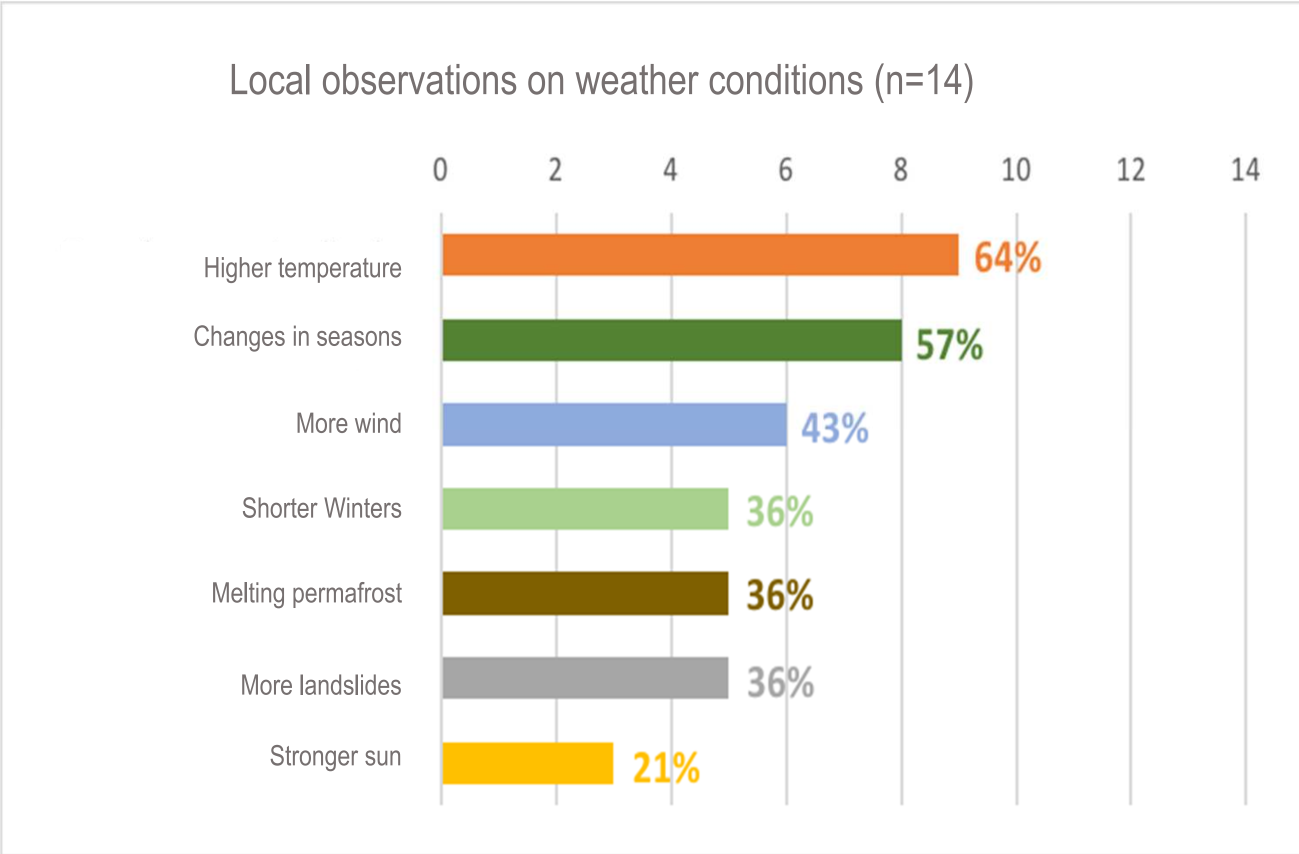

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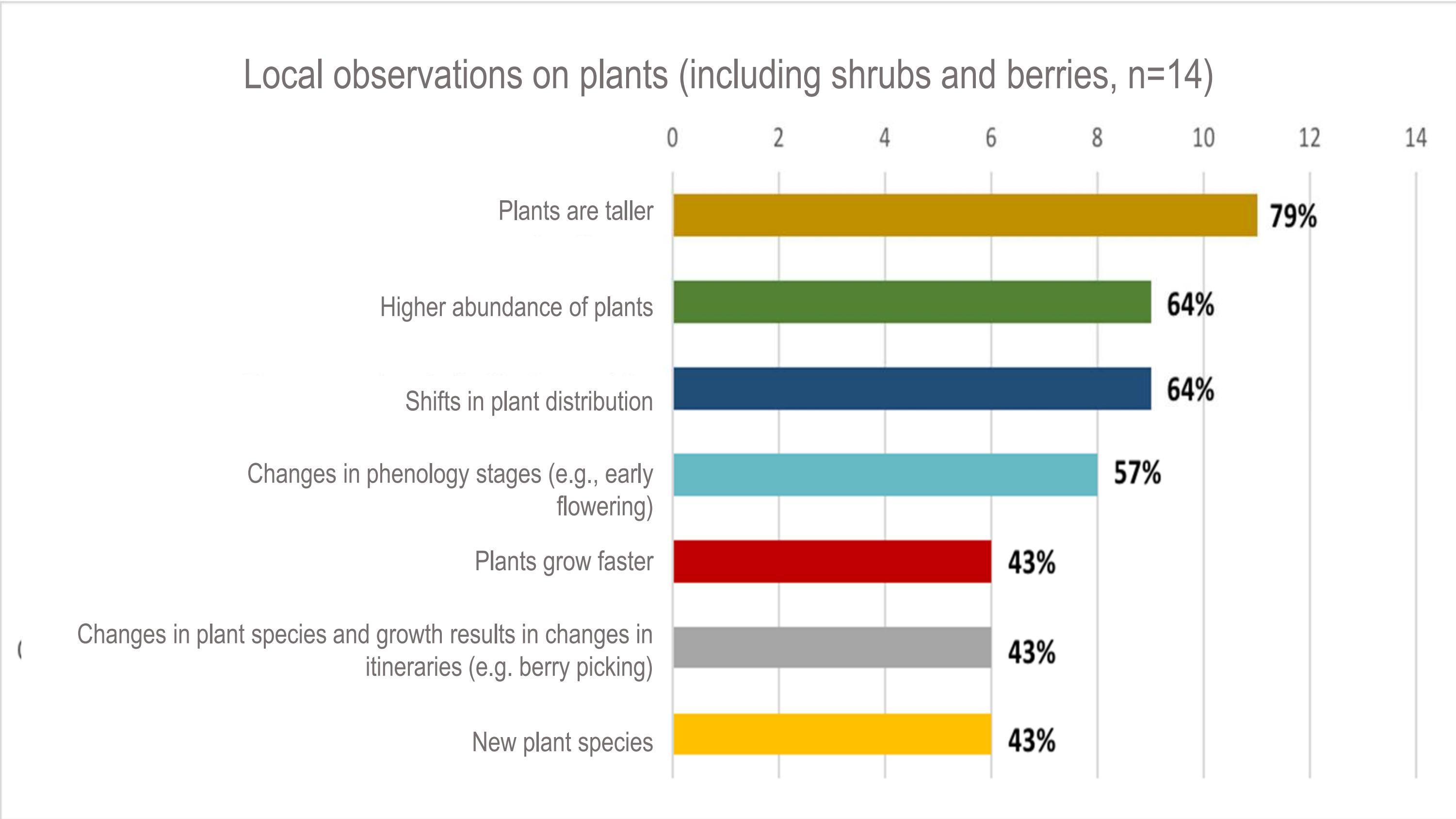
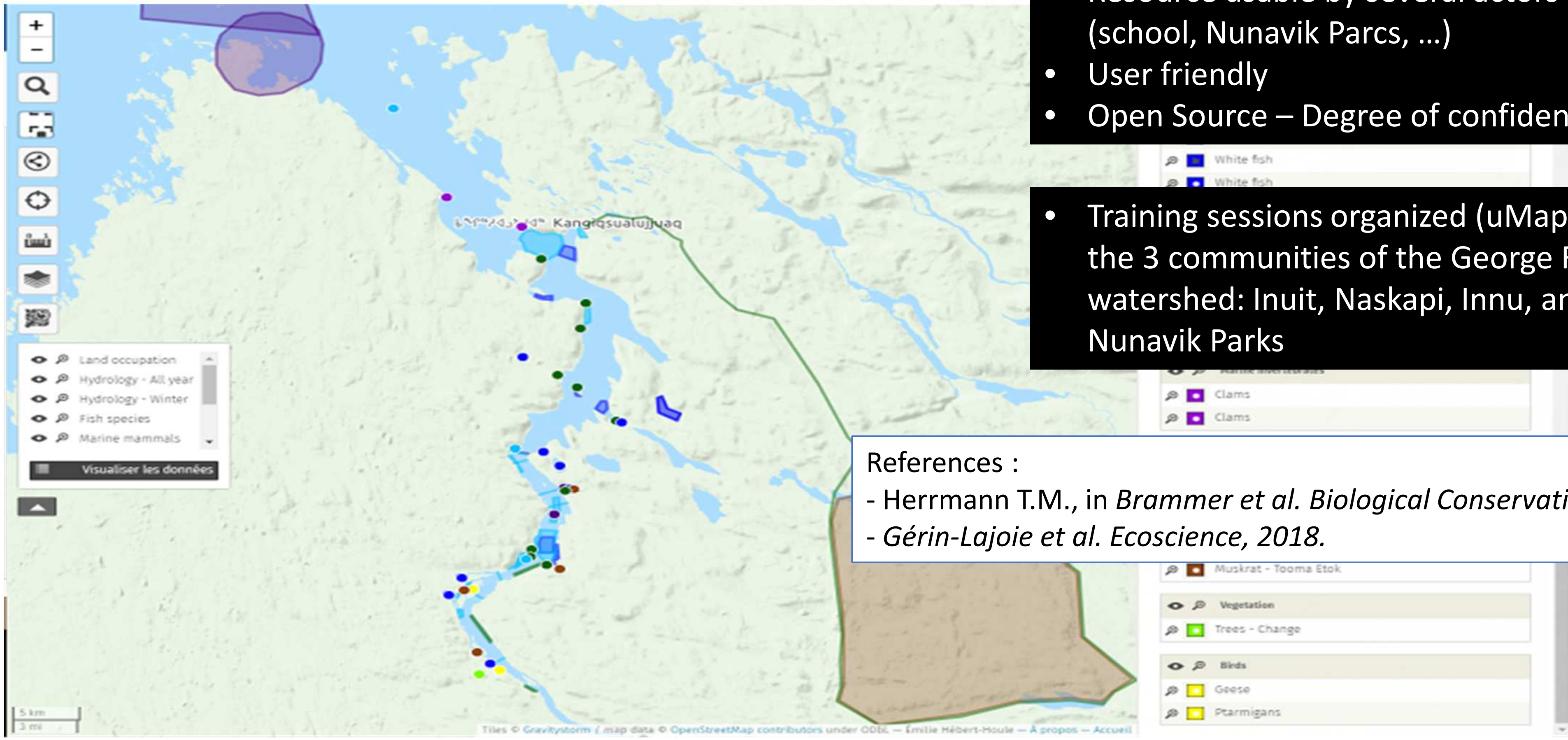


Scientific Application

3. Interactive mapping (CBEM approach)

❖ Results



- Resource usable by several actors (school, Nunavik Parcs, …)
- User friendly
- Open Source – Degree of confidentiality

- Training sessions organized (uMap) with the 3 communities of the George River watershed: Inuit, Naskapi, Innu, and Nunavik Parks

References :
- Herrmann T.M., in *Brammer et al. Biological Conservation, 2016*
- *Gérin-Lajoie et al. Ecoscience, 2018.*

Conclusions and outlook

❖ **Complementarity** of local and scientific knowledges are necessary to improve the understanding of rapidly changing Arctic ecosystems impacting on natural and human resources.
Permitting protocols for research in Canada's North have to be respected.

❖ The **IMALIRIJIIT** integrated project is based on a community-based environmental monitoring (CBEM) approach, and at same time aims to contribute for fundamental/applied science progress and valorization, i.e. Science Camps with the community.

❖ **Future perspective in the George River basin study**

- Water quality and chemistry: to extent monitoring to the upper water bodies (lakes)
- Hydrology: to integrate snow monitoring (past and present)
- Vegetation monitoring: collaboration with Nunavik Parks (shrubs)
- Local collaboration: to extent with the 3 communities of the watershed: Inuit, Naskapi, Innu. (ArcticNet Program 2019-2022)

IMALIRIJIIT Team 2018-2019













Thanks for your attention !

(Photo J. Housset, 2018)

ᓇᑯᕐᒦᒃ Nakurmiik!