Assessing the Local Nature of Arctic Nearshore Environments using Bio-Optical Parameters

A Case Study from Herschel Island, Western Canadian Arctic

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Introduction

The Arctic Ocean is subject to substantial changes due to climate change[1]. Much research has been conducted on bio-geochemical changes related to changing river discharge, but there is little knowledge on the effects to nearshore environments along shores.

However, permafrost thaw leads to a greater input of sediment and organic matter to the coastal zone, which has the potential to substantially impact the climate and the subsistence economy of the Inuit people.

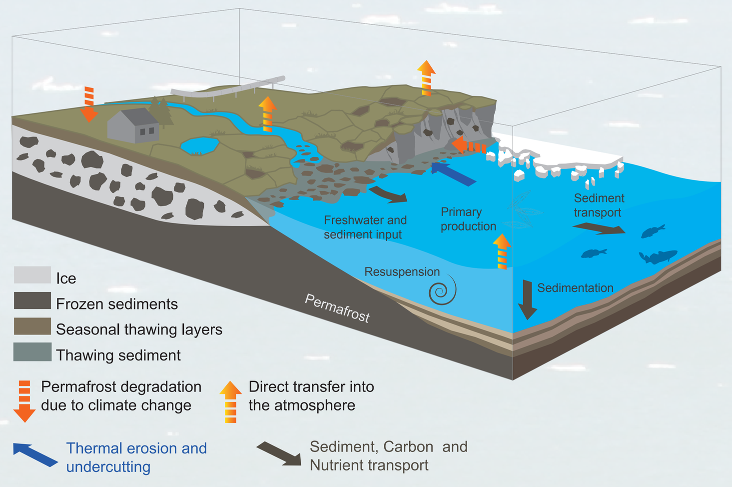

Figure 1: Impact of thawing and erosion on Arctic permafrost coasts[2]

Goal

Investigate the impacts of global climate change on Arctic nearshore environments

Study Area

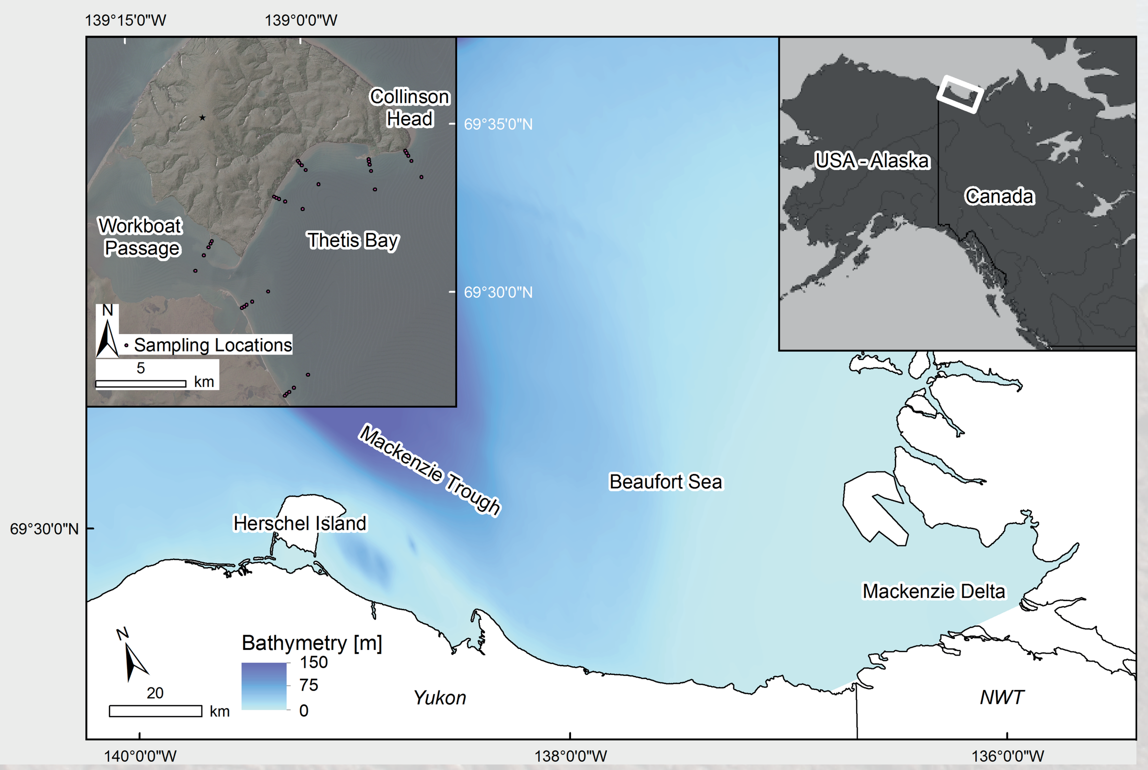

Figure 2: Map of the study area.

Our study area is the nearshore zone of Herschel Island on the Canadian Beaufort Shelf (figure 2). It was chosen because of its position at the Canadian Beaufort Shelf near the Mackenzie Delta, the presence of a strongly eroding coast[3,4] and a large amount of recently collected field data.

The wind regime in the southern Beaufort Sea is strongly bimodal (ESE and NW)[5]. The influence of the Mackenzie River plume varies seasonally and depends on the prevailing wind direction (figure 3).

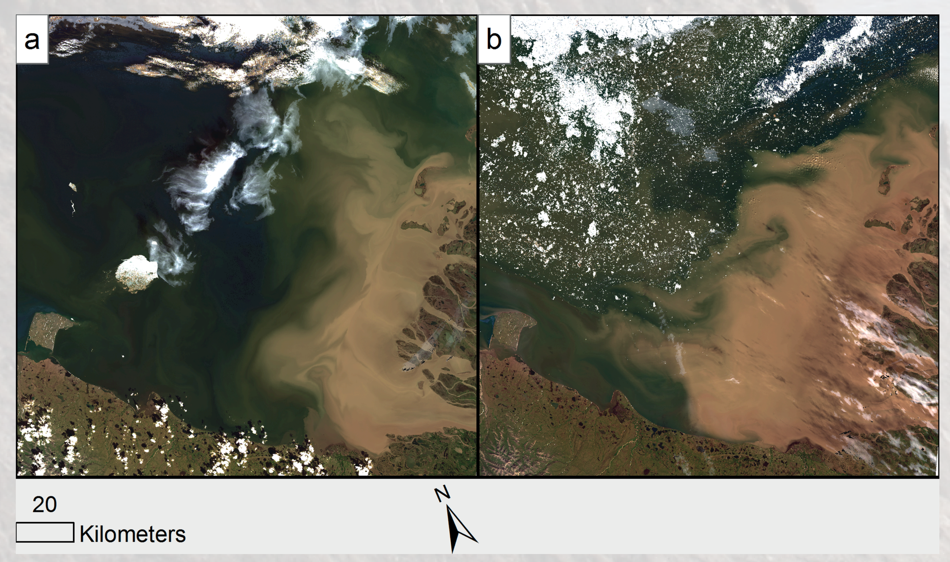

Figure 3: Extent of the Mackenzie River Plume during (a) NW wind conditions and (b) ESE wind conditions.

Materials and Methods

In-situ Sampling

Sampling period

JULY						
MO	TU	WE	TH	FR	SA	SU
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

2018

AUGUST						
MO	TU	WE	TH	FR	SA	SU
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Sampled Parameters

- Water Leaving Reflectance
- Sea Surface Temparature
- Suspended Particulate Matter (SPM)
- Turbidity

- Total sampling points: 60, 3 water samples per spot (180 samples)
- Processing of Water Samples: Filtering through pre-weighed Whatmann GF/F Filters

Reflectance Measurements: Hydrocolor App[6]

Requirements:
- Smartphone
- Standard Grey Card

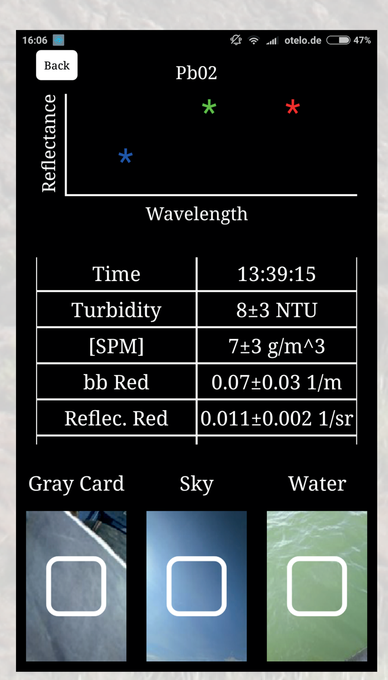

Figure 4: Hydrocolor App interface

Results and Discussion

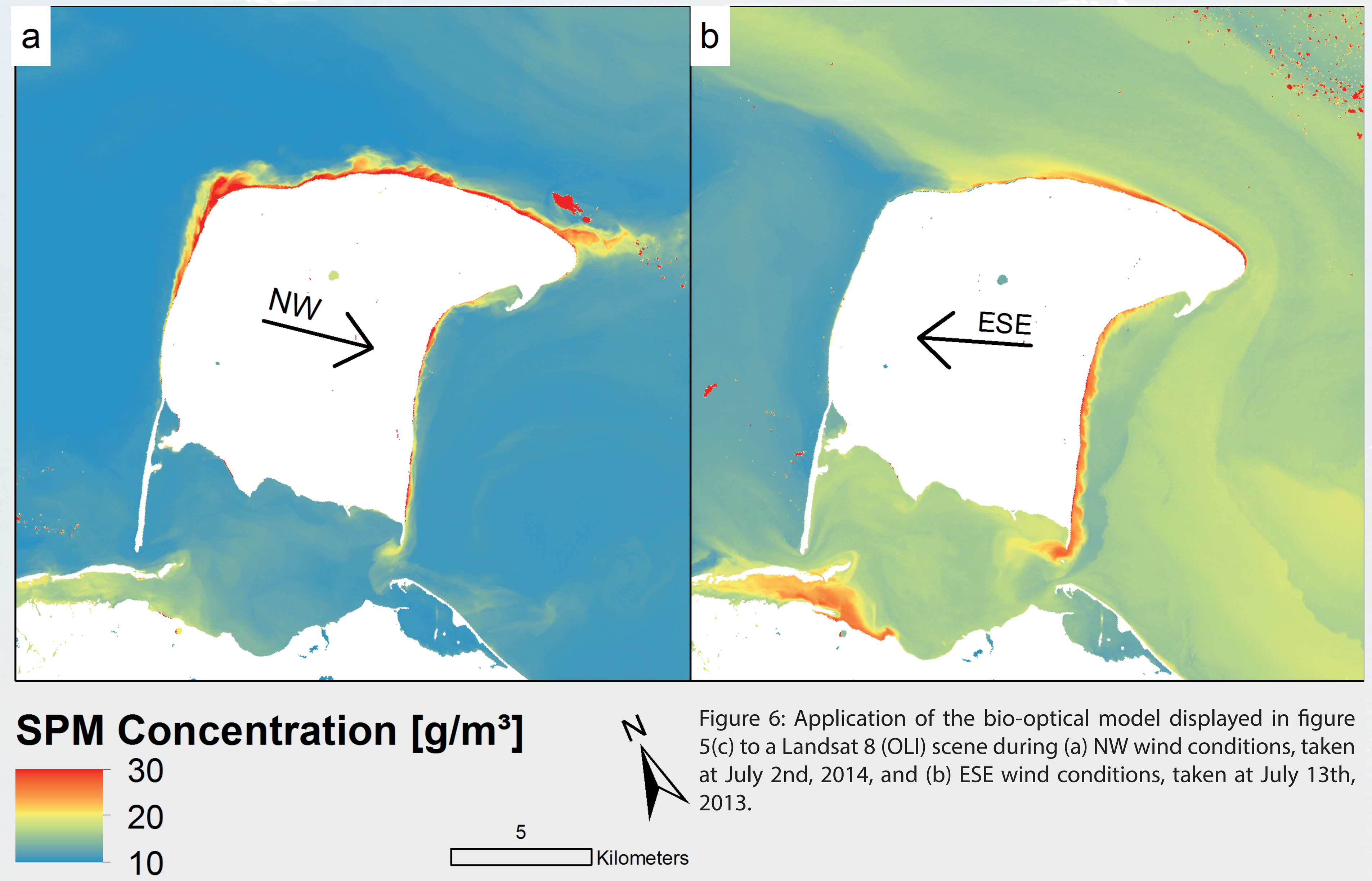

Figure 6: Application of the bio-optical model displayed in figure 5(c) to a Landsat 8 (OLI) scene during (a) NW wind conditions, taken at July 2nd, 2014, and (b) ESE wind conditions, taken at July 13th, 2013.

Model Application

We applied our model displayed in figure 5(c) to two test scenes taken by Landsat 8 (OLI) during NW wind conditions (figure 6 a) and during ESE wind conditions (figure 6 b). During easterly wind conditions, the Mackenzie River plume gets distributed over large parts of the Canadian Beaufort Shelf and is the main explanatory variable for sediment dispersal, while during northwesterly wind conditions, coastal hydrodynamics are the main factor.

Interpretation of the Results

Our modelled results are low compared to the range of the in-situ measurements displayed in figure 5(c). This might be caused by several reasons: (i) biased in-situ measurements (SPM and reflectance); especially the Hydrocolor app measurements reveal a large uncertainty depending on the weather conditions; (ii) challenging atmospheric correction of the satellite imagery; (iii) wrong spectral channels of the satellite imagery; and (iv) variable weather conditions and thus rare opportunities to test the model due to a lack of available satellite imagery.

Quality Assessment of the In-situ Sampling

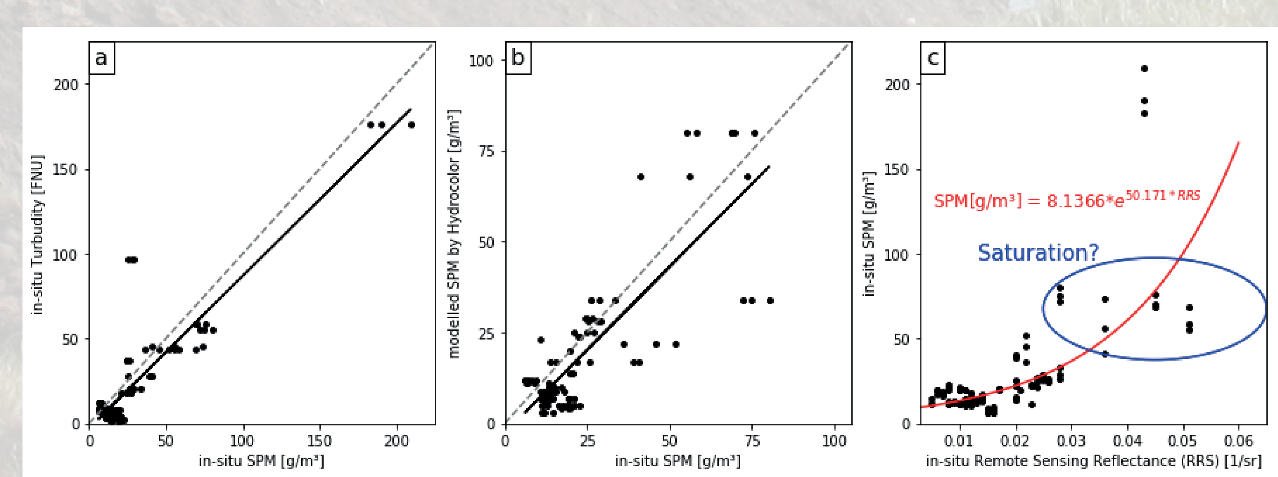

Figure 5: Quality assessment of the in-situ sampling. (a) correlation of in-situ turbidity and SPM measurements. The dashed line indicates the 1:1 line. (b) correlation of Hydrocolors SPM calculations and in-situ SPM measurements. The dashed line indicated the 1:1 line. (c) Correlation of in-situ SPM measurements and in-situ water-leaving reflectance. The red line indicates the best exponential fit.

- In-situ Turbidity and SPM samples are well correlated
- Large uncertainities of the reflectance measurements
- Similar SPM- concentrations between RRS values 0.03 and 0.06 indicate a saturation, meaning higher concentrations than ~100 g/m³ can not be detected in the red wavelengths

Key Findings

- Spatial distribution of sediment dispersal around Herschel Island depends on the wind direction
- The influence of coastal erosion on the nearshore sediment budget is highest during NW wind conditions
- The Hydrocolor App is semi-suitable for Ocean Color Remote Sensing in the Arctic

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Herschel Island Qikiqtaruk Yukon Parks

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2 DOI: 10.1038/nclimate3188
3 DOI: 10.1016/j.geomorph.2006.07.040
4 DOI: 10.3402/polar.v35.30313
5 DOI: 10.1007/s12237-015-0046-0
6 DOI: 10.3390/s18010256
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