Landsat Imagery is a Powerful Tool to Map Long-Term Sediment Pathways at High Spatial Resolution

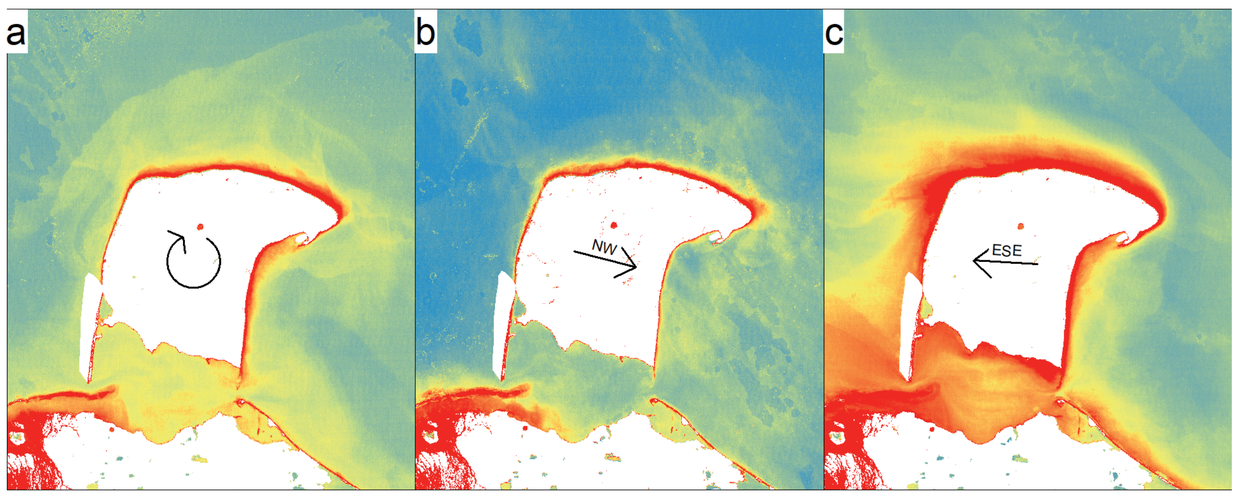

Figure 1: Mean Surface Reflectance in the red band, that was used as proxy for turbidity, for (a) changing wind conditions, (b) stable NW wind conditions and (c) stable ESE wind conditions. Data available from the U.S. Geological Survey.

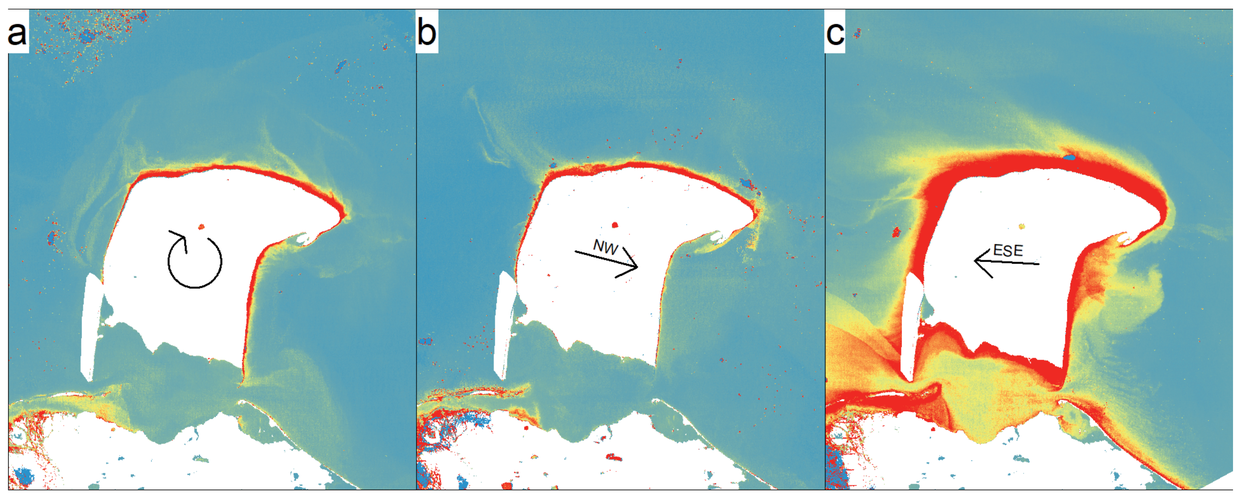

Figure 2: Mean modelled turbidity based on Dogliotti et al. (2015)[1], for (a) changing wind conditions, (b) stable NW wind conditions and (c) stable ESE wind conditions. Data available from the U.S. Geological Survey.

Thirty years of Landsat imagery were analyzed under seasonal changing meteorological forcing to investigate hydrodynamics in coastal and innershelf waters of the Canadian Beaufort Sea. Clear spatial differences were detected under the two prevailling wind conditions (ESE and NW). The Mackenzie River plume extend is the main explanatory variable for differences of nearshore sediment dispersal. It is shown that Landsat imagery provides coastal and nearshore observations at a high spatial resolution in contrast to coarser Ocean Color satellite sensors.

Long-Term High Resolution Sediment and Sea Surface Temperature Spatial Patterns in Arctic Nearshore Waters retrieved using 30-year Landsat Archive Imagery

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Introduction

The Arctic Ocean is subject to substantial changes due to climate change[2]. Yet, the exact patterns of sediment dispersal in nearshore zones are not well known, because ships do not often reach shallow waters and satellite remote sensing in traditionally focussed on less dynamic environemts. However, permafost thaw leads to a greater input of sediment and organic matter to the coastal zone[2], which has the potential to substantially impact the climate and the subsistence economy of the local population.

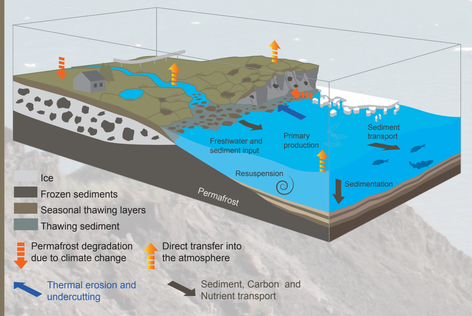

Figure 3: Impact of thawing and erosion on Arctic permafrost coasts[3]

Study Area

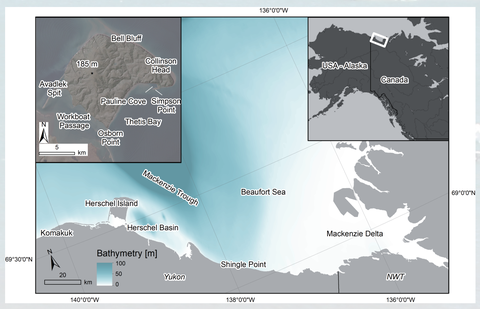

Figure 4: Map of the study area.

Our study area are the coastal and innershelf waters of the Canadian Beaufort Shelf around Herschel Island Qikiqtqruk (figure 2). It was chosen because of its proximity to the Mackenzie Delta, the presence of a strongly eroding coast[4,5], and a large amount of recently collected field data.

The wind regime in the southern Beaufort Sea in strongly bi-modal (ESE and NW)[6]. The influence of the Mackenzie River plume varies seasonally and depends on the prevailling wind direction.

Materials and Methods

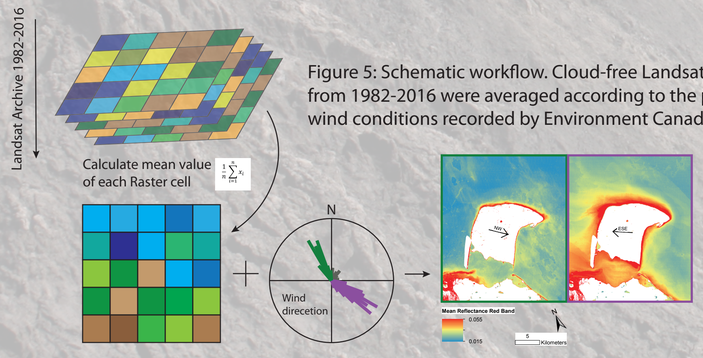

Figure 5: Schematic workflow. Cloud-free Landsat aquisitions from 1982-2016 were averaged according to the prevailling wind conditions recorded by Environment Canada[7].

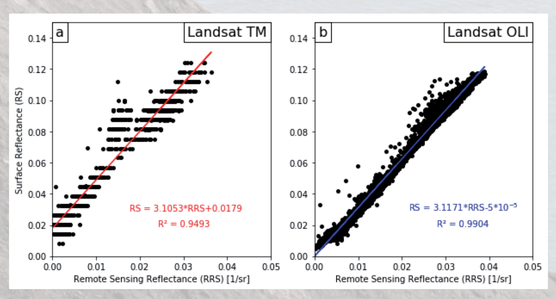

Figure 6: Comparison of red band Surface Reflectance and Remote Sensing Reflectance data products. Both parameters are well correlated for Landsat TM and Landsat OLI. The Surface Reflectance data product was used in this study, because of the higher signal-to-noise ratio over water surfaces with low sediment load.

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Discussion

Our results suggest that most of the suspended material in the nearshore zone of Herschel Island Qikiqtaruk gets transported alongshore and only limited amounts are transferred offshore. The gradients from the nearshore to offshore show very high values compared to turbidity values reported elsewhere in the Arctic in the literature. This large sediment load, potentially holding large amounts of organic matter was until now not resolved by other remote sensing platforms. We show that even the older Landsat sensors (TM and ETM+) were able to resolve these features.

References

1 DOI: 10.1016/j.rse.2014.09.020; 2 IPCC Climate Change Report 2013; 3 DOI: 10.1038/nclimate3188; 4 DOI: 10.1016/j.geomorph.2006.07.040; 5 DOI: 10.3402/polar.v35.30313; 6 DOI: 10.1007/s12237-015-0046-0; 7 http://climate.weather.gc.ca/historical_data/search_historic_data_e.html; Backgroud Photo: J.Gimsa, AWI

Acknowledgements

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