Sediment-laden meltwater plume variability in Kongsfjorden, Svalbard

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Background

• Sediment-laden meltwater plumes from glacier-fed rivers and tidewater glacier systems are great proxies for glacier runoff

• They are also easily observable using satellite remote sensing – see Planet image from 27/07/2019

• Sediment-laden plumes at tidewater glacier systems deposit large amounts of sediment at their termini, reducing water depth, which can lead to increased glacier stability
Aims and objectives

• Aim - determine controls on sediment-laden meltwater plume variability and behaviour in response to changing meltwater runoff inputs from a terrestrial glacier-fed river and marine terminating glacier system during multiple Arctic summer melt seasons

• The key objectives can be seen on the infographic to the right:
Study sites

• Kongsfjorden, NW Svalbard
  - Glacier-fed Bayelva river, draining Austre and Vestre Brøggerbreen glaciers through Brøggerdalen
  - Blomstrandbreen, tidewater glacier system, close to retreating onto its bed

Vihtakari (2019) - PlotSvalbard
Field data collection

- Spectral reflectance measurements – for calibration/validation of remotely sensed data

- Conductivity, temperature, depth (CTD) profiles to determine plume thickness and extent

- Sediment sampling – for calculating suspended sediment concentrations (SSC)
Airborne and satellite remote sensing

- Acquisition of satellite remote sensing (surface reflectance) data from various research and commercial sources, including:
  - MODIS
  - Landsat 7 and 8
  - Sentinel 2
  - Planet

- Airborne data are supplied by NORCE – more information here: https://bit.ly/32yOfHx

Image source: Landsat
Preliminary results

SSC-reflectance (L) correlation of field data from the Bayelva plume in 2019 in Sentinel 2's b04 wavelength (650-680 nm) ≈ red band

SSC-reflectance (L) correlation of field data from the Bayelva plume in 2019 in Planet's b04 wavelength (780-860 nm) ≈ near infrared band
Preliminary results

(a) CTD profile from Bayelva sediment-laden meltwater plume collected on 11/07/2019, the data show a plume thickness ~0.2-0.4 m;
(b) CTD profile from the Blomstrandbreen sediment-laden meltwater plume collected 13/07/2019, showing a plume thickness in excess of 2 metres.
Early conclusions

• SSC-reflectance relationships are consistent when applied to bandwidths from all satellite platforms – but more positive in near infrared bands

• Clear lag between input of meltwater runoff to systems and changes in metrics (i.e. surface area, length/width) of sediment-laden meltwater plumes – influence of rainfall, increased air temperatures, snow and/or ice melt

• Glacier-fed Bayelva plume remains at a thickness between 0.3 - 0.5 m, compared with more variable plume thicknesses at Blomstrandbreen ~1 - 3 m
  - Bayelva catchment, ice area ~16 km²
  - Blomstrandbreen (and Isachsenfonna ice cap), ice area ~90 km²
Future plans

• A further field season in Svalbard is planned for this summer, if travel restrictions allow

• This project has been severely impacted by the COVID-19 pandemic, and is still a work in progress – final analyses to be completed later in the year
References


Vihtakari, M., 2019. PlotSvalbard: PlotSvalbard - Plot research data from Svalbard on maps. R package version 0.8.5. https://github.com/MikkoVihtakari/PlotSvalbard