REMOTE SENSING OF TURBIDITY PLUMES IN GLACIATED AND ICE-FREE FJORDS OF SVALBARD (ARCTIC)

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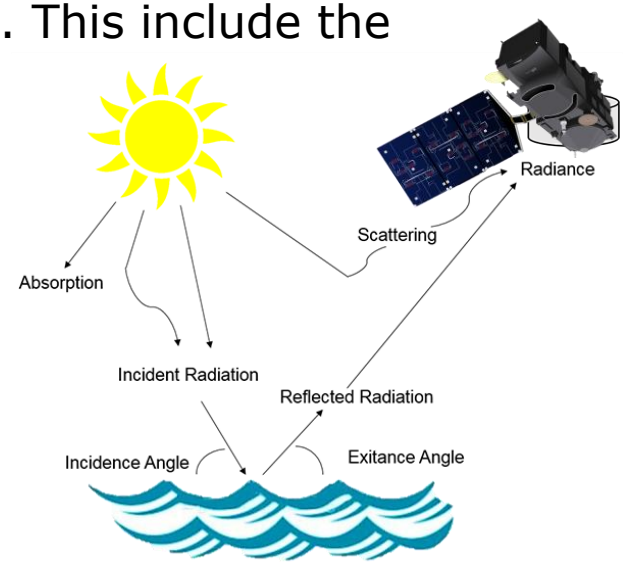
Relevance

- Enhanced melting of the Arctic ice increases fresh water intake into the marine environment, thus influencing the external supply of suspended solids and nutrients;
- The increase of water turbidity alters the changes in the underwater light climate.
- Both processes significantly affect pelagic communities and benthic habitats;
- The turbidity plumes/frontal zones can be comprehensively mapped using multi-mission satellite data;
- The major challenge – to determine the approach of satellite data processing. This include the **atmospheric correction** and **in-water constituent retrieval algorithms**.
- Once it is done, new scientific curiosities can be fulfilled:
  - Annual/seasonal spatial variability, link with the climate;
  - Hot spots of external nutrient supply;
  - Effect on the underwater light climate;
  - Changes of pelagic communities and benthic habitats;
  - And many more...



This work is aiming *to map turbidity plumes and thermodynamic exchanges across ice-turbidity plume-ocean boundary layers in glaciated and ice-free fjords of Svalbard through the application of in situ surveys and multispectral satellite imagery.*

Study area

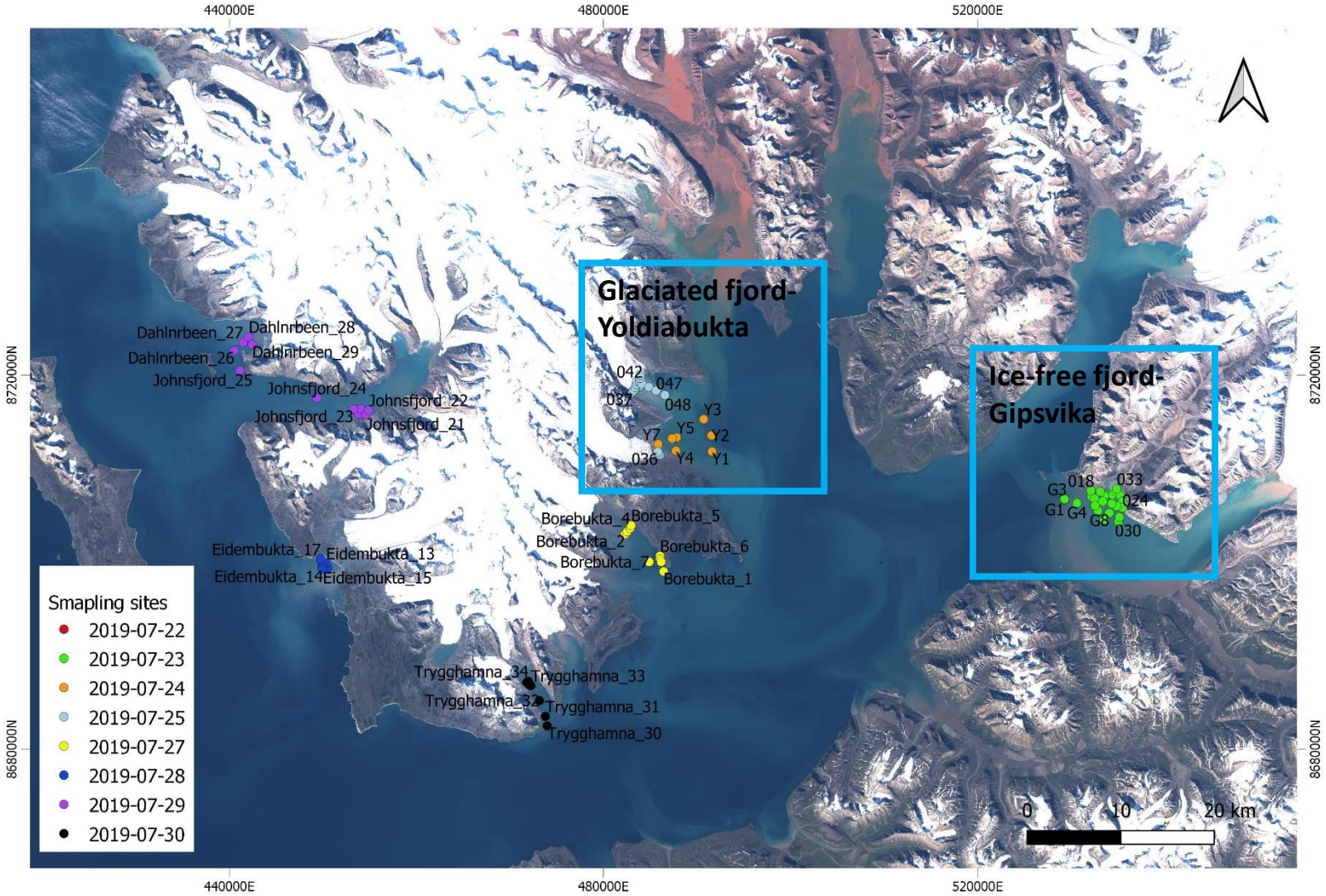


Fig 1. Sampling sites in the Isfjorden (Svalbard) during 22-30 July 2019. Sentinel-2 MSI RGB composite acquired on 27th July 2019 is used as a background.

Material and Methods

In situ data collected on 22-30 July 2019:
- Water turbidity (NTU), Eutech TN100 instrument;
- Remote Sensing Reflectance (R_{rs}, sr^{-1}), WISP-3 spectroradiometer;
- Total Suspended Matter (g m^{-3})

including organic and inorganic fraction – *in progress*.

Satellite data:
- Sentinel-2 A/B MSI (4 images processed for validation,

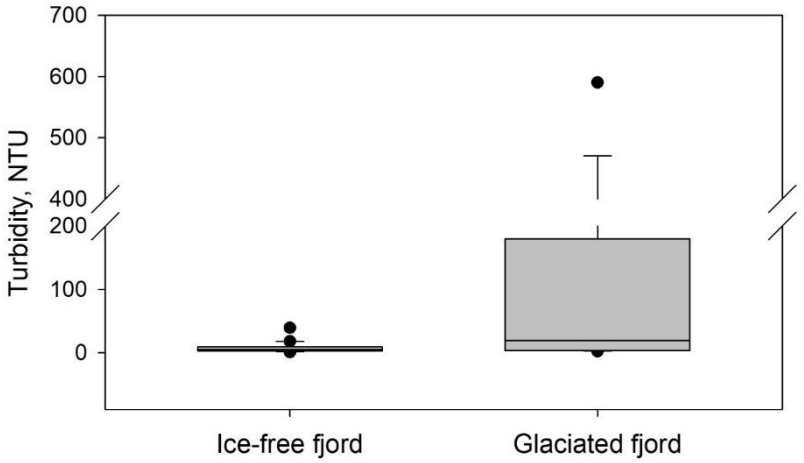
66 - for seasonal mapping);
- Landsat-8 OLI (*in progress*);
- Landsat-8 TIRS (4 images processed);

Atmospheric correction:
- *ACOLITE* (RBINS, Belgium);
- *iCOR with and without SIMEC adjacency correction* (VITO, Belgium);
- *Sen2Cor* (Telespazio VEGA Deutschland GmbH on behalf of ESA);
- *C2R-CC* (Brockman Consult, Germany);
- *Polymer* (HYGEOS, France).

Turbidity retrieval:
- ACOLITE, using Dogliotti et al. (2015, http://dx.doi.org/10.1016/j.rse.2014.09.020) approach;

Temperature retrieval:
- the water surface temperature, i.e., skin temperature (°C) was obtained using Landsat-8 imagery.

RESULTS: *in situ* turbidity and R_{rs} variations



In situ turbidity:
Ice free site (Gipsvika)
17.18±80.60 NTU

Glaciated (Yoldiabukta)
116.29±184.24 NTU

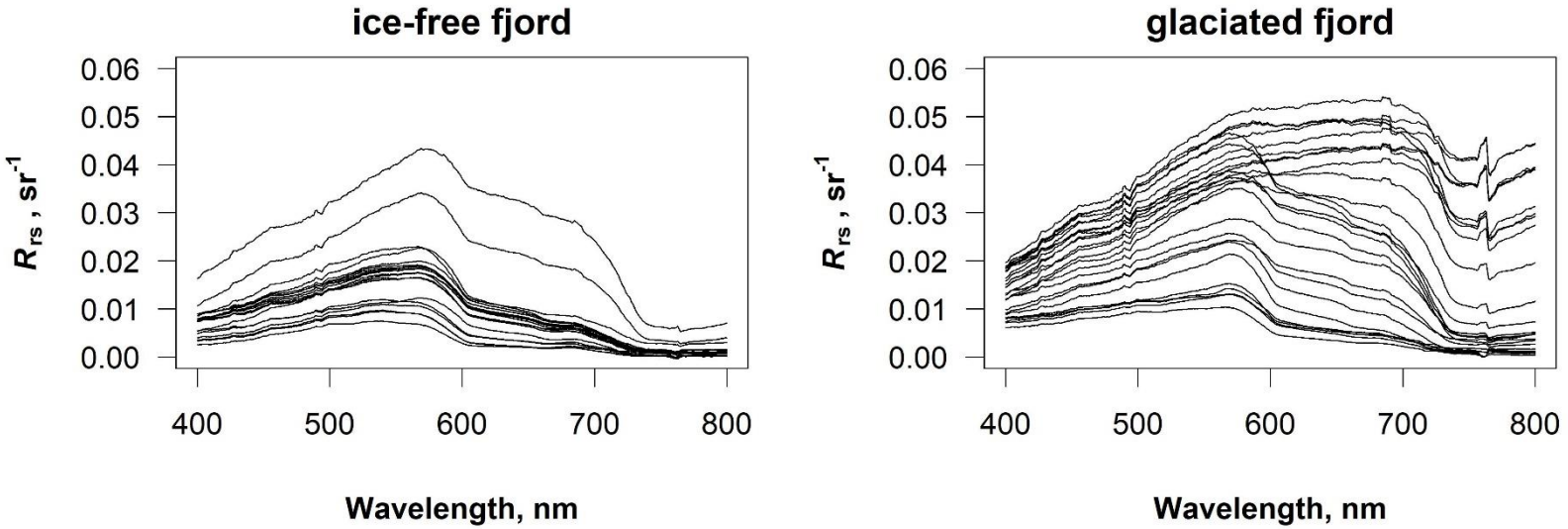
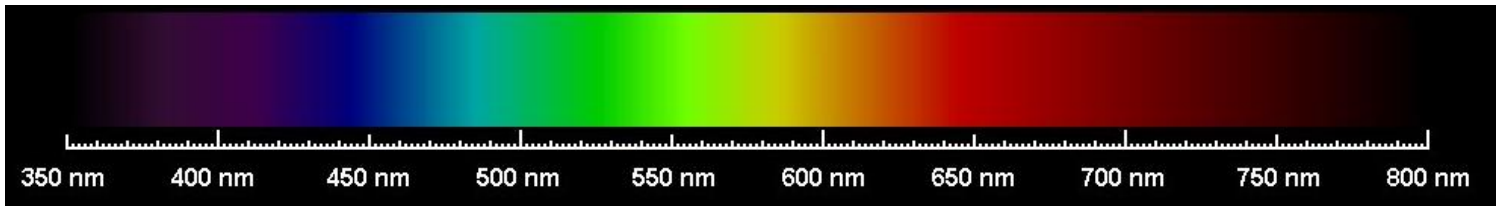


Fig 2. In situ turbidity and R_{rs} variations in ice-free (Gipsvika) and glaciated (Yoldiabukta) fjords during 22-31 July, 2019.



RESULTS: Sentinel-2 data validation

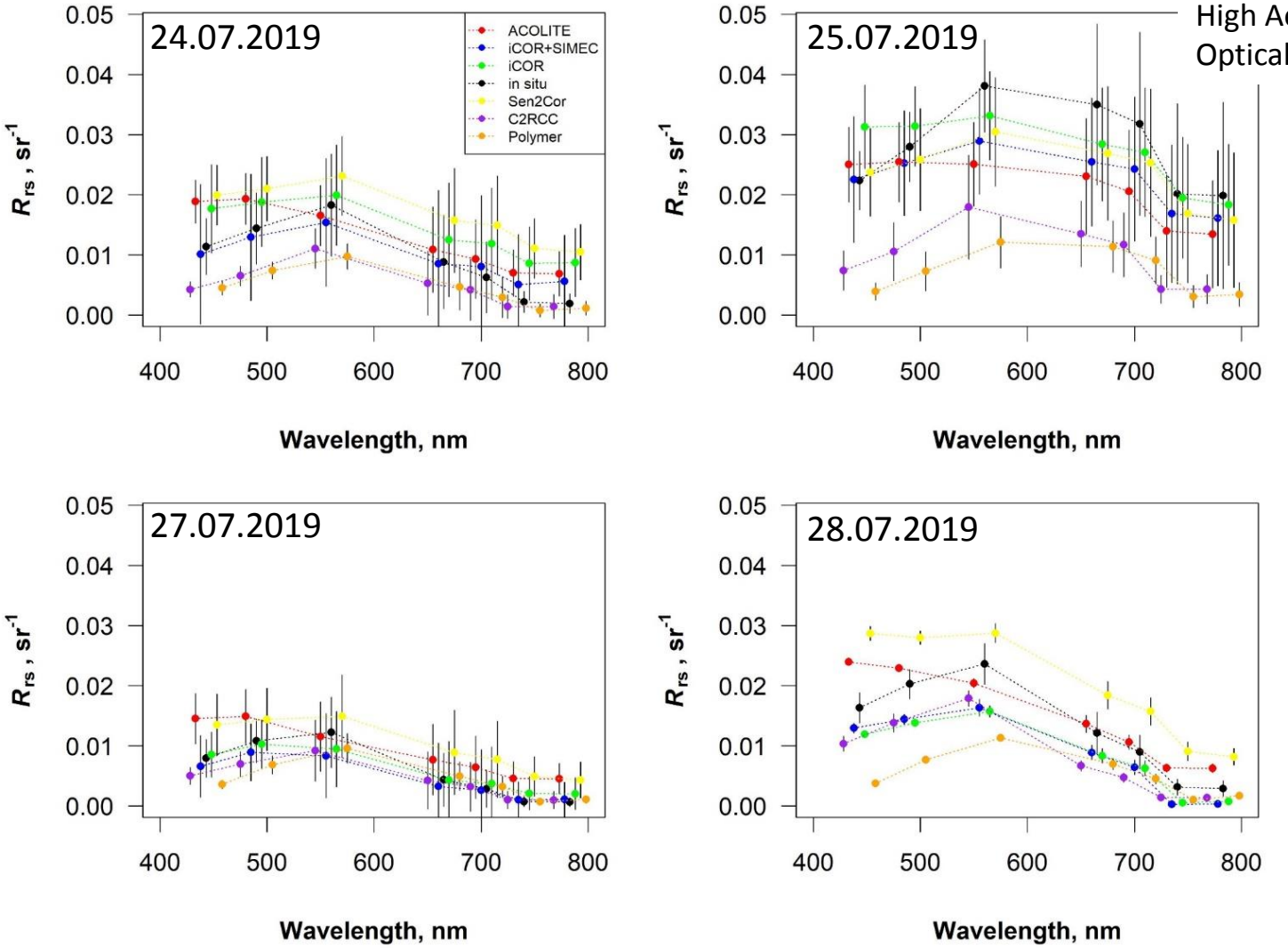


Fig 3A. Mean R_{rs} obtained by five atmospheric correction algorithm: ACOLITE, iCOR with SIMEC adjacency effect correction (iCOR+SIMEC) and without (iCOR), SenCor, C2RCC and Polymer from four S2 MSI data and retrieved in situ (black line) in the Isfjorden.

High Aerosol Optical Thickness

ACOLITE

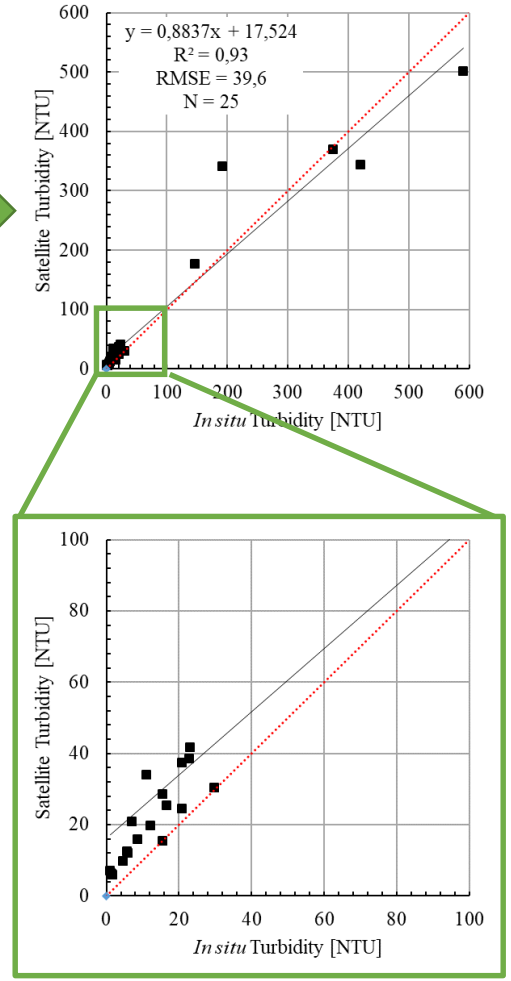


Fig 3B. Relationship between in situ measured and derived from S2 turbidity values (NTU).

RESULTS: Spatial variability of turbidity plume in 2019

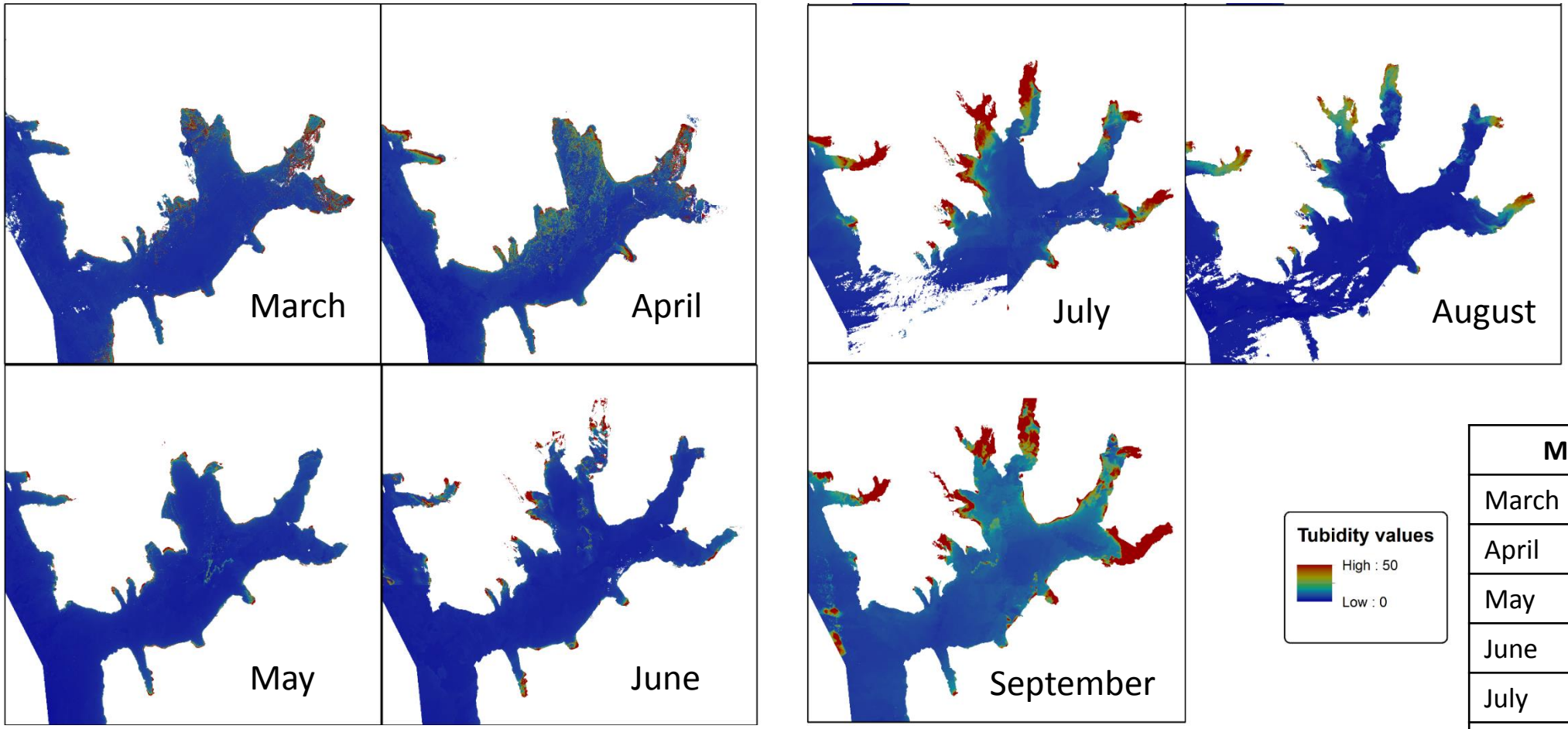


Fig 4. Monthly mean turbidity (NTU) during the period of March–September 2019.

Month	No. of images
March	4
April	10
May	16
June	10
July	7
August	11
September	8
TOTAL	66

RESULTS: Turbidity vs. temperature frontal zones

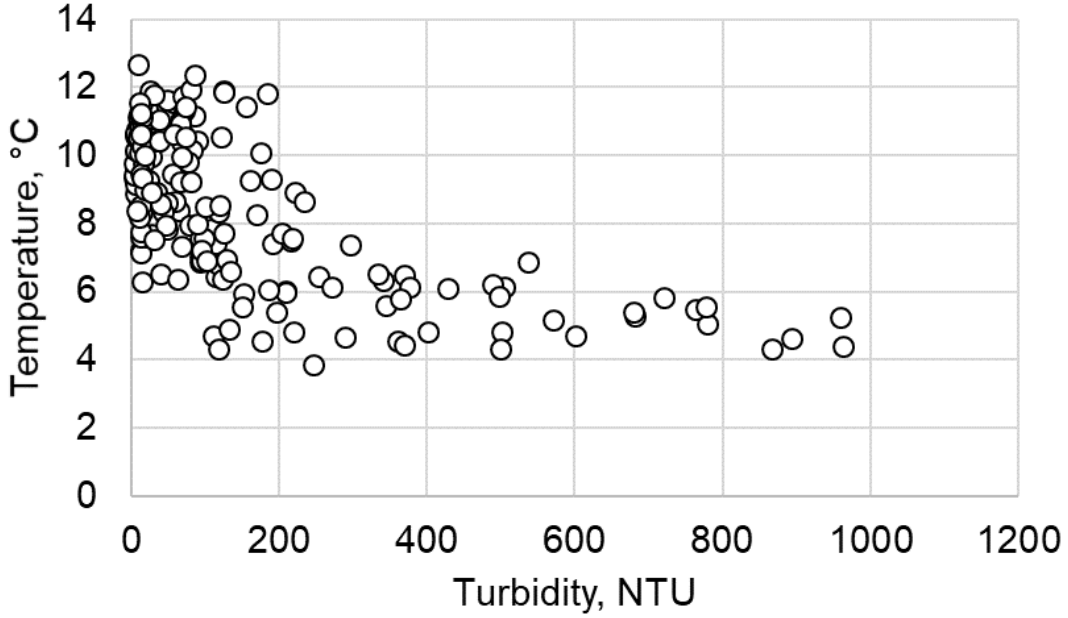


Fig 5A. Relationship between water surface temperature and turbidity. Four concurrent Landsat-8 and Sentinel-2 images have been used.

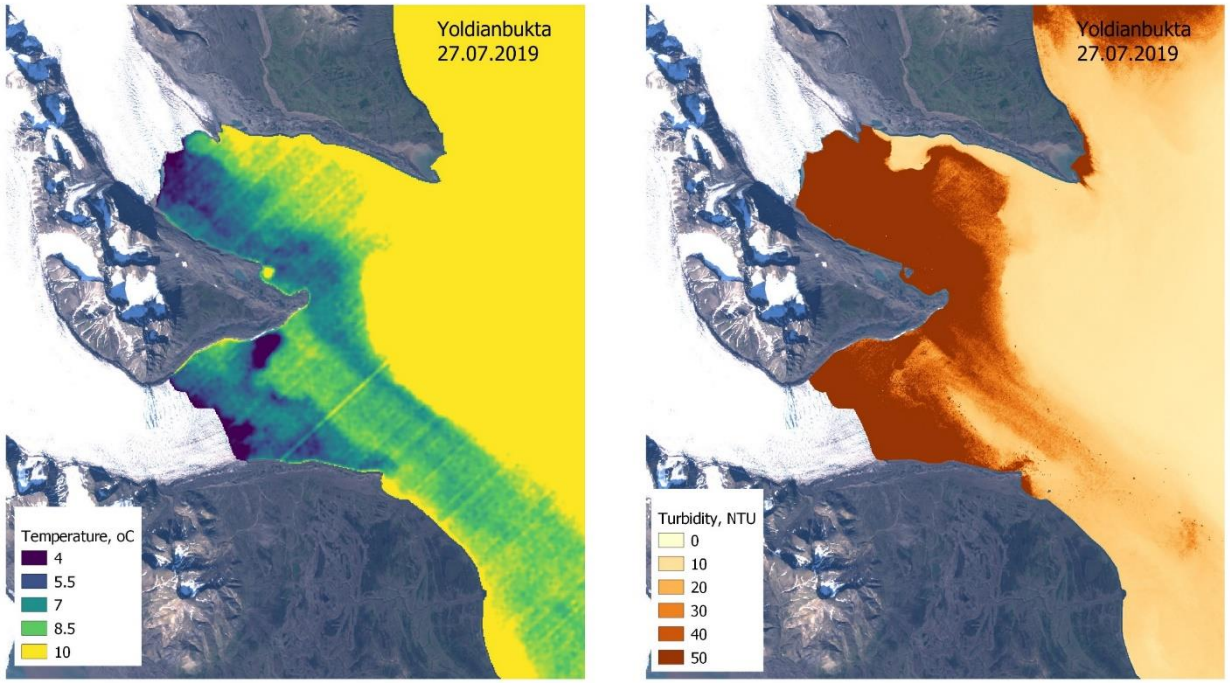


Fig 5B. An example of spatial variability of water surface temperature and turbidity in Yoldiabukta fjord on 27 July 2019.

Take home messages

- *In situ* measured turbidity revealed high variability between glaciated and ice-free fjords.
- Significantly different R_{rs} was between the waters of low turbidity values (with peak in green-yellow region) and high turbidity values (with consistent increase of R_{rs} in red-NIR region).
- A good agreement was found between atmospherically corrected Sentinel-2 and *in situ* measured R_{rs}. Sen2Cor and C2RCC slightly underestimated R_{rs} in comparison with *in situ* measurements. ACOLITE and iCOR without SIMEC slightly overestimated R_{rs} in a blue region. Adjacency correction (SIMEC) use in iCOR AC improved the retrieval of R_{rs} in a blue region. However, both atmospheric correction approaches could be used for further study of in-water constituents.
- Higher turbidity values have been observed during July-August in the glaciated fjords. A negative trend of turbidity and water surface temperature revealed the ongoing intensive melting of glaciers and total suspended matter transport during the summer.

Next steps

- Invitation to work on the joint manuscript.
- Is ther any water surface temperature data available for Landsat-8 data validation?