Institute of Geophysics
Polish Academy of Sciences

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for Polar
Studies

Accelerated glacier melt drives changes in the flux of terrestrial material to Svalbard fjords

Ekaterina Rets, Meri Korhonen, Batłomiej Luks, Lavkush Patel, Mateusz Moskalik

Institute of Geophysics Polish Academy of Sciences

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GLACIERS RETREAT AND FIORDS WITHER

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Head of the project: Mateusz Moskalik

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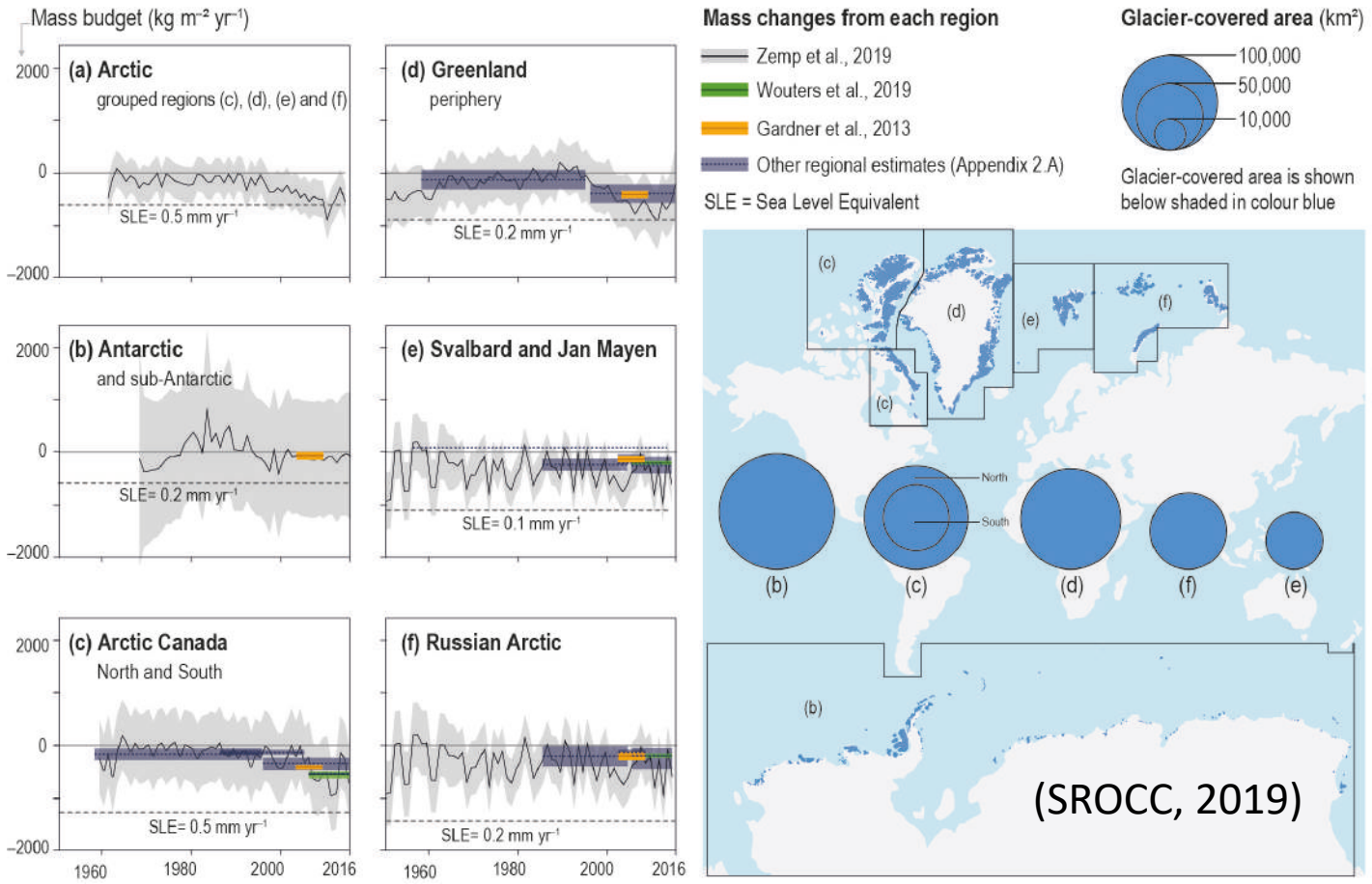
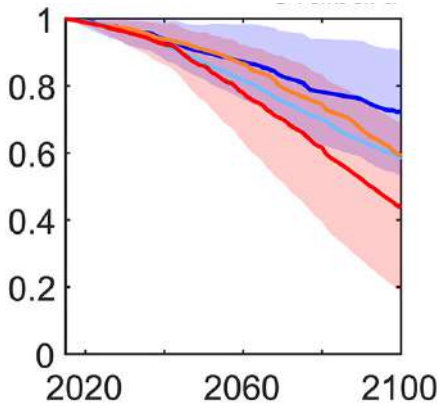
3 Accelerated glacier melt in Arctic regions

There is limited evidence (high agreement) that the current rate of glacier mass loss is larger than at any time during the past 4000 years (SROCC, 2019, Fisher et al., 2012; Zdanowicz et al., 2012)



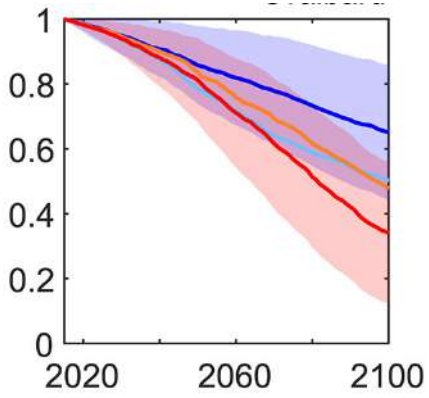
Projected changes in glacier area and mass balance on **Svalbard** (Marzeion et al, 2020)

Glacier Area



RCP 2.6
RCP 8.5

Glacier Mass



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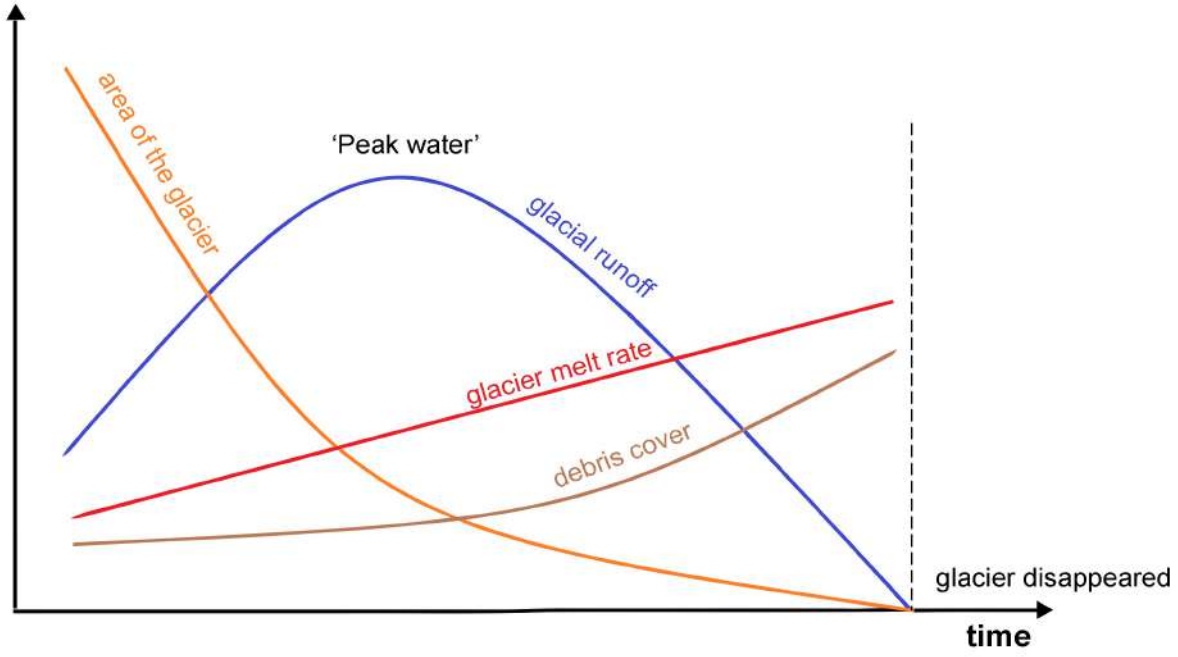
4 Consequence of deglaciation in Arctic regions

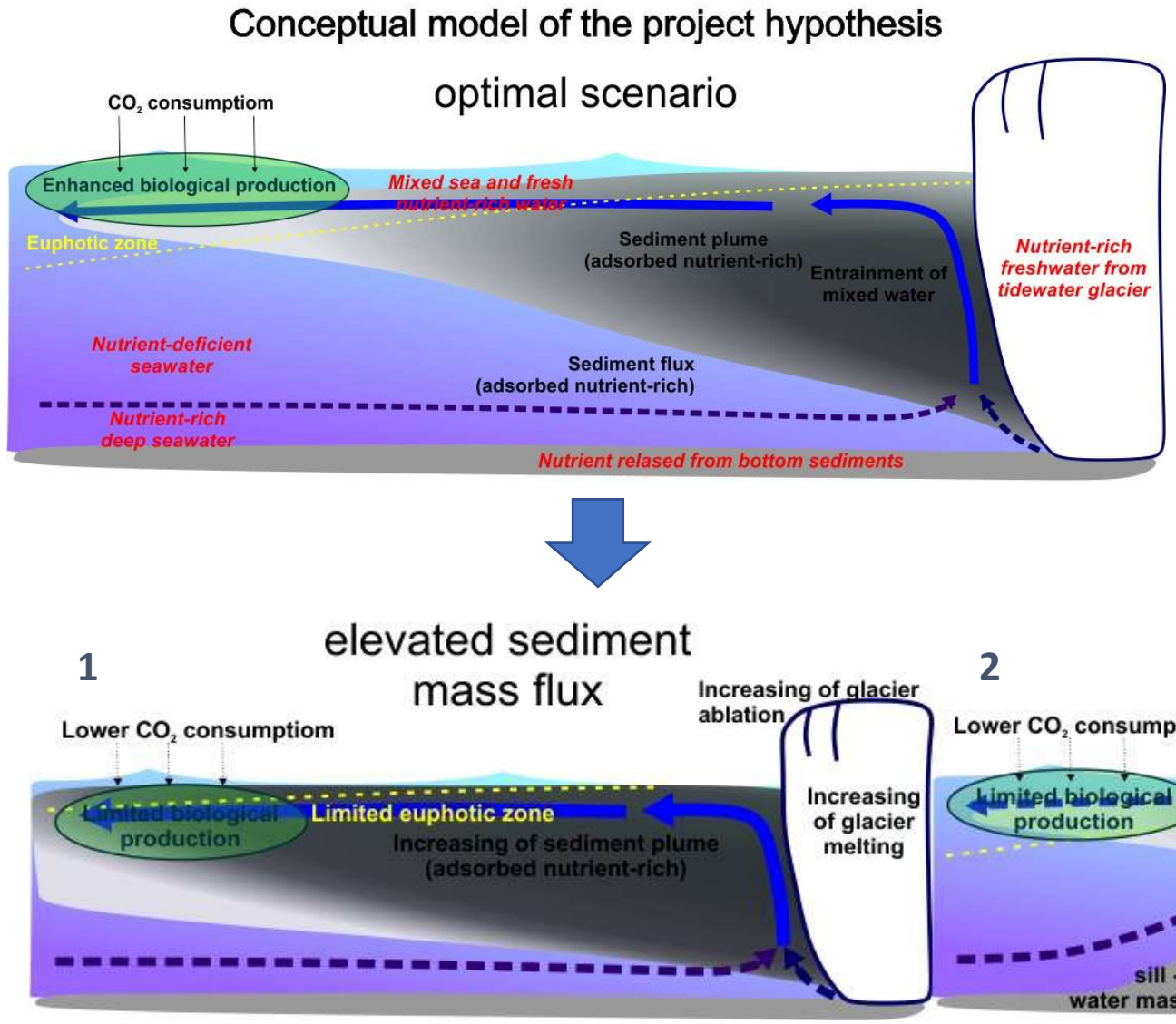
Fresh water supply dynamics:



? Sediments
? Chemical elements
? Circulation in fjords
? Marine ecosystems productivity

Glacial-derived suspended matter is an **important source of nutrients** to Svalbard fjords, including bioessential nutrients such as iron, ammonia, trace metals (etc. Co, Mo, Mn) (Hallet at al. 1996; Hawkings et al. 2014, 2017; Hodson et al. 2017; Moskalik et al. 2018)..

5 Increase of tidewater glaciers frontal melting



Deep water upwelling at the terminus of tidewater glaciers causes an increase in primary production

Probable consequence 1:
Shallowing the euphotic zone caused by increased surface suspended sediments concentration

Probable consequence 2:
Reduction of water mass exchanges and sediment-bound nutrients transfer between the fjord/open sea and newly formed bay due to hydrography and formation of natural sediment traps

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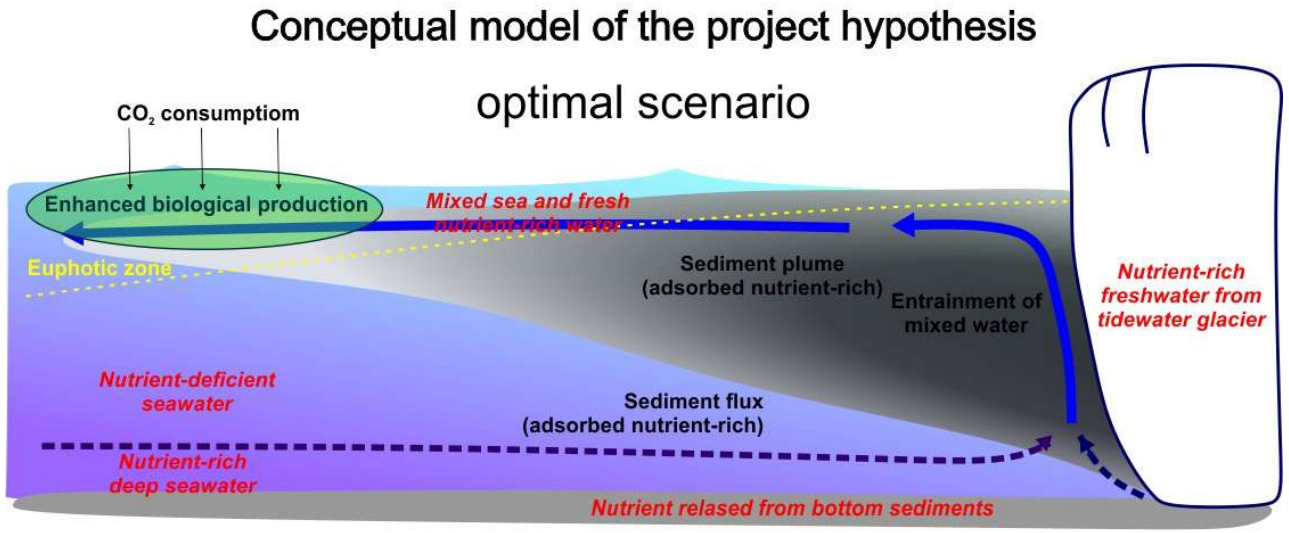
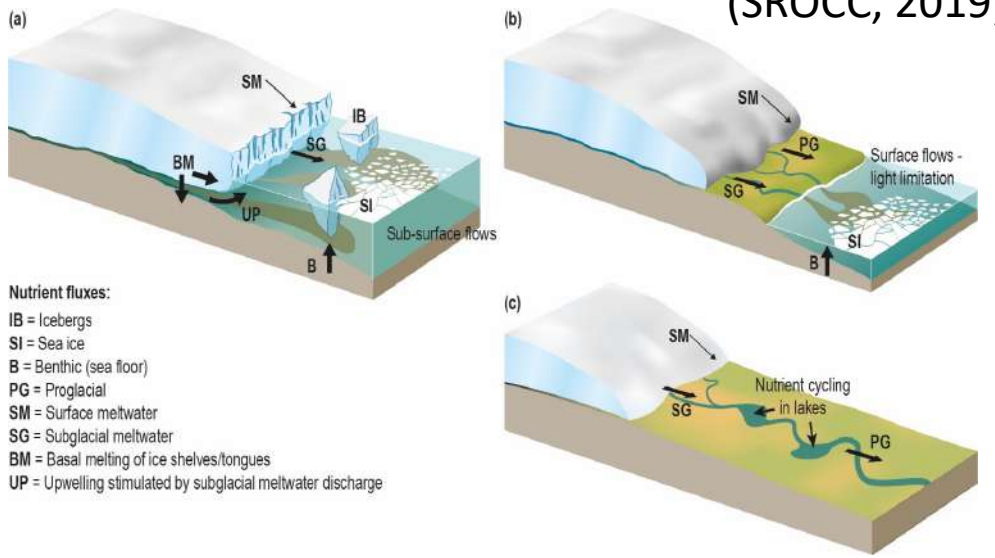
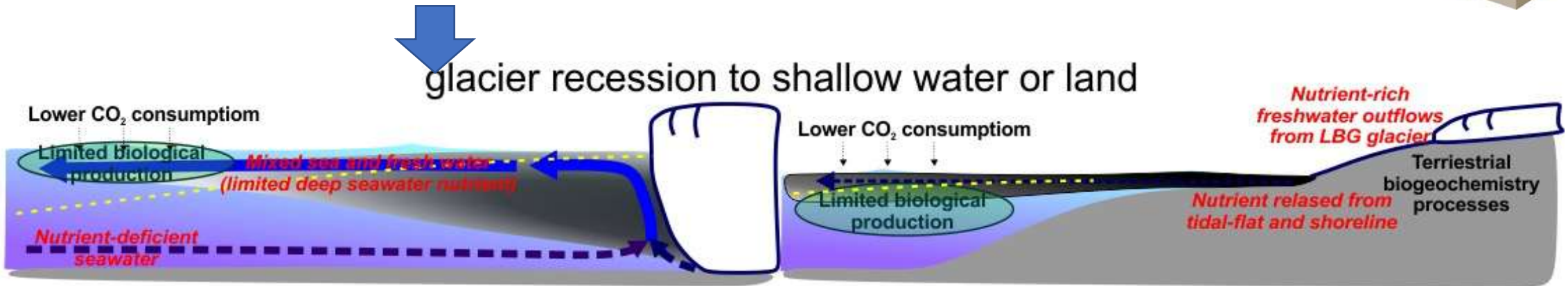
6 Transition from tidewater to land-based glcaiers glacier

(SROCC, 2019)







Change the glacial regime from predominately tidewater to land-based may alter the total nutrient flux supplied to euphotic zone (either directly via runoff or indirectly via reduced tidewater glacier inducted deep water upwelling)

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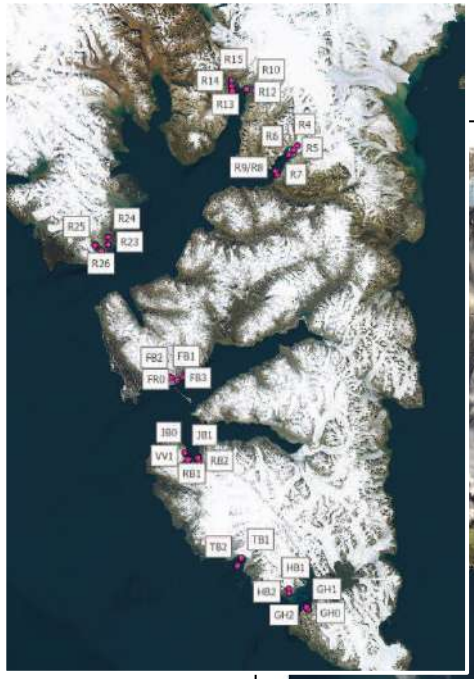
7 Study area

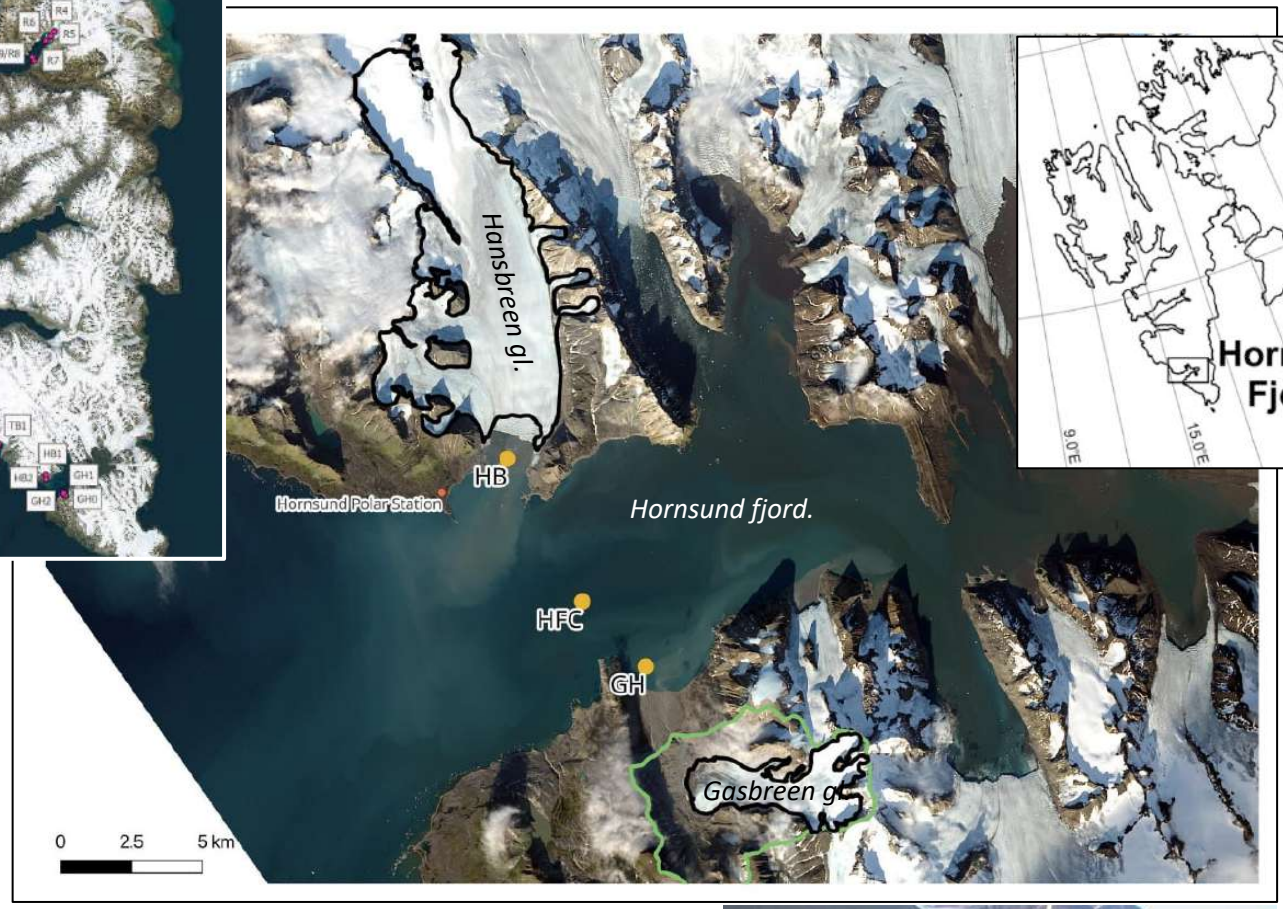
Fieldwork
- July – October 2022
- June – October 2023 ✅ process)

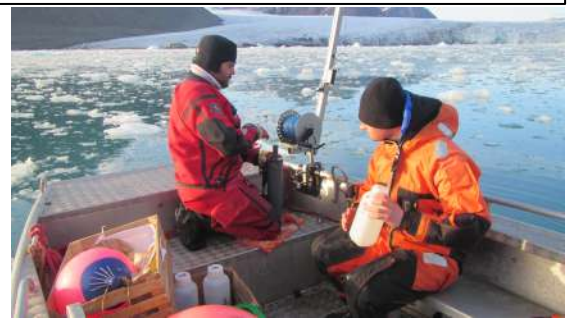
Vertical profiles (every 1-2 weeks)
- CTD,
- Turbidity
- dissolved O2

+ **Sediment Flux** measurements

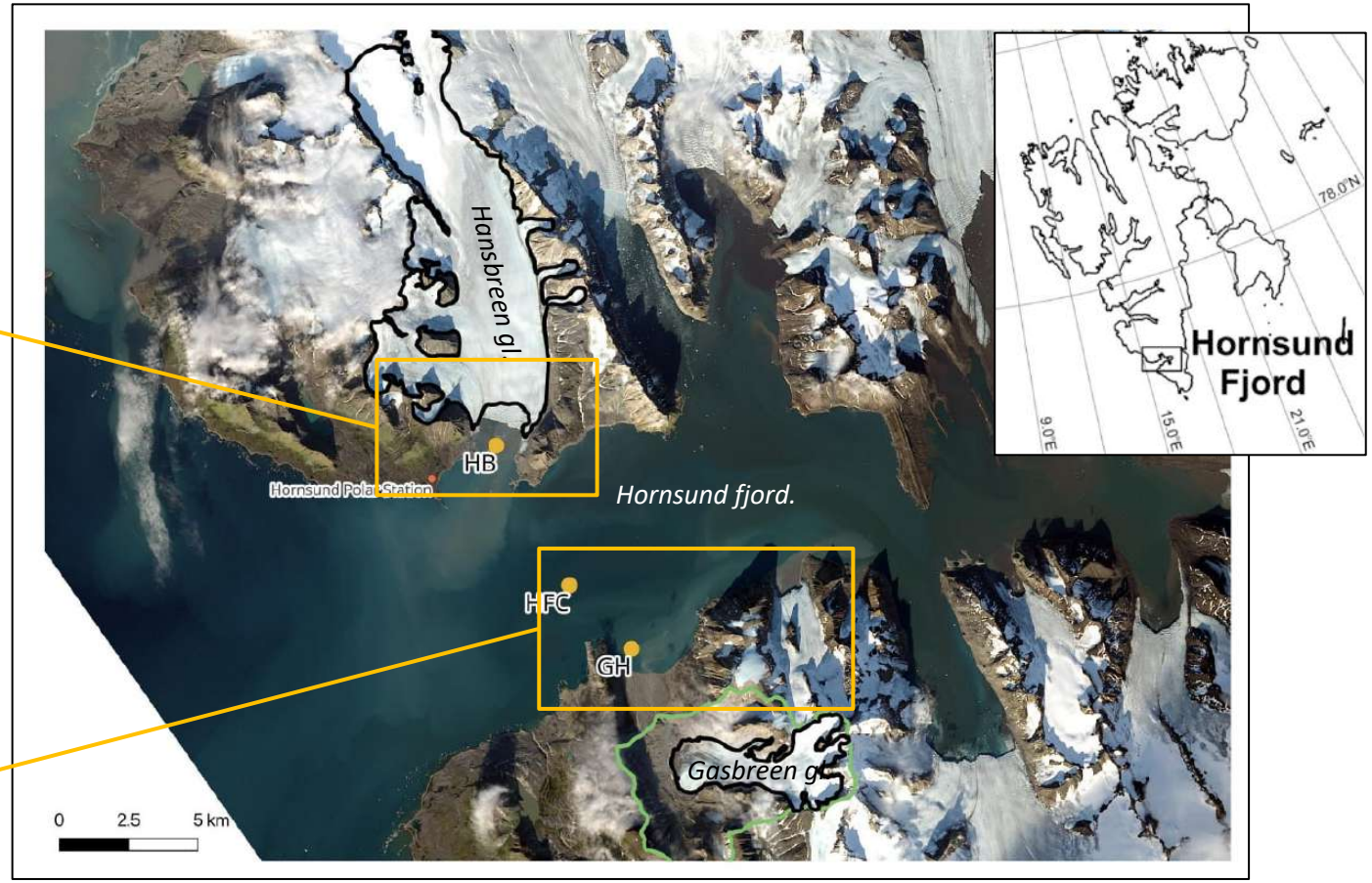
Simultaneously with:
- Sediment-bound iron and manganese sampling (IGF PAN, IO PAN)
- Plankton analysis (IO PAN)
- Glaciological observations on Hansbreen gl. (IGF PAN)
- Meteorological measurements on Hornsund Polar Station (IGF PAN)







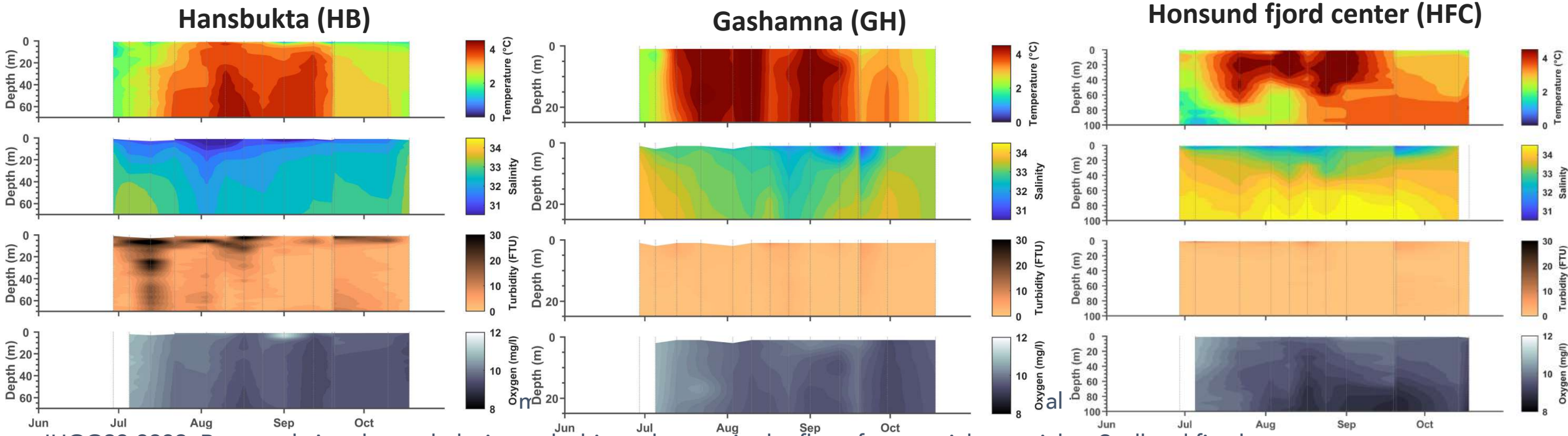
8 Study area



Landsat 25.08.2015

9 Seasonal changes in water column

- Hansbukta is colder, fresher and more turbid due to the presence of the tidewater glacier compared to Gashamna.
- Temperature, salinity and turbidity in Gashamna are very similar to those in the upper 30 m of the central basin.



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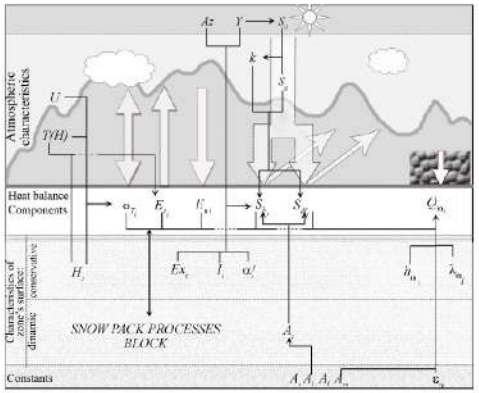
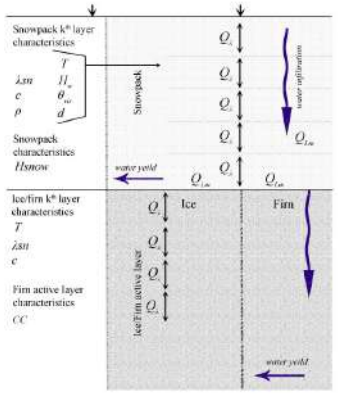
10 AMelt model - energy-balance based distributed snow&ice Melt model in Alpine areas

Snow and ice surface processes:



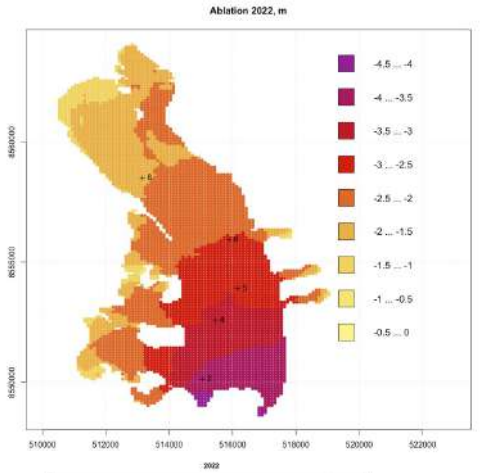
Snow Pack processes:

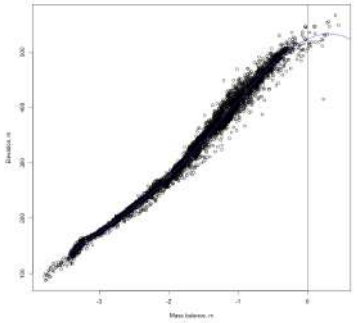


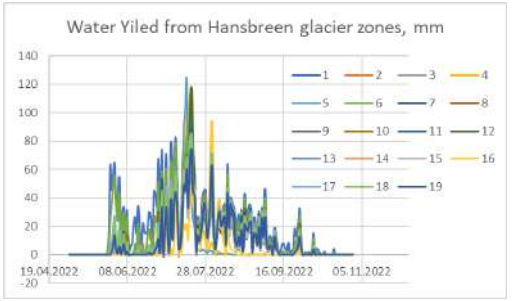
Previously applied for glacial catchments in:

- **Svalbard** (Elagina et al., 2021),
- **Caucasus** (Rets and Kireeva, 2010),
- **Tien Shan** (Rets et al., 2021)
- and and for 9 glacier around the globe in course **of Debris-Covered Glacier melt Model Intercomparison exPeriment** (DCG-MIP) (Pelicciotti et al., 2022).

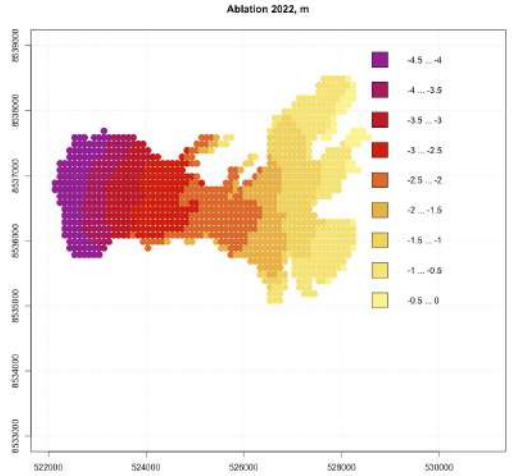
Hansbreen glacier

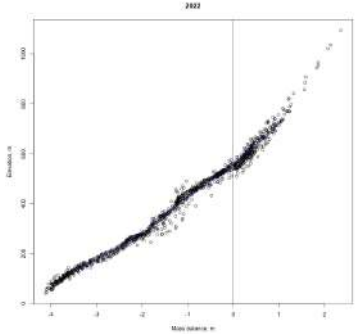


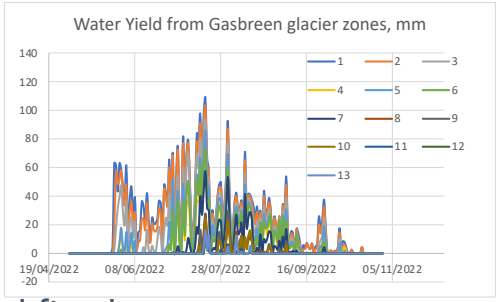




Gasbreen glacier







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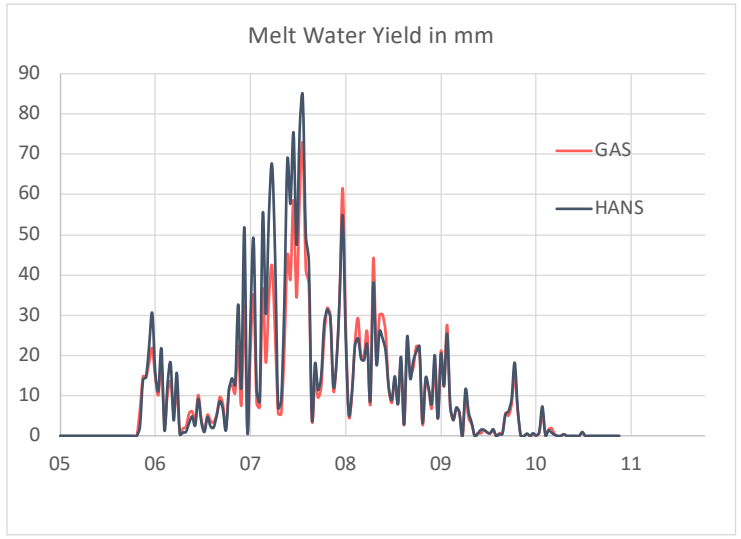
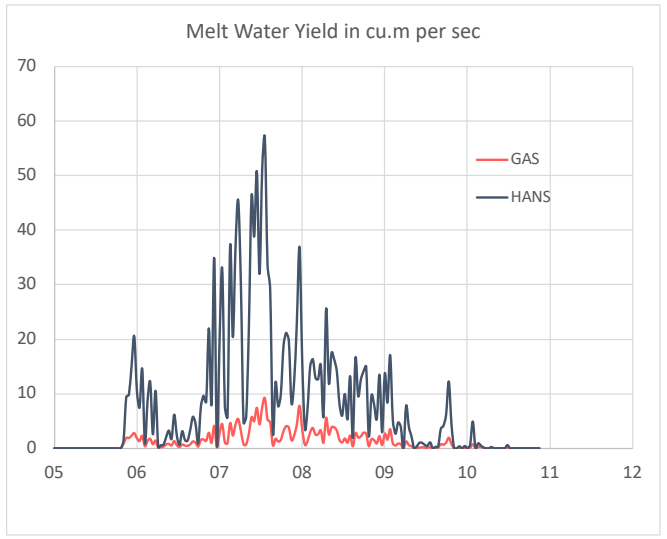
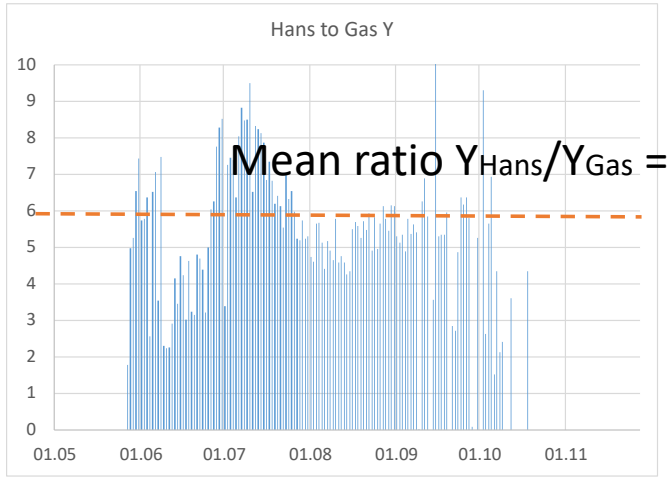
11 Melt water yield from Hansbreen and Gasbreen glaciers







Mean ratio Y_{Hans}/Y_{Gas} = 5.4

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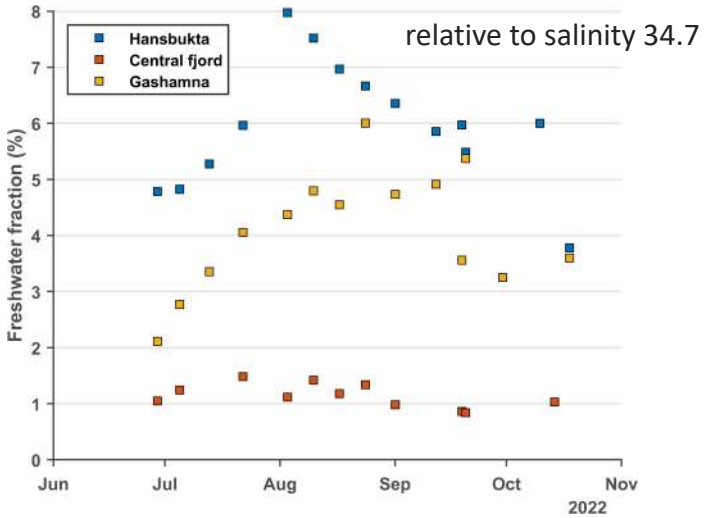
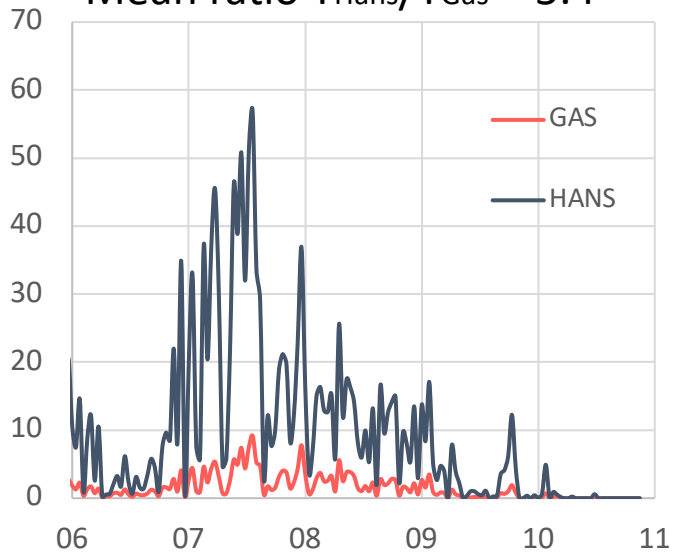
12 Freshwater fraction in the water column vs Melt water yield

Mean ratio FF_{Hans}/FF_{Gas} = 1.5



Mean ratio Y_{Hans}/Y_{Gas} = 5.4



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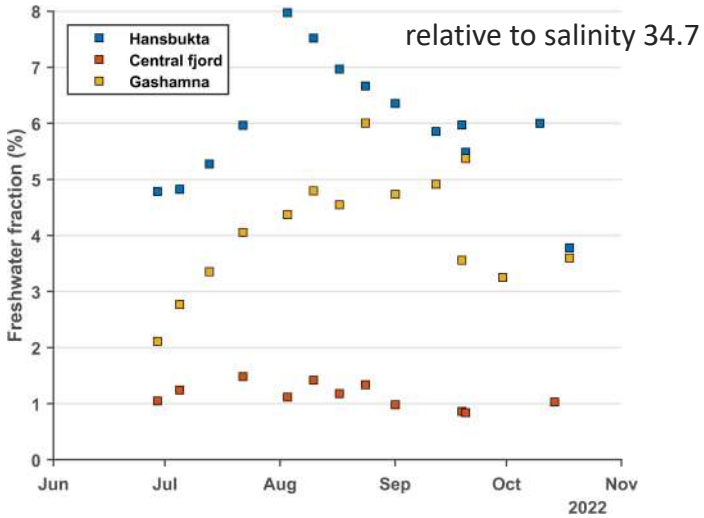
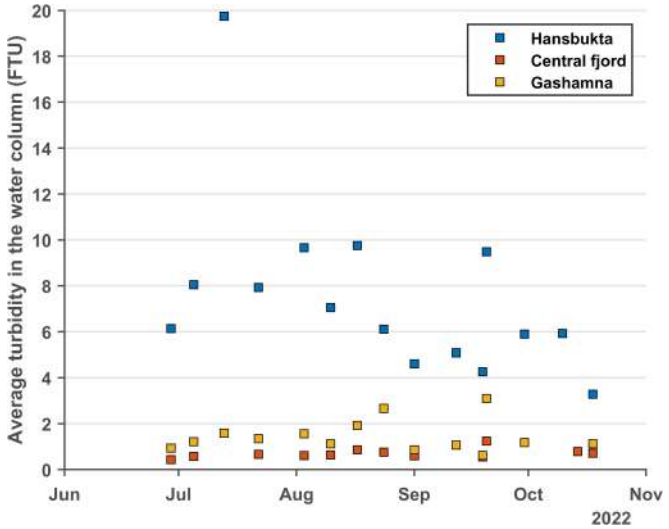
13 Freshwater fraction vs Turbidity vs Melt water yield

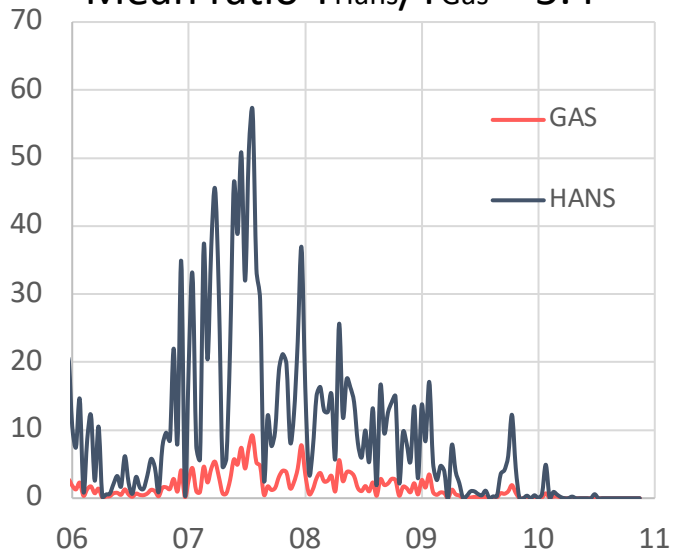
Mean ratio FF_{Hans}/FF_{Gas} = 1.5



Mean ratio SSM_{Hans}/SSM_{Gas} = **5.8**



Mean ratio Y_{Hans}/Y_{Gas} = 5.4



view on Gashamnoyra plain

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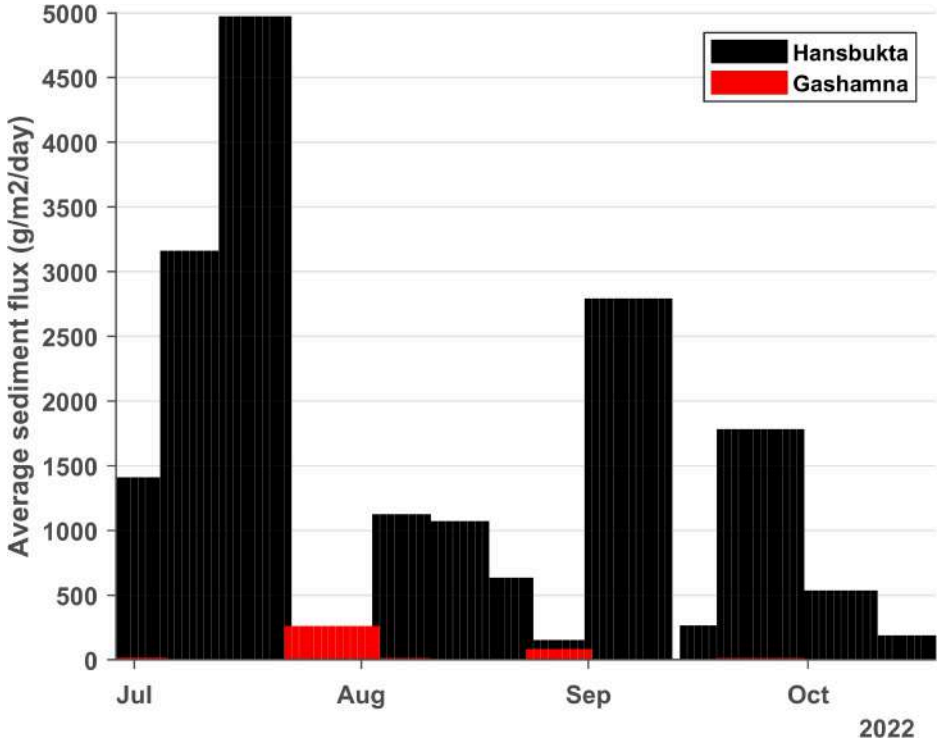
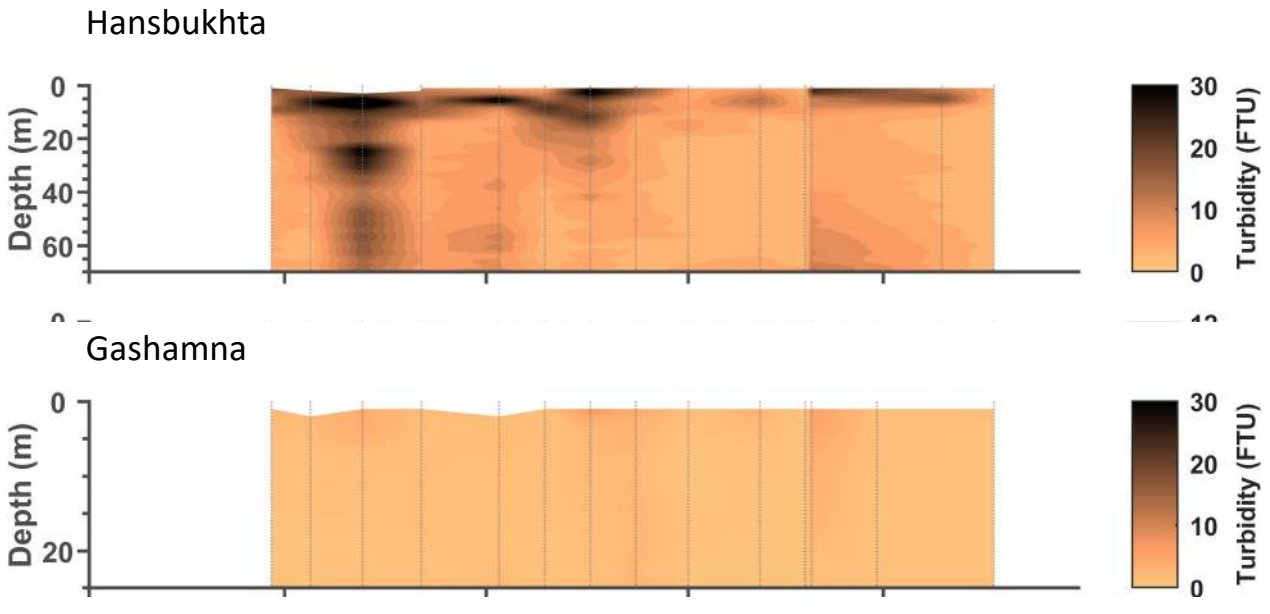
14 Sediment flux





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15 Further study…

- River gauges (water discharge, temperature, turbidity) has been installed downstream of the Hansbreen and Gasbreen glaciers in June 2023
- Modelling of suspended sediments runoff from the glaciated basins
- Coupling the results of hydrological modelling and direct measurements of suspended sediments dynamics in the water column and primary production in Gåshamna and Hansbukta
- Achievement of better understanding of deglaciation influence on the marine biological production in High Arctic areas

16 Take-away message:

- Deglaciation is expected to result not only in volumetric changes in matter supply of nutrients to Svalbard fjords, but substantial shift in the mechanics of this process with transition from predominately tidewater to land-based glaciers
- Marine bays fed by tidewater glaciers and and land-based glacier exhibit distinct differences in terrestrial material flux regime
- In case of a land-based glacier substantial part of the glacial-runoff suspended sediments can be deposited on land not reaching the bay

ekaterina.p.rets@gmail.com

Ekaterina Rets

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