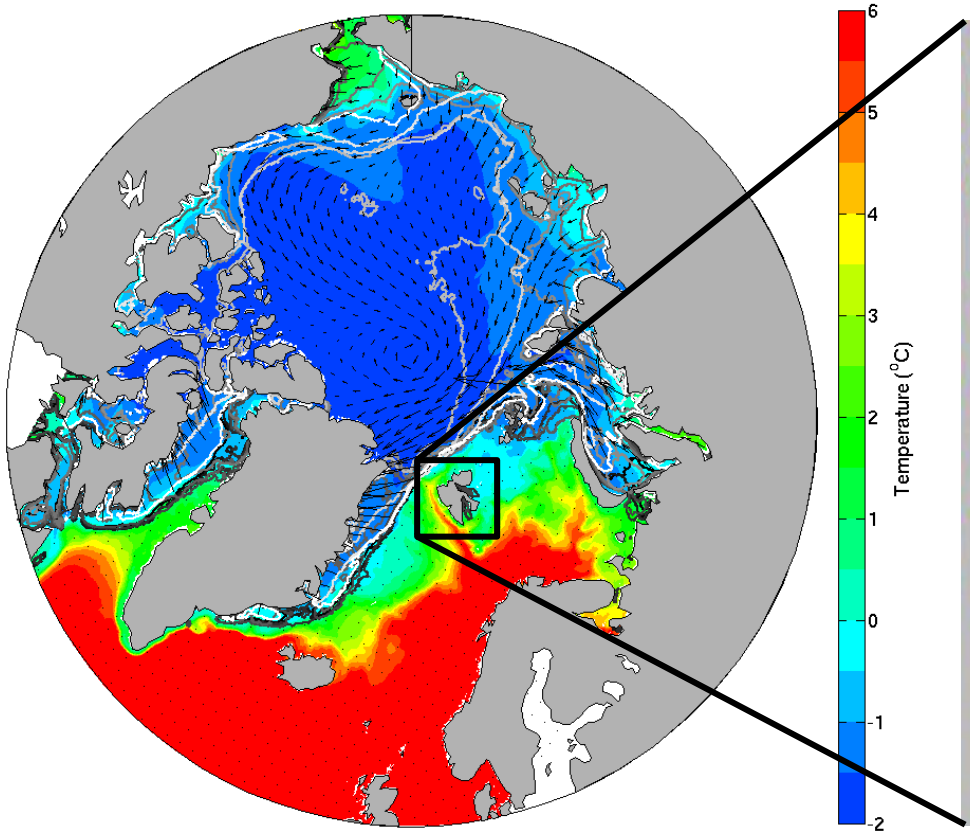
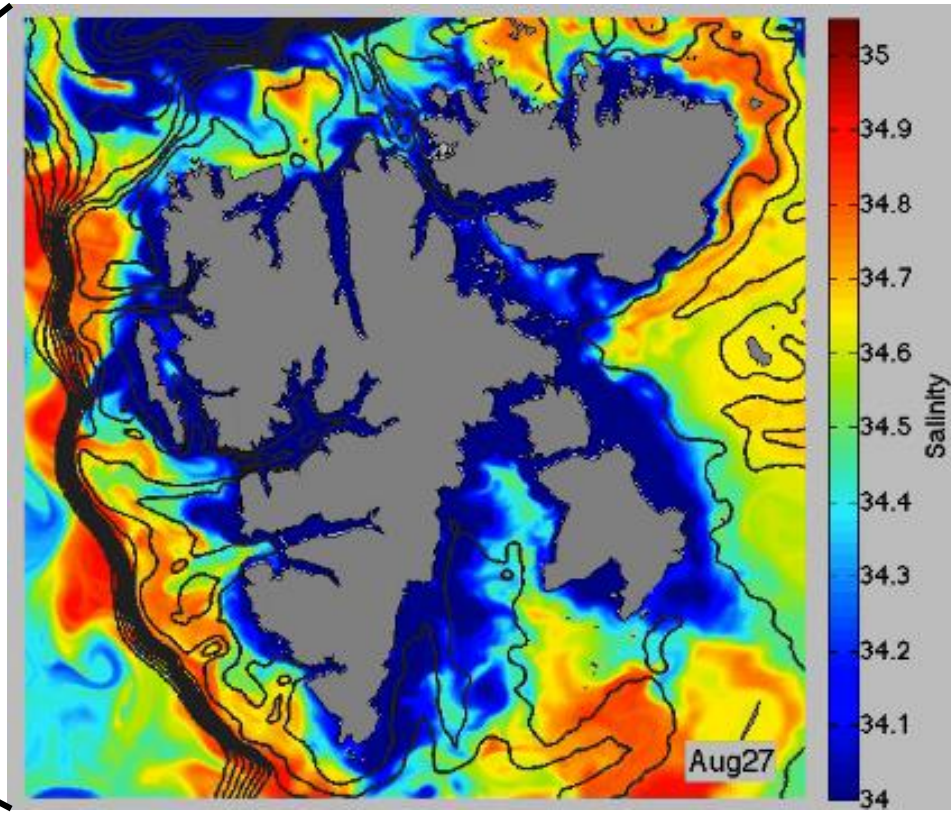
Coastal and regional circulation in Svalbard; cross-scale needs for data and numerical model tools.



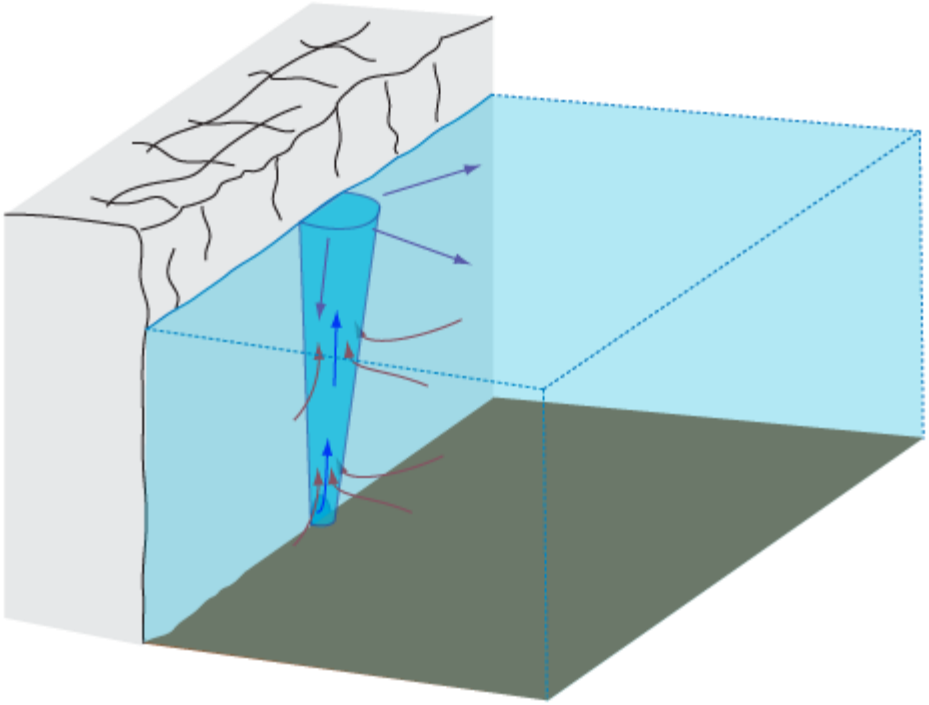


Late-summer distribution of freshwater (blue) around Svalbard, from model simulations.

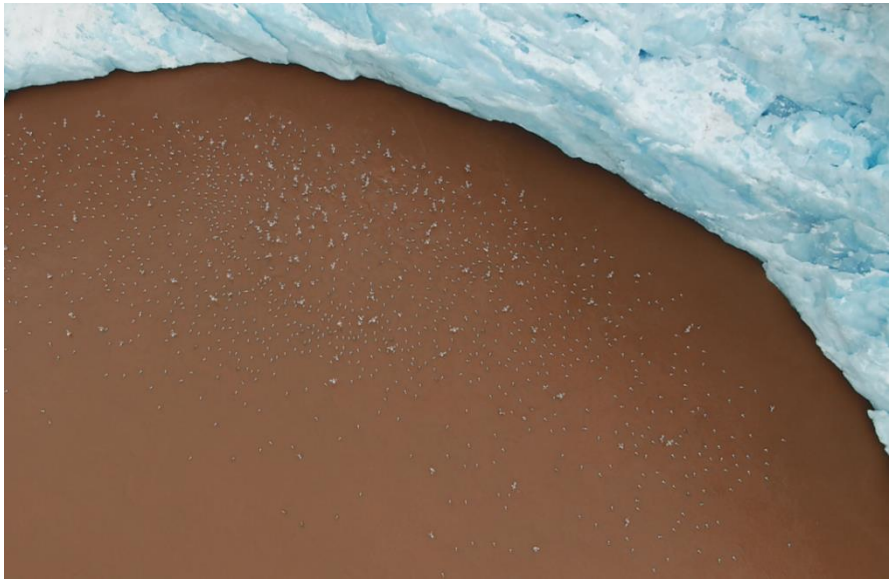
Dr Arild Sundfjord, Norwegian Polar Institute

Tidewater glaciers: refugia for Arctic species in a warming climate

Question: how do these hot-spots work, how do they vary, how will they change?



Meltwater plume rising in front of a glacier.
[Courtesy A. Everett]



Foraging birds having a good time in a sediment rich tidewater glacier plume.
[Photo: Sky News]

Tidewater glaciers: refugia for Arctic species in a warming climate

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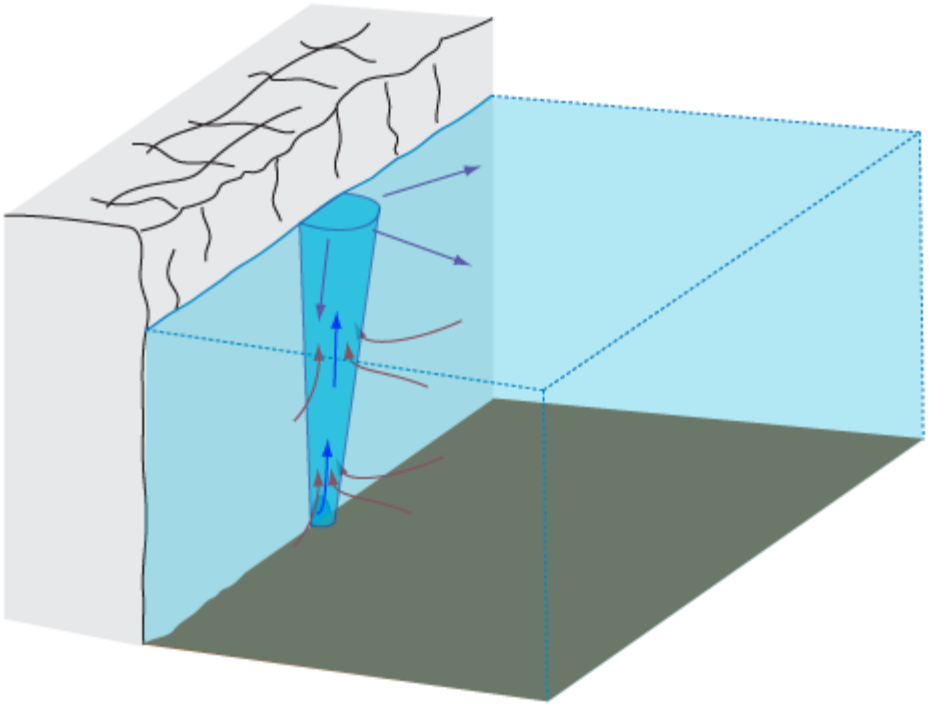
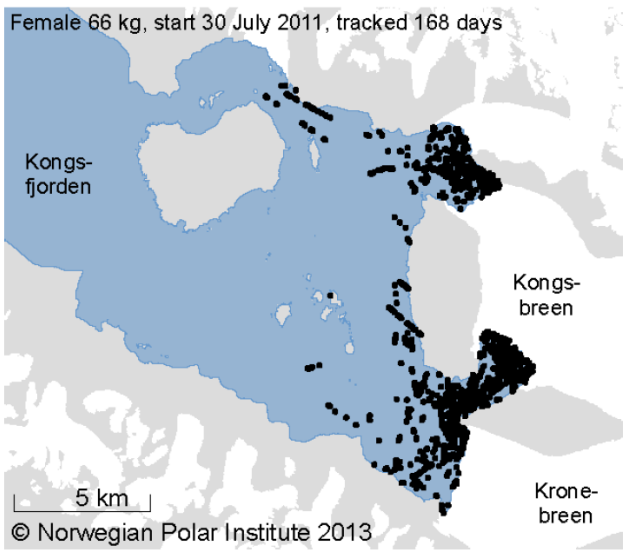


Meltwater plume rising in front of a glacier.
[Courtesy A. Everett]

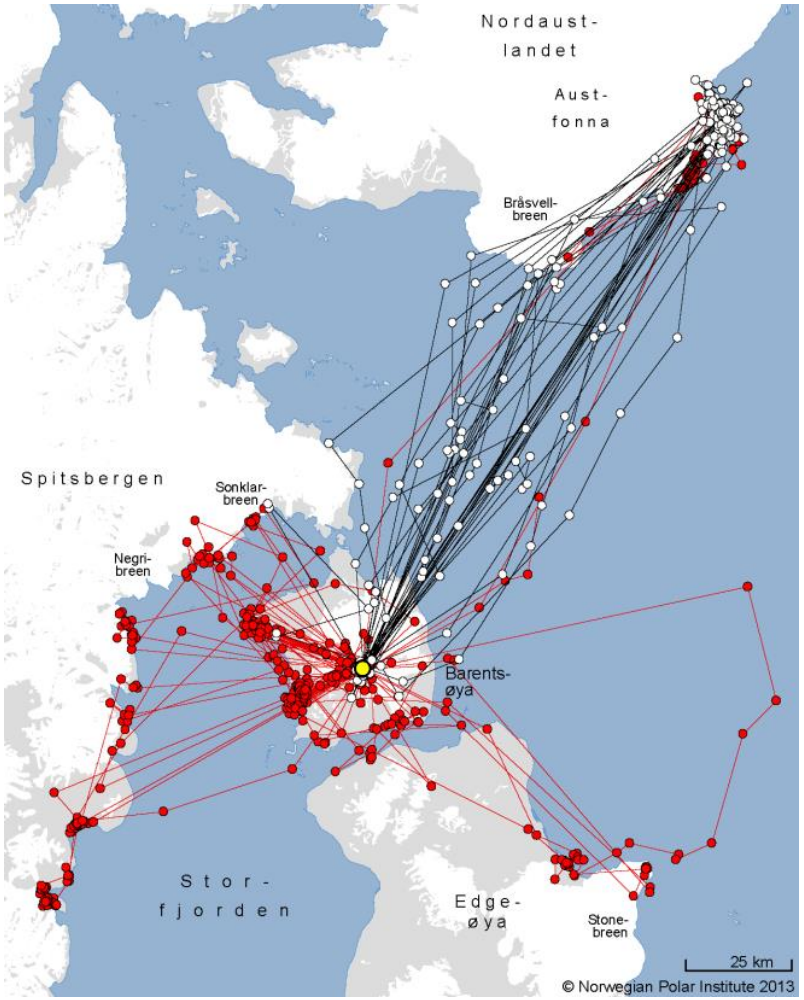
Ringed seal with Satellite Relay Data Logger.
[Photo: Kit Kovacs]



Positions in Kongsfjorden from a tagged Ringed seal.
[Lydersen et al., 2014]

This is not an isolated phenomenon, but widespread around Svalbard

Ivory gull



Breeding pair based on Barentsøya, with little sea ice around

[Strøm et al., unpub. data]

How do we analyze snapshots from a highly variable environment?

Glacier melt water runoff varies on daily scales depending on sun angle, weekly scales depending on weather, seasonal scales depending on solar input and air temperature, and inter-annually depending on large-scale atmospheric pressure and oceanic transports.

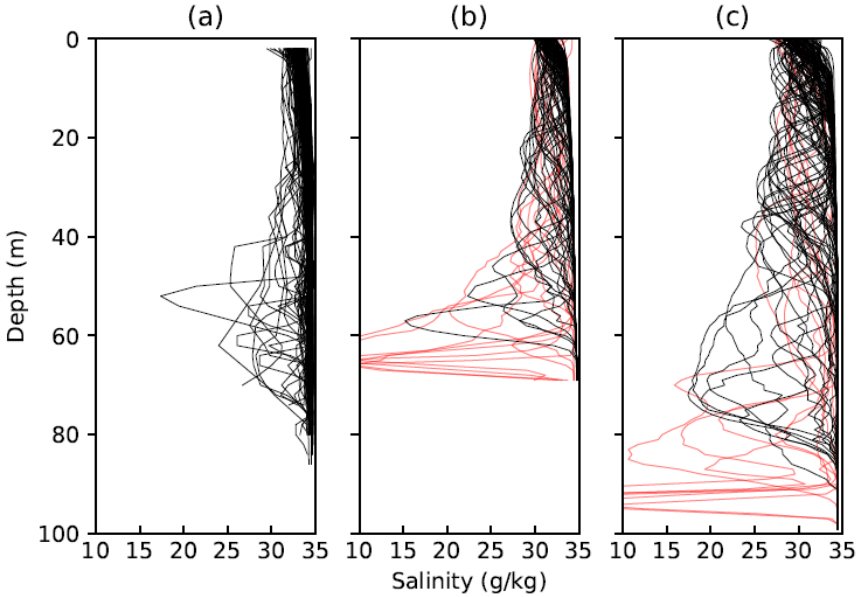
We need to know how the glaciers provide runoff; digital terrain models, mass balance time series, their response to atmospheric forcing, internal routing of meltwater.

The density of the water in front of the glacier - determined by its temperature and salinity - depends on internal fjord circulation dynamics and exchanges with the shelf and slope outside.

These factors together determine the runoff plume dynamics.

Numerical models are useful tools; both fine-scale and regional scale models are needed

Near-field: non-HS plume model



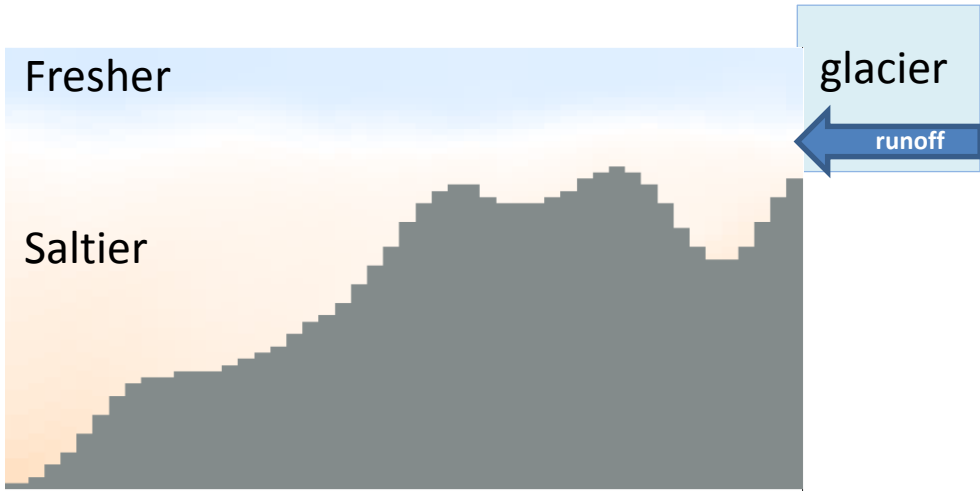
a) Salinity profiles from **seals**

b) **Simulated** salinity: 10 m^3s^{-1} @ 70 m

c) **Simulated** salinity: 50 m^3s^{-1} @ 100 m

[Everett et al., manuscript in prep]

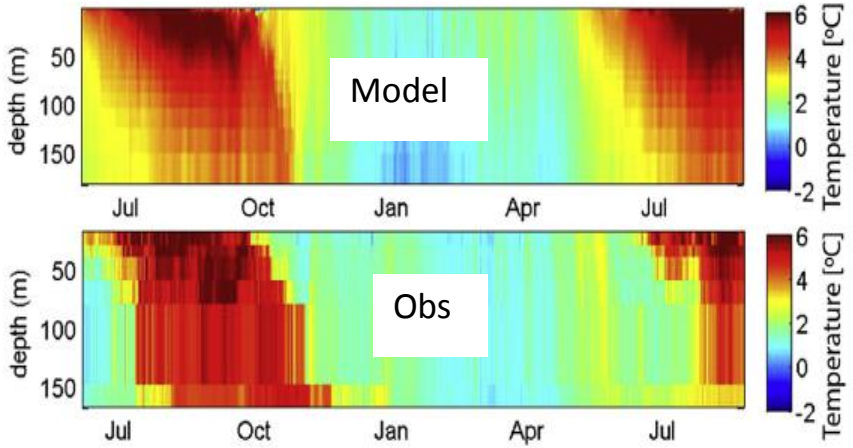
Fjord scale: high-resolution, runoff at depth



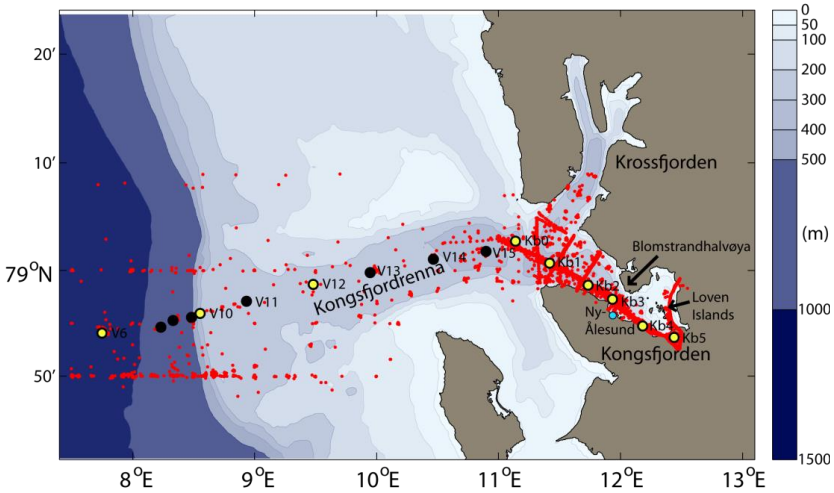
[Albretsen et al., manuscript in prep]

Follow the freshwater runoff to look at connections to larger area

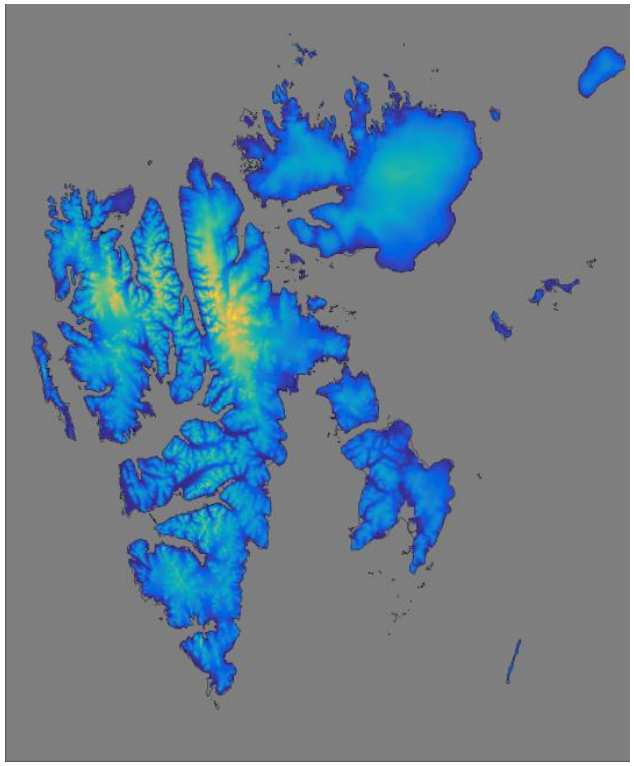
Simulated freshwater content (relative to S =34.9) in Kongsfjorden. [Fram metROMS model K160]



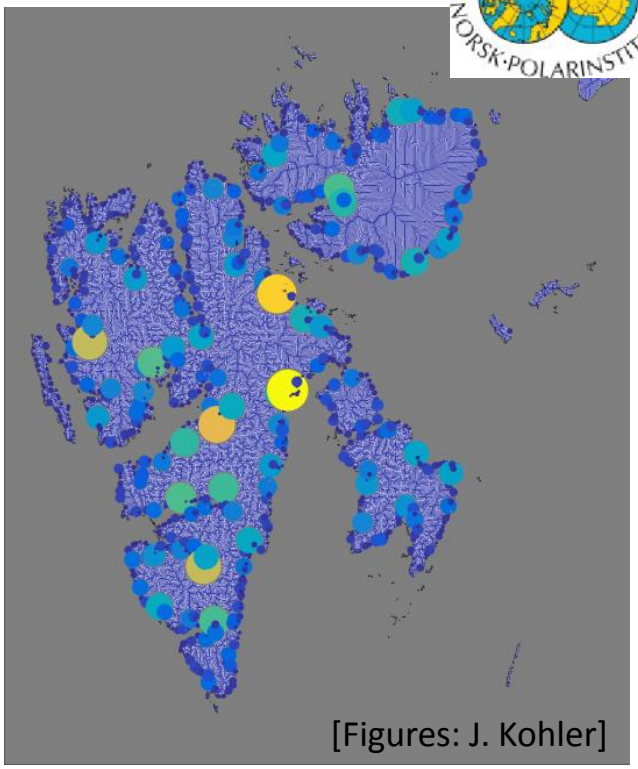
One-year temperature development from simulations [Sundfjord et al., 2017] and mooring (F. Cottier, SAMS).



CTD data from multiple institutes. [R. Skogseth, UNIS]



+ **Runoff** calculated from atmospheric model and glacier mass balance =



[Figures: J. Kohler]

Glacier database: Glacier outline database: (data.npolar.no).
Tidewater glacier fronts updated until 2015, update ongoing.

Mass balance data. Mass balance data available at World Glacier Monitoring Service.
Svalbard glaciological community has assembled a data set for mass balance model.

Mass balance and snow models: several available, continuous development

Aggregated freshwater circulation from all Svalbard glaciers

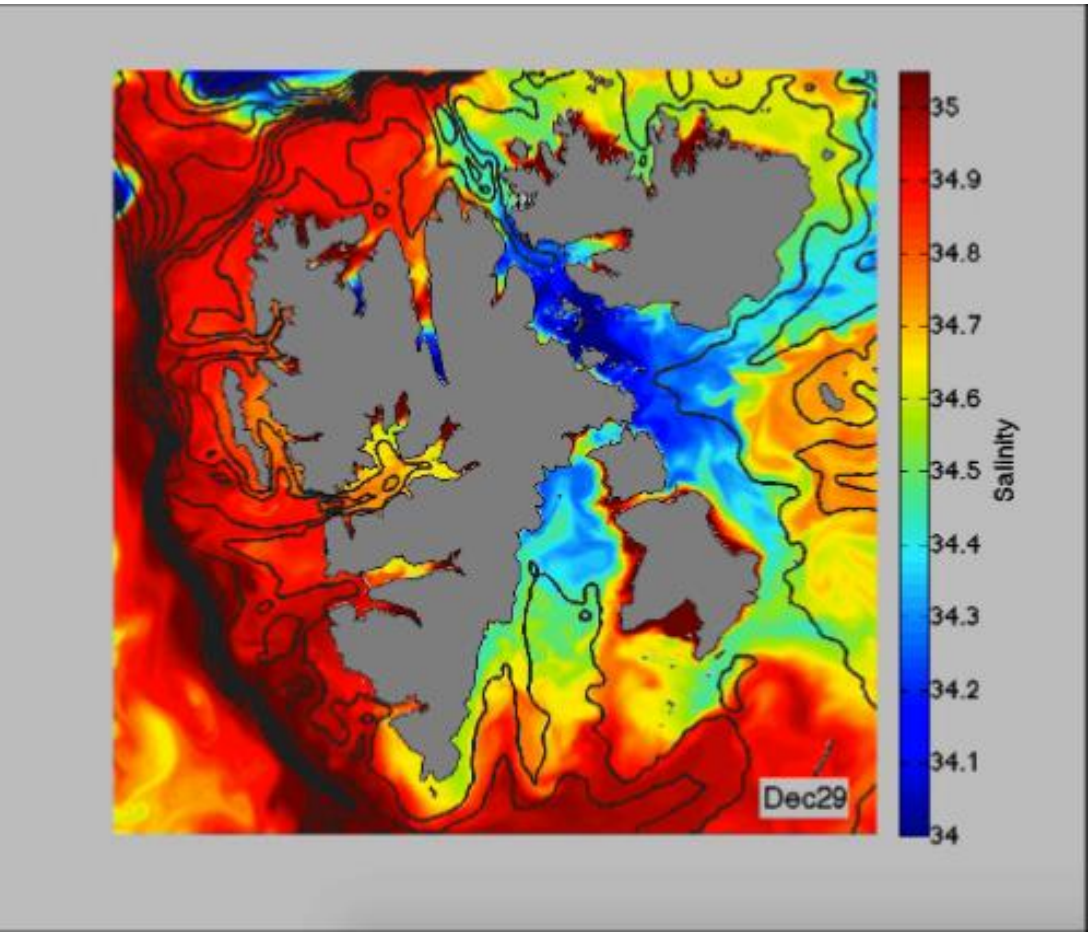
Simulated salinity in upper 10 m.
[Hattermann et al., 2016]

Sea ice cover next winter depends on atmospheric conditions (FDD, clouds etc), (upper) ocean heat content - and freshwater content.

Air temperatures in Svalbard depend on sea ice concentration north and east of Svalbard.

Air temperature affects snow accumulation as well as fjord sea ice formation and hence AW exchange because fast ice modifies the wind-driven transports.

Aggregated freshwater circulation from all Svalbard glaciers



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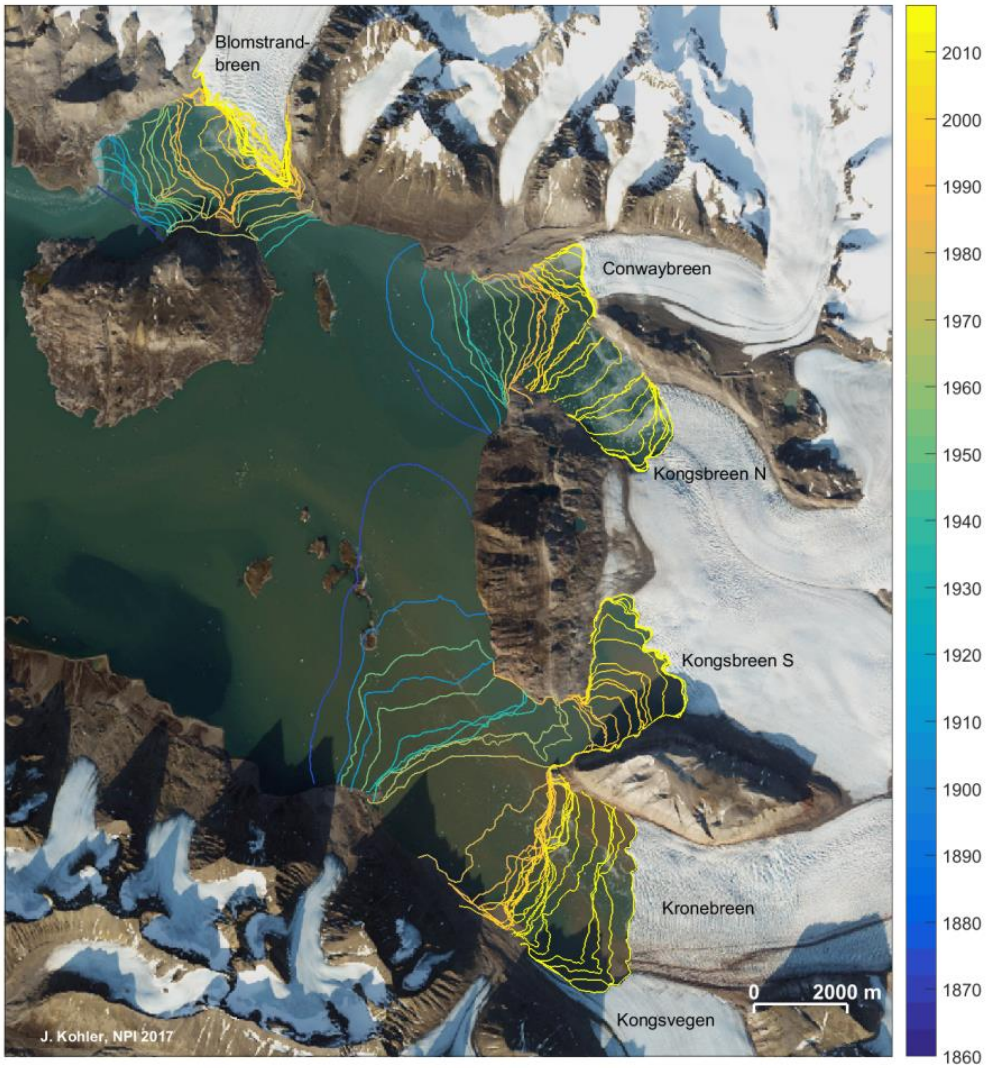
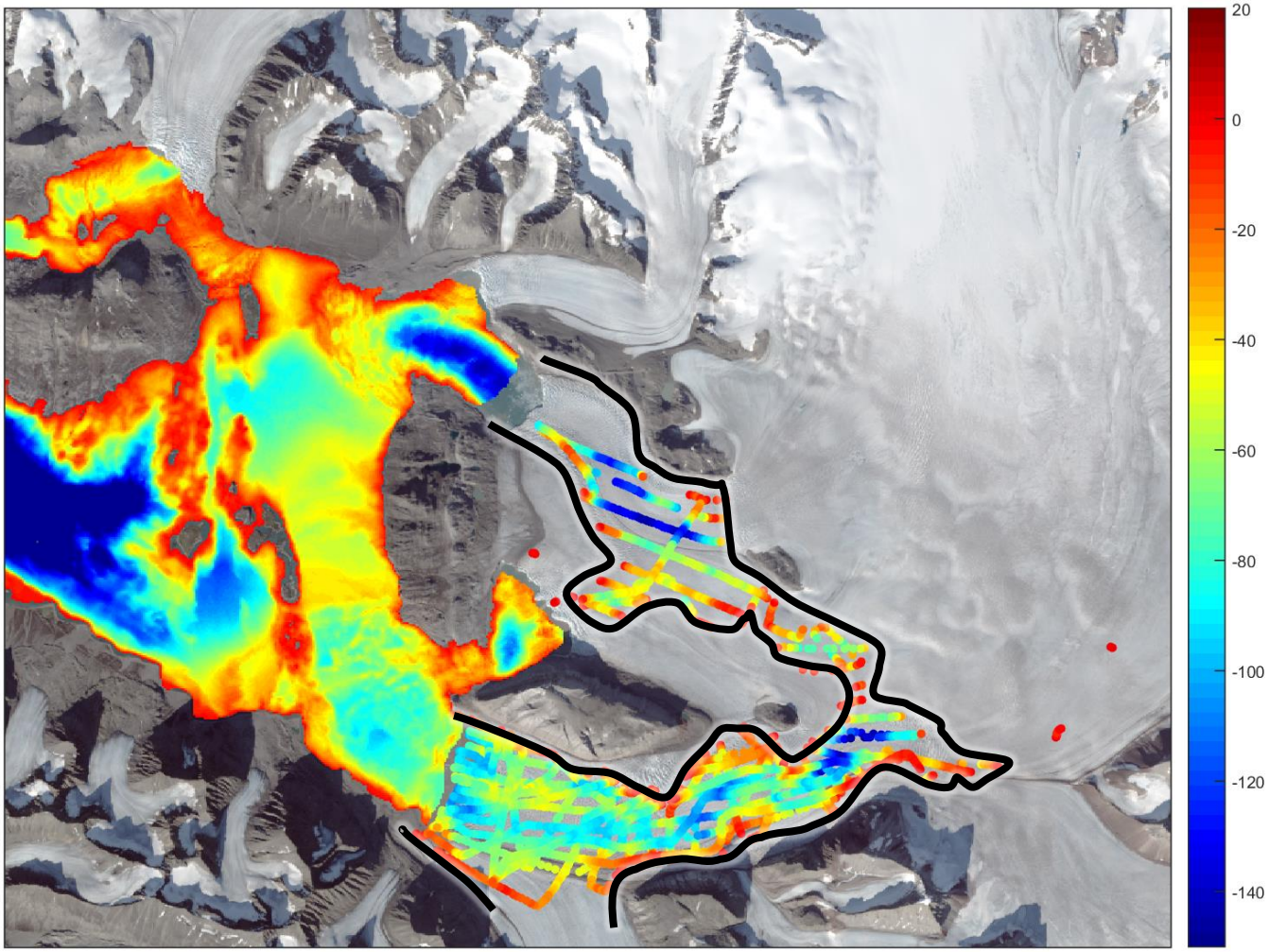


Most glaciers around Svalbard are rapidly retreating – here the example of Kongsfjorden

Glacier front positions in Kongsfjorden last 150 years [courtesy J. Kohler]



Bedrock depth under glaciers
[courtesy J. Kohler & K. Lindbäck]

Runoff hotspots now and in the future

If we are to understand why the glacier runoff plumes under certain conditions are attractive feeding hotspots we need to learn more about the interplay between glaciers, atmosphere and ocean – setting the stage for the marine ecosystem.

A strong, surfacing plume is a requirement for a hot-spot to be established, but sufficient exchange with offshore waters is also necessary. We see instances of strong surface plumes without aggregation of feeders, could this be in periods when the inflow is limited? Observations and model results indicate that strong inflow events are intermittent; some long, some short, and many not reaching the interior fjord.

If we want to predict how this will evolve in the future we need to know how runoff and plume dynamics as well as Atlantic Water inflow will change in a warmer climate.

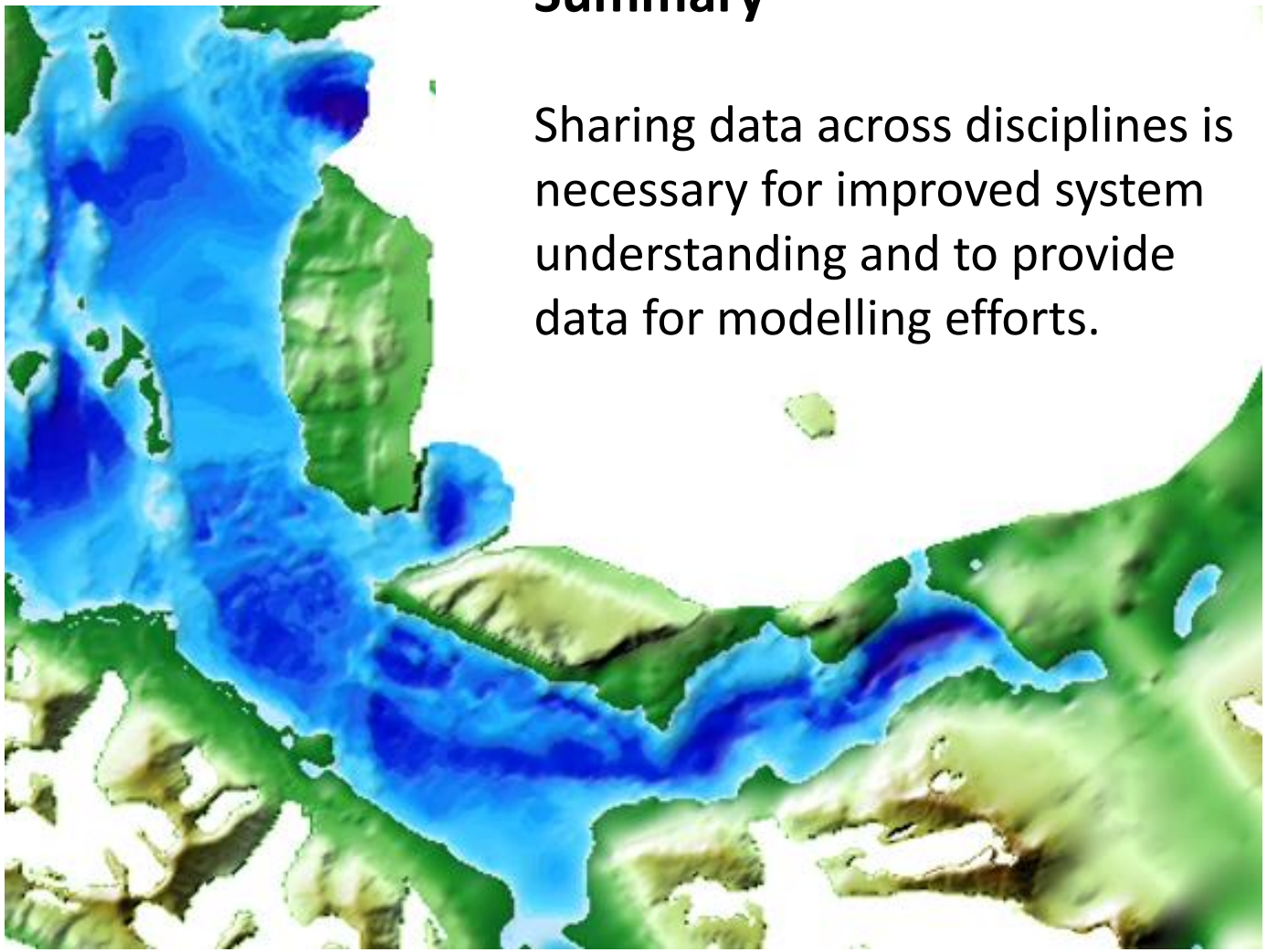
As the glaciers retreat onto land the runoff will be in form of rivers - can increased river runoff to some degree compensate for disappearing plumes?

To what extent will the future longer fjords increase tidal exchange?

Connected or coupled models – quality controlled against large data sets - are needed.

Summary

Sharing data across disciplines is necessary for improved system understanding and to provide data for modelling efforts.



[courtesy J. Kohler & K. Lindbäck]

Acknowledgements

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