Modeling study of the Svalbard fjord - Hornsund

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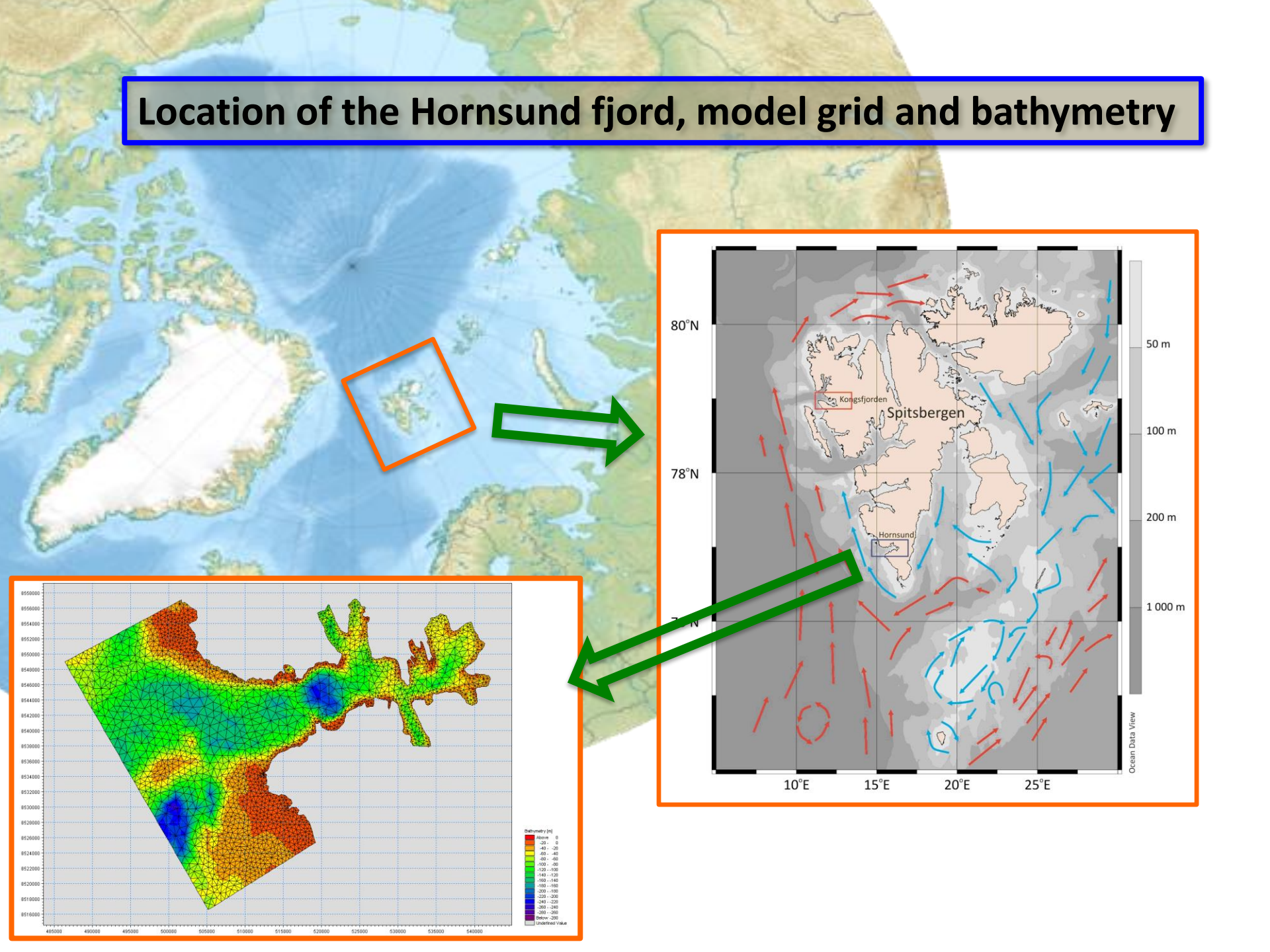
Location of the Hornsund fjord, model grid and bathymetry



Motivation:

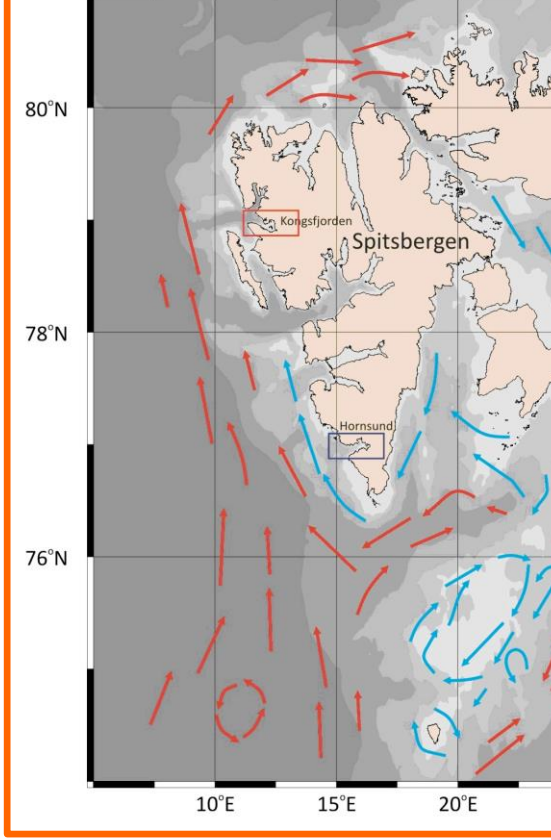
Hornsund is the most southern fjord of the Svalbard archipelago. But in biological point of view the fjord has slower growing up (aging). So although the Hornsund is in the southern part of archipelago, it is called cold by biologist. One of the main part of our work is to understand why this fjord is colder then other fjords.

Also it is important to understand the interactions between the key components of the climate system in the Svalbard area.

The work is done in the frame of two projects:

GAME – Growing Arctic Marine Ecosystems

AWAKE2 - Arctic Climate System Study of Ocean, Sea Ice and Glaciers Interactions in Svalbard Area



PAN

GAME

Growing of the Arctic Marine Ecosystem

Outline:

1) Short model description
2) Three levels of validation:
    - Tides
    - Shelf area
    - Fjord area
3) Selected results
4) Conclusions and future plans

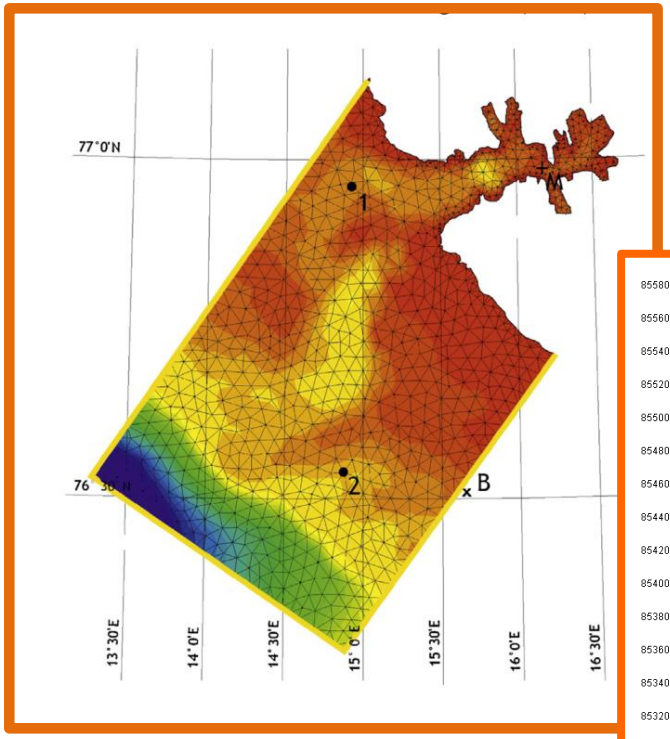
Model description:

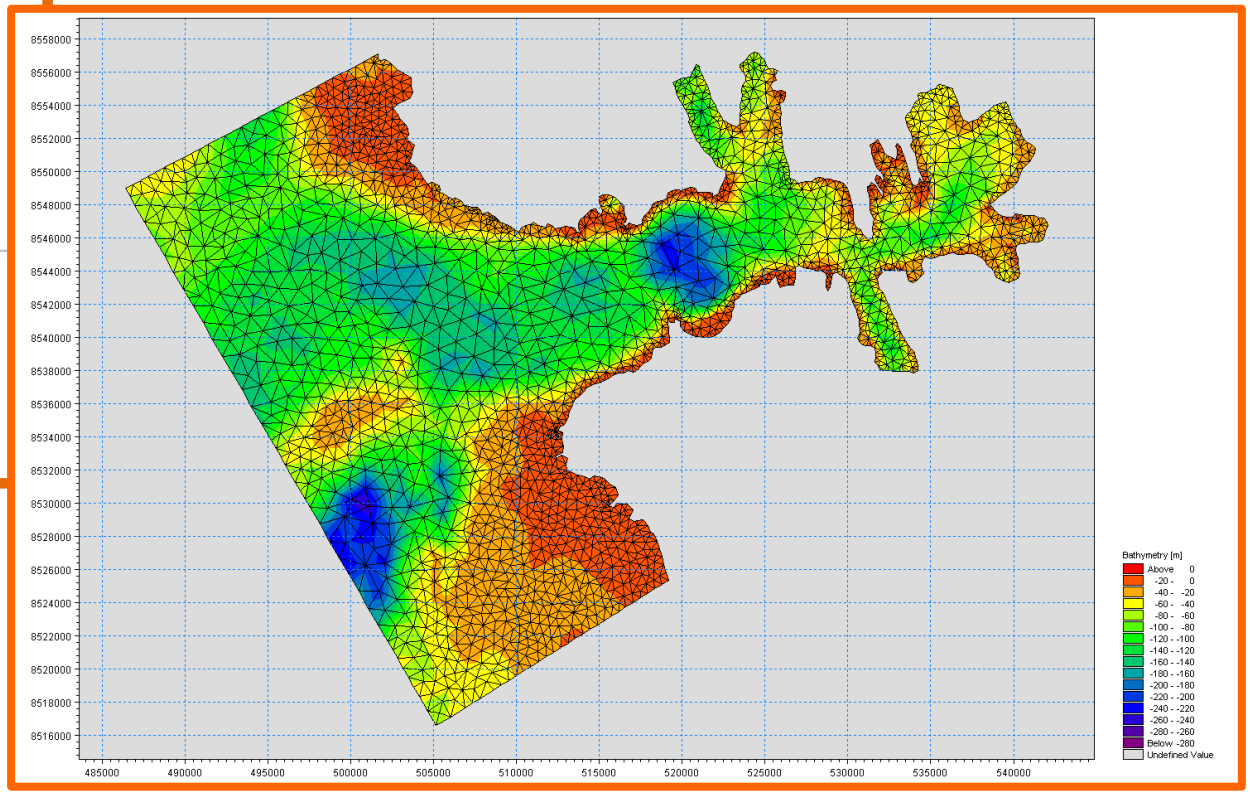
1) **Model engine – MIKE by DHI (commercial product)**
2) **Open boundary conditions**
   - **Data (temperature, salinity, barotropic velocity) from Norway Arctic Model (ROMS) – 800 meters horizontal resolution**
   - **Tidal sea level data from global tidal model (0.25 degrees resolution)**
   - **At the lateral boundary implemented flather boundary (combined sea level with barotropic velocity)**
3) **k-epsilon vertical mixing scheme**
4) **Variable roughness for the whole domain**
5) **Atmospheric data from ECMWF (except ice concentration and thickness)**
   - **Precipitation**
   - **Winds**
   - **Visibility (cloud cover)**
   - **temperature**
6) **Ice cover also from Norway Model**
7) **Fresh water fluxes from two simple images (next slides)**

Very limited sources of data that covers Hornsund area (mostly resolution for climate models – not for regional small domains)

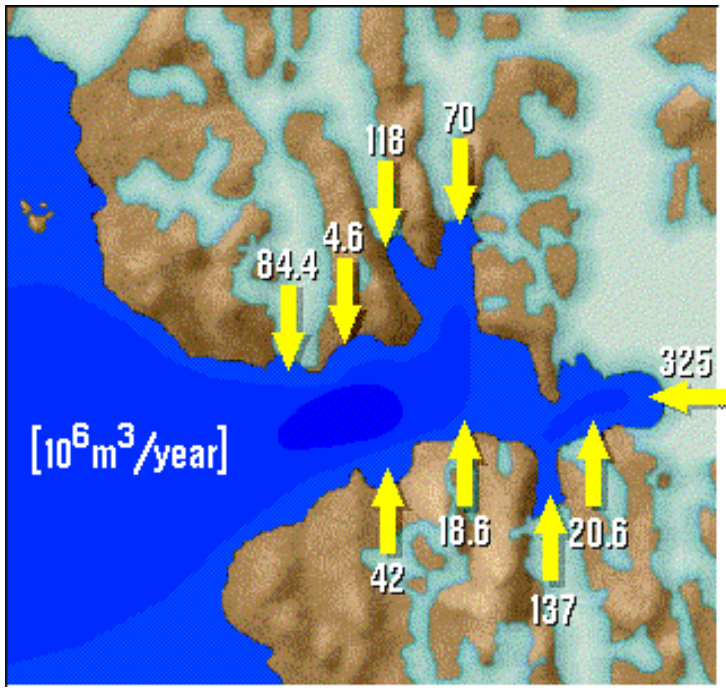
This work is still in progress

Model domain, bathymetry and lateral boundary

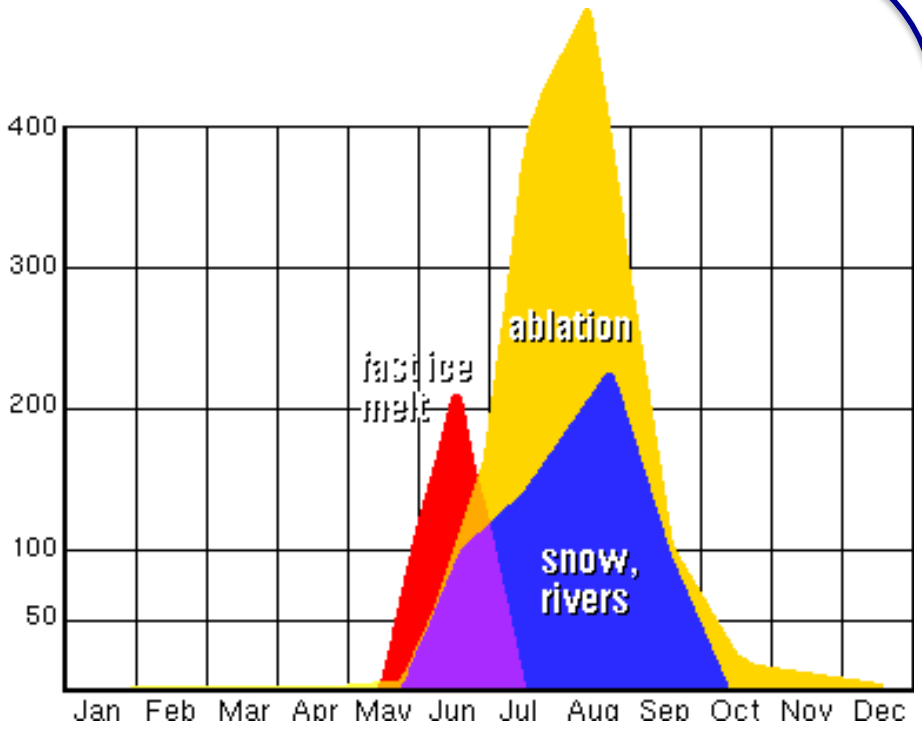




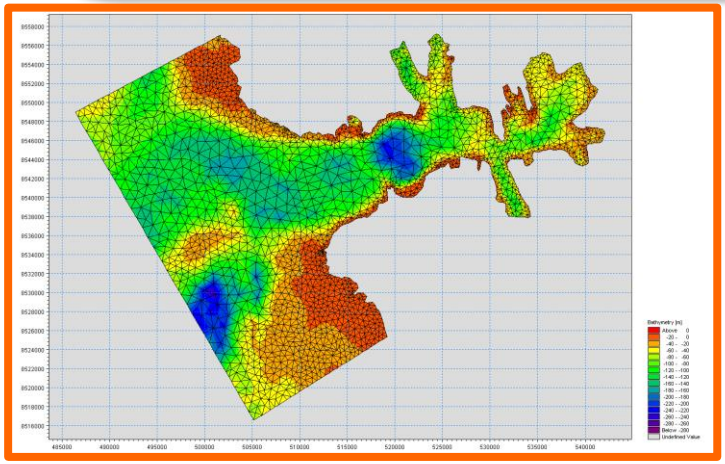
- **Fresh water sources**



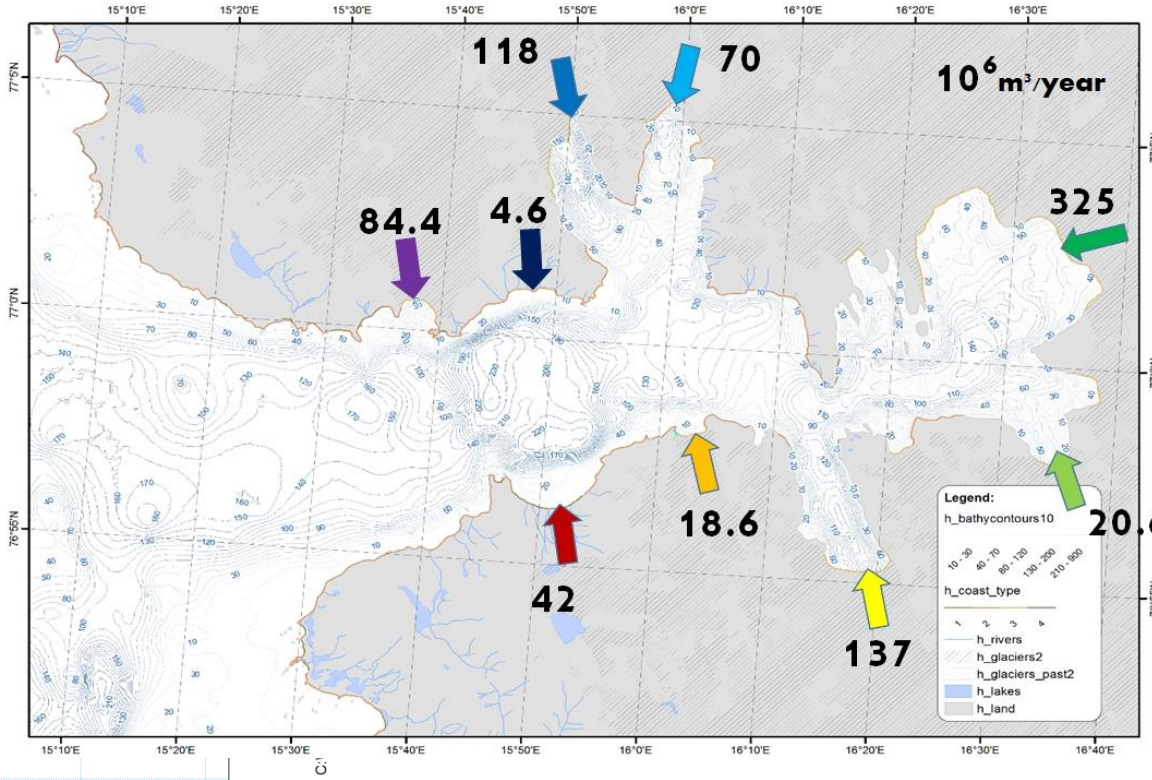
Pulina & Jania 1994

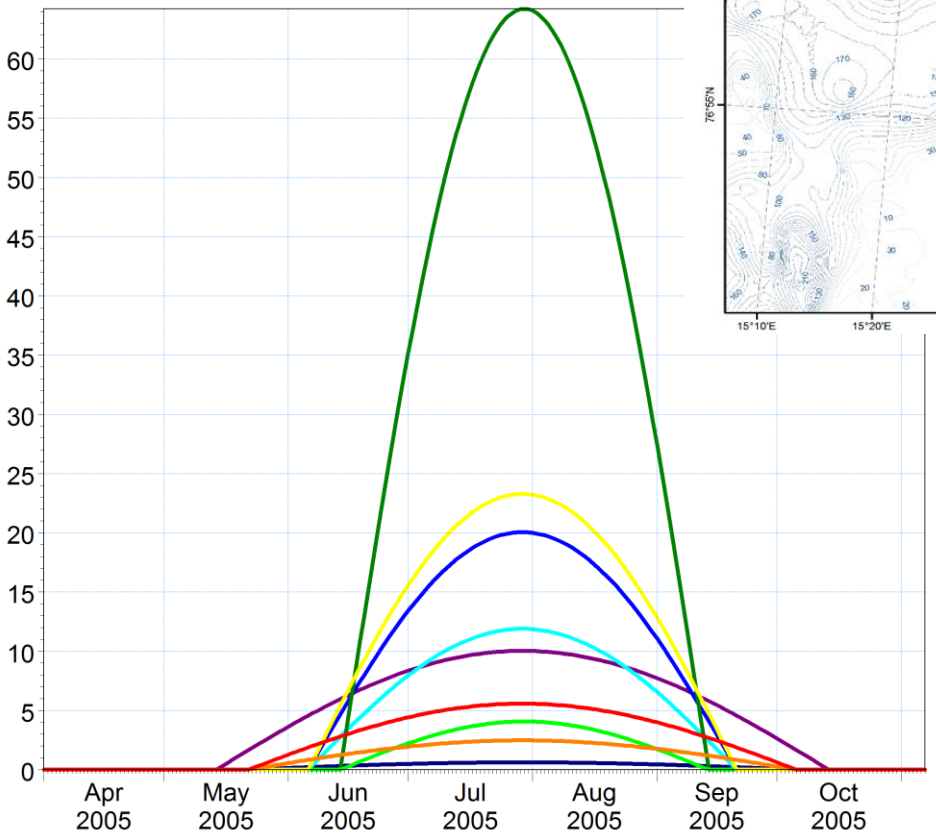


Weslawski et al. 1995



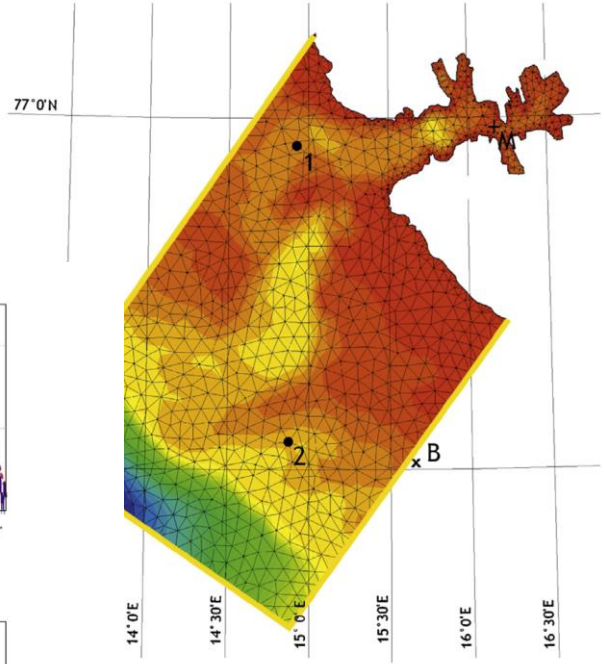
Fresh water sources interpolated for the model



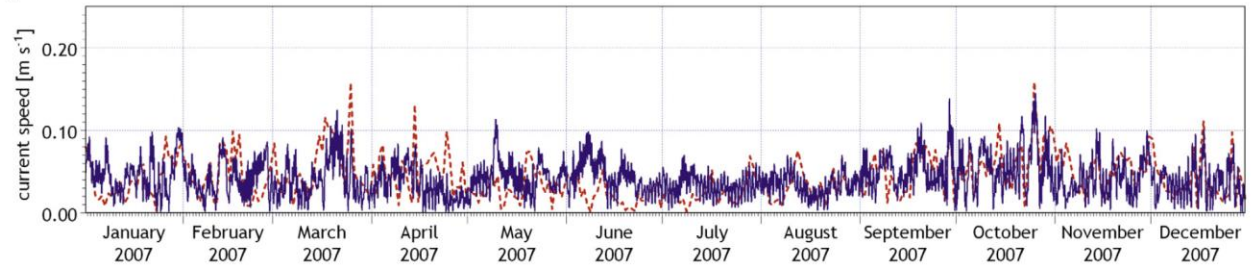


Validation in the shelf area – batrotropic currents

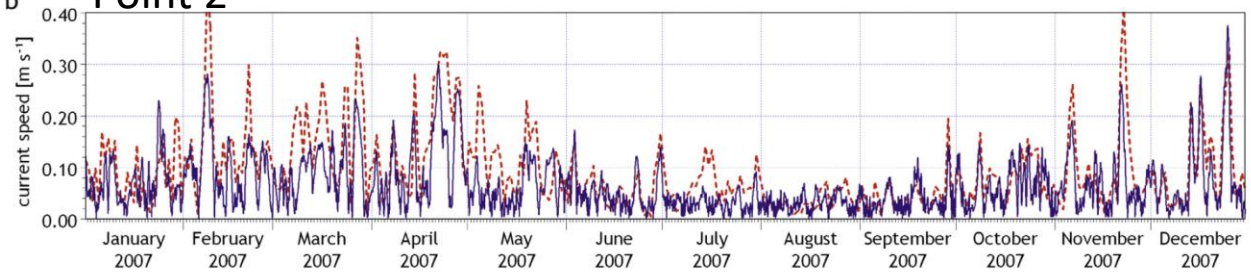
(blue lines – our model)



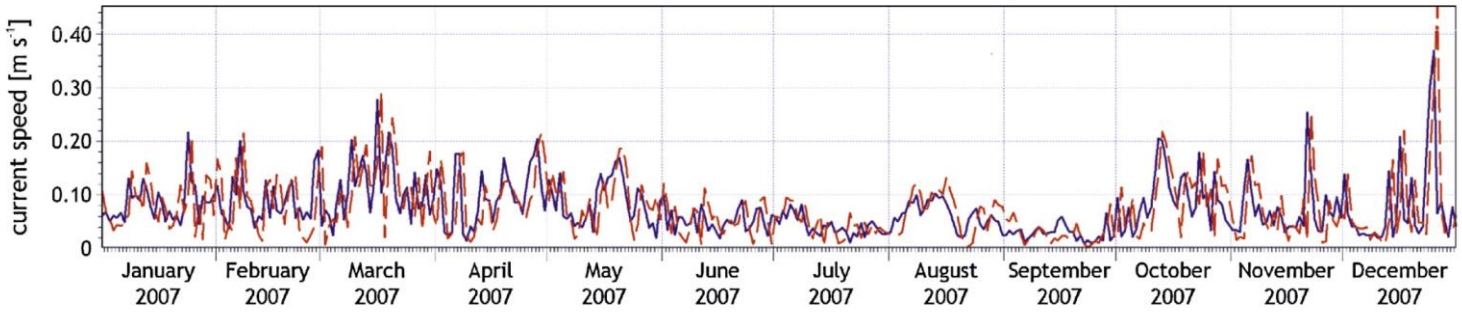
Point 1

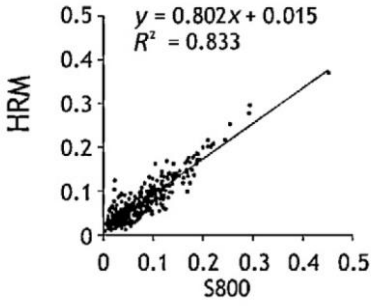


Point 2



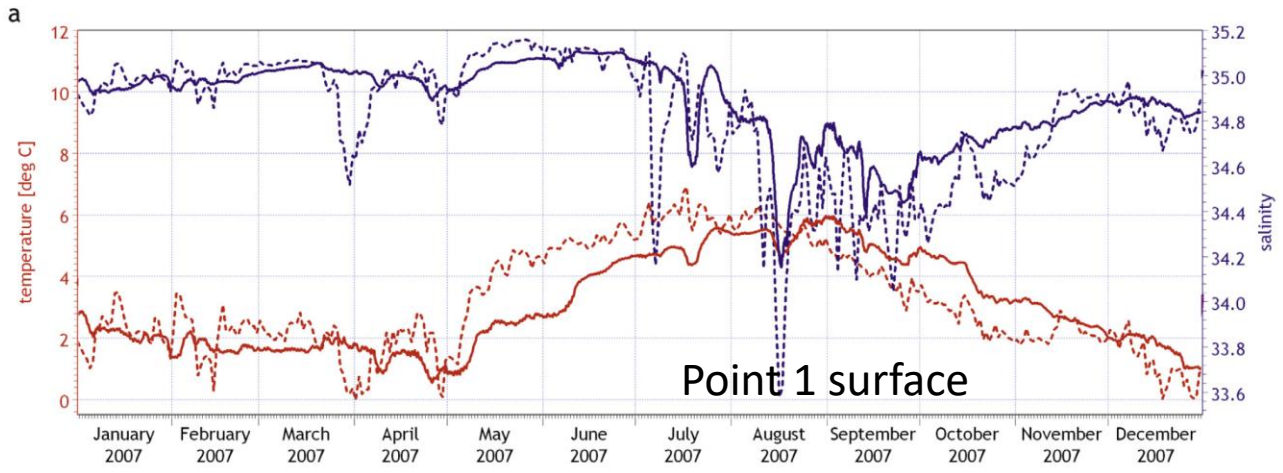
Point B

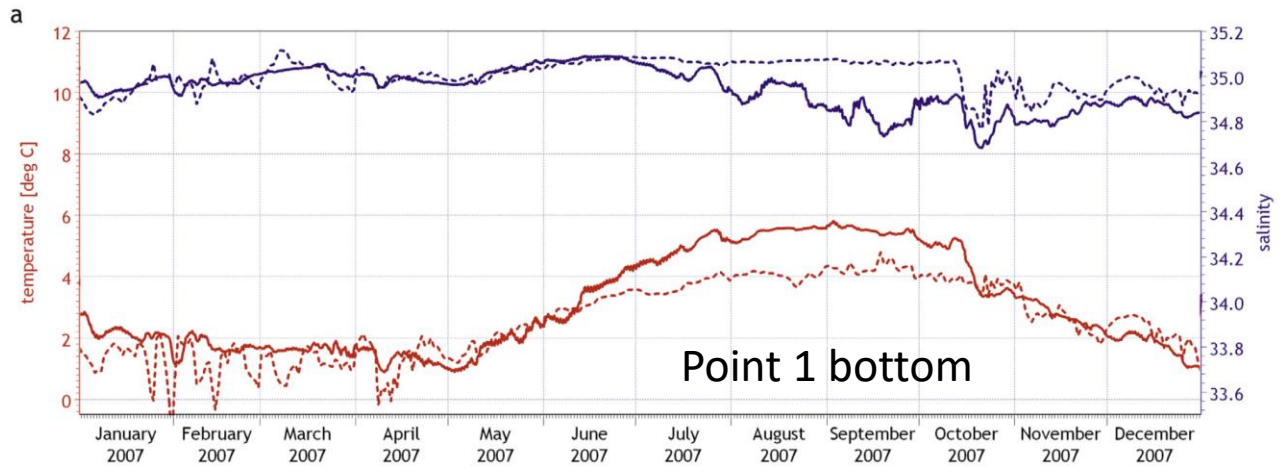


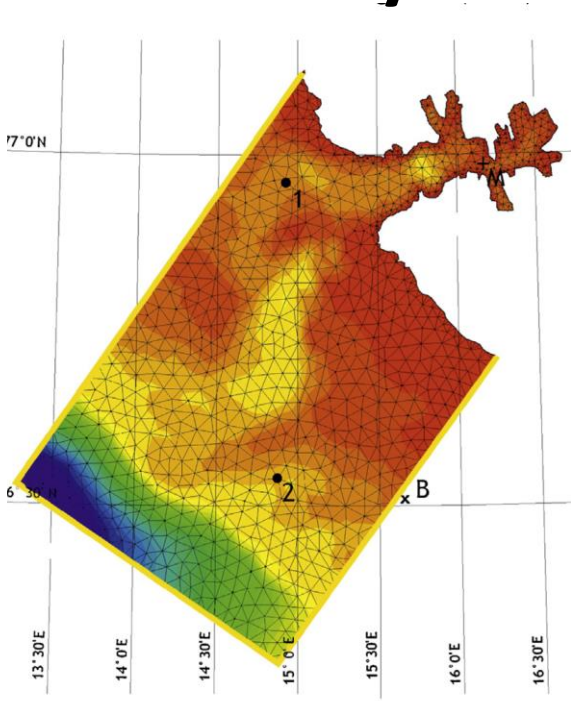


Validation in the shelf area – surface and bottom temperature and salinity

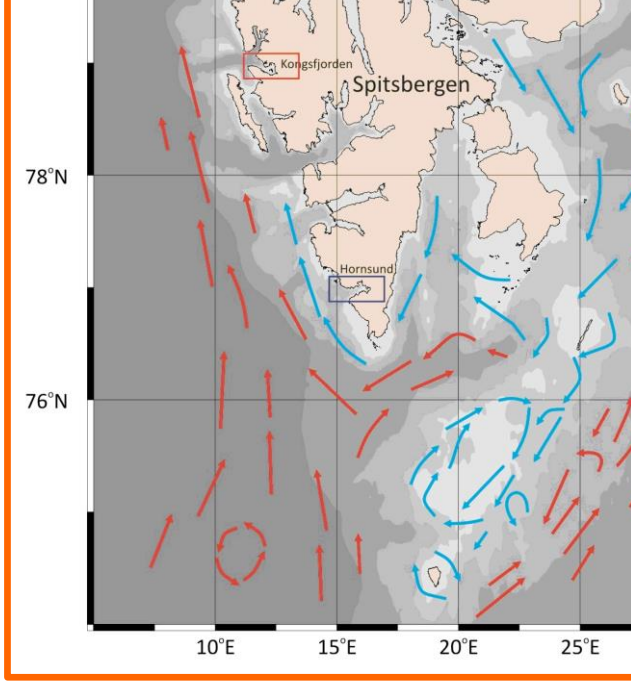
(solid lines – our model)

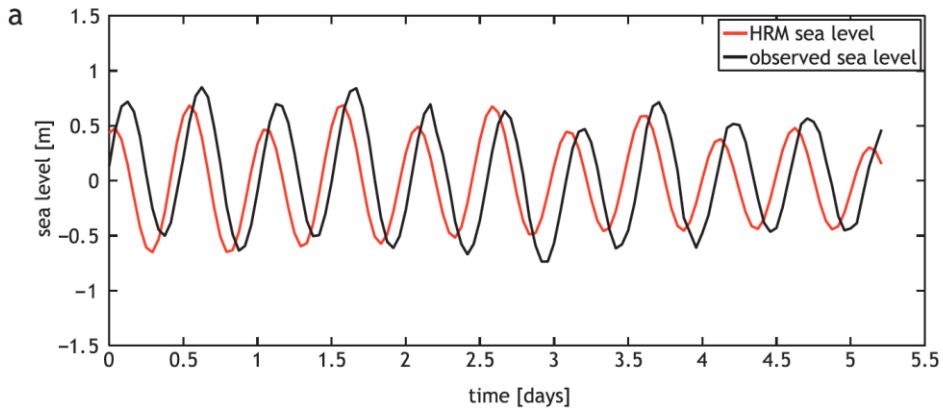


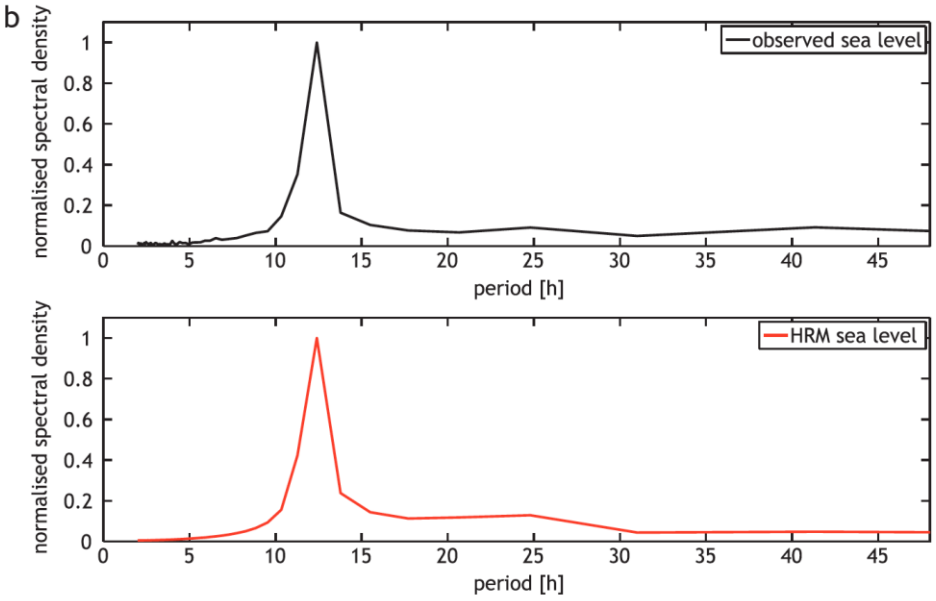


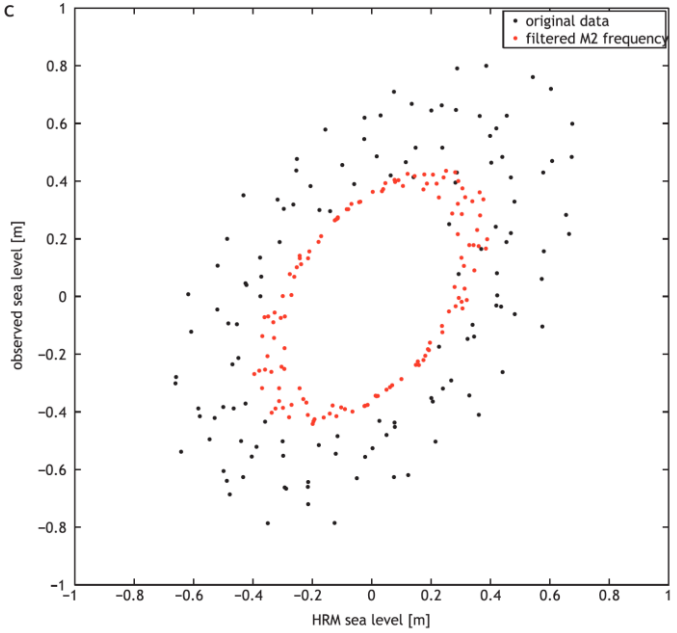


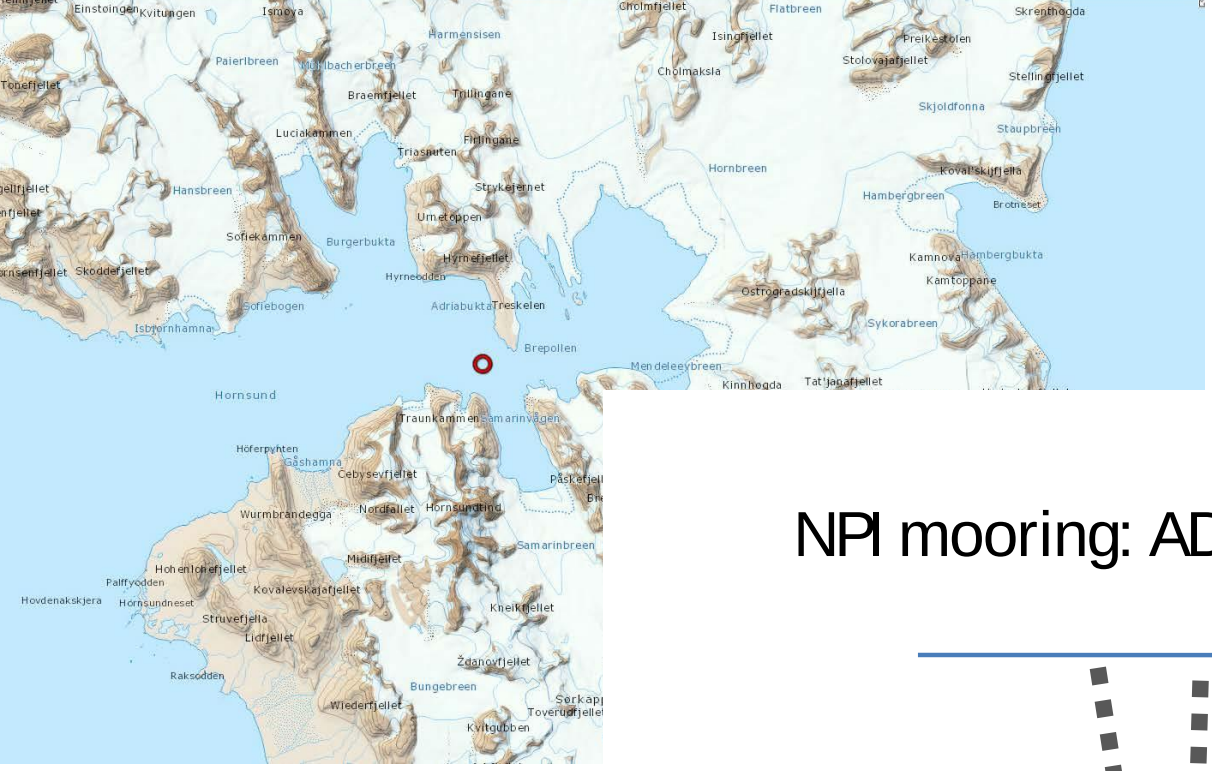
Sea level validation (tides) – only term comparison



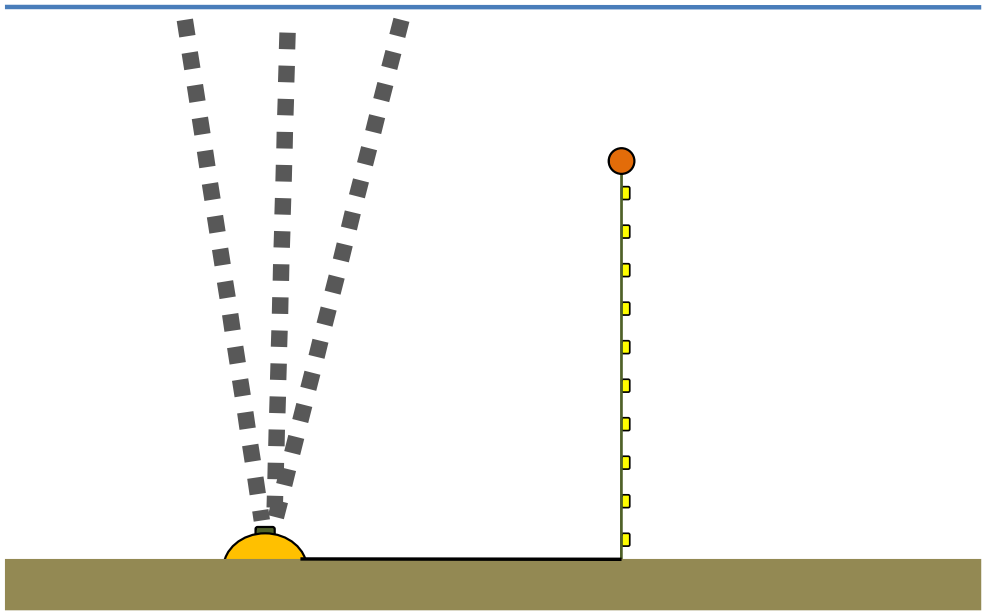








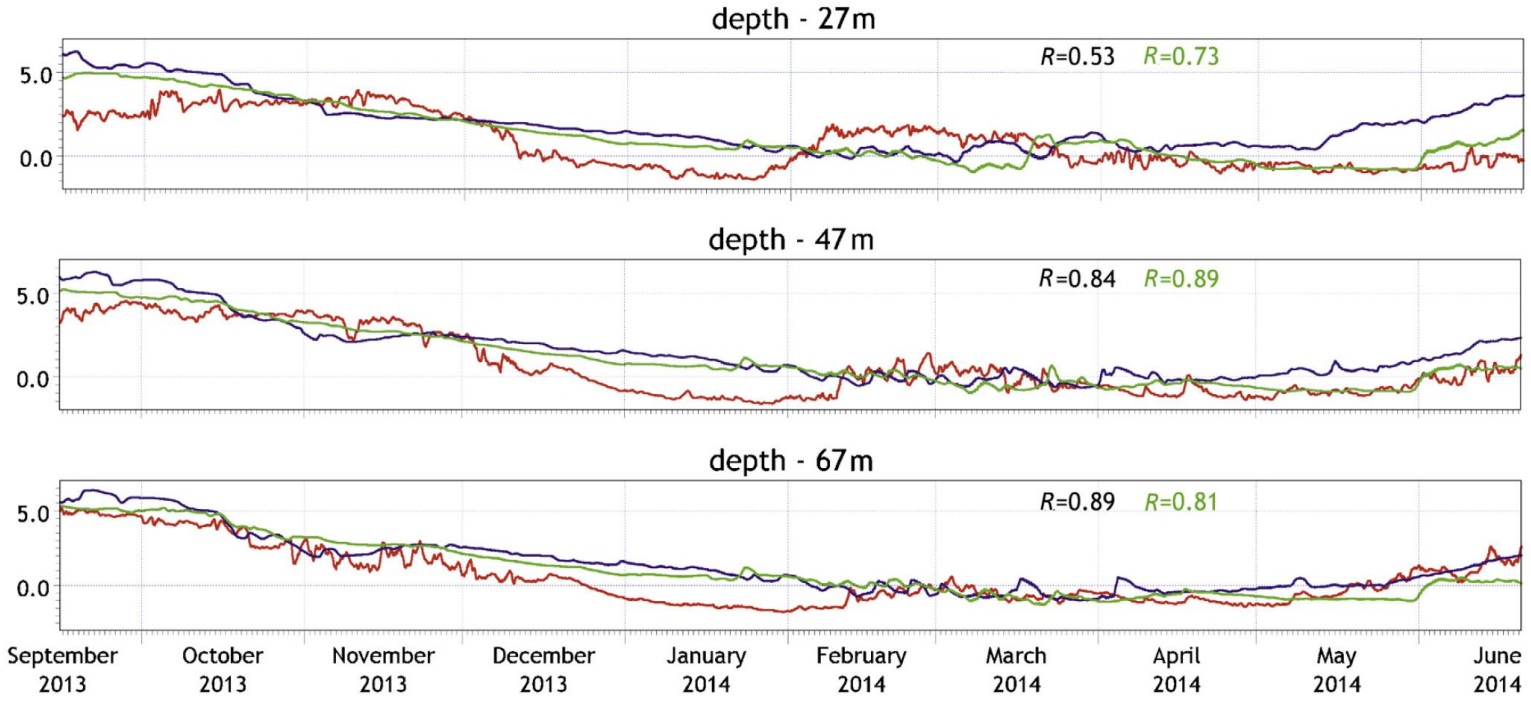
NPI mooring: ADCP w/ CTD + thermistor stri



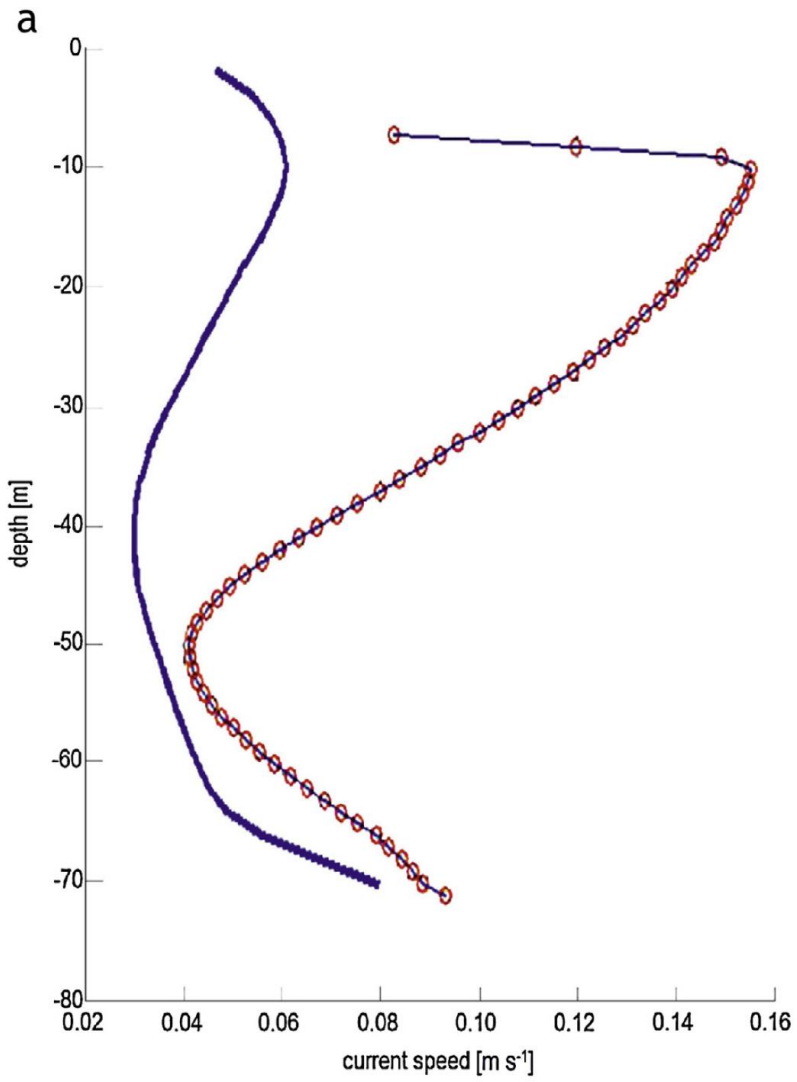
Available one year real time series
(Arild Sundfjord, Norwegian Polar Institute, project AWAKE2)

Measured (red line) and modelled (black and green lines) temperature for three depths

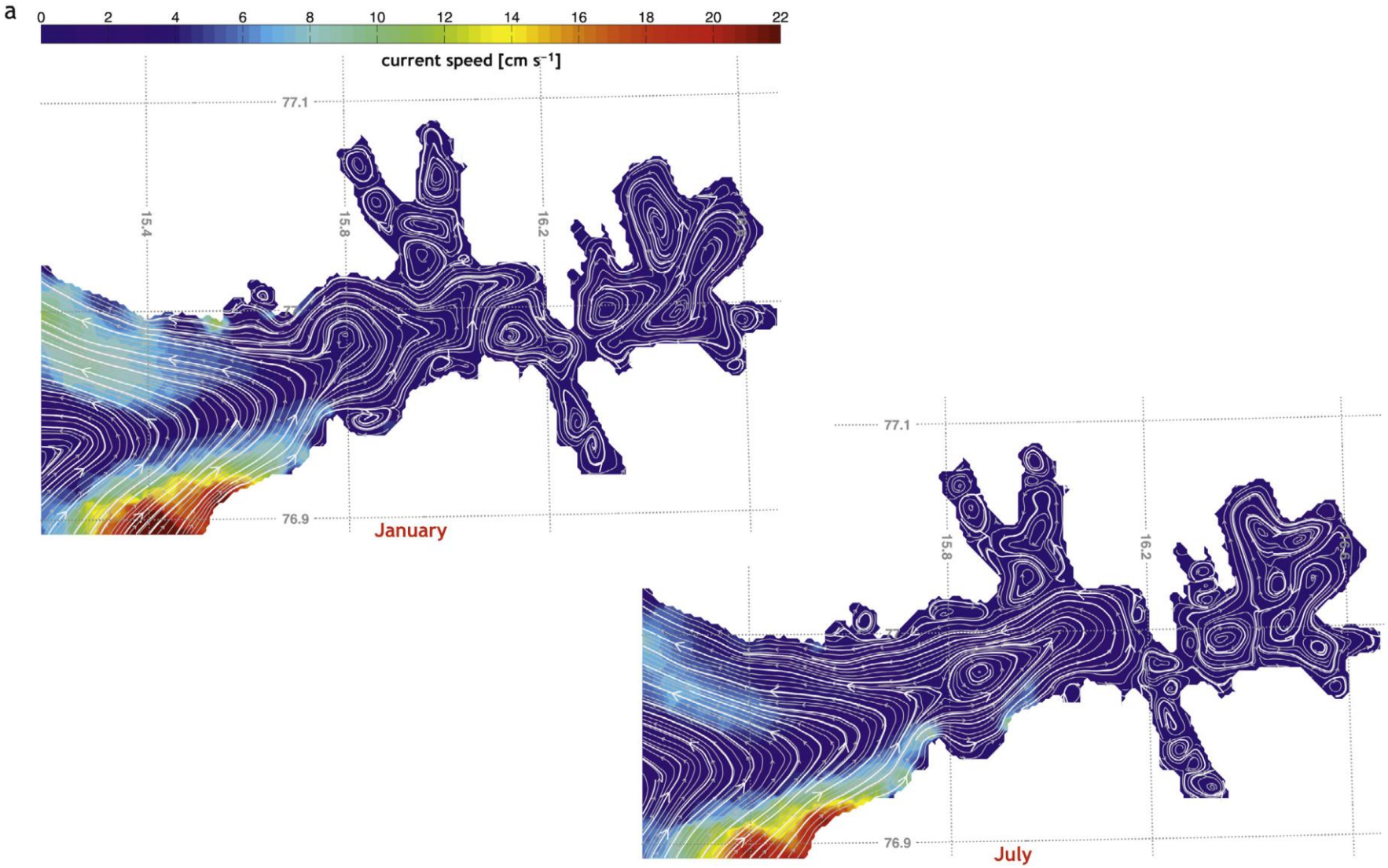
[note: different years]



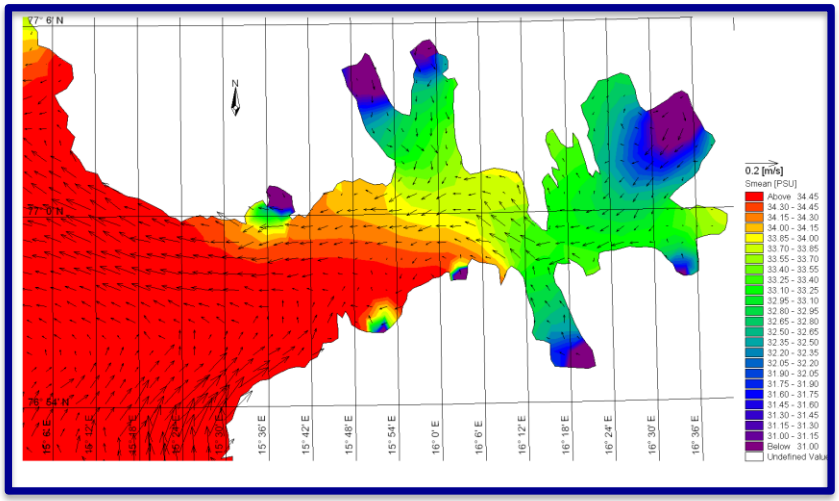
Measured (ADCP, 2013-2014) and modeled (2006-2007) average velocity profiles

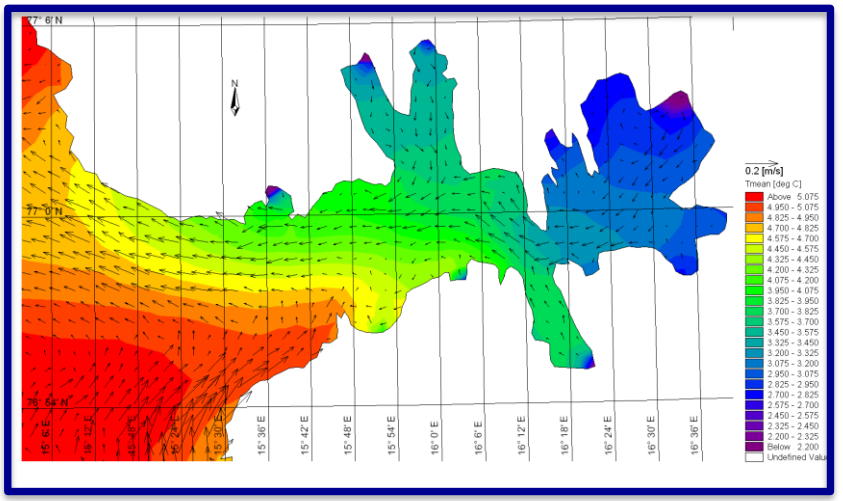


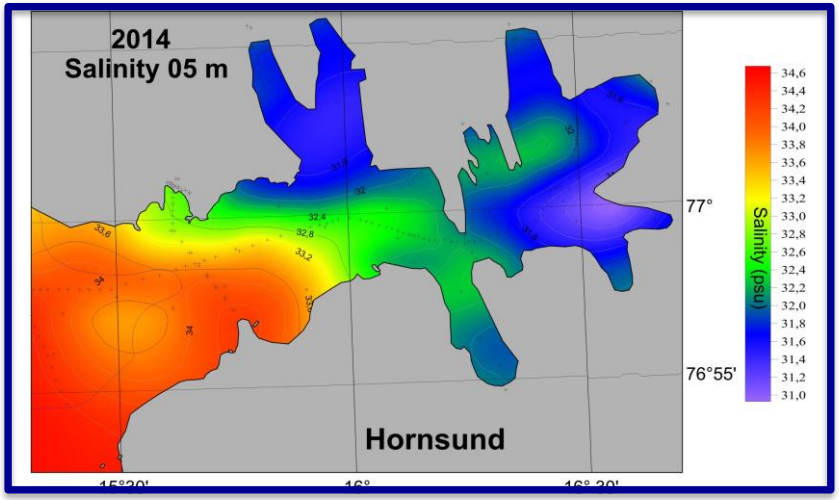
Modelled, average currents for the whole domain for January and July

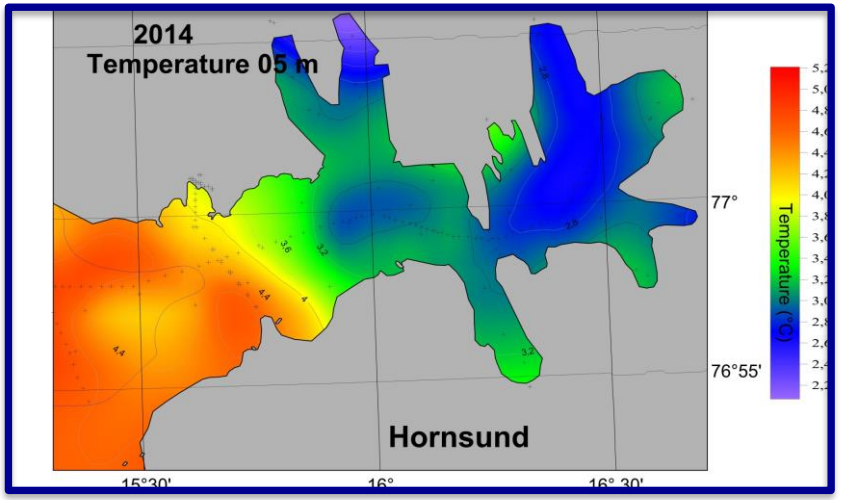


Modeled (July 2006, average) and measured (July 2014 , snapshot) surface temperature and salinity





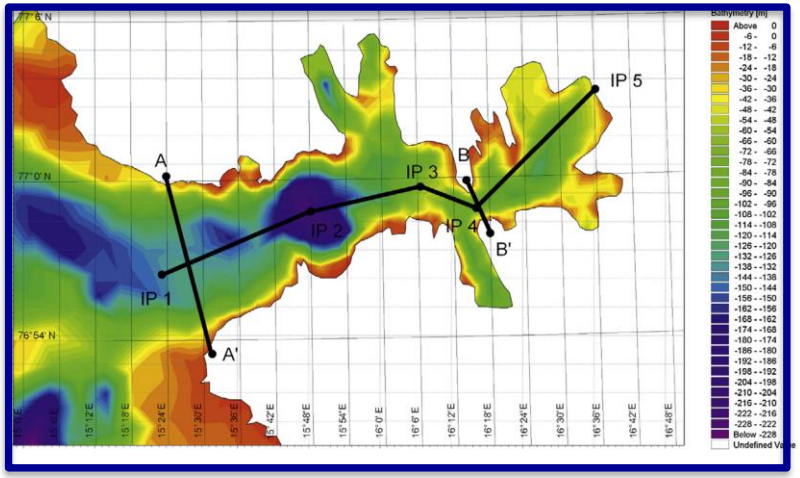


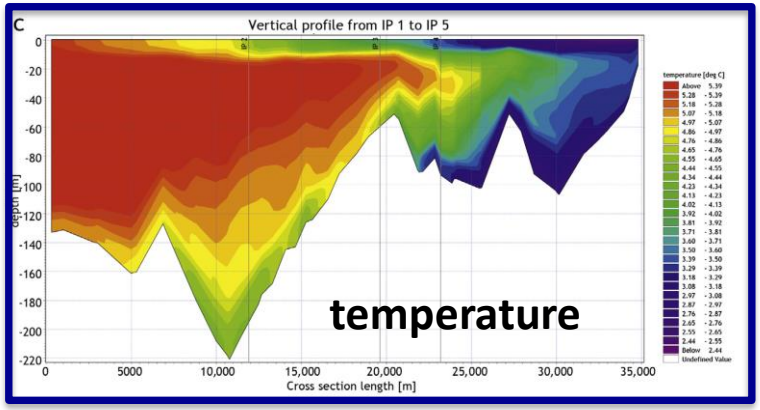


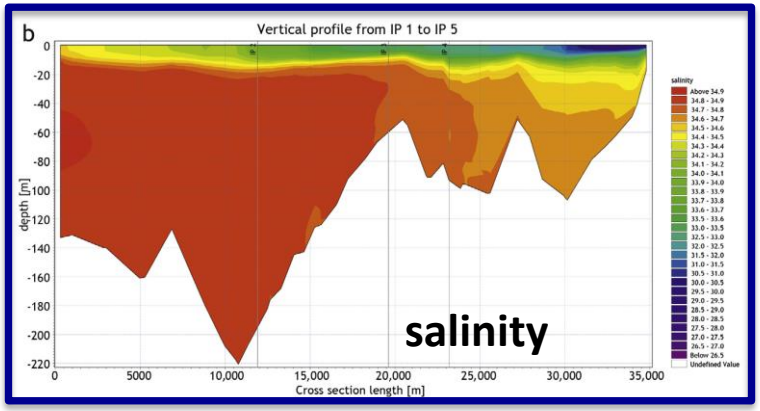
Surface salinity

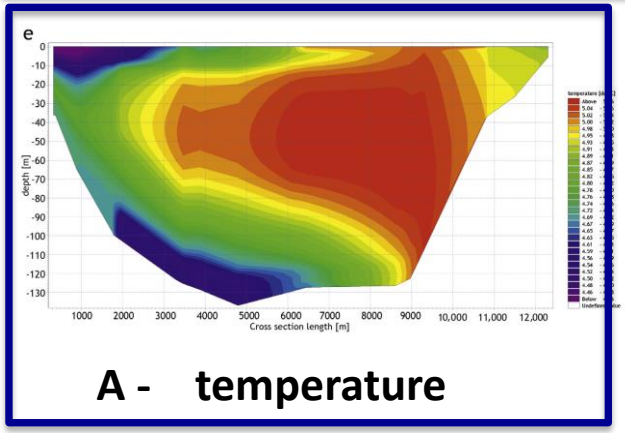
Surface temperature

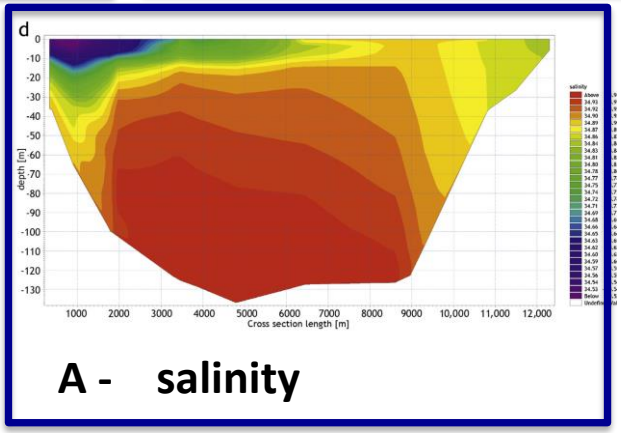
Transect and vertical profiles of temperature, salinity and currents (model, average of July 2007)

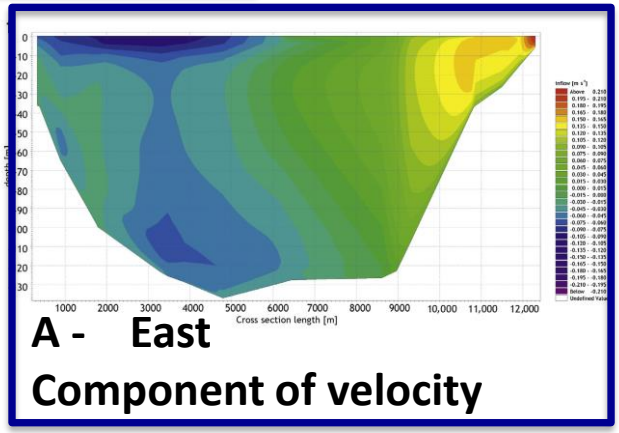




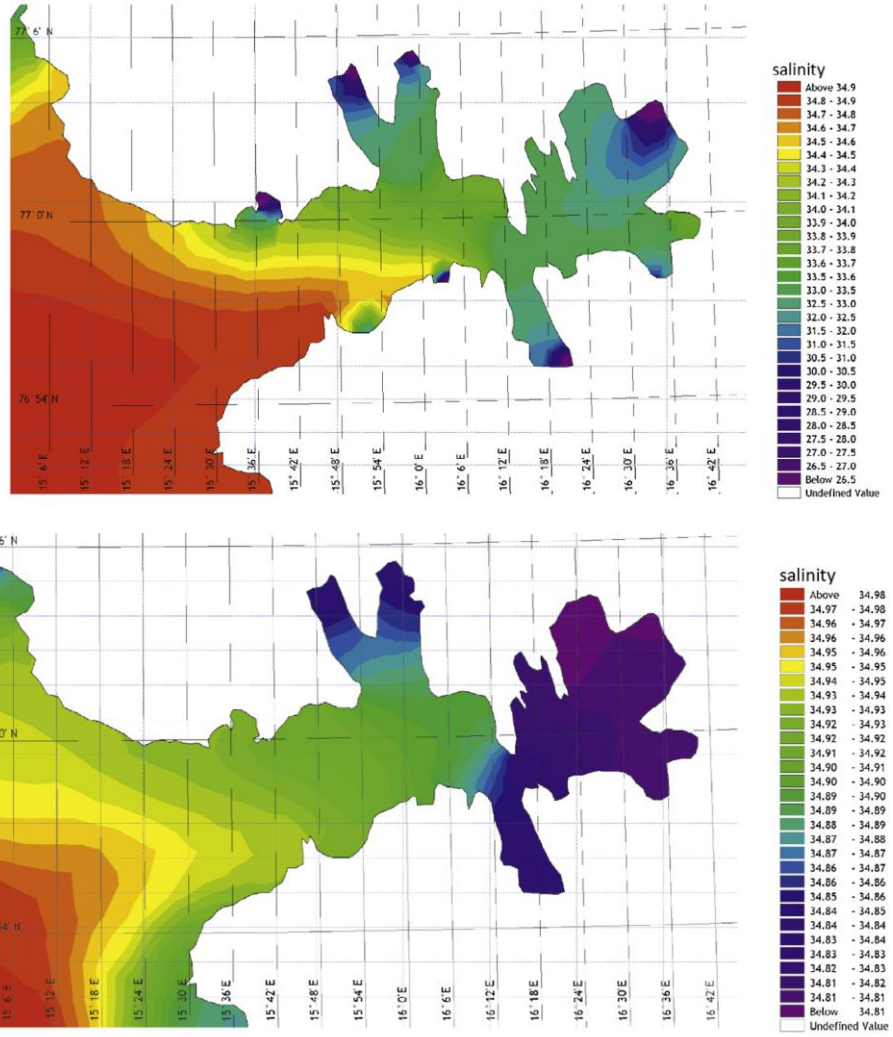


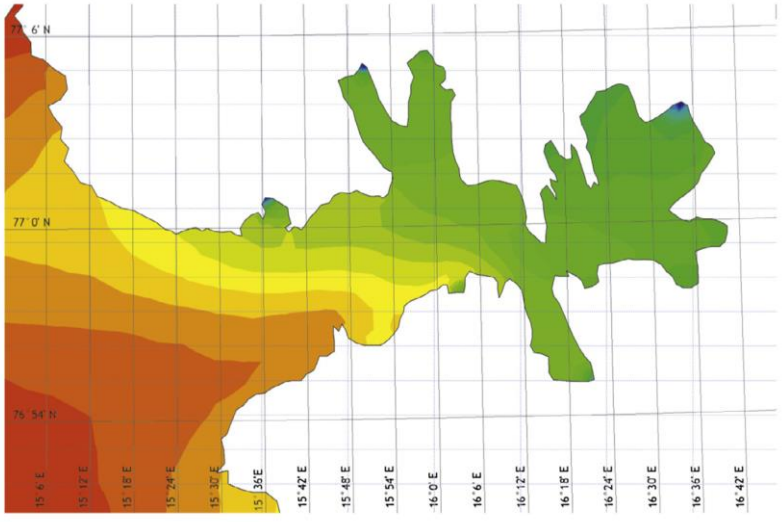


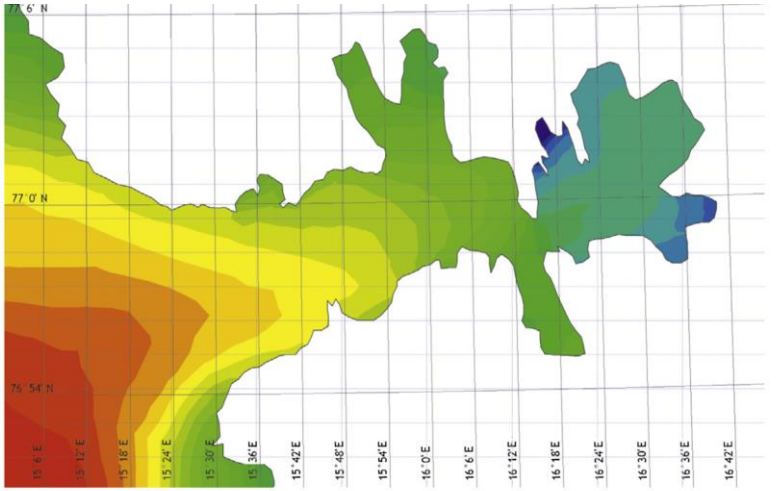




Hydrological front – annual variability (salinity – left images)

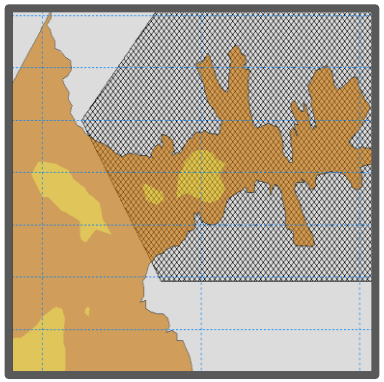




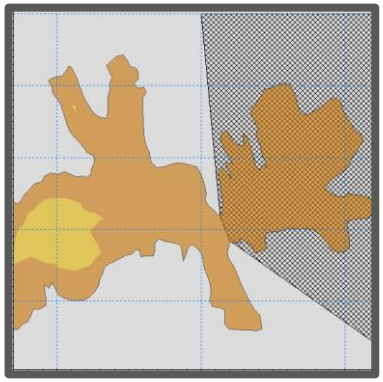


Salt content and heat content and its anomaly

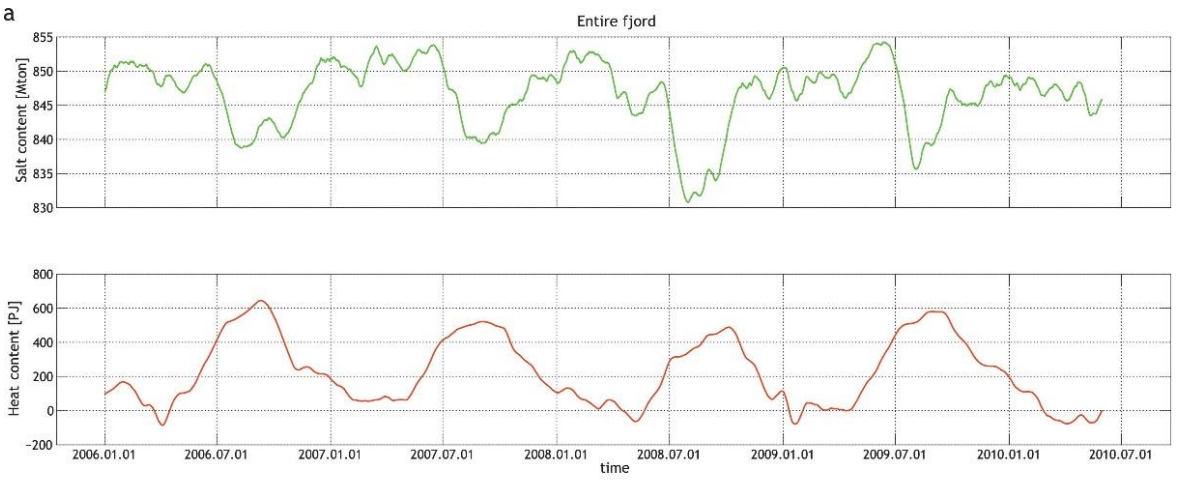
FJORD HORNSUND

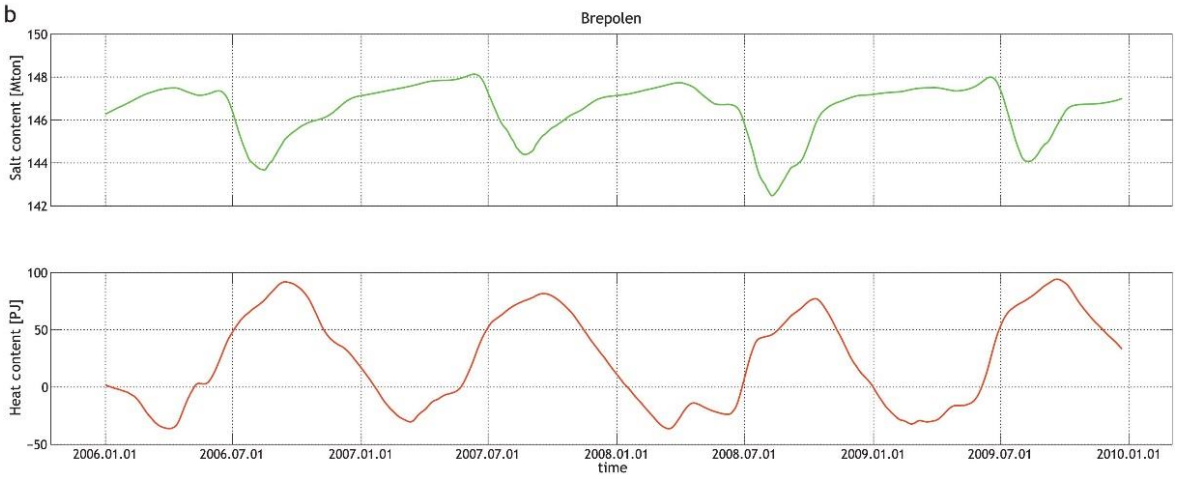


BREPOLLEN



Seasonal variability of the entire fjord and Brepollen (salt and heat content)



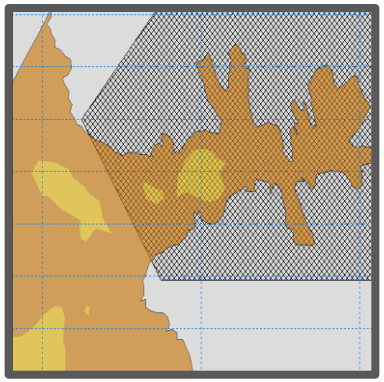


Integrated over time salt content anomaly and its time derivative for entire fjord and for Brepollen

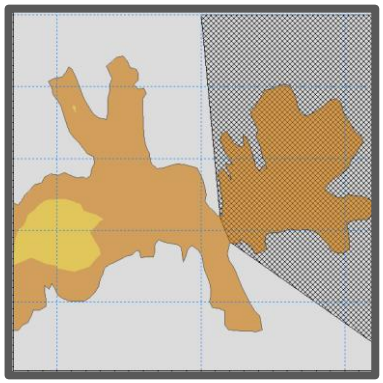
$$\Theta_A(t) = \int_0^t (\Theta(t') - \overline{\Theta}) dt',$$

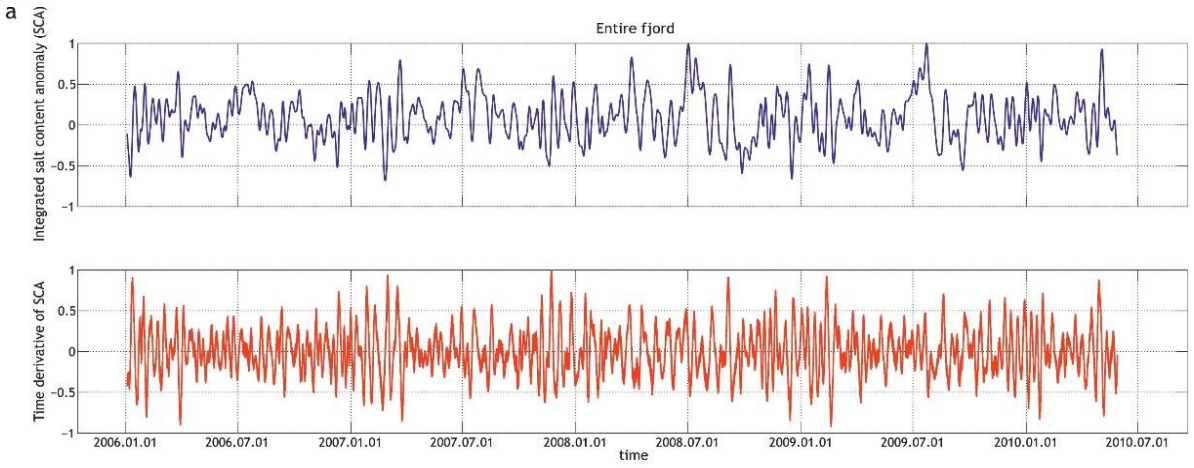
$$\Theta'_A(t) = \frac{d\Theta_A}{dt},$$

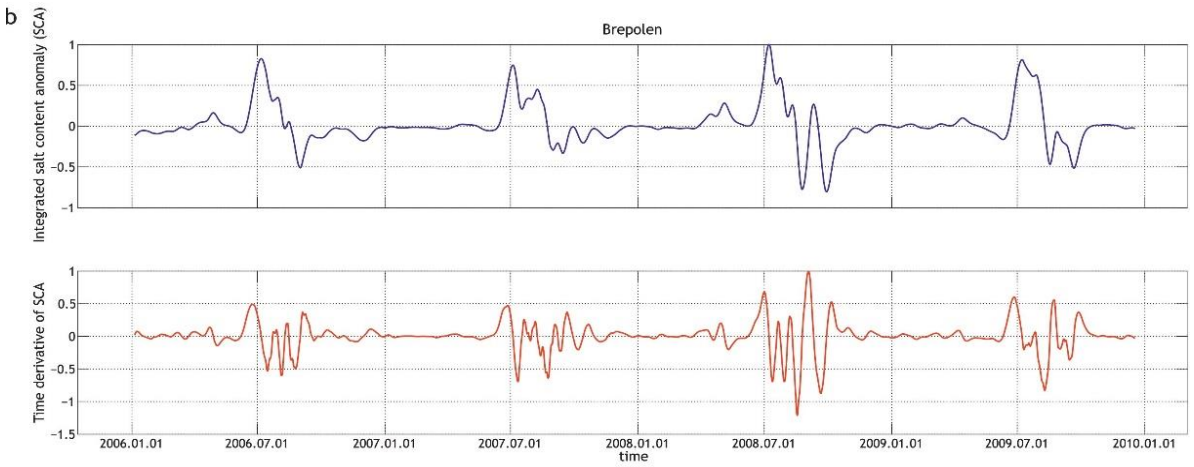
FJORD HORNSUND



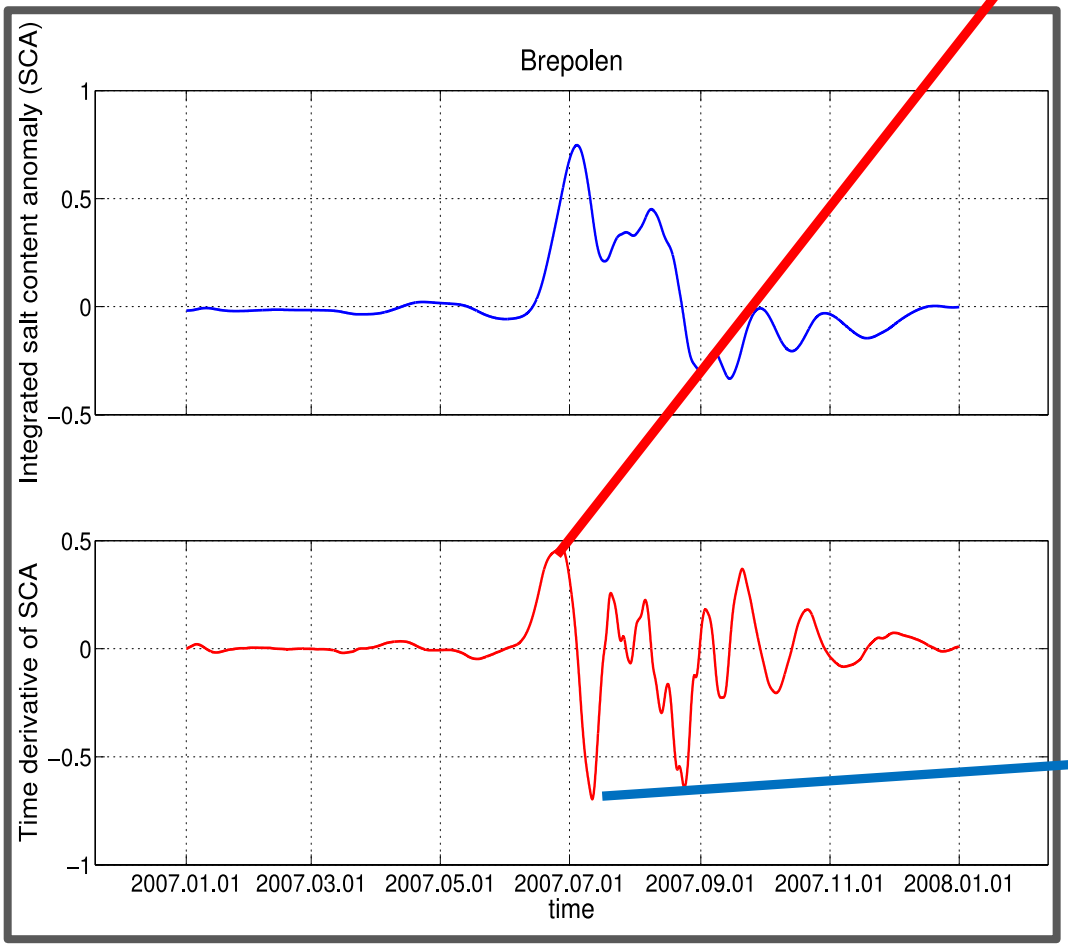
BREPOLLEN

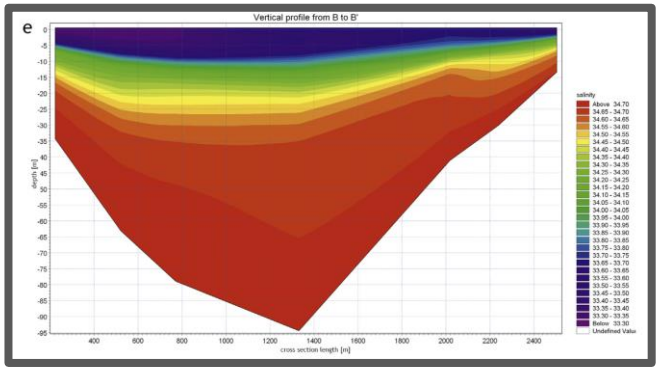




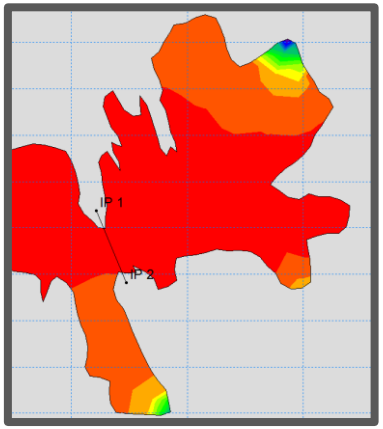


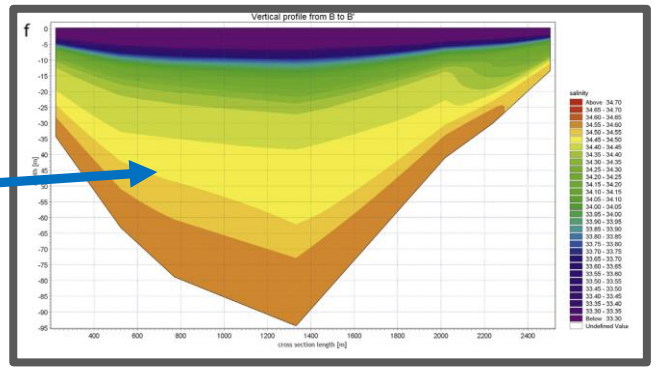
Time derivative of salt content anomaly (Brepollen)



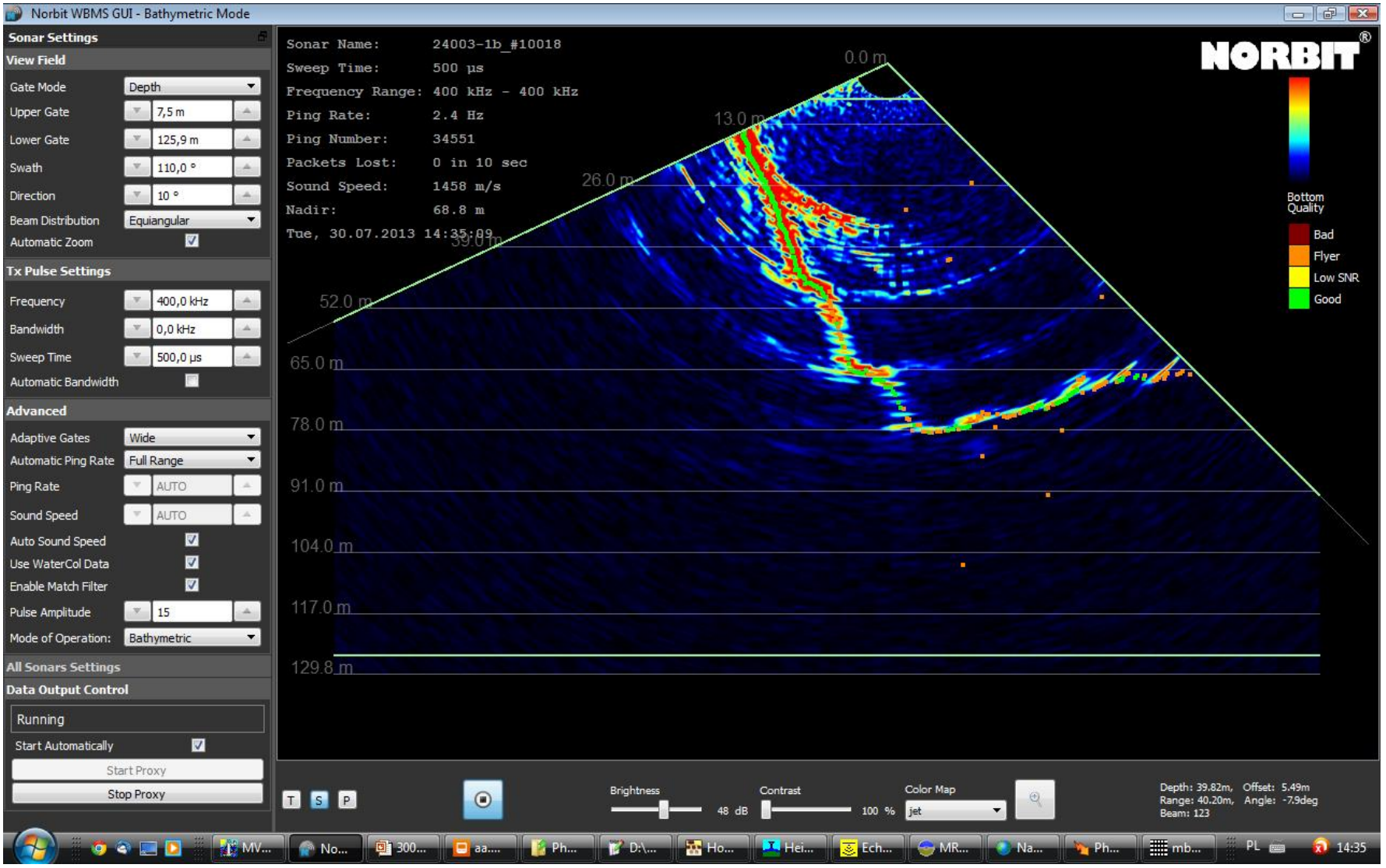


BREPOLLEN

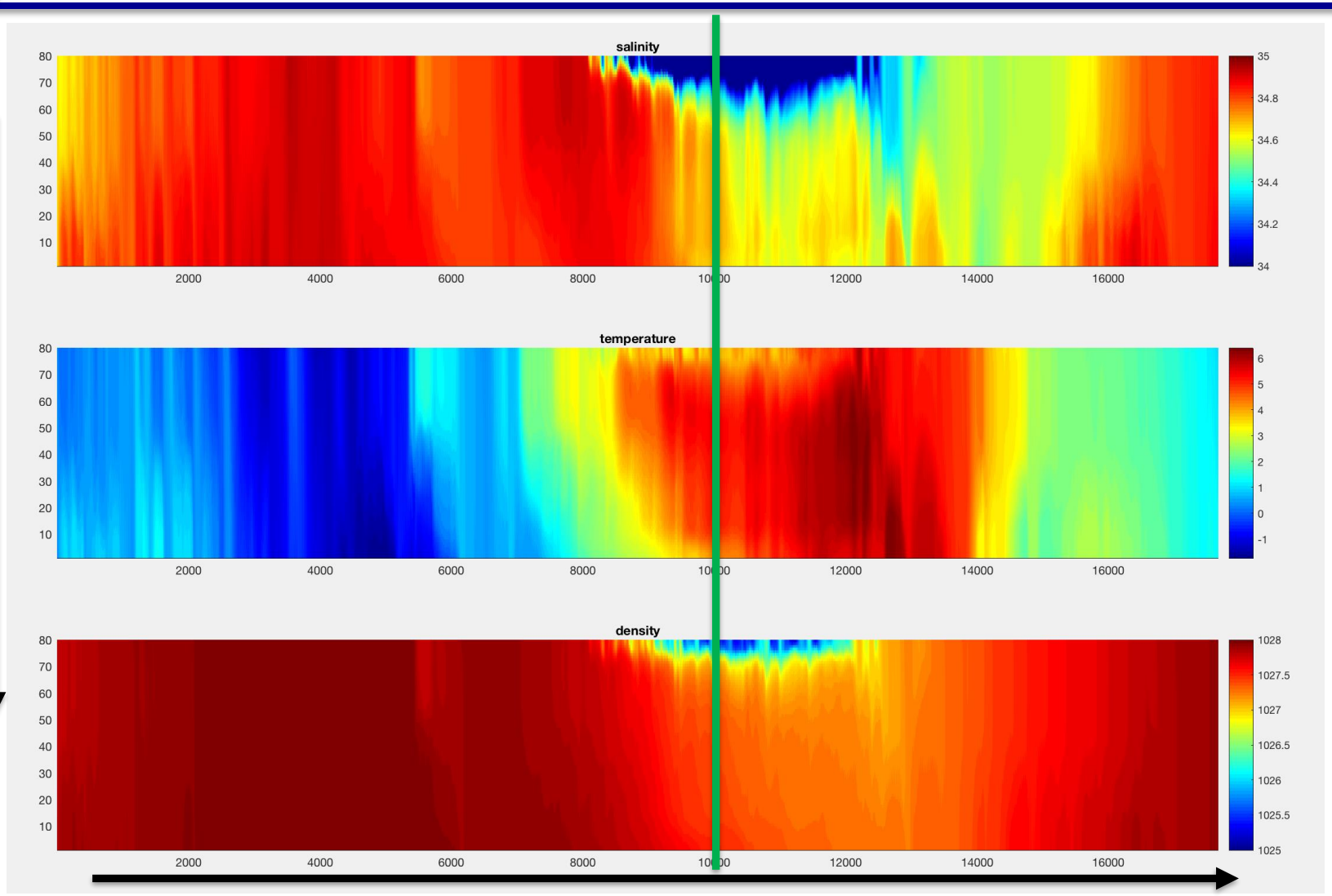




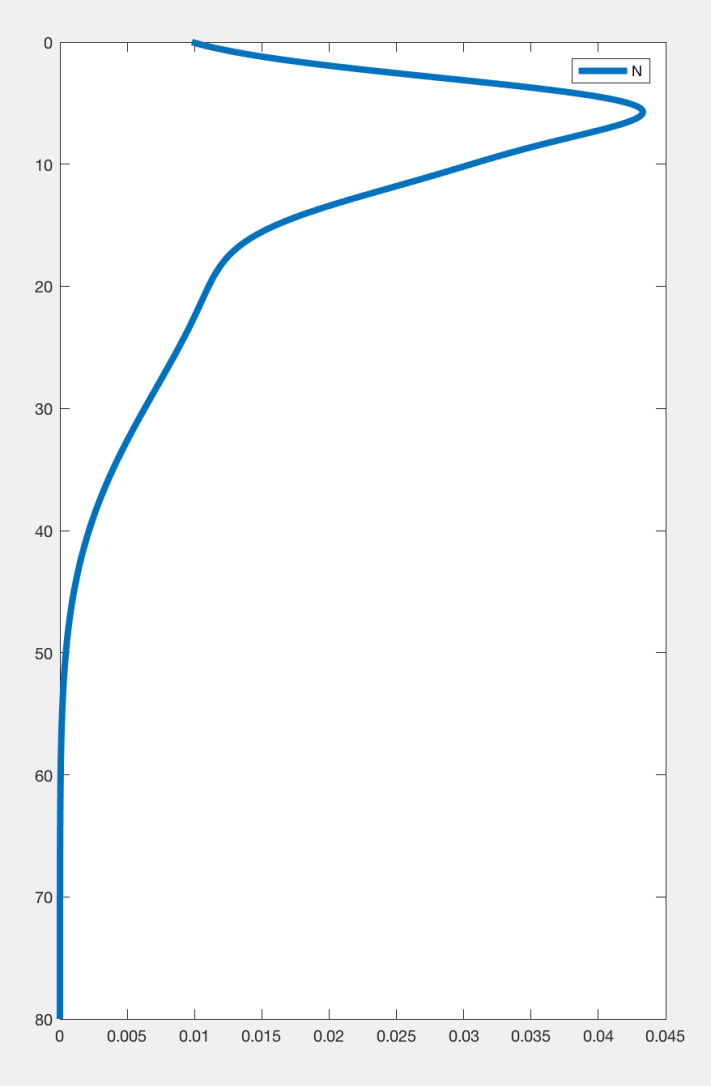
Underwater part of glacier (acoustical detection)



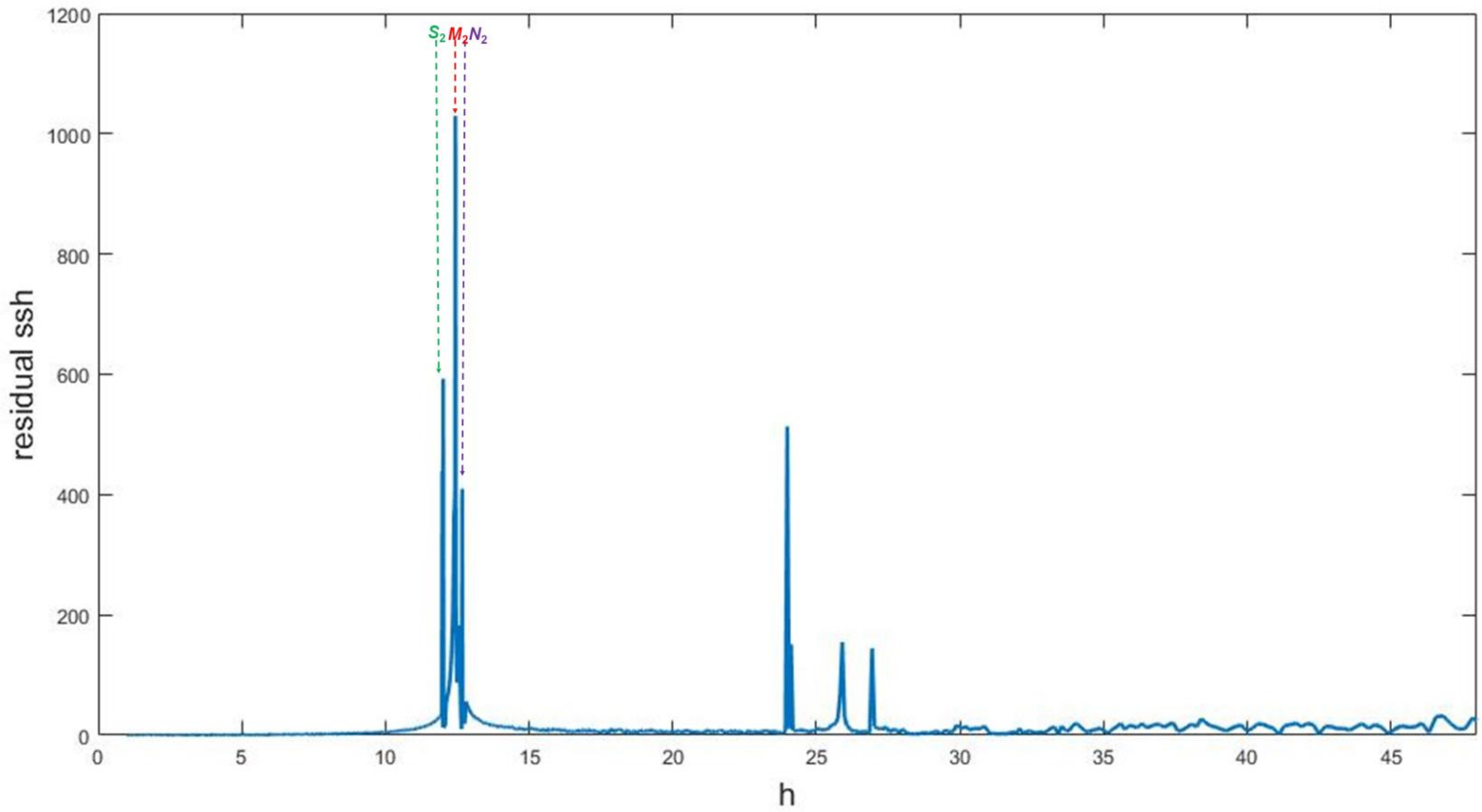
Vertical structure and its temporal variability
(at ADCP location)



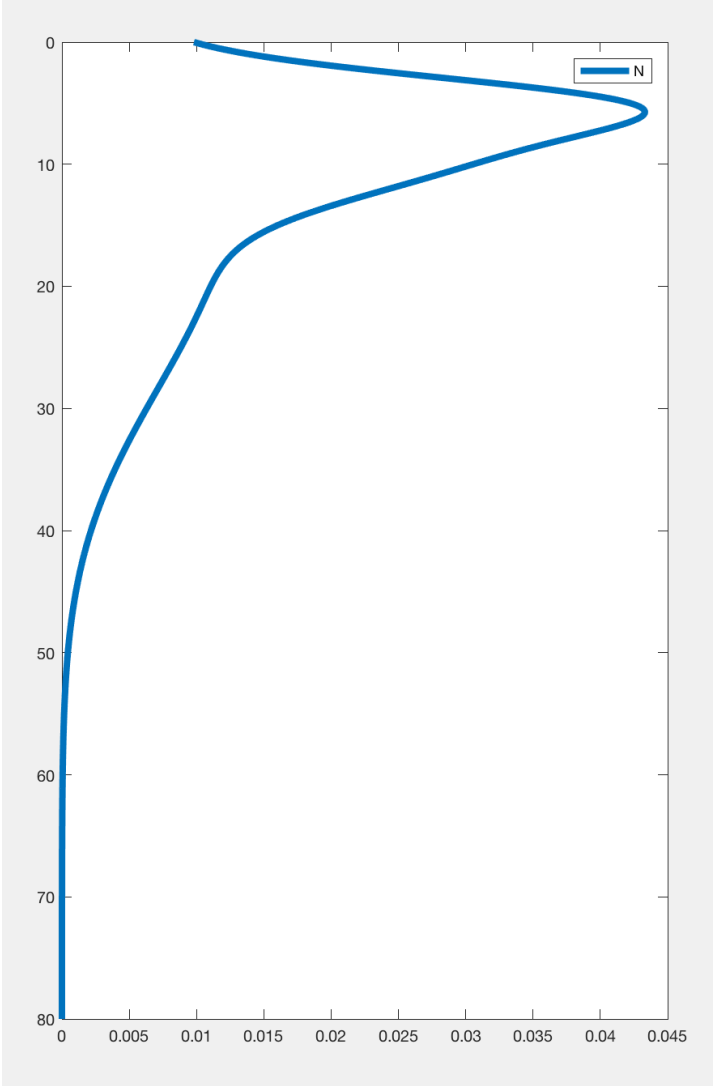
Buoyancy frequency (left) for selected profile and calculated internal tides (modes 1-4)

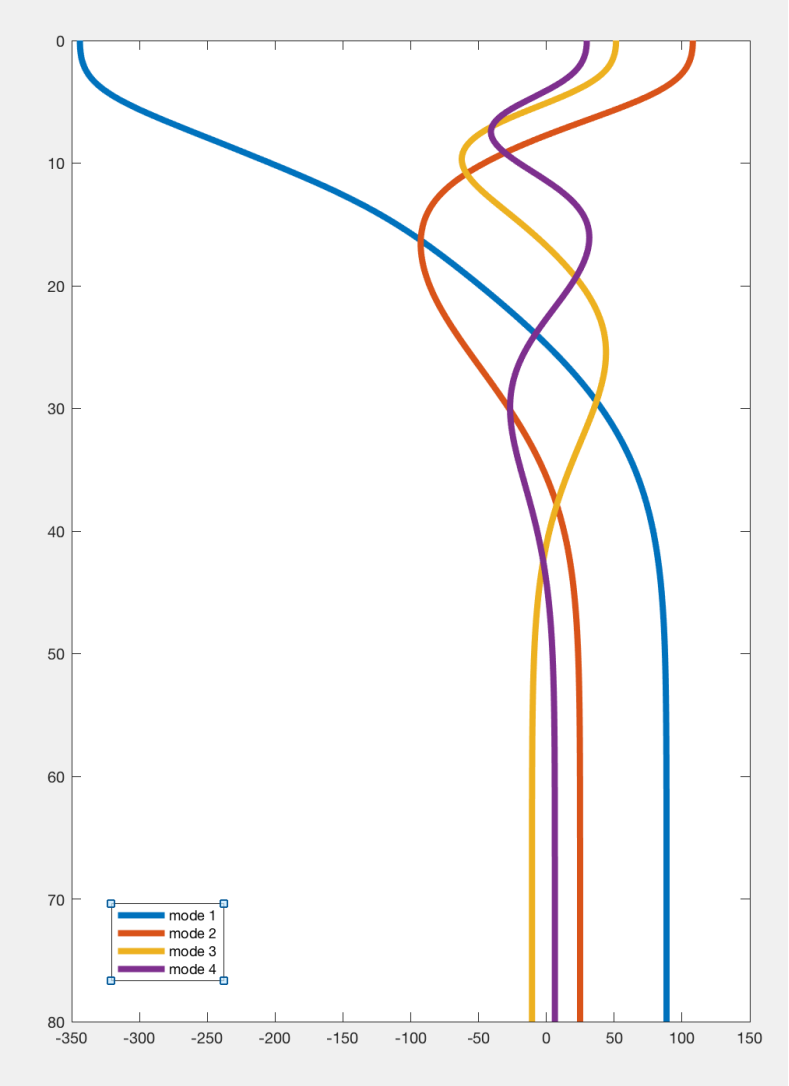


Spectrum of residual part of ssh (most of energy is located in M2)



Buoyancy frequency (left) for selected profile and calculated internal tides (modes 1-4)





Conclusions and future plans:

- **In the seasonal scale results are reasonable**
- **The limited experimental data (time series) does not permit to make full validation process (but we hope there will be more data from AWAKE2 project) and next projects**
- **The important part is underwater melting. To have correct energy budget this melting should be taken in to account.**
- **Vertical structure and its variability suggests annual variability of the internal tides thus we are going to work on it in the future**

Thank you for your attention