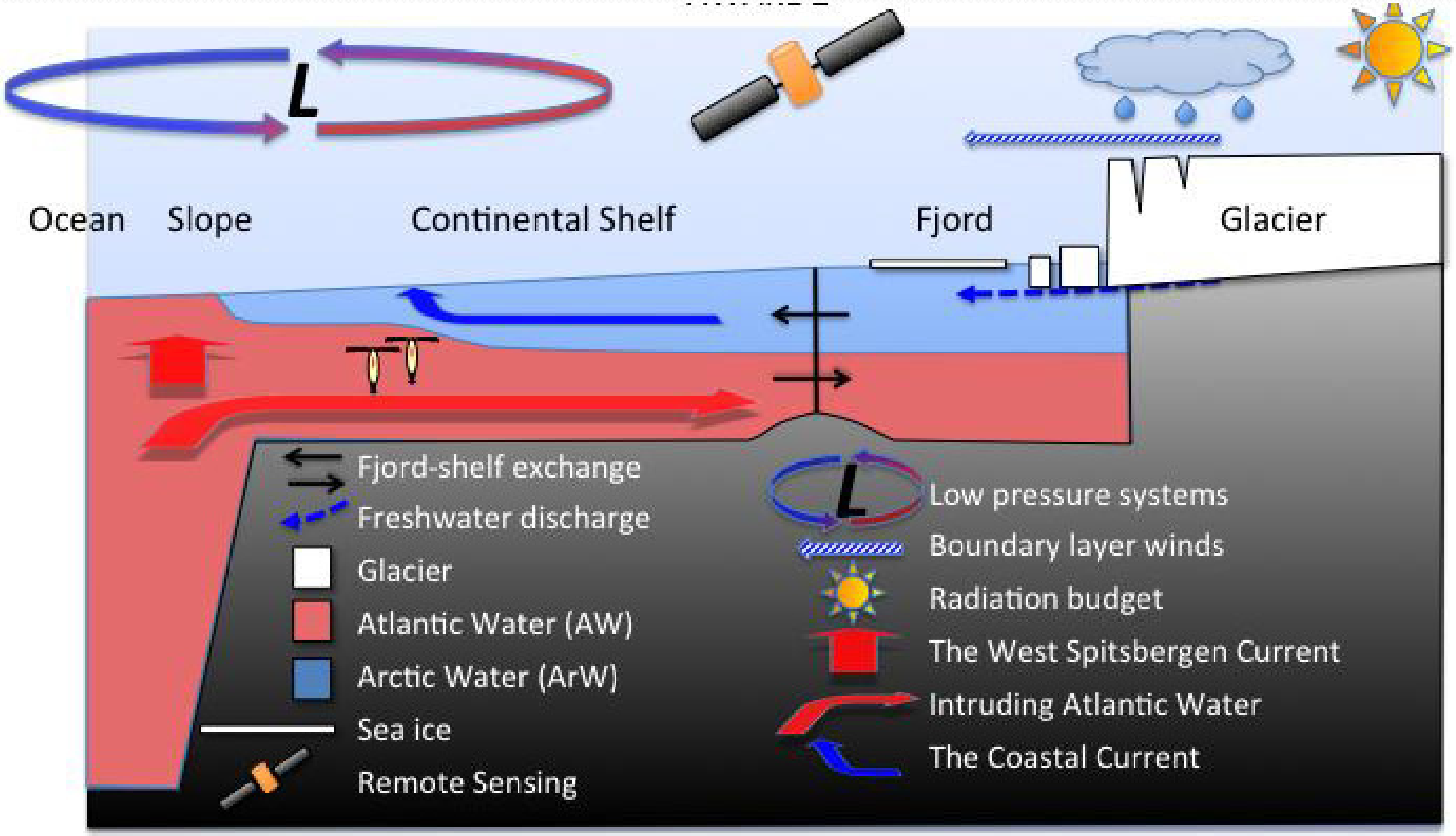
Sopot

19 May 2016

GLAERE
Glaciers as Arctic Ecosystem Refugia

INSTITUTE OF OCEANOLOGY
POLISH ACADEMY OF SCIENCES

WP2 Physical Drivers


L
Ocean
Slope
Continental Shelf
Fjord
Glacier
Fjord-shelf exchange
Freshwater discharge
Glacier
Atlantic Water (AW)
Arctic Water (ArW)
Sea ice
Remote Sensing
Low pressure systems
Boundary layer winds
Radiation budget
The West Spitsbergen Current
Intruding Atlantic Water
The Coastal Current

- Objectives
  There are two main objectives – one is based on the field work in selected model sites – here we aim to assess the circulation patterns in glacial bays. Field study will be performed in two glacial bays in Brepolen (inner part of Hornsund) and inner Kongsfjorden basin in the peak of summer melt season (late July). The work will consist of fjord hydrography (CTD measurements in fine scale, close to the glacier with the use of remotely controlled swimmers, sedimentation (sediment traps deployed near and in the distance from the main glacial plume) and light regime measurements (in situ light transmission vertical profiling and satellite imagery analyses). Archival data collected over last years by Polish hydrographers near the glacial fronts in Kongsfjorden and Hornund are going to be included into the analyses. Modeling approach will permit to provide scenarios about hydrographic consequences of glacial retreat in particular bays (to answer the question what are the conditions - depth, meltwater intensity etc., needed to produce an upwelling and estuarine circulation in the glacial bay). Second objective is the assessment of glacial bays occurrence on Svalbard, with special reference to their possible state (retreating glaciers, grounded glaciers, surging glaciers) that will allow the spatial analyze and hydrological scenarios creation (which bays are likely to be the sites of upwelling, which bays are soon becoming a mudflats etc). Data on glaciers mass balance and freshwater outflow will be incorporated into the analyses, as well as the aerial and satellite imagery analyze (cooperation with WP3). The existing literature on the Svalbard tidewater glaciers (e.g Hagen et al 1993, Blaszczyk et al 2009) will be reviewed supplied with new data. Participants are A. Beszczyńska-Möller, Waldemar Walczowski, Sławomir Sagan, Marek Zajączkowski, IOPAS PhD student and Jack Kohler from NP

Tasks

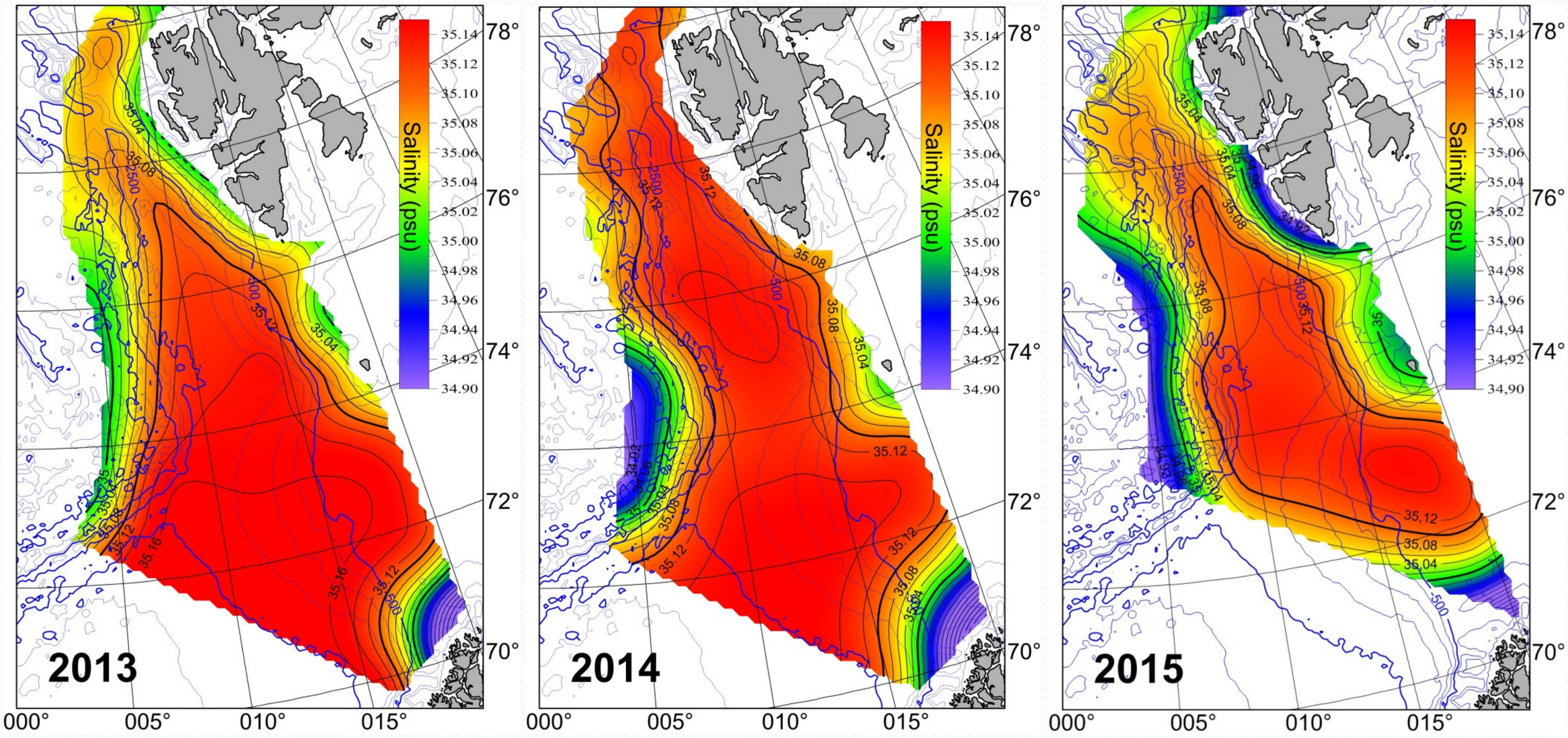
- T_2.1 Establishing the data base of tidal glacier bays hydrography in selected sites
- T_2.2 Assessment of the glacial bays role for coastal waters formation
- T_2.3. Assessment of the euphotic layer thickness in analysed areas
- T_2.4. Assessment of flow intensity and dynamics of turbid water in glacial bays
- T_2.5. Establishing the data base of tidal glacier bays on Svalbard based on the archival NP data

Deliverables

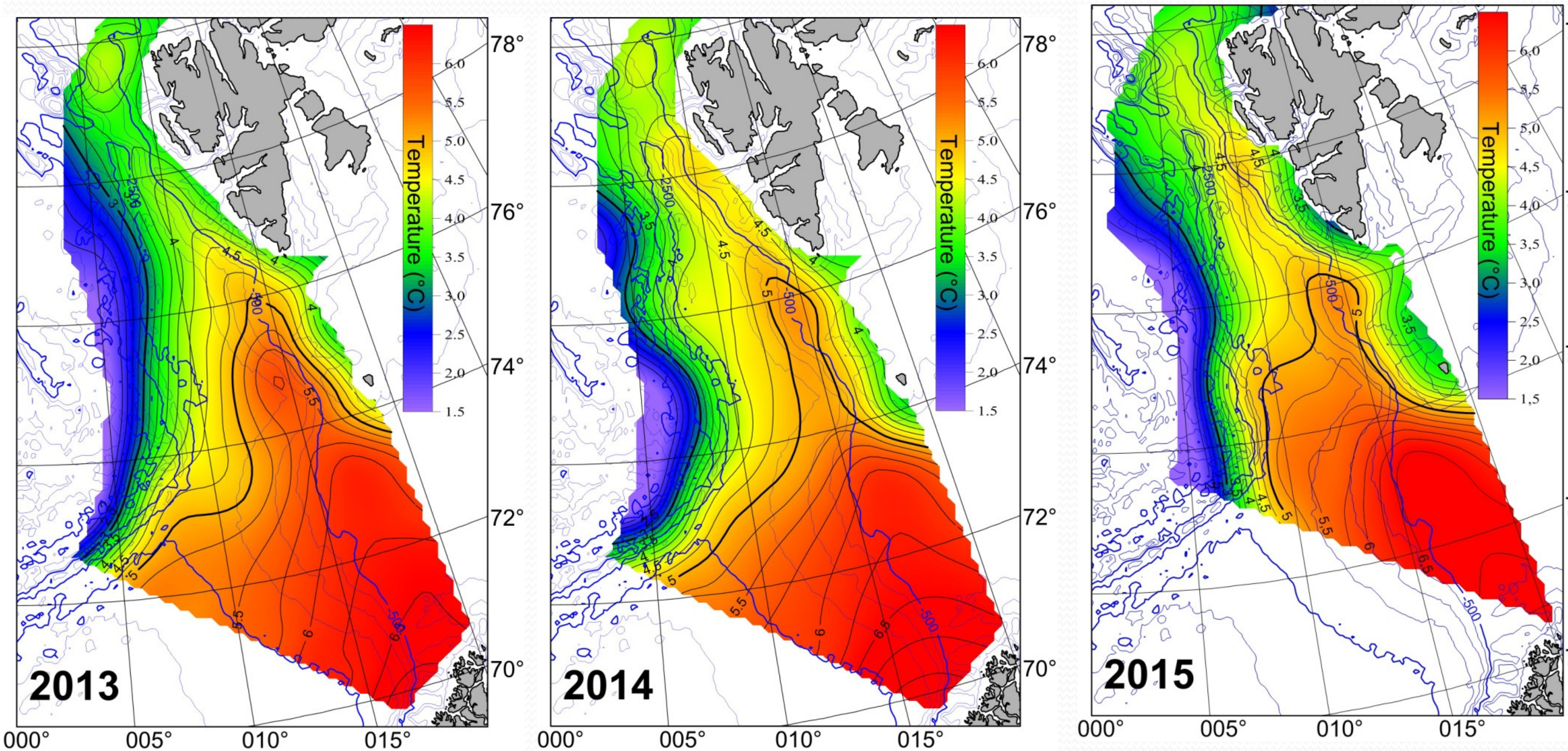
- D_2.1 Collection of archival data on physical environment in tidal glacier bays – M24
- D_2.2 Collection of new data from the dedicated field work – M24
- D_2.3 Publication about the importance of glaciers as a areas of coastal waters modification (dense water formation, freshwater outflow, suspensions export) - M34

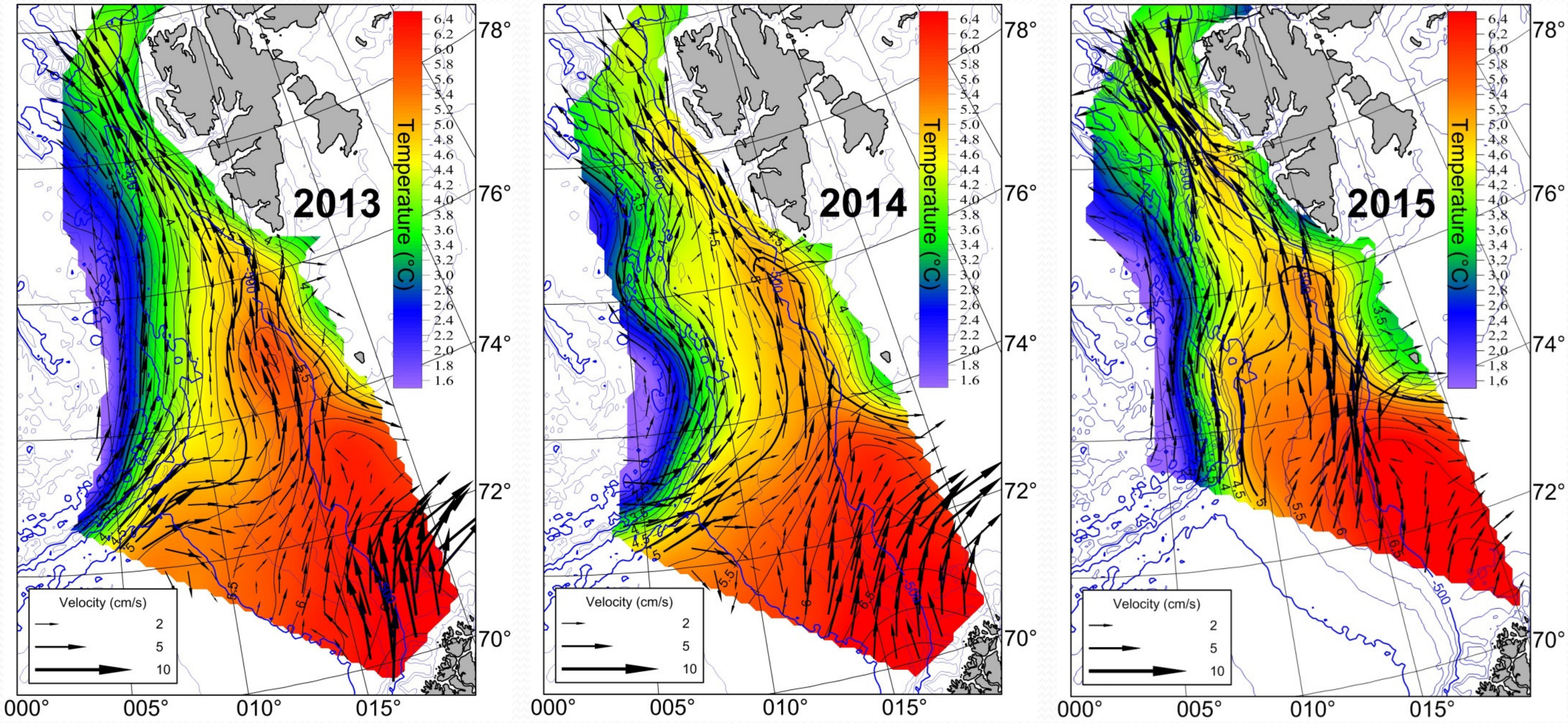
Milestones

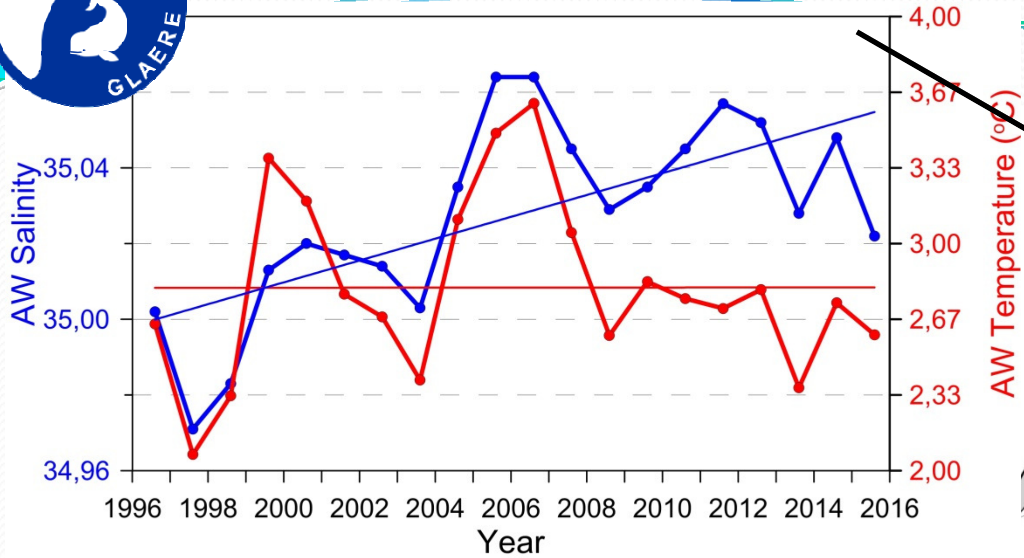
- M_2.1 Archival material completed – M12
- M_2.2 Field work data delivered to data base – M24
- M_2.3 Presentation of the results at the scientific conference – M34
- M_2.4 Processed data available from the web page – M34
  Interdependence with other work packages (up to 1000 characters)
  This work package will provide data for other work packages, and help in biological data interpretation. It will also feed the GIS work package with the spatial data.
  Person*months 62

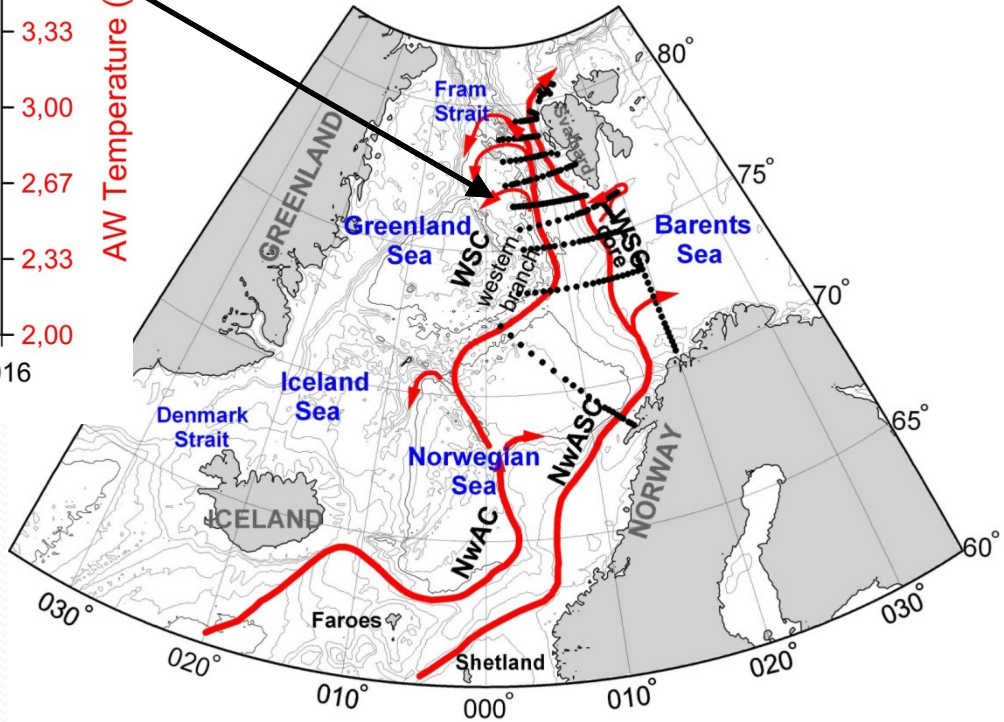


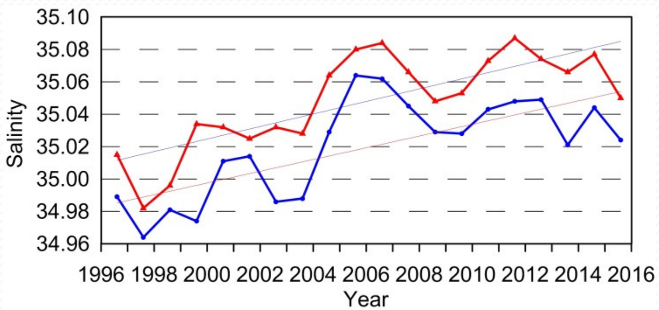
2013
2014
2015
Salinity (psu)
35.14
35.12
35.10
35.08
35.06
35.04
35.02
35.00
34.98
34.96
34.94
34.92
34.90
78°
76°
74°
72°
70°
000°
005°
010°
015°

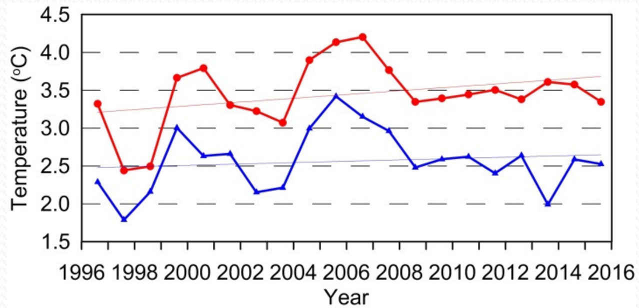

2013
2014
2015
Temperature (°C)
78°
76°
74°
72°
70°
000°
005°
010°
015°


2013
2014
2015
Temperature (°C)
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
Velocity (cm/s)
2
5
10
78°
76°
74°
72°
70°
000°
005°
010°
015°


AW Salinity
AW Temperature (°C)
35,04
35,00
34,96
4,00
3,67
3,33
3,00
2,67
2,33
2,00
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Year

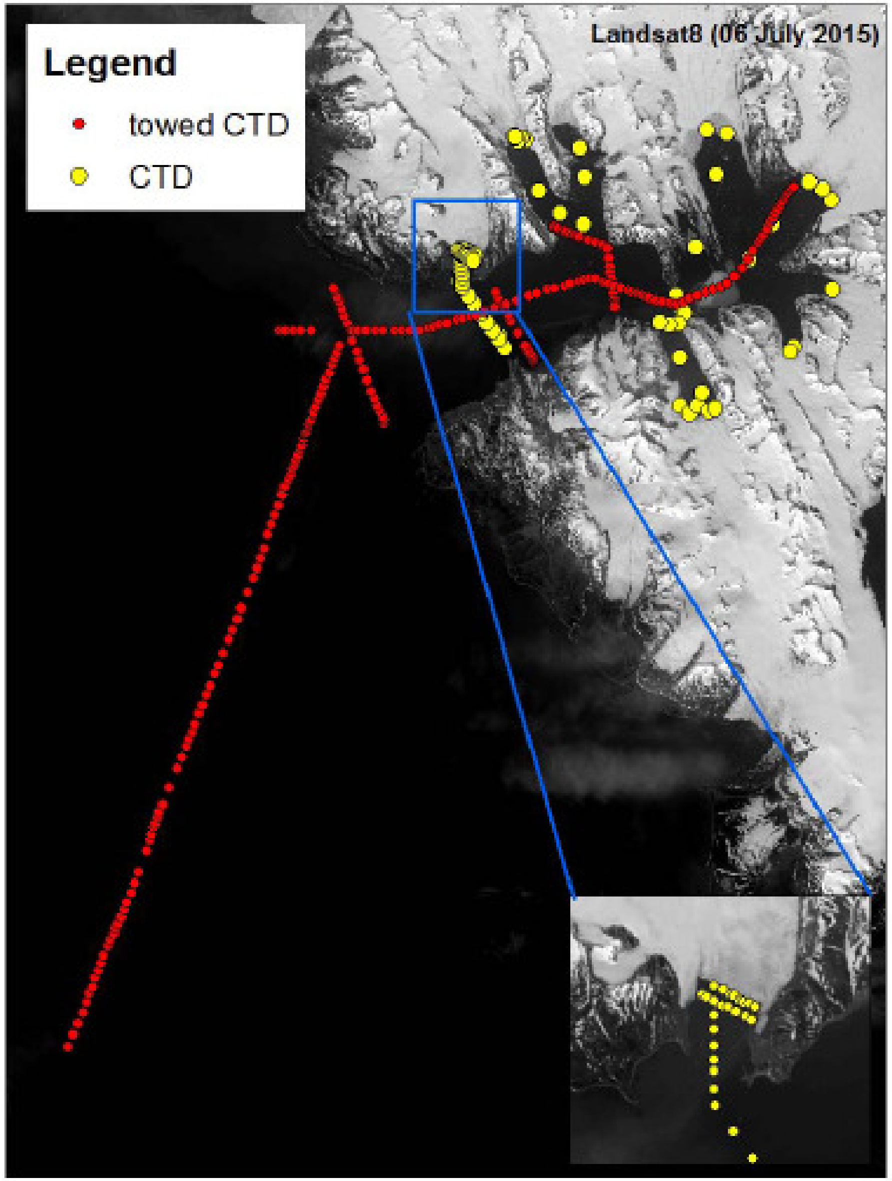

Fram Strait
GREENLAND
Greenland Sea
WSC
western branch
core
Svalbard
Barents Sea
Iceland Sea
Denmark Strait
Norwegian Sea
NwASC
NwAC
ICELAND
NORWAY
Faroes
Shetland
80°
75°
70°
65°
60°
030°
020°
010°
000°
010°
020°
030°

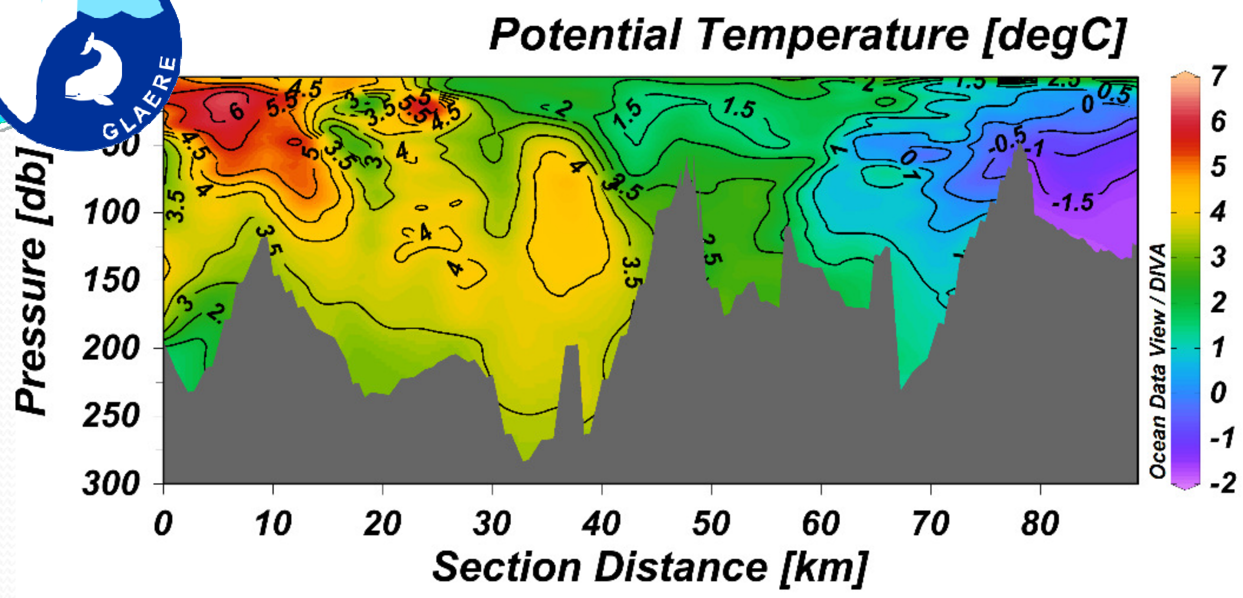

Salinity
35.10
35.08
35.06
35.04
35.02
35.00
34.98
34.96
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Year

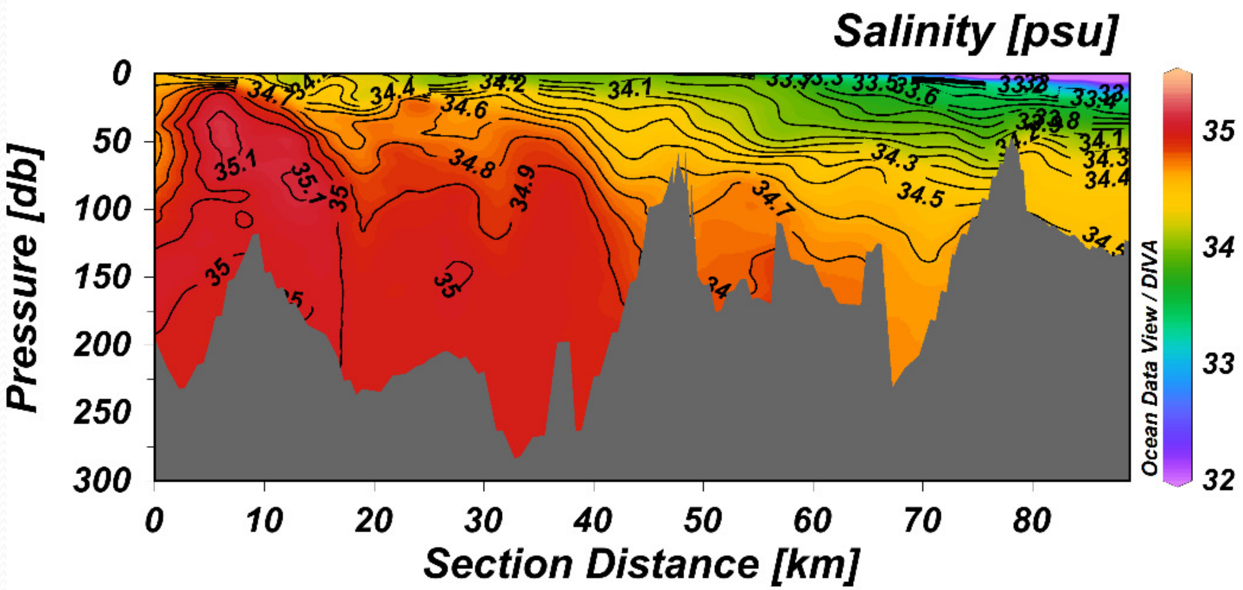

Temperature (°C)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Year

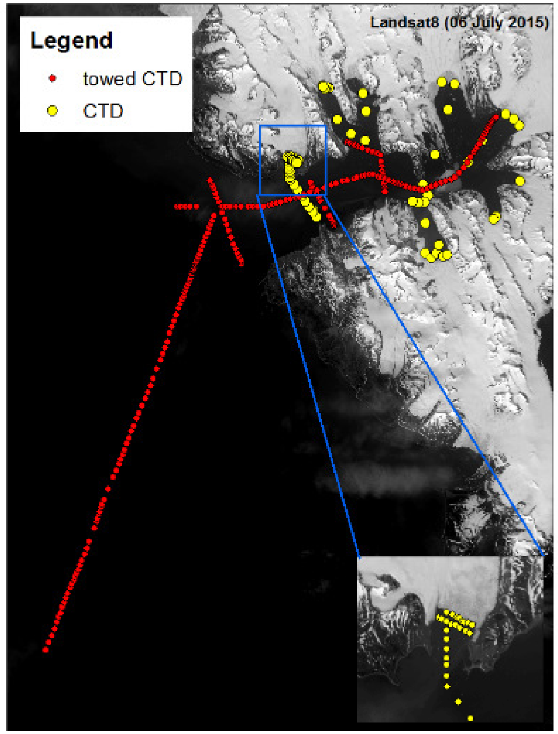
Fieldwork 2015

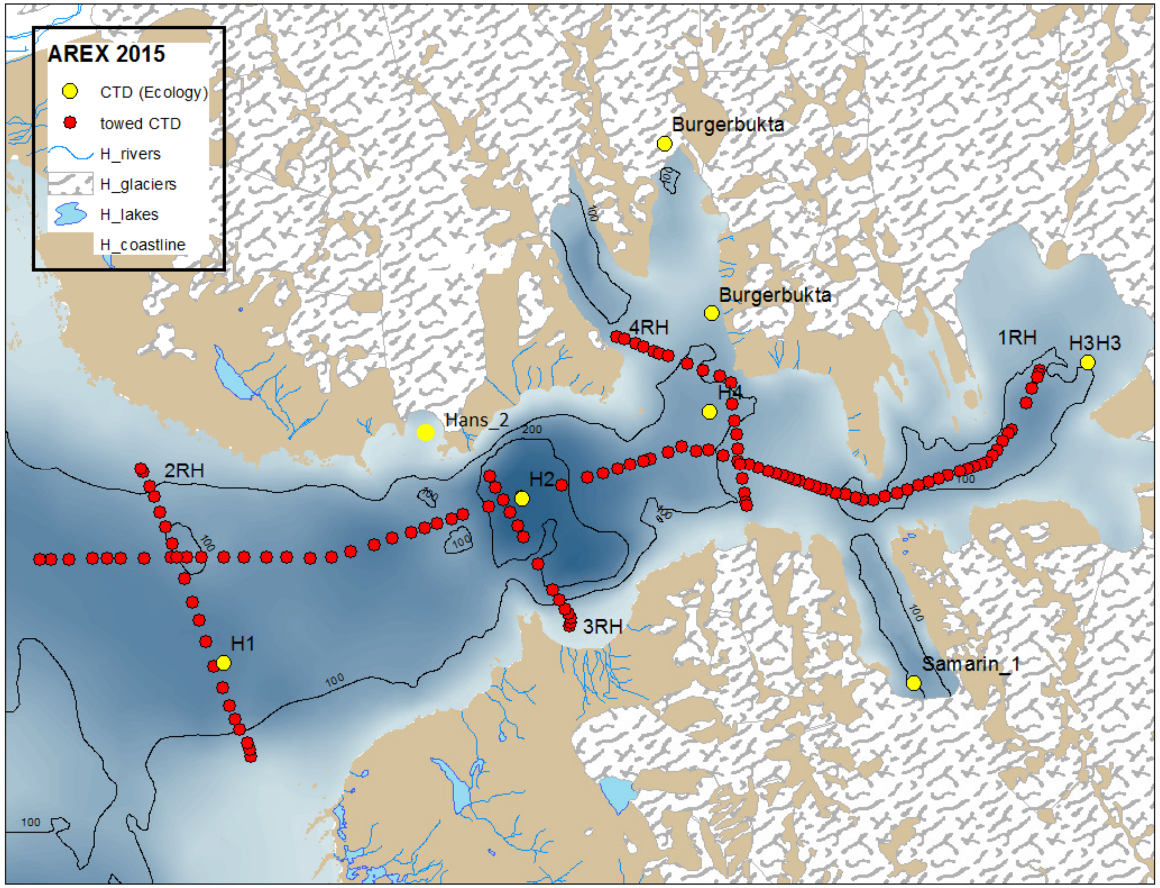
- 4 monitoring sections in the fjord
- One section at the fjord foreground
- CTD's collected from April to August (yellow dots)

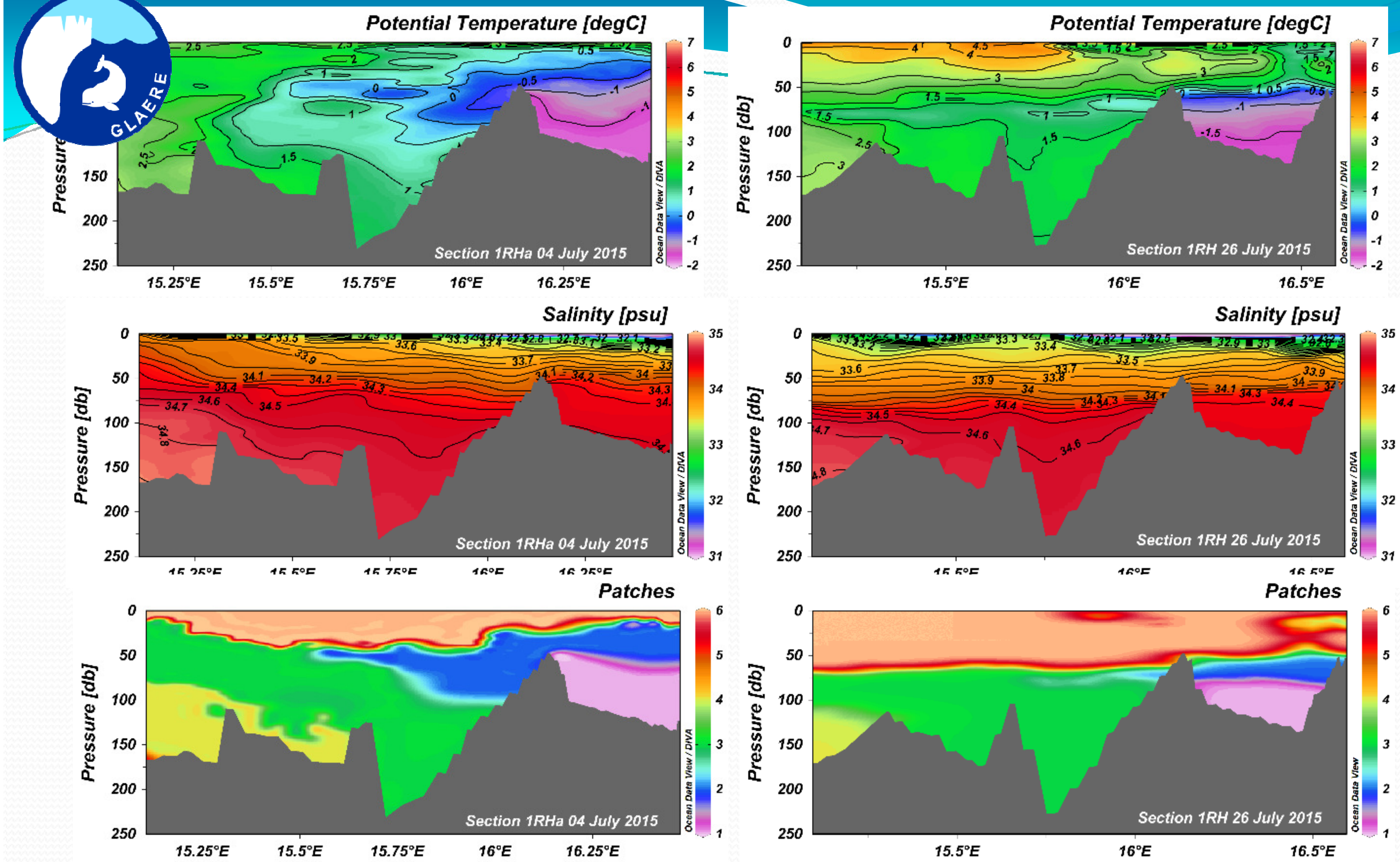



Potential Temperature [degC]
Pressure [db]
Section Distance [km]
Ocean Data View / DIVA

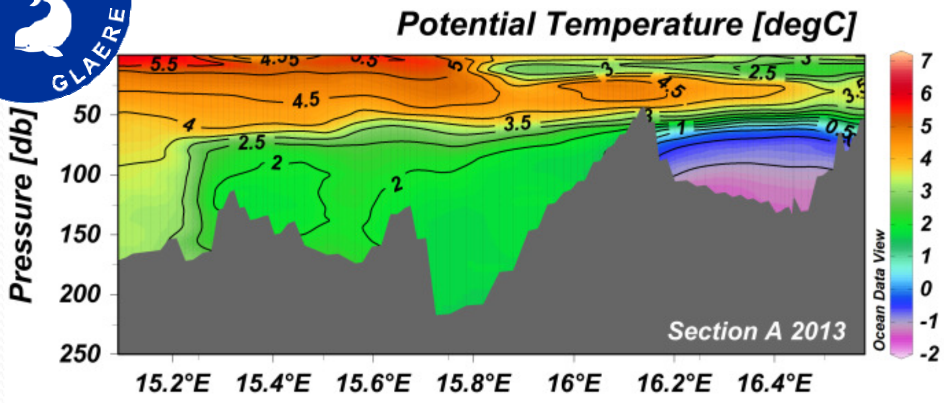

Salinity [psu]
Pressure [db]
Section Distance [km]
Ocean Data View / DIVA

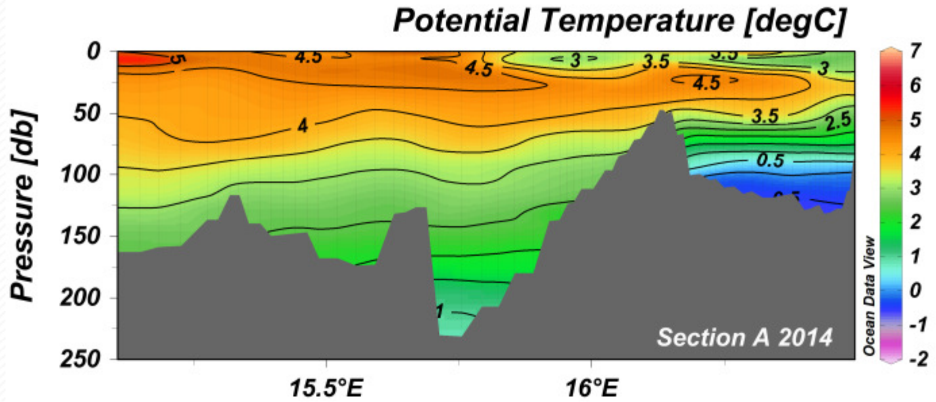

Legend
towed CTD
CTD
Landsat8 (06 July 2015)

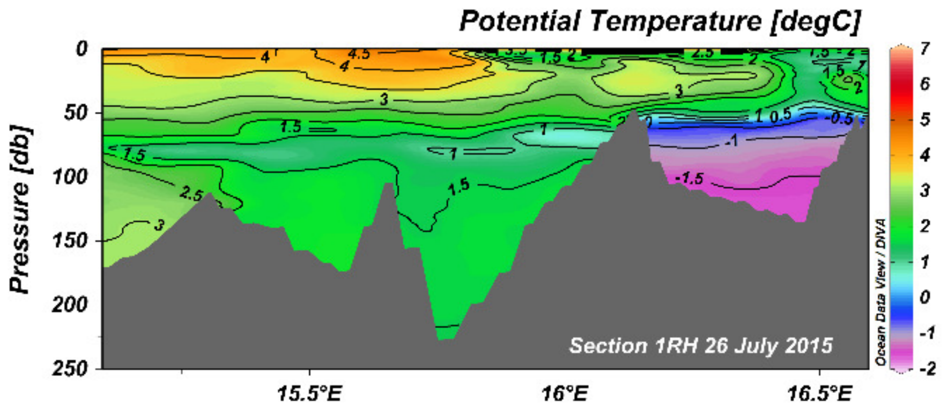

AREX 2015
CTD (Ecology)
towed CTD
H_rivers
H_glaciers
H_lakes
H_coastline
Burgerbukta
Burgerbukta
4RH
1RH
H3H3
H4
Hans_2
H2
2RH
3RH
H1
Samarin_1
100
200

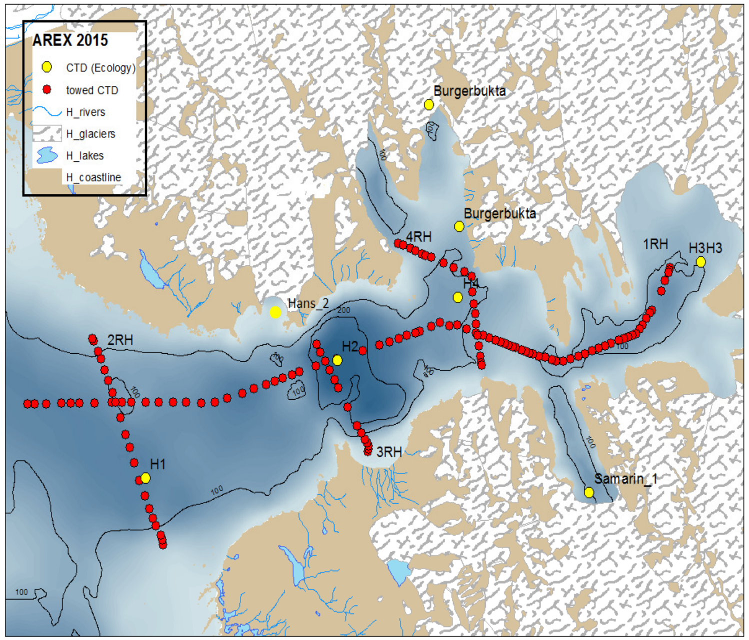


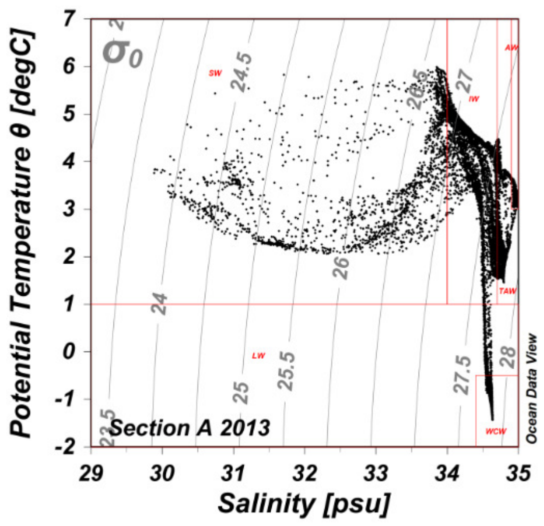
Rozkład temperatury, zasolenia oraz mas wodnych wzdłuż Hornsundu 04 lipca (lewa strona) oraz 26 lipca (prawa strona).
Początek lipca chłodne masy wewnątrz fiordu, basen główny wypełniony ciepłymi wodami pochodzenia Atlantyckiego.
Pod koniec lipca chłodne masy zostają zastąpione ciepłymi wodami z zewnątrz.
W Brepollen widoczne pozostałości wody zimowej poniżej progu (50m).
Brak czystej wody Atlantyckiej w fiordzie.

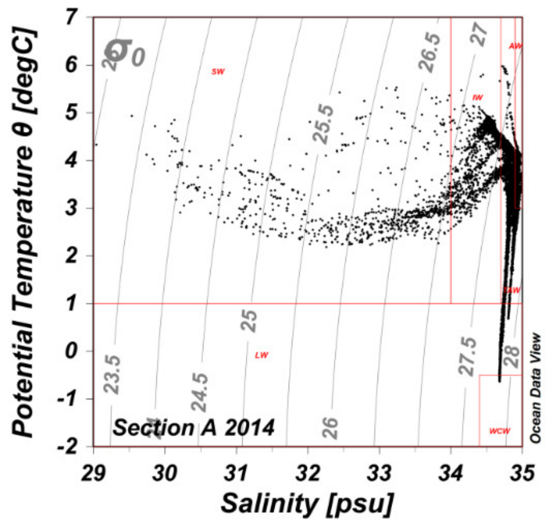

Potential Temperature [degC]
Pressure [db]
Section A 2013
15.2°E 15.4°E 15.6°E 15.8°E 16°E 16.2°E 16.4°E
Ocean Data View

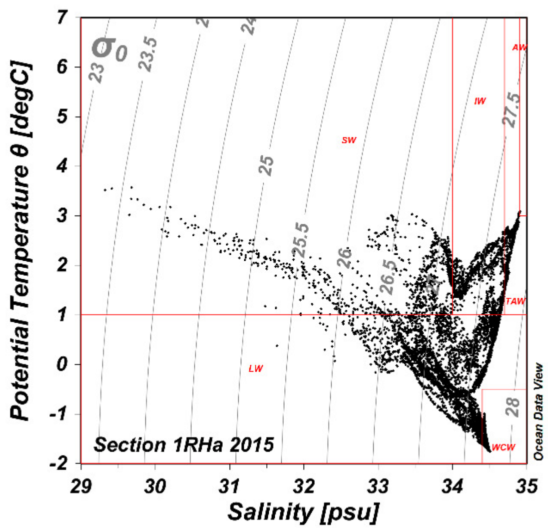

Potential Temperature [degC]
Pressure [db]
Section A 2014
15.5°E 16°E
Ocean Data View

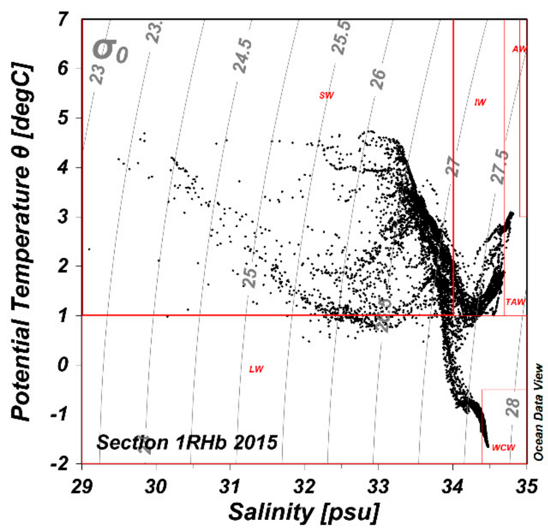

Potential Temperature [degC]
Pressure [db]
Section 1RH 26 July 2015
15.5°E 16°E 16.5°E
Ocean Data View / DIVA


AREX 2015
CTD (Ecology)
towed CTD
H_rivers
H_glaciers
H_lakes
H_coastline
Burgerbukta
Burgerbukta
4RH
1RH
H3H3
H4
Hans_2
2RH
H2
3RH
H1
Samarin_1

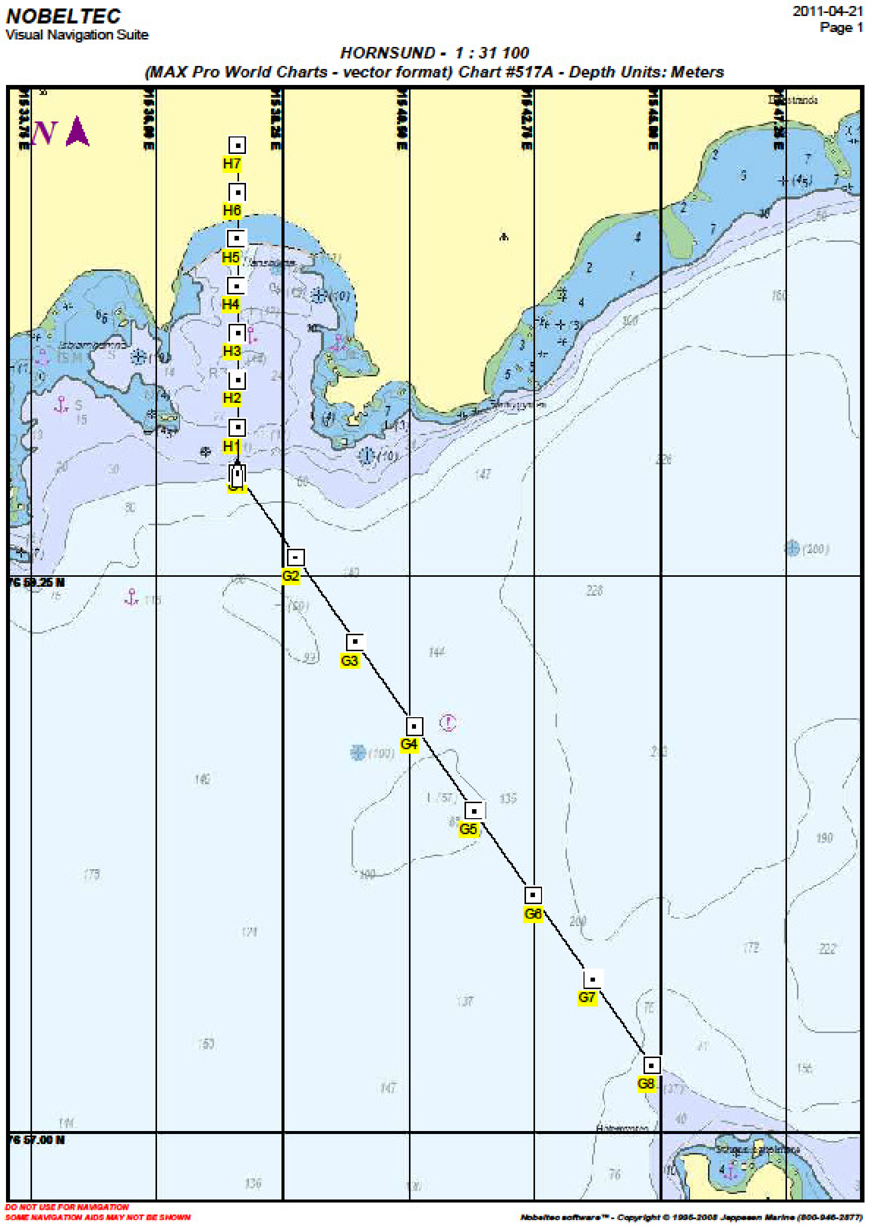

Potential Temperature θ [degC]
Salinity [psu]
Section A 2013
Ocean Data View


Potential Temperature θ [degC]
Salinity [psu]
Section A 2014
Ocean Data View


Potential Temperature θ [degC]
Salinity [psu]
Section 1RHa 2015
Ocean Data View


Potential Temperature θ [degC]
Salinity [psu]
Section 1RHb 2015
Ocean Data View

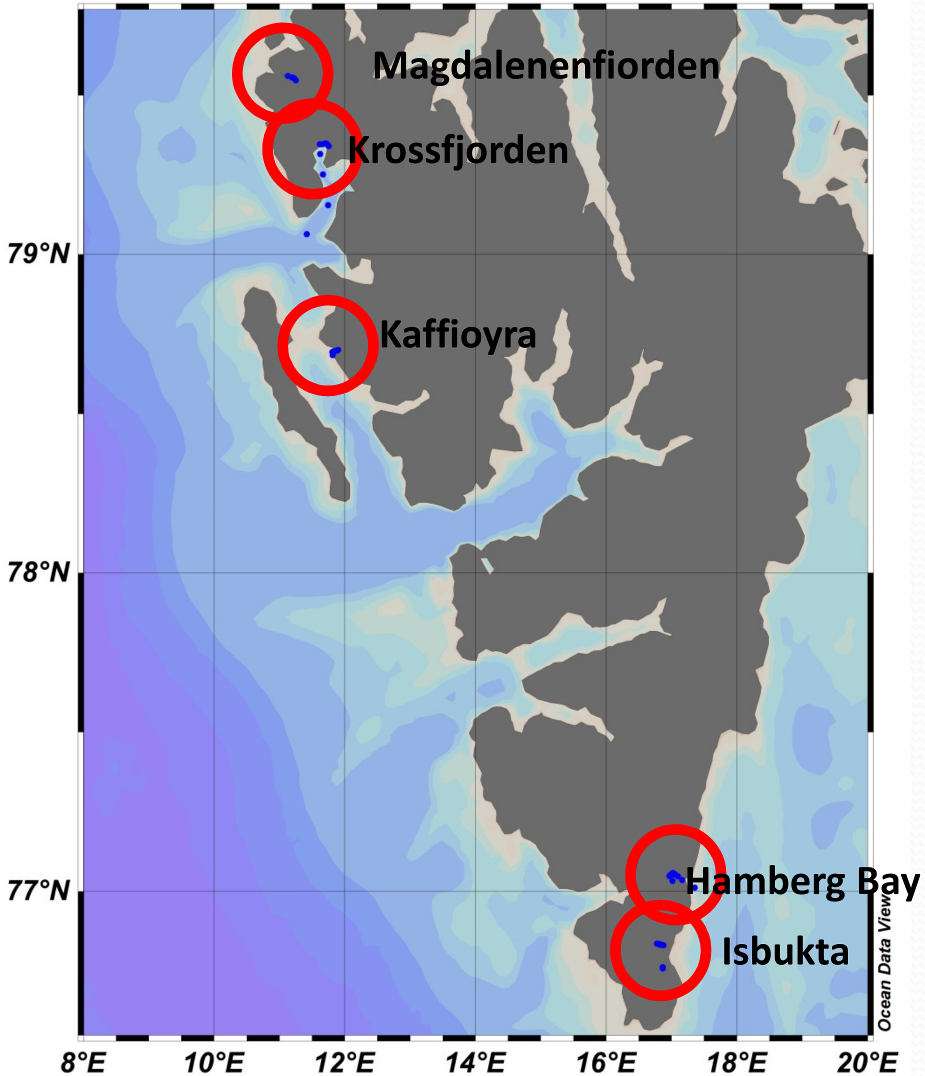
Standard CTD sections in Hornsund



S/Y Barlovento cruise
15.07-21.07. 2015

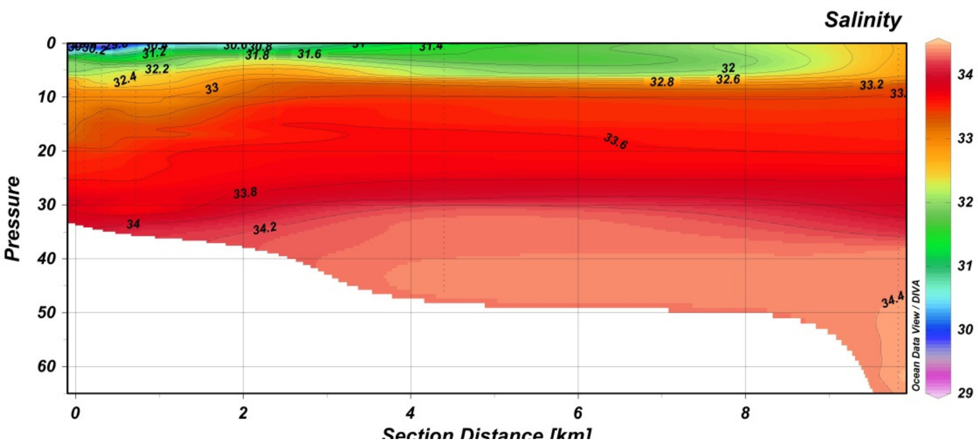
S/Y Barlovento cruise

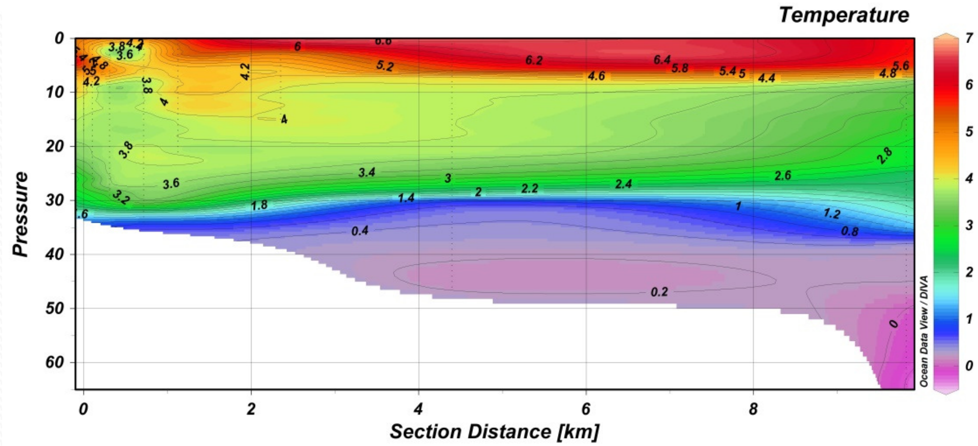
SD 200W probe
40 CTD profiles, 5 sections

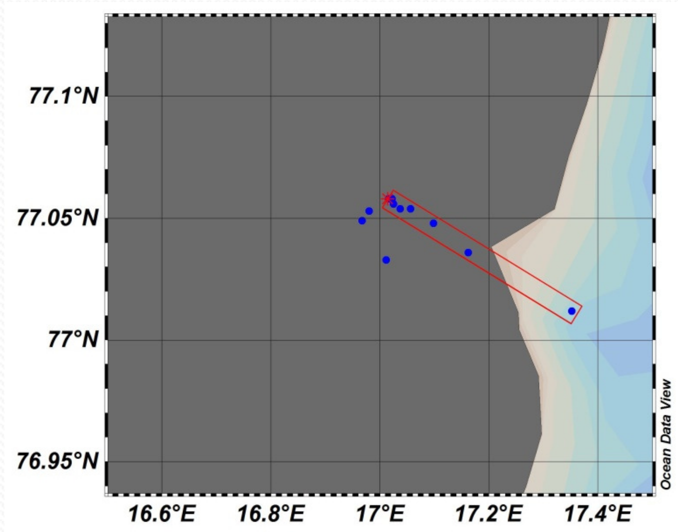


S/Y Barlovento cruise

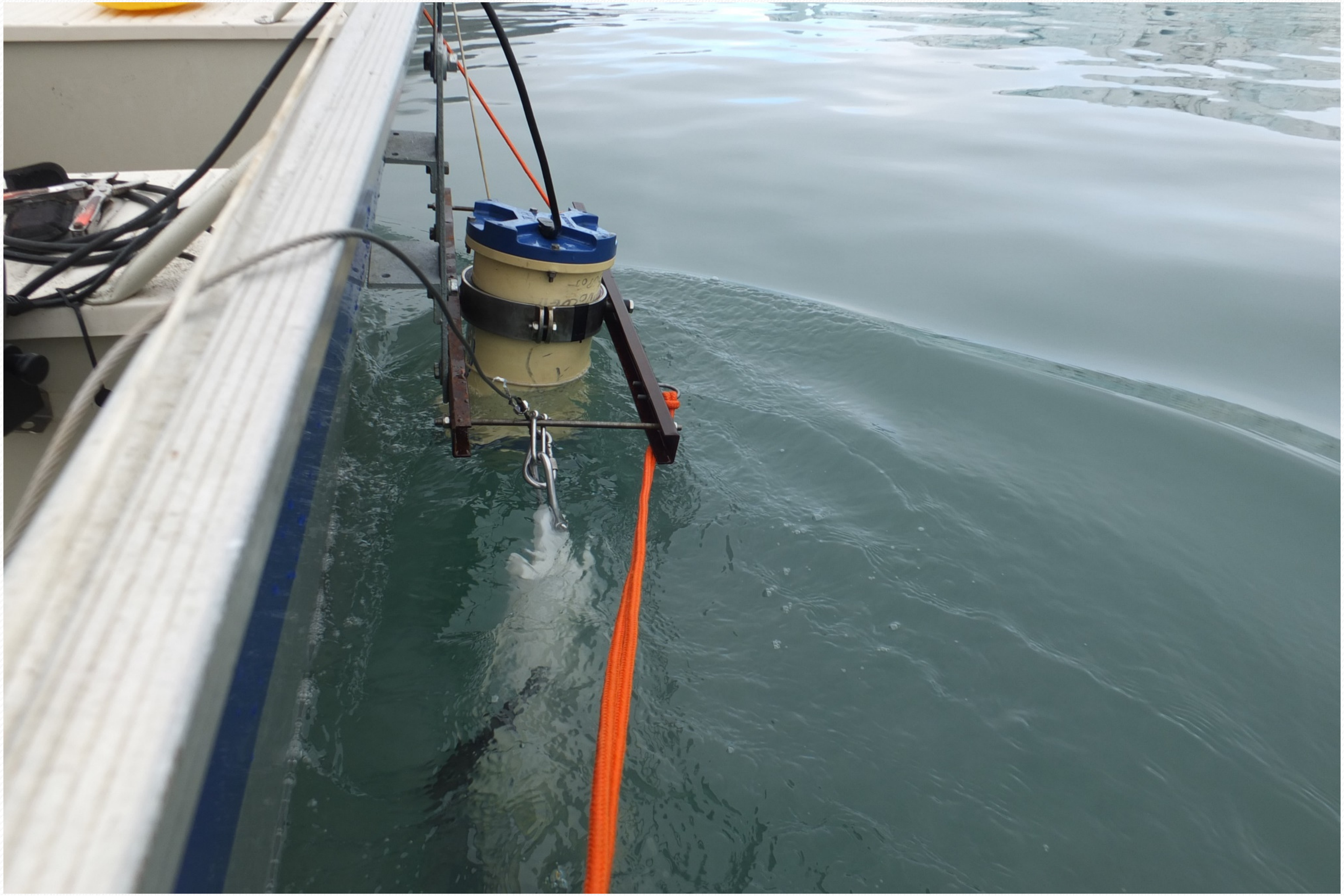
S/Y Barlovento cruise
Hamberg Bay



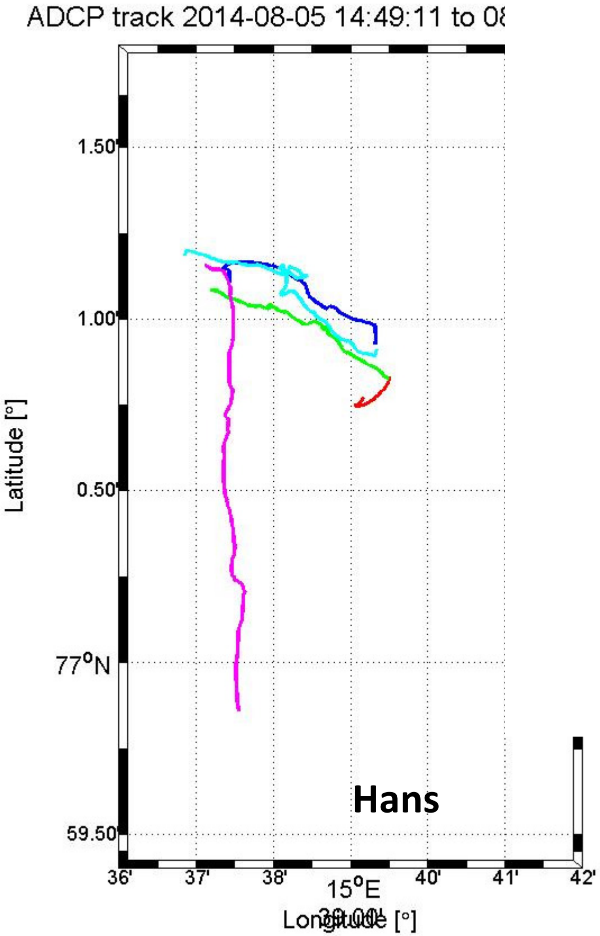


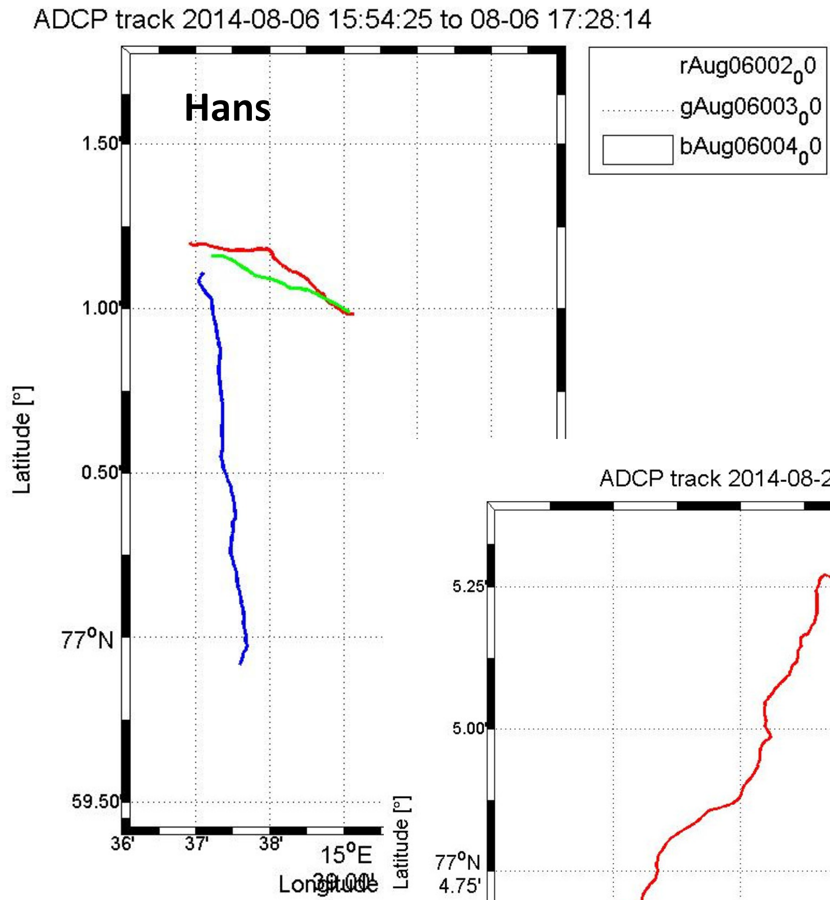


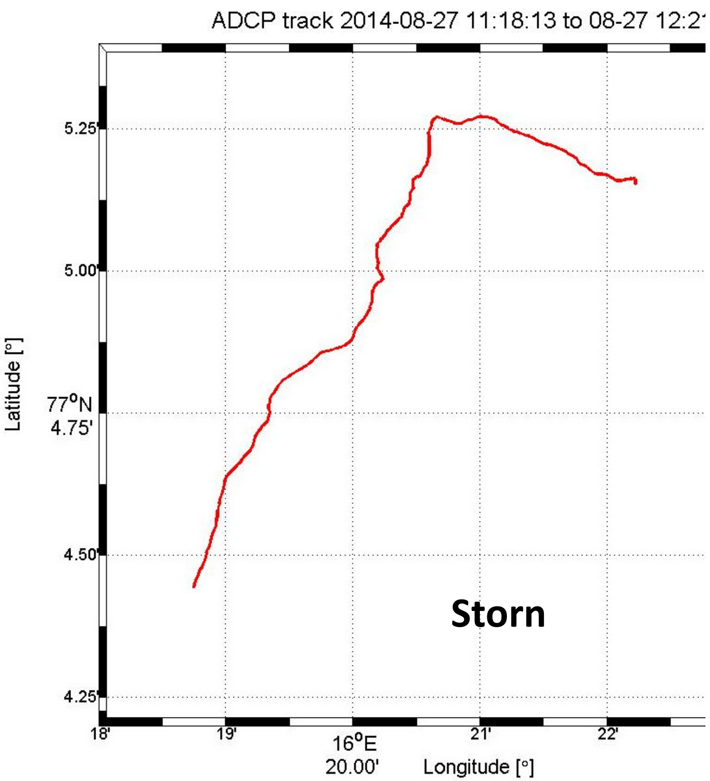
Hornsund ADCP measurements

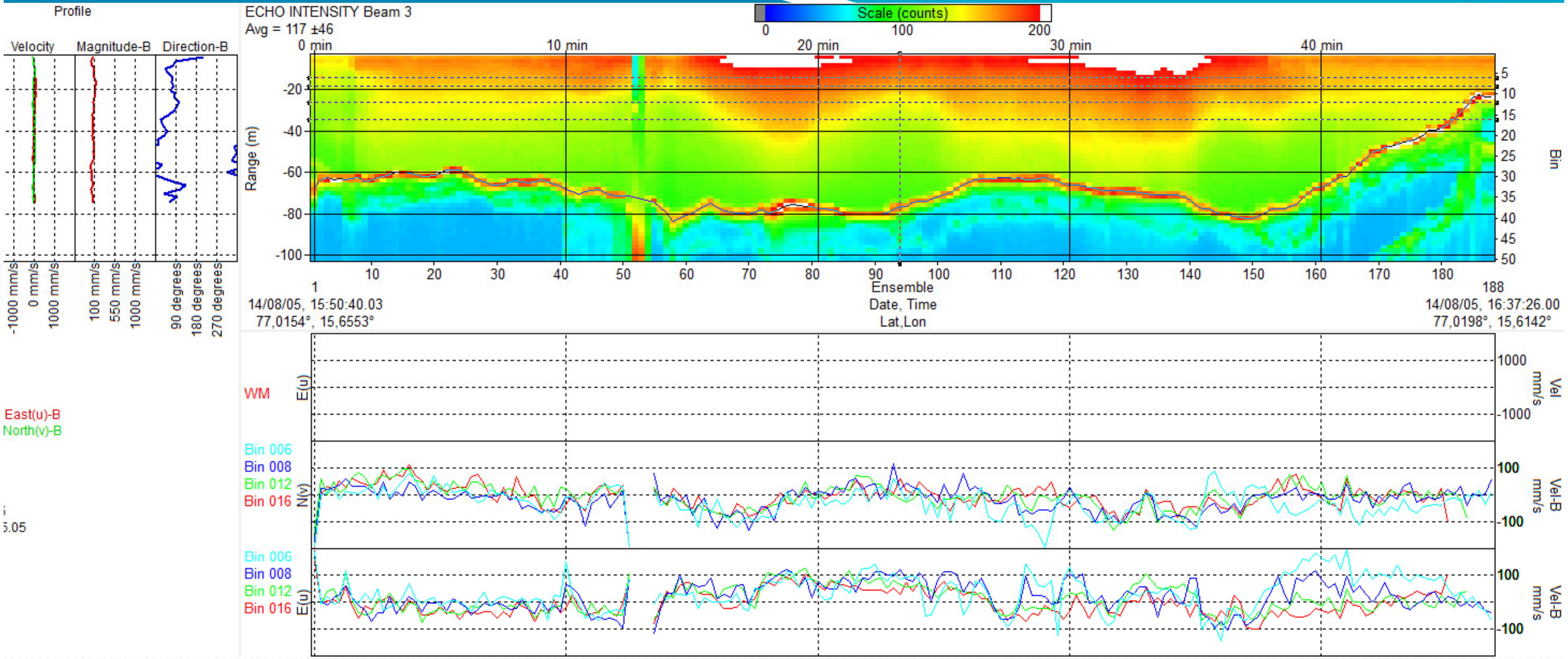


Hornsund ADCP tracks

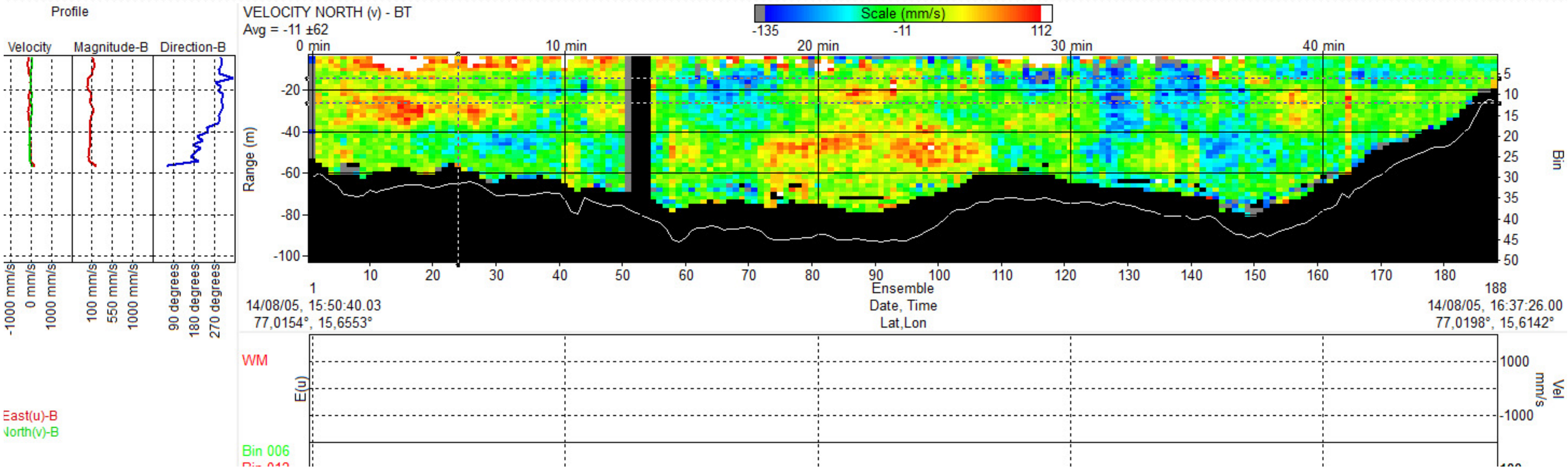






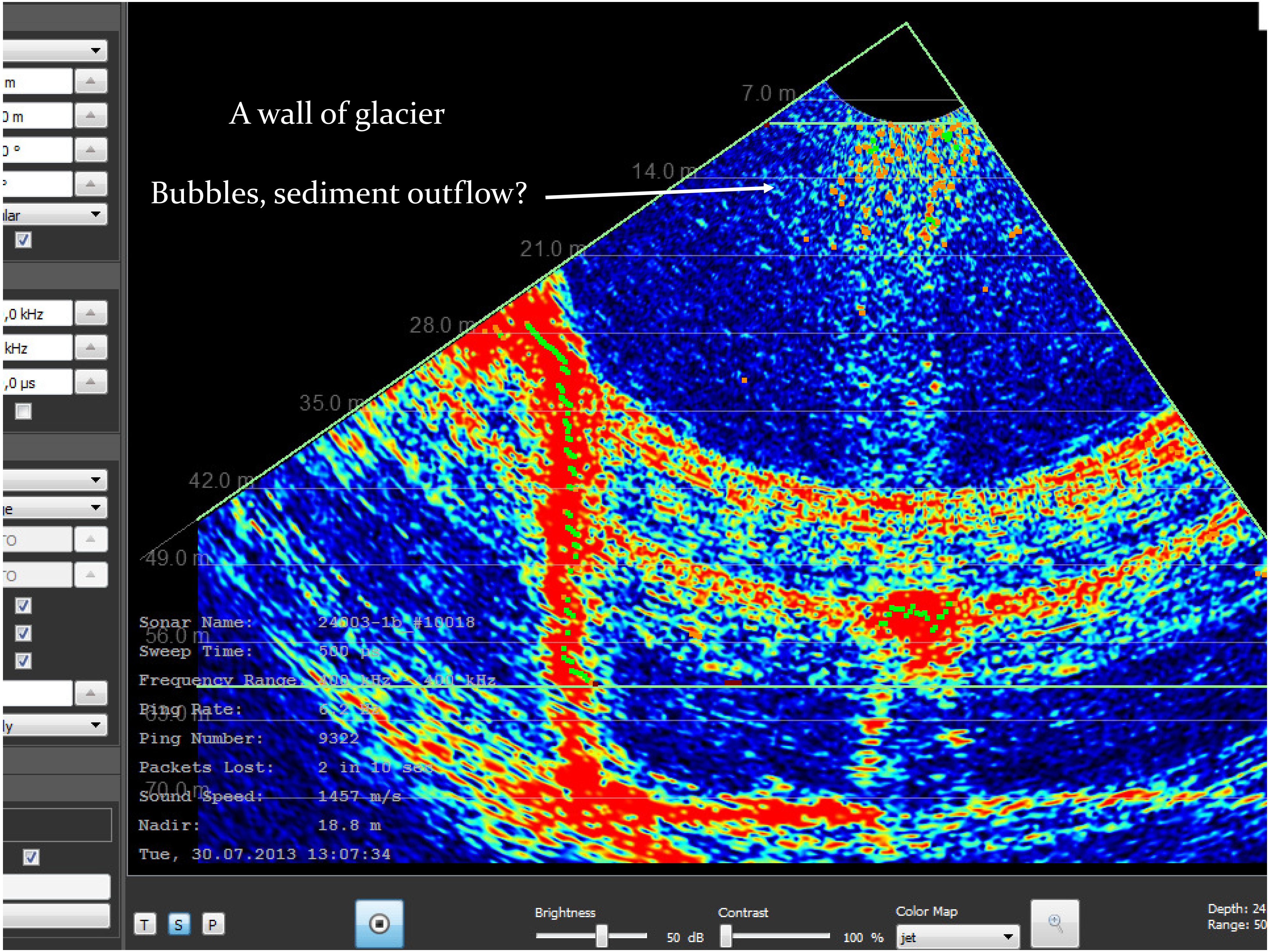


Profile
Velocity
Magnitude-B
Direction-B
ECHO INTENSITY Beam 3
Avg = 117 ±46
Scale (counts)
0
100
200
0 min
10 min
20 min
30 min
40 min
Range (m)
Bin
Ensemble
Date, Time
Lat,Lon
14/08/05, 15:50:40.03
77,0154°, 15,6553°
14/08/05, 16:37:26.00
77,0198°, 15,6142°
-1000 mm/s
0 mm/s
1000 mm/s
100 mm/s
550 mm/s
1000 mm/s
90 degrees
180 degrees
270 degrees
WM
E(u)
East(u)-B
North(v)-B
Vel mm/s
Bin 006
Bin 008
Bin 012
Bin 016
N(v)
Vel-B mm/s



Profile
Velocity
Magnitude-B
Direction-B
VELOCITY NORTH (v) - BT
Avg = -11 ±62
Scale (mm/s)
-135
-11
112
0 min
10 min
20 min
30 min
40 min
Range (m)
Bin
Ensemble
Date, Time
Lat,Lon
14/08/05, 15:50:40.03
77,0154°, 15,6553°
14/08/05, 16:37:26.00
77,0198°, 15,6142°
-1000 mm/s
0 mm/s
1000 mm/s
100 mm/s
550 mm/s
1000 mm/s
90 degrees
180 degrees
270 degrees
WM
E(u)
East(u)-B
North(v)-B
Vel mm/s
Bin 006

Hornsund Multibeam Echosounder



A wall of glacier
Bubbles, sediment outflow?
7.0 m
14.0 m
21.0 m
28.0 m
35.0 m
42.0 m
49.0 m
Sonar Name:
Sweep Time:
Frequency Range:
Ping Rate:
Ping Number: 9322
Packets Lost: 2 in 10 sec
Sound Speed: 1457 m/s
Nadir: 18.8 m
Tue, 30.07.2013 13:07:34
Brightness
50 dB
Contrast
100 %
Color Map
jet

Time Lapse Camera

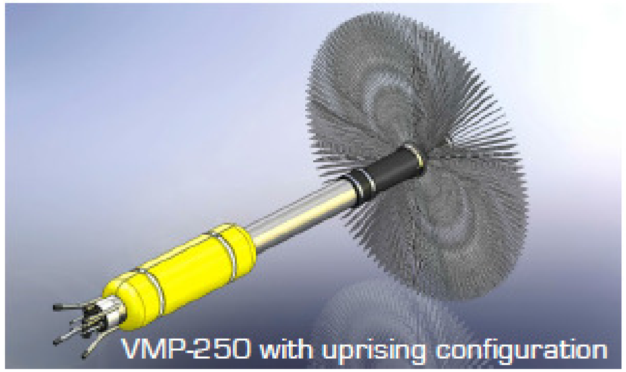
2016

- *Planned process oriented observations close to glaciers fronts – multibeam echosounder, ADCP*

Specifications

Configuration	
Standard sensors	2x Shear Probe, 1x Micro-temperature (FP07), 2x Accelerometer, 1x Pressure, 1x Tilt sensor
Optional sensors	Conductivity-temperature combo sensor, Fluorometer-turbidity combo sensor, Micro-conductivity sensor, Additional Micro-temperature (FP07)
Uprising profiling kit	Floatation, ballasting, and weight release hardware for uprising measurements.

General Specifications	
Model Designations	VMP-250-IR (Internal Data Recording)
	VMP-250-RT (Real-time data transmission)
Depth Range	0 - 500 m (1000 optional)
Weight in air / water	10 kg / 4.1 kg
Length housing / overall	1.3 m / 1.7 m
Sampling rate	512 Hz / 64 Hz fast channel/slow channels
Data Acquisition	Internal recording (Real-time transmission, optional)


VMP-250 with uprising configuration

Sensor Specifications		Range	Accuracy	Resolution	Bandwidth (standard*)
Velocity Shear Probe		0 - 10 s^{-1}	5%	10^{-3} s^{-1}	0.1 – 100 Hz
Micro-Temperature FP07		-5 – 35 ºC	0.01 ºC	10^{-5} ºC	0 – 25 Hz
Pressure		50 / 100 bar	0.1% FS	5 × 10^{-4} bar	0 – 5 Hz
Accelerometer		±1g	2%	3 × 10^{-5} g	0.1 – 100 Hz
Micro-Conductivity SBE7		0 – 70 mS/cm	0.005 mS/cm	0.001 mS/cm	0 – 100 Hz
CT sensor	**Conductivity** **Temperature**	2 – 65 mS/cm -3 – 45 ºC	0.01 mS/cm 0.01 ºC	0.001 mS/cm 0.001 ºC	0 – 16 Hz
FT sensor	**Fluorescence** **Turbidity**	0 – 400 ppb 0 – 1000 FTU	1% of FS 0.3 FTU or 2% of Measured Value	0.01 ppb 0.03 FTU	0 – 100 Hz

VMP-250 Internal Recording Coastal Vertical Turbulence Pr

PBP Forkos

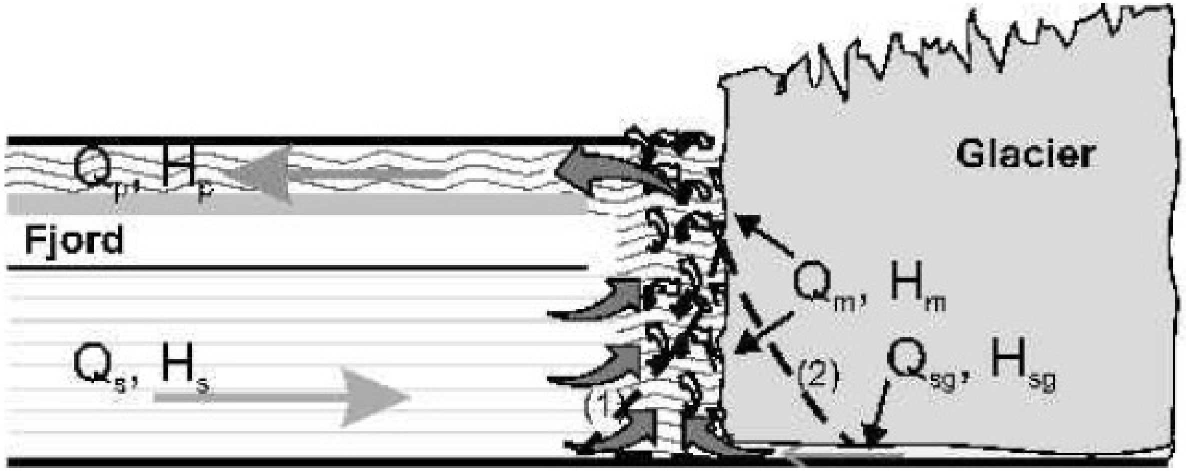
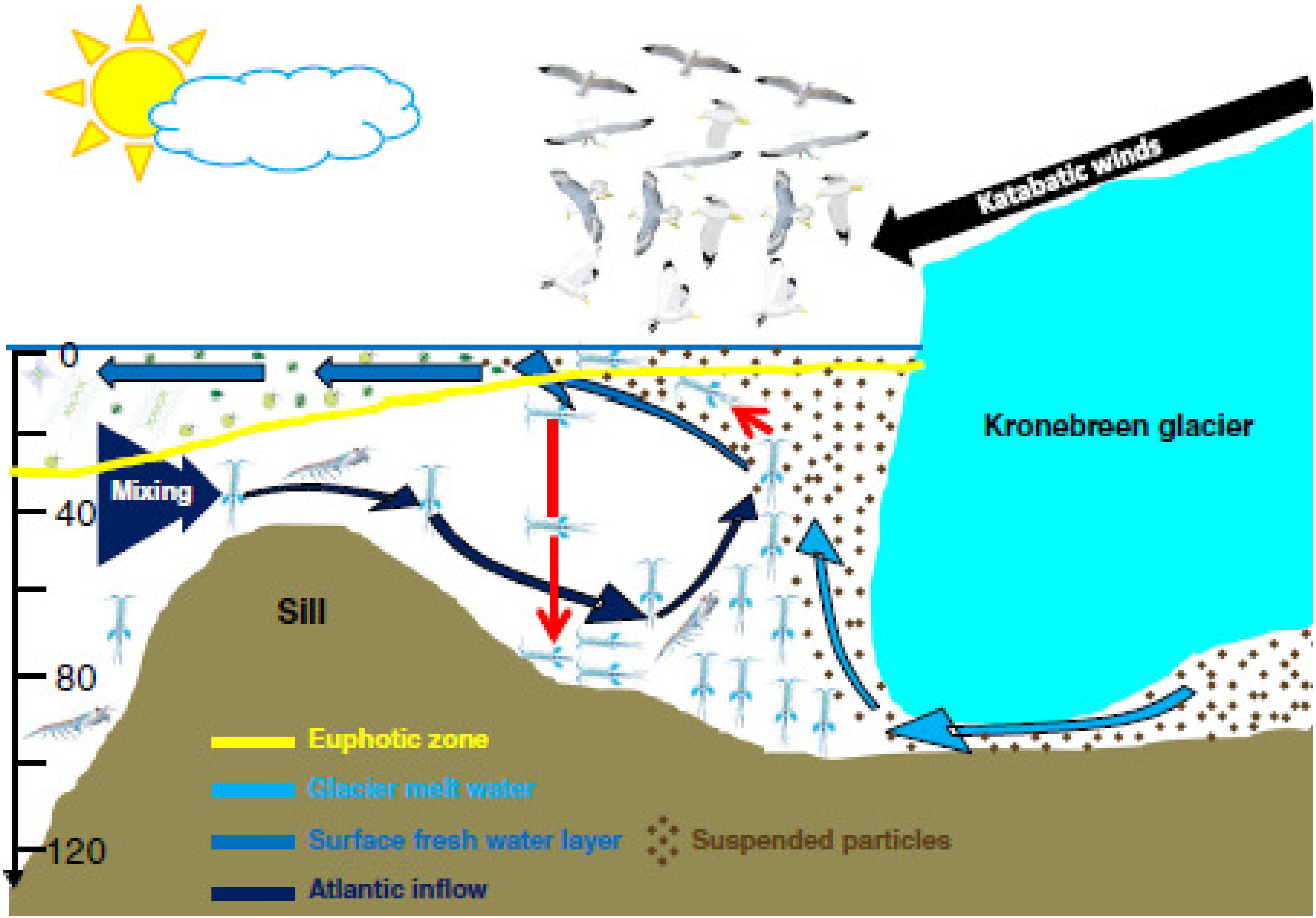
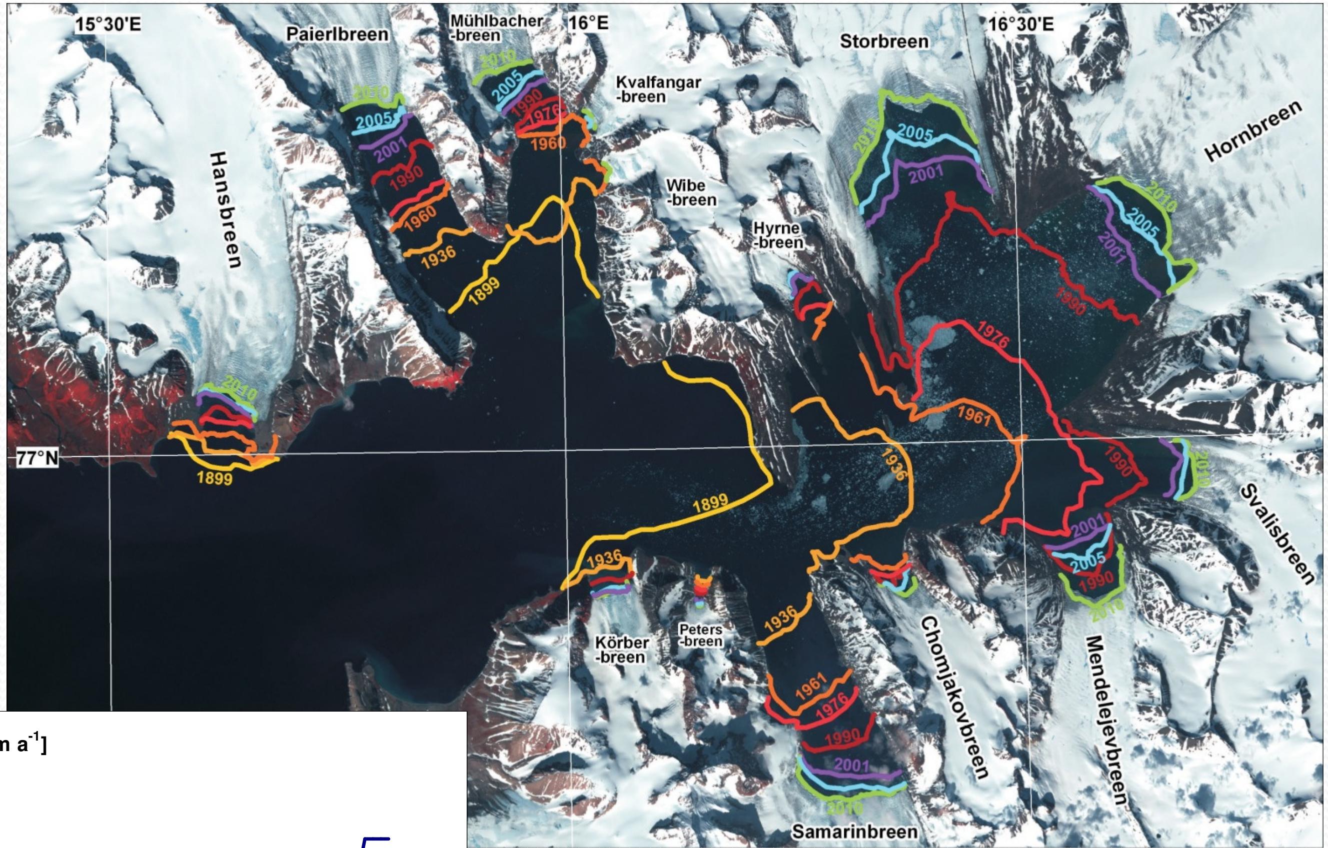


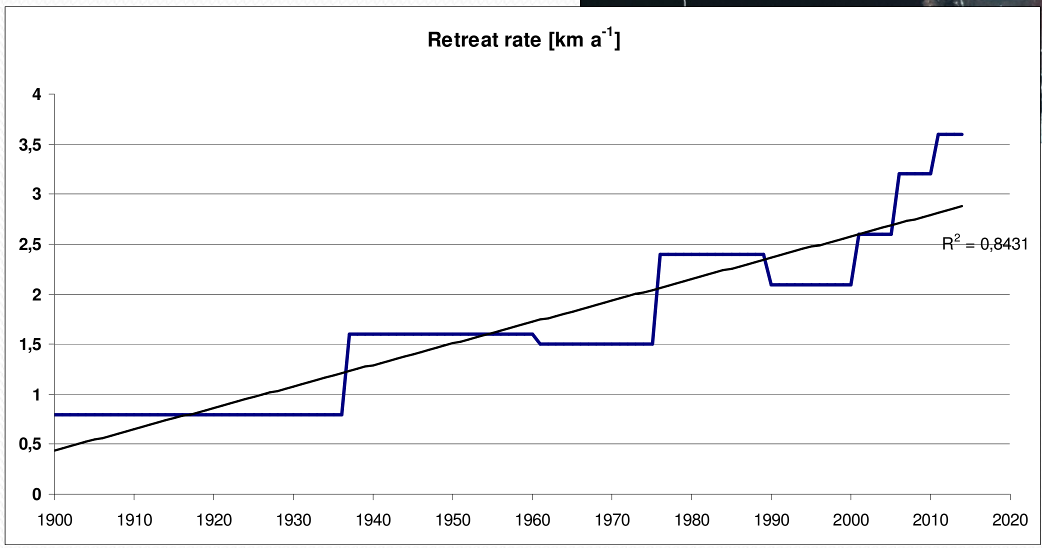
Fig. 5. Model of forced convective flow in proglacial fjord. Subglacial discharge, Q_{sg}, carrying heat, H_{sg}, drives convection, drawing deep saline water (Q_s, H_s) towards terminus where the two components mix and turbulently rise along the ice face. The ascending waters melt ice along the face (Q_m, H_m), which adds to convection. The turbulent plume reaches the water surface then flows away from the terminus in overflow plume (Q_p, H_p). Dashed lines show possible seasonal geometries of submarine face for conditions of (1) little or no subglacial discharge and melting, and (2) significant submarine melting (see text for discussion).

Submarine melting at the terminus of a temperate tidewater glacier, LeConte Glacier, Alaska, U.S.A.
Roman J. MOTYKA,1, 3 Lewis HUNTER,2* Keith A. ECHELMEYER,1 Cathy CONNOR3


Katabatic winds
Kronebreen glacier
0
40
80
120
Mixing
Sill
Euphotic zone
Glacier melt water
Surface fresh water layer
Suspended particles
Atlantic inflow

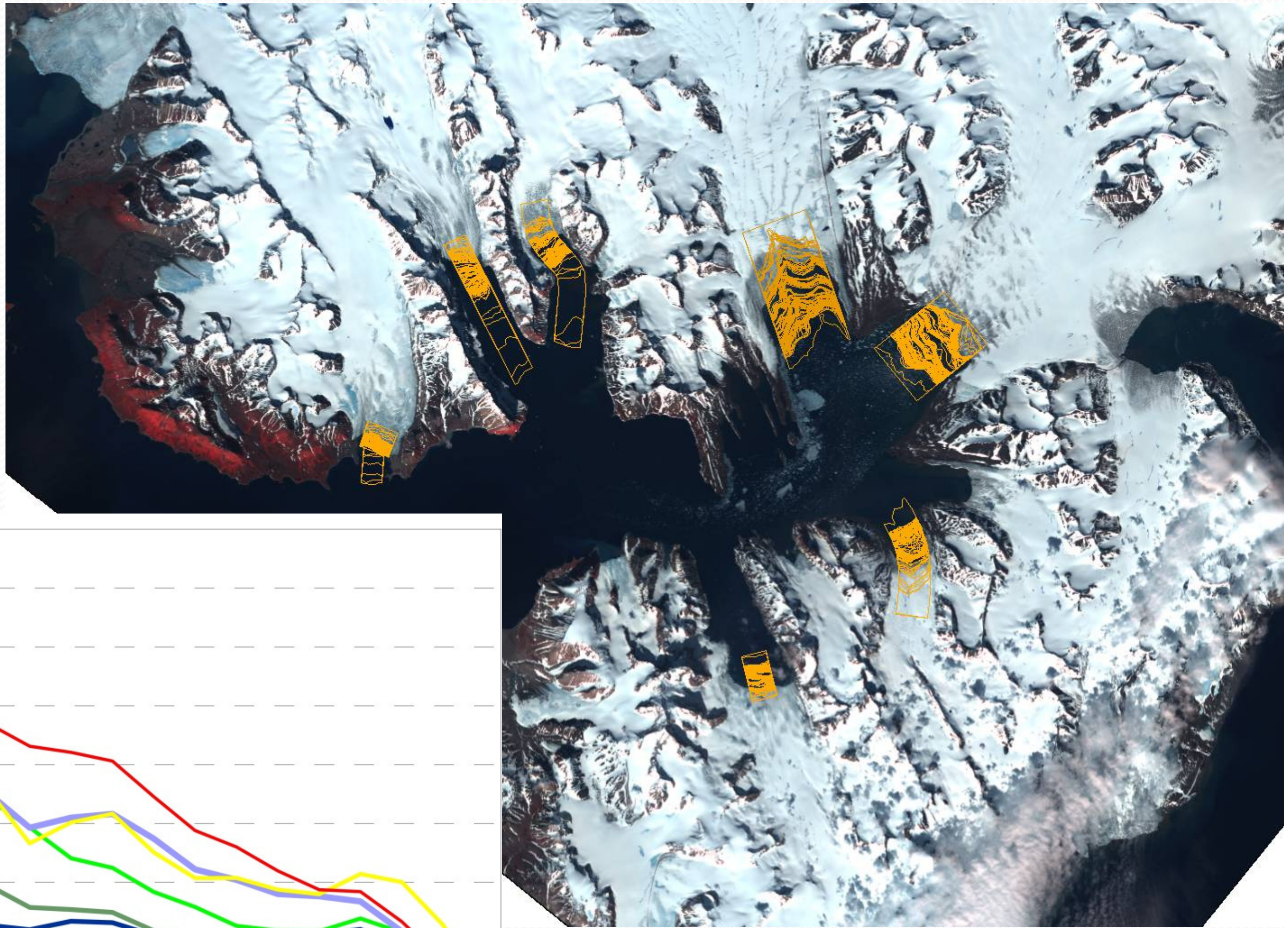
Retreat of glaciers in Hornsund since 1899

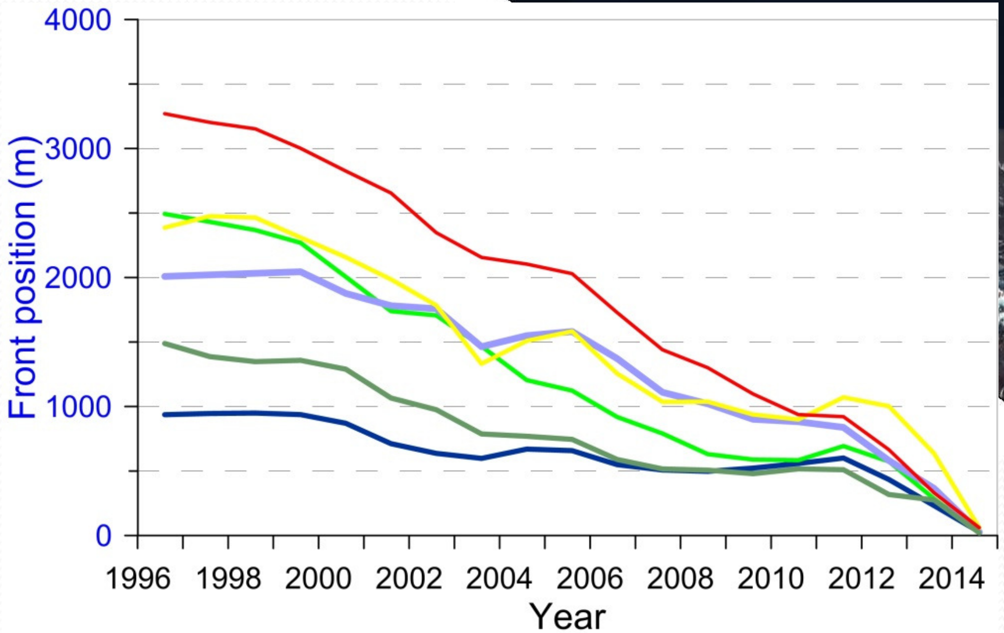




Błaszczyk et. Al. 2013

Hornsund. Retreat of glaciers





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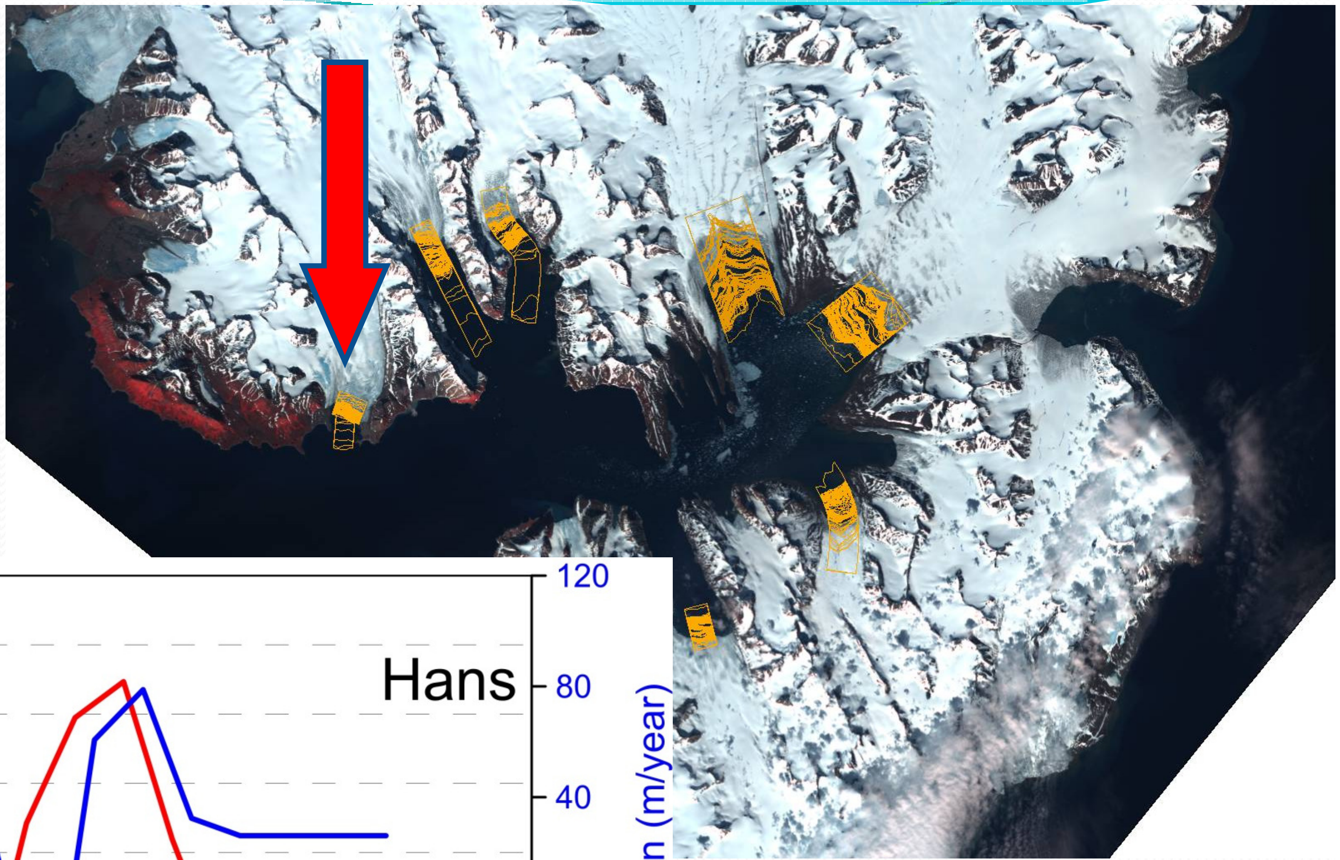

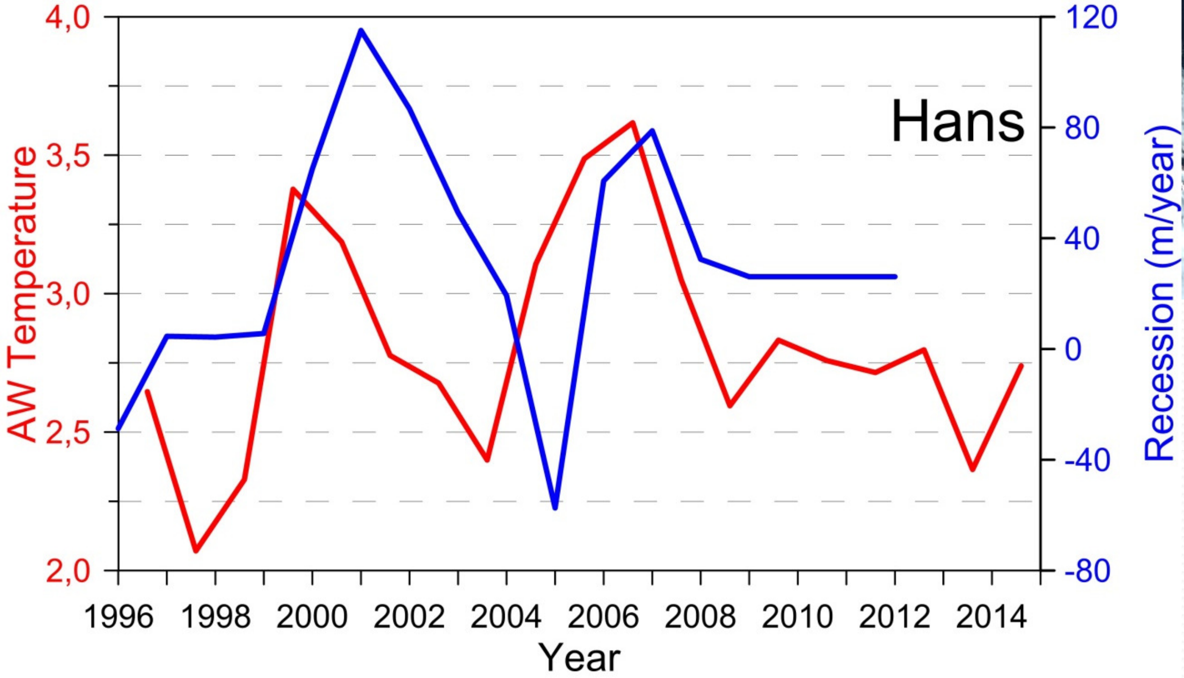

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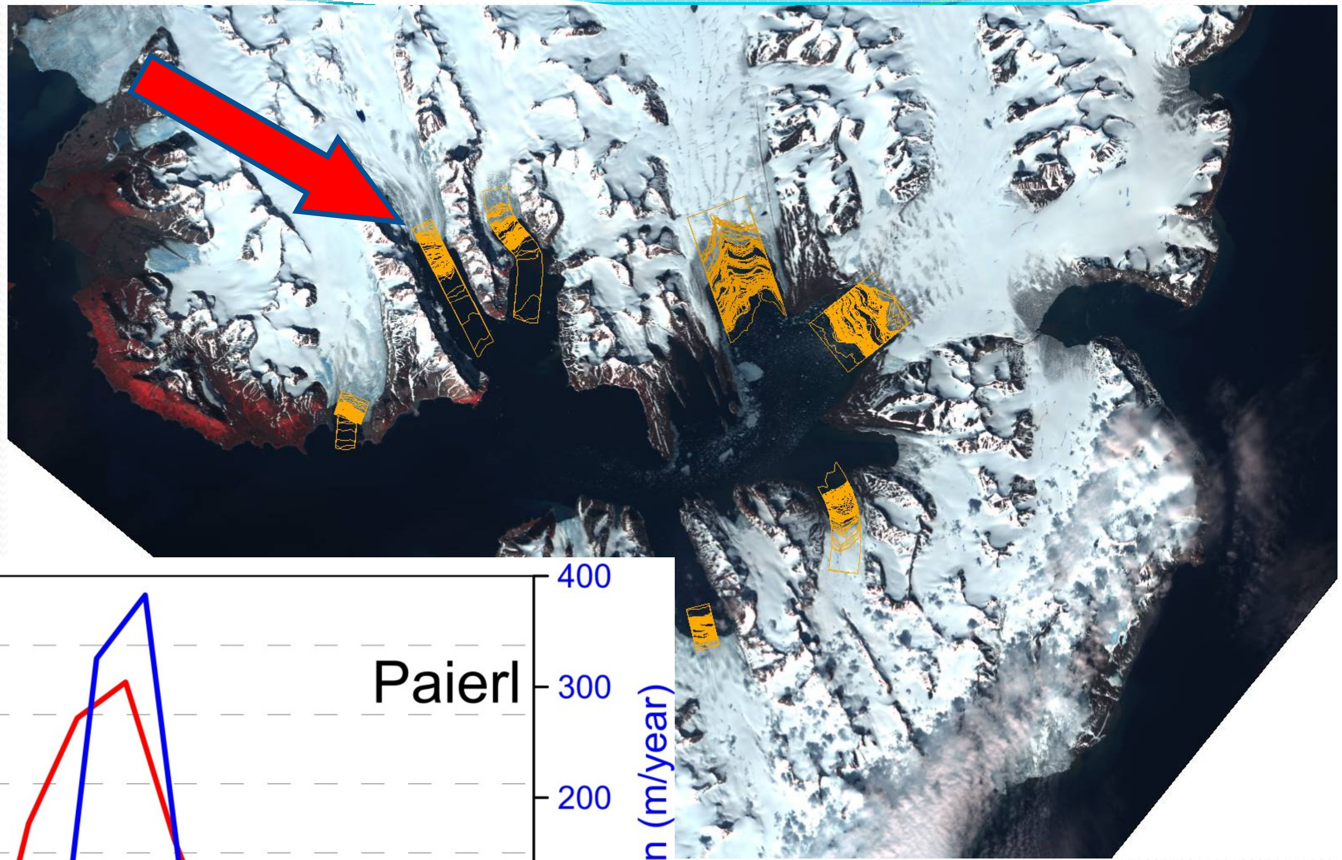

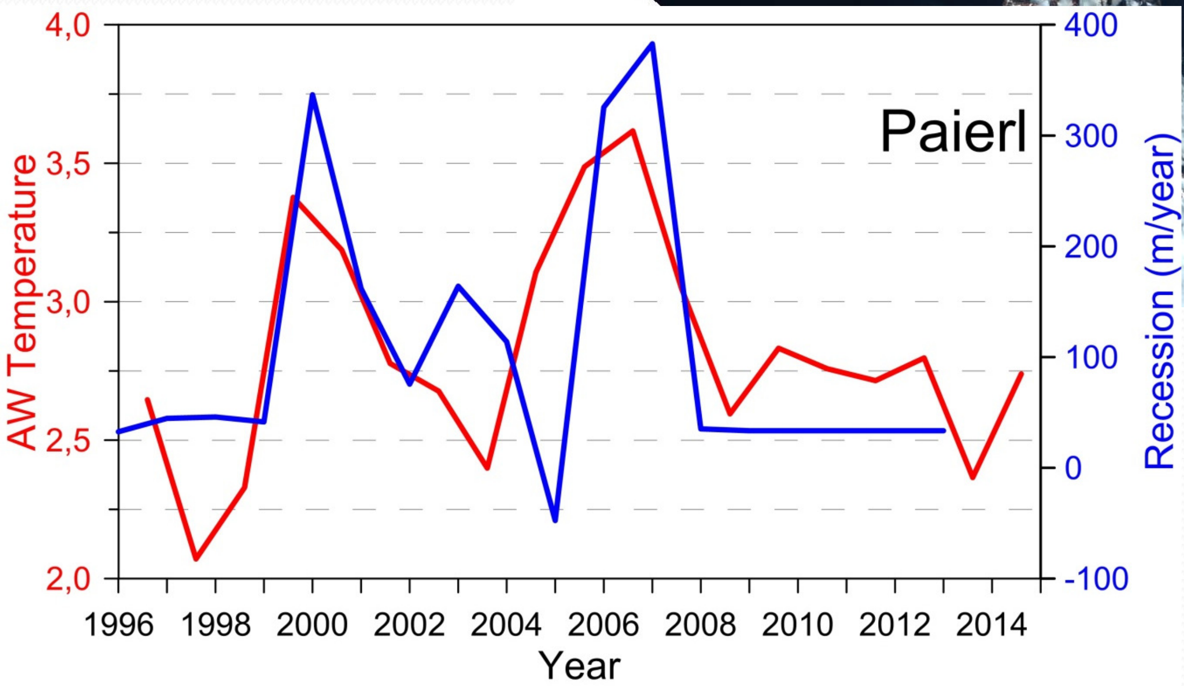

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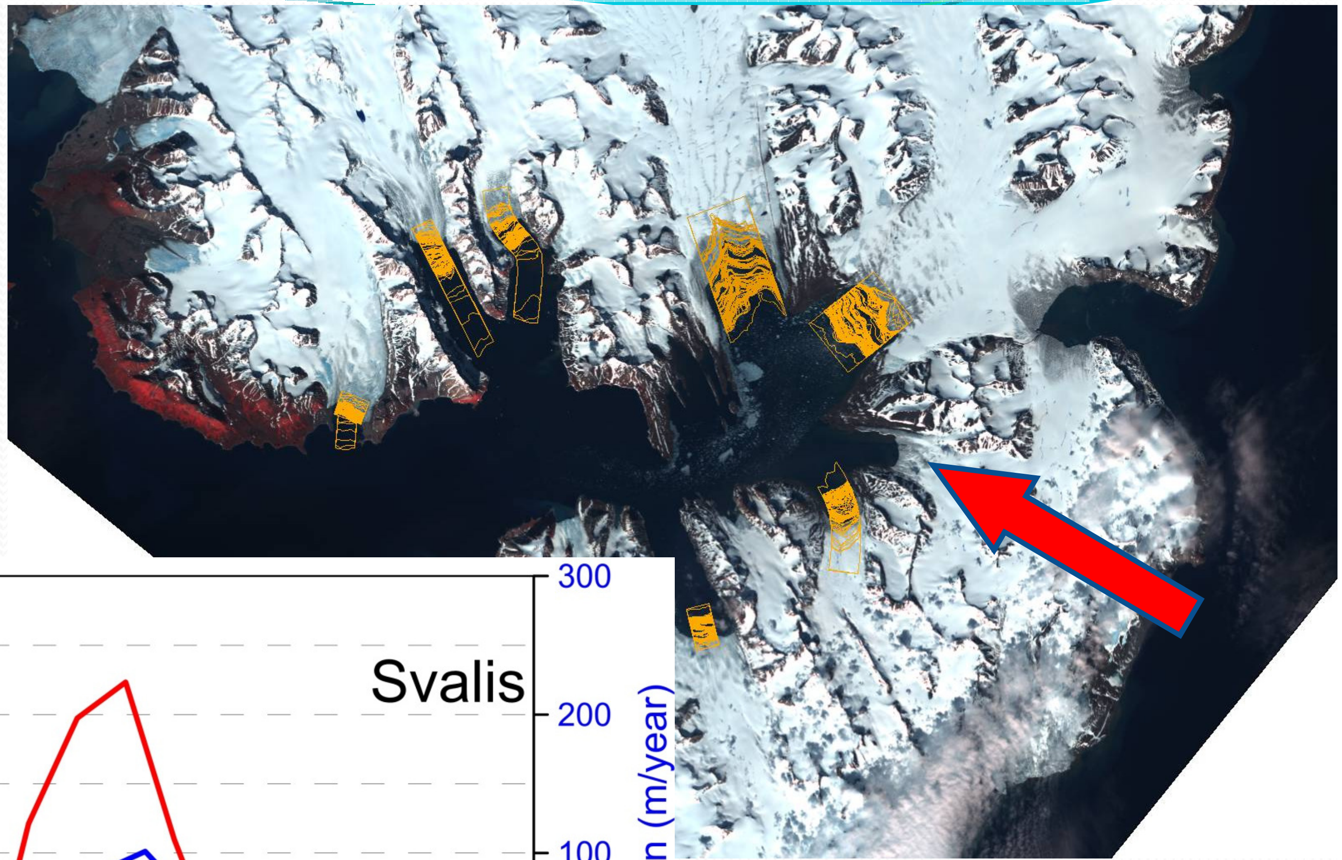

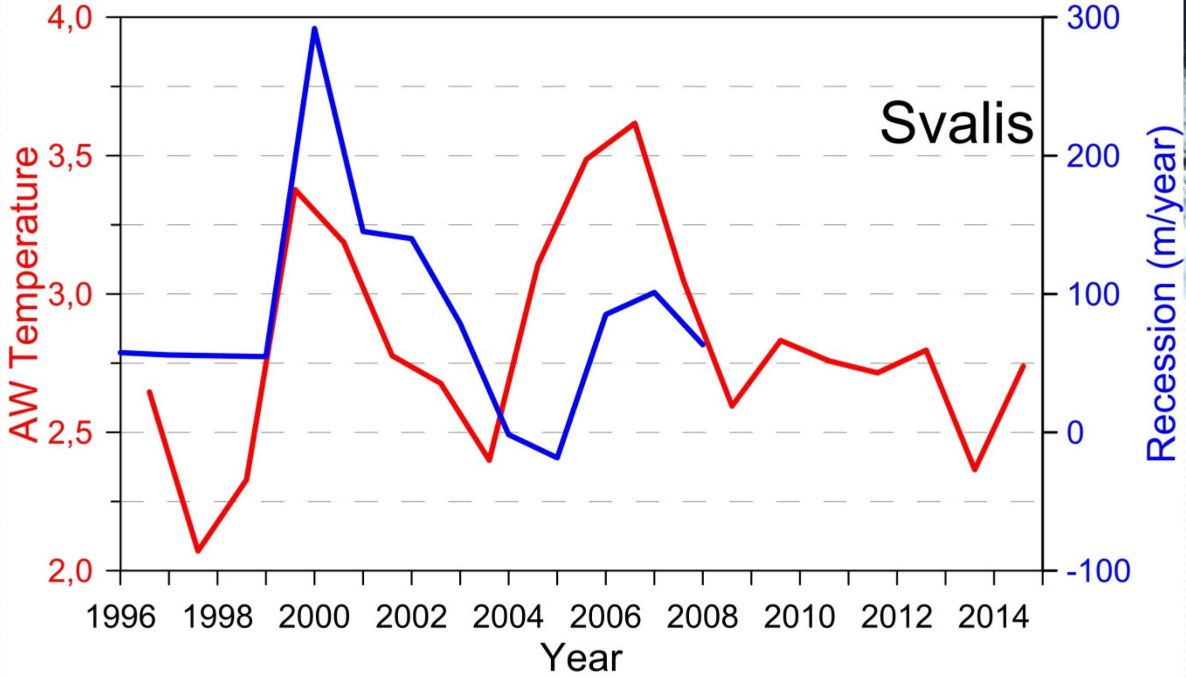

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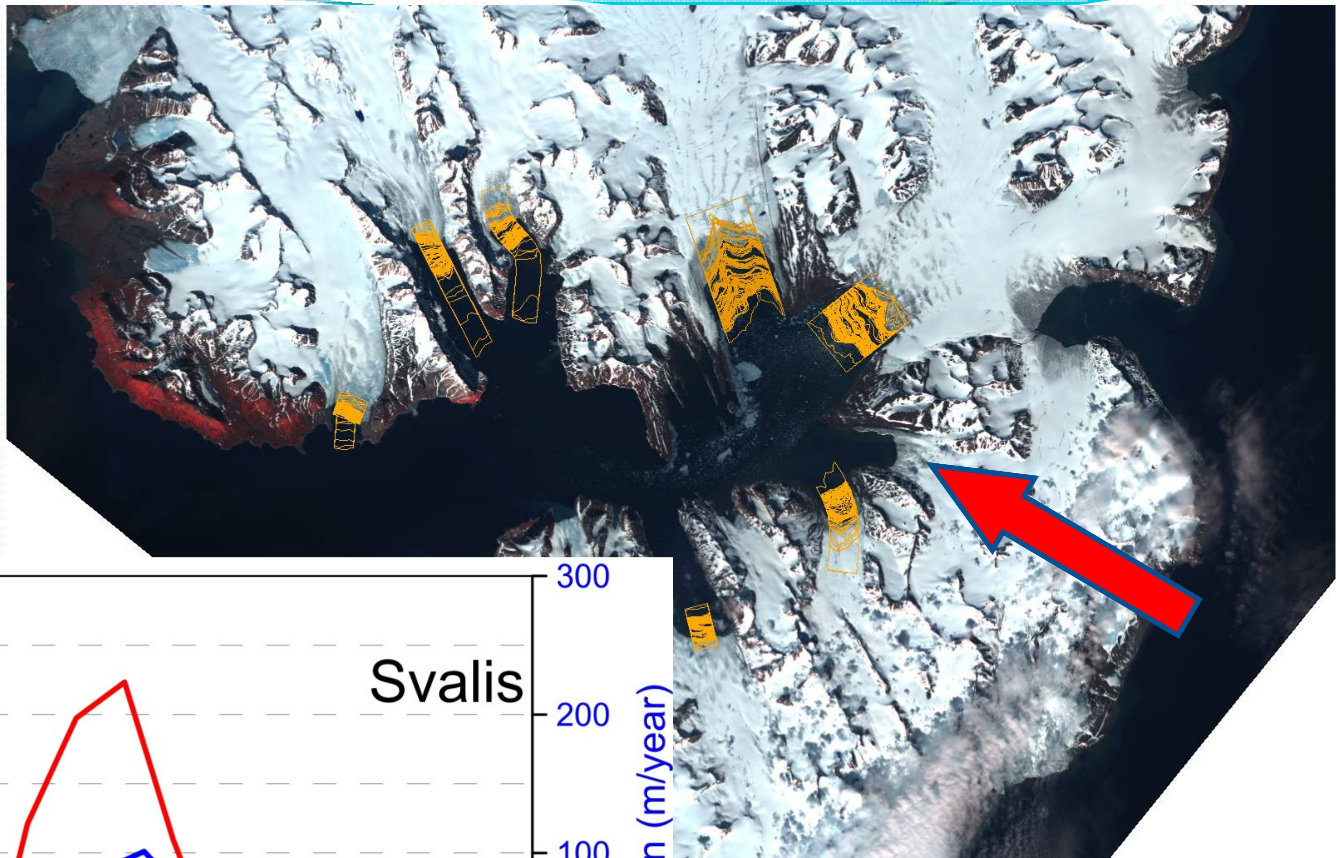

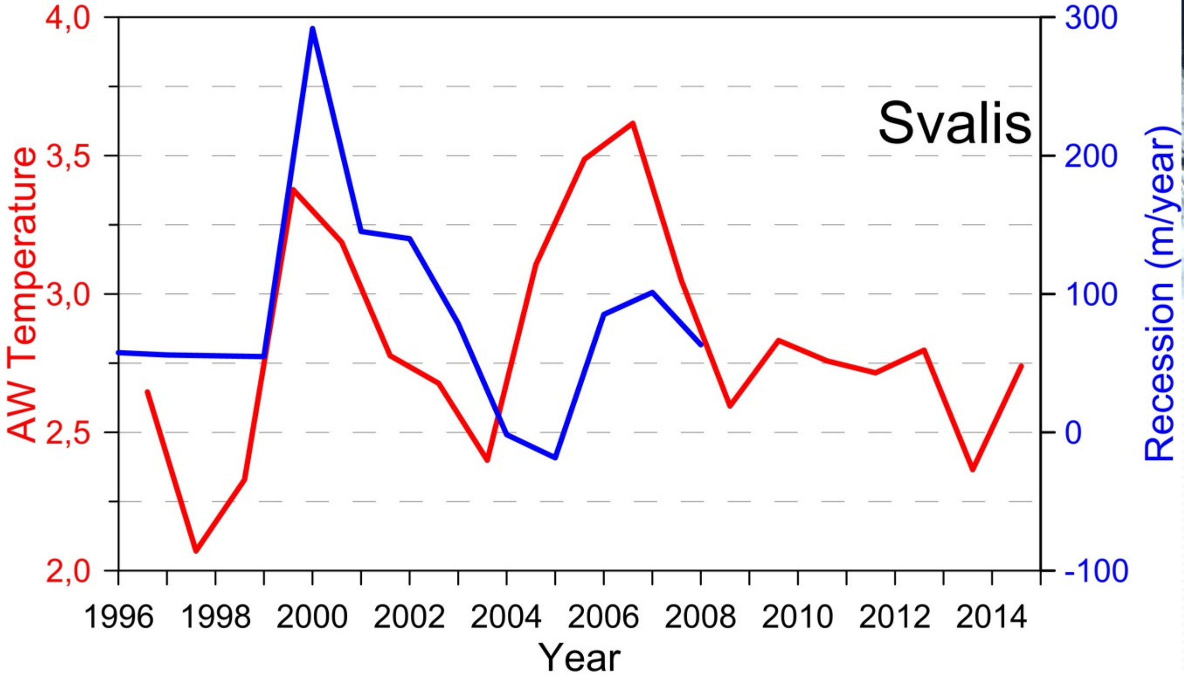

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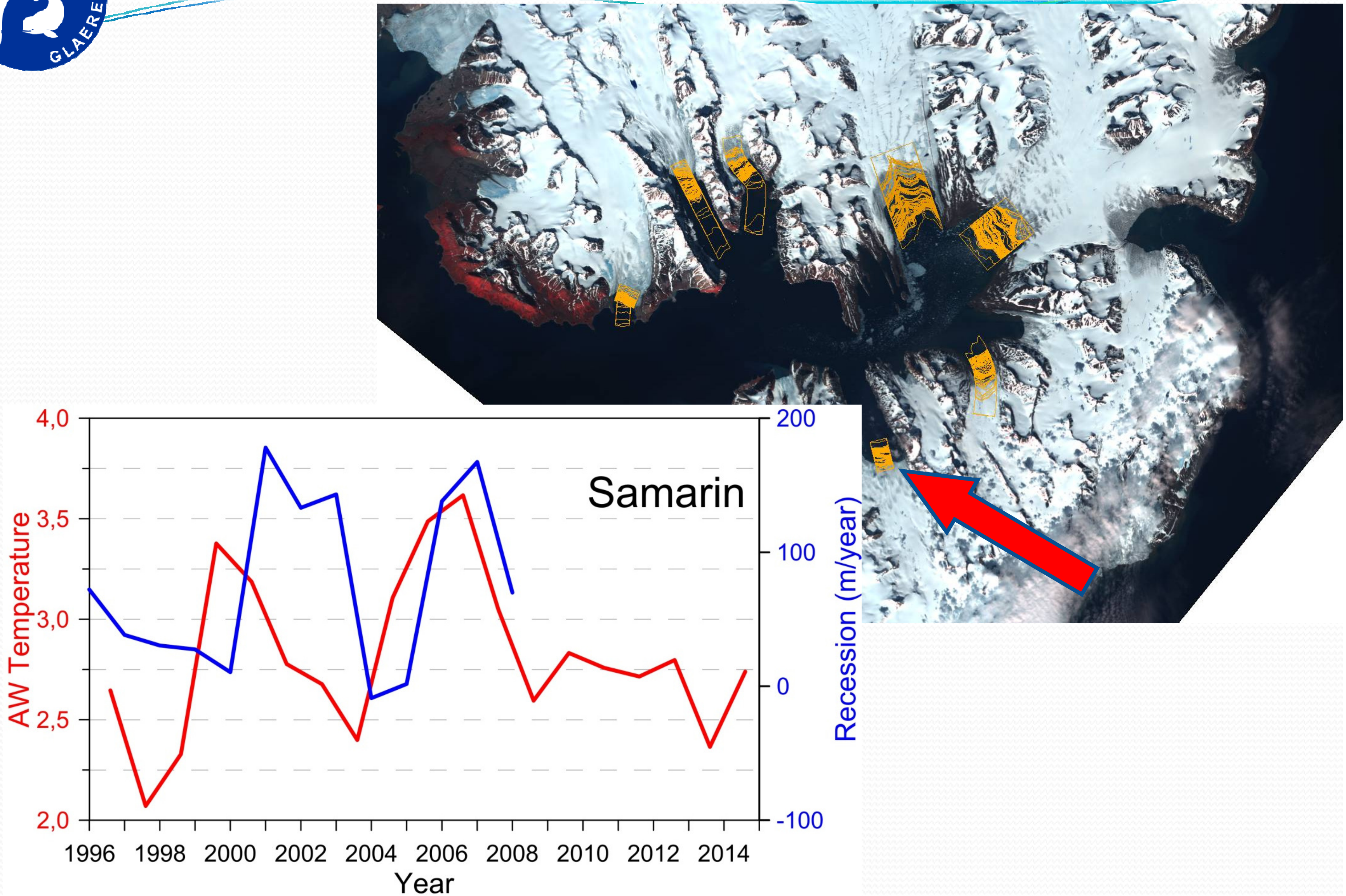

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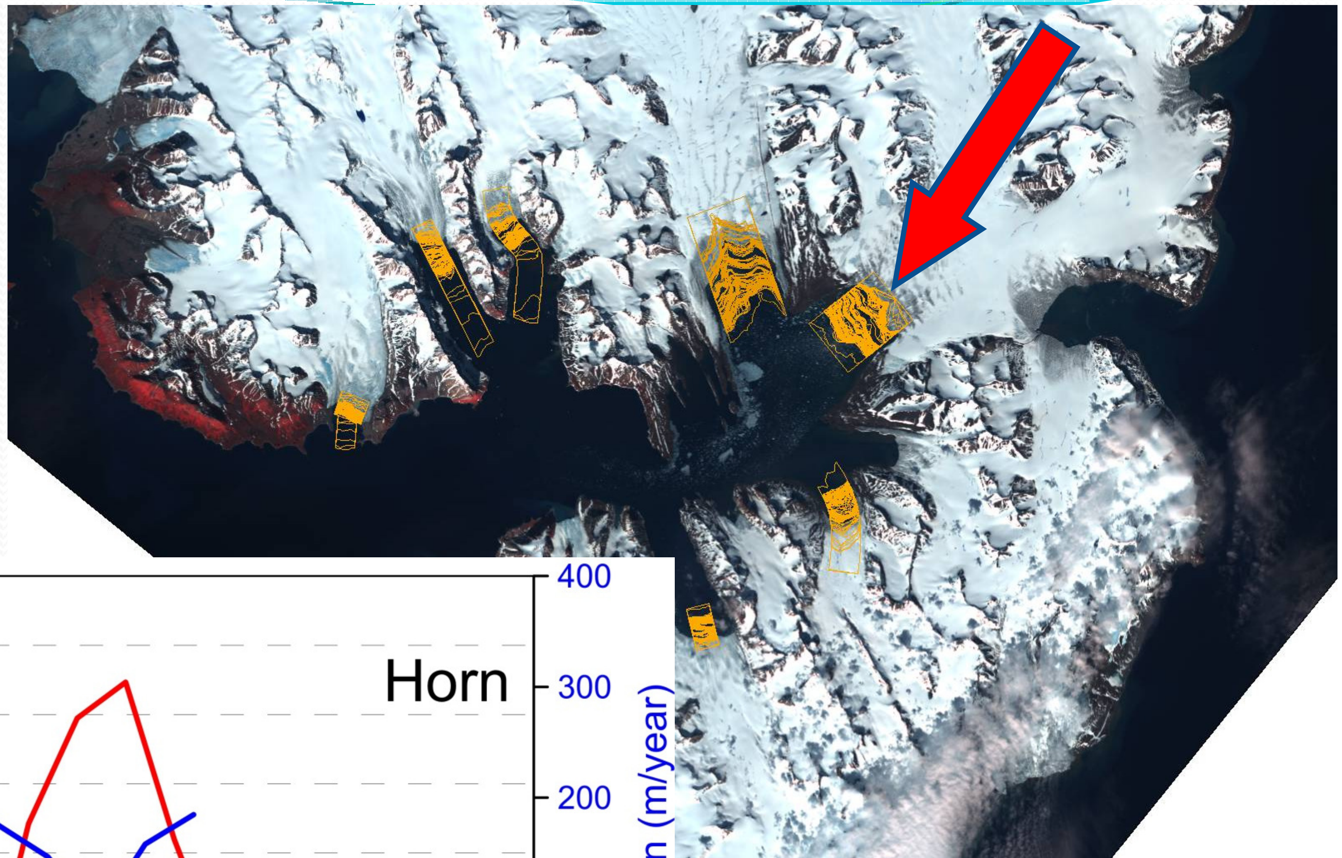

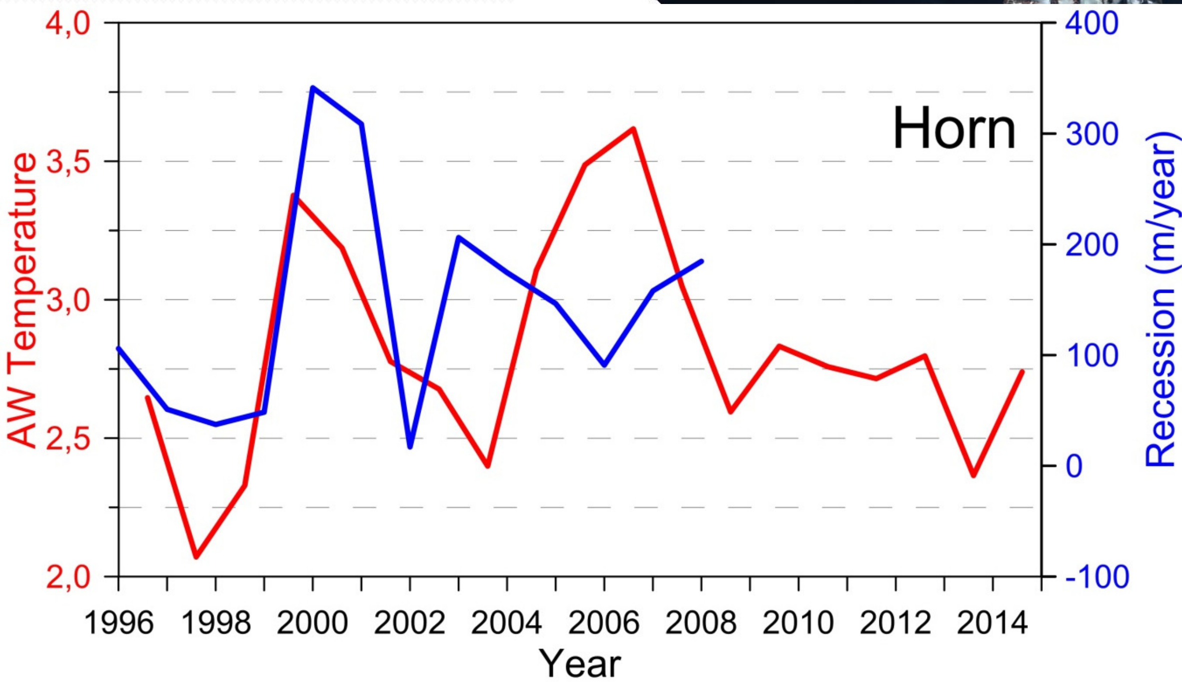


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