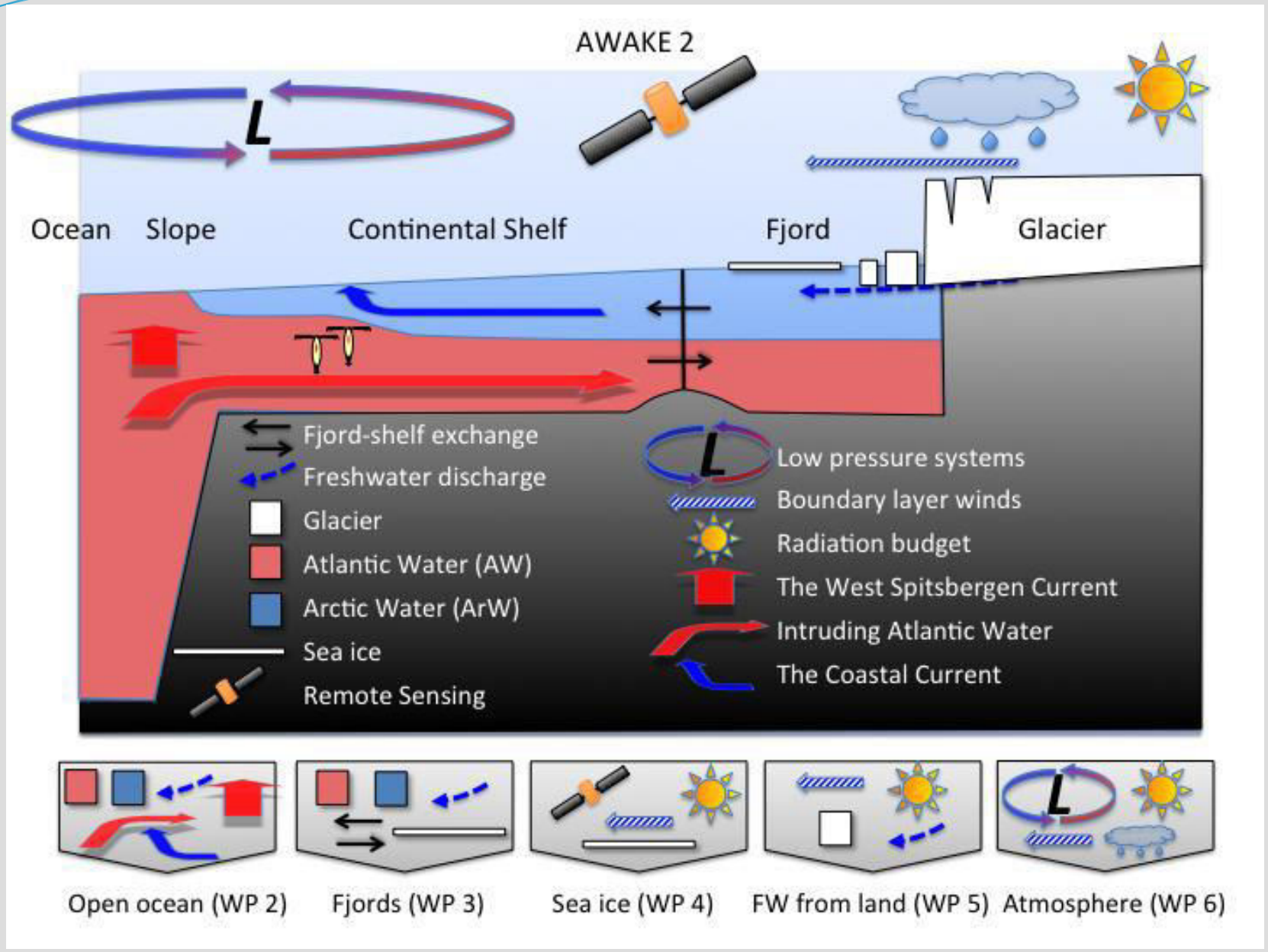
GAME
Growing of the Arctic Marine Ecosystem

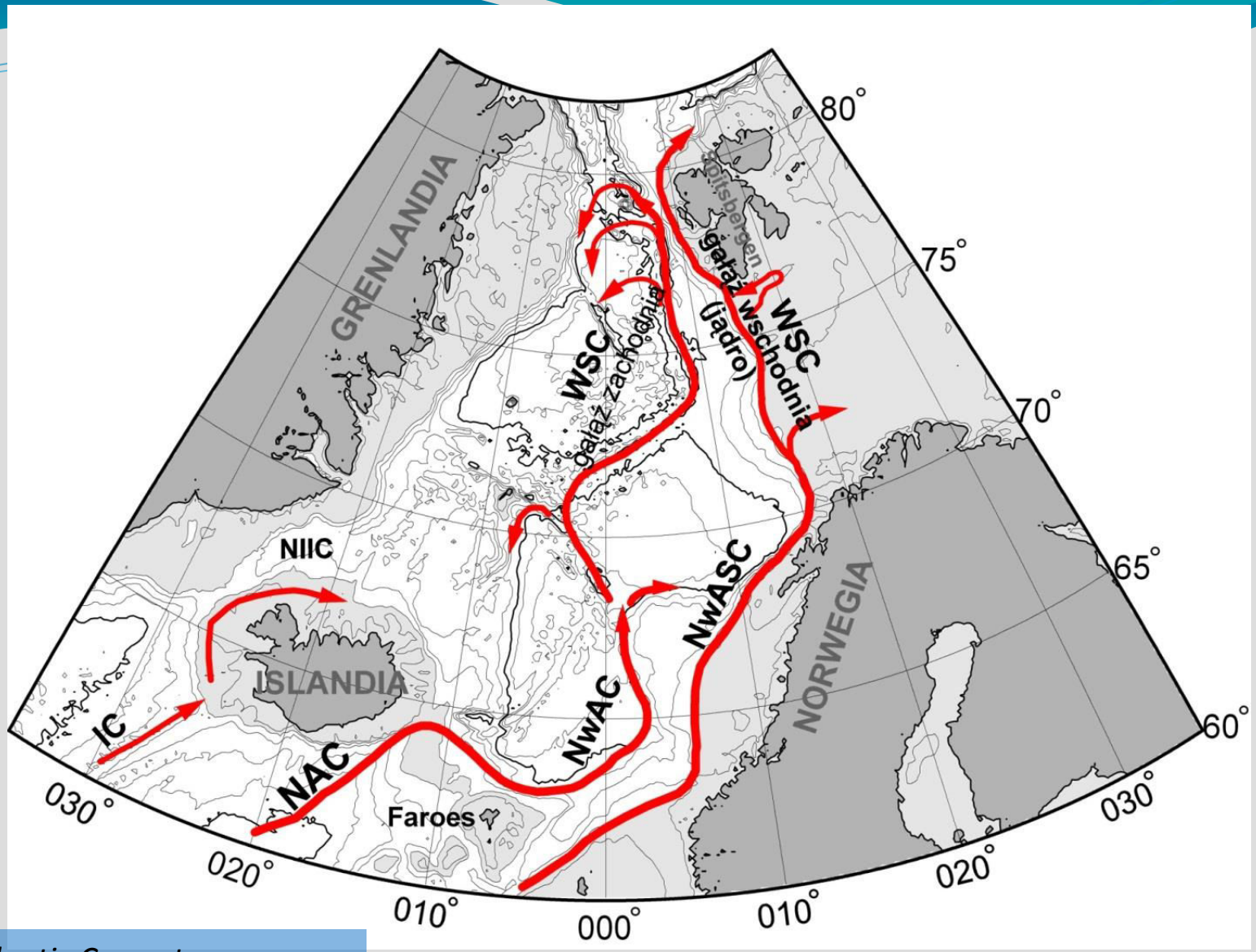
Sopot

25 April 2016

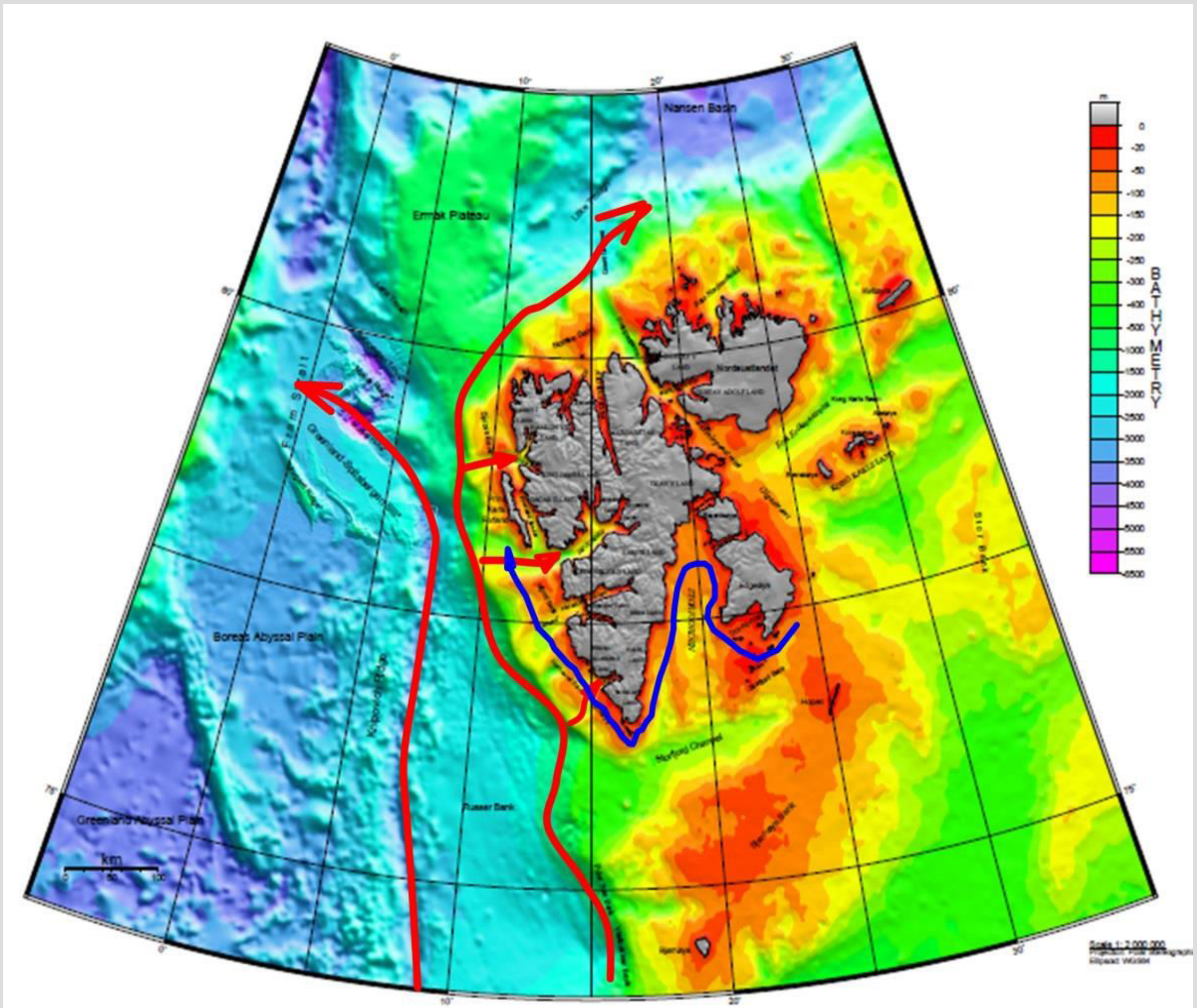
norway grants

External forcing of the western Spitsbergen fjords: Hornsund and Kongsfjorden


AWAKE 2
L
Ocean
Slope
Continental Shelf
Fjord
Glacier
Fjord-shelf exchange
Freshwater discharge
Glacier
Atlantic Water (AW)
Arctic Water (ArW)
Sea ice
Remote Sensing
L
Low pressure systems
Boundary layer winds
Radiation budget
The West Spitsbergen Current
Intruding Atlantic Water
The Coastal Current
L
Open ocean (WP 2)
Fjords (WP 3)
Sea ice (WP 4)
FW from land (WP 5)
Atmosphere (WP 6)



NAC North Atlantic Current
NwAC Norwegian-Atlantic Current
NwASC Norwegian Atlantic Slope Current
WSC West Spitsbergen Current
IC Irminger Current


Nansen Basin
Ermak Plateau
Boreas Abyssal Plain
Greenland Abyssal Plain
BATHYMETRY
km

- **External forcing of the western Spitsbergen fjords**
- **Ocean**
  - Large scale currents

    West Spitsbergen Current – complicated multibranch system of streams with the eastern border limited over the western Svalbard slope and shelf-break.

    heat and volume transport, ocean-atmosphere heat exchange, direct inflow of warm Atlantic water into the fjords;

  - Local currents

    Sørkapp Current (Sørkappstrømmen) - a local flow continuing northward over the western Svalbard shelf, as a continuation of the East Spitsbergen Current (ESC)

    Transport of fresher and colder Polar Water, transport of seaice, border between the warm WSC and fjords

Both currents systems are separated by the shallow-water

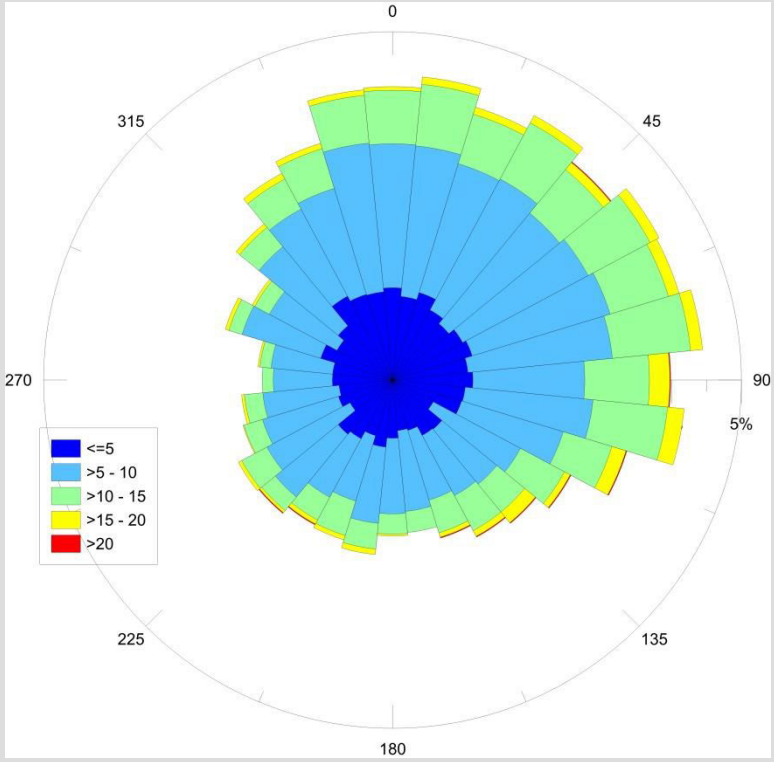
Atmospheric forcing

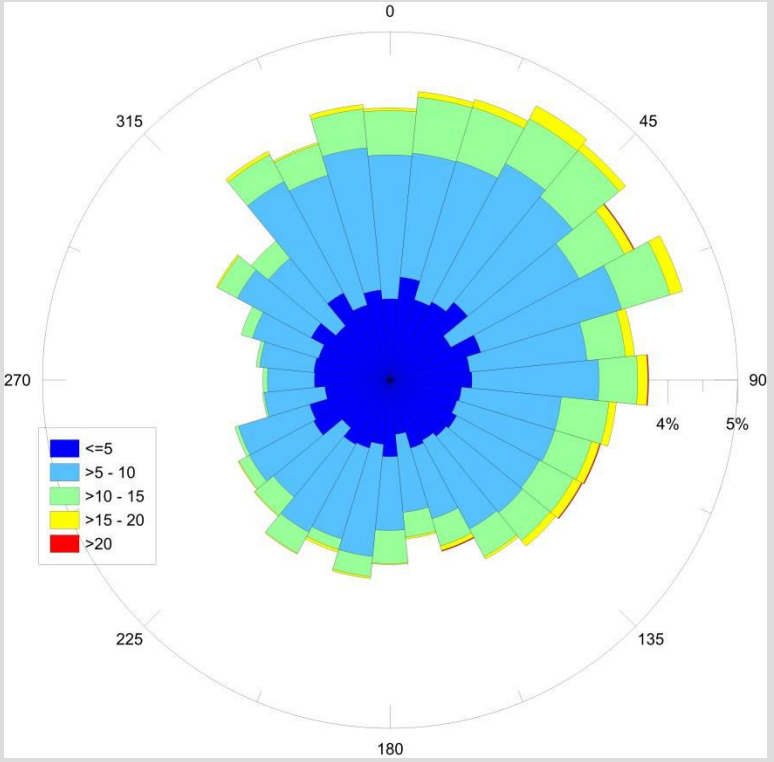
Large scale winds

- The large-scale oceanic circulation - Meridional Overturning Circulation (MOC) is forced both, by wind and thermohaline forces
- Ocean-Atmosphere fluxes

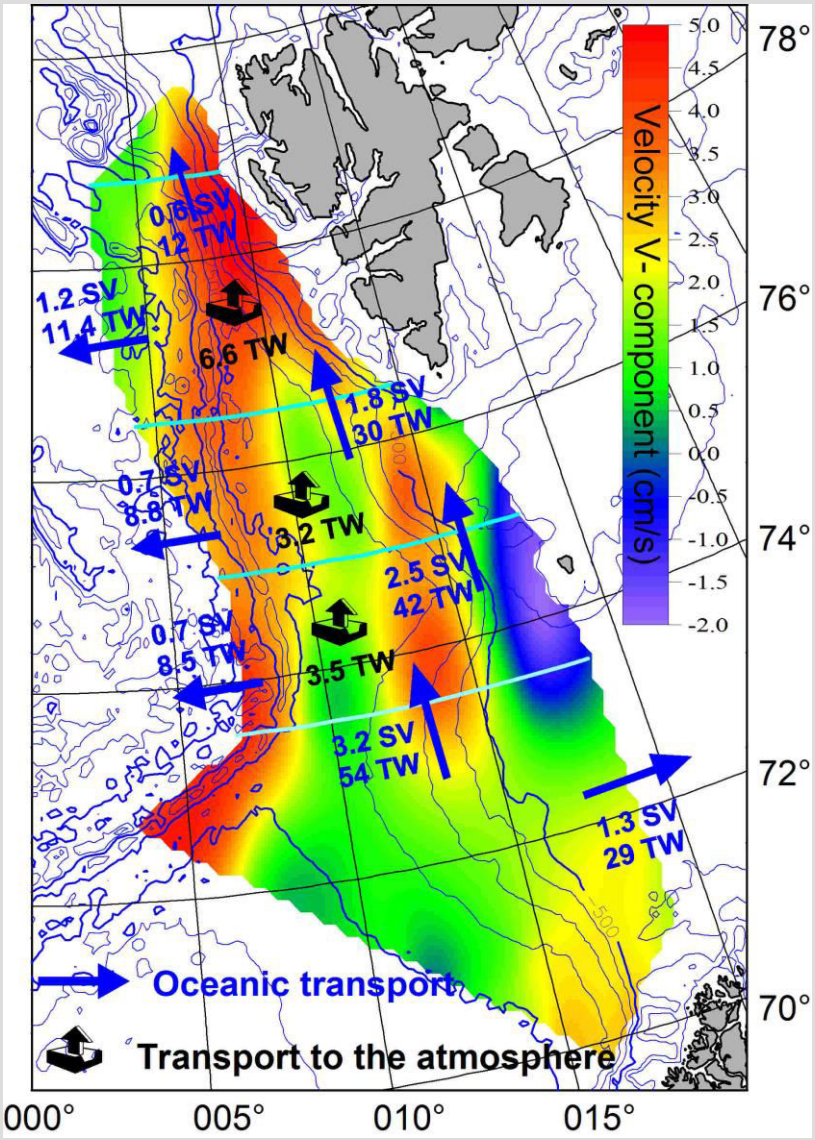
Local winds

NCEP/NCAR reanalysis.
Wind Rose for the region close to the Hornsund (77.5°N, 15° E) and Kongsfjorden (80°N, 15° E) for 1995-2015 period.
Daily data, angles in rhumbs (11.25°)





AW heat divergence

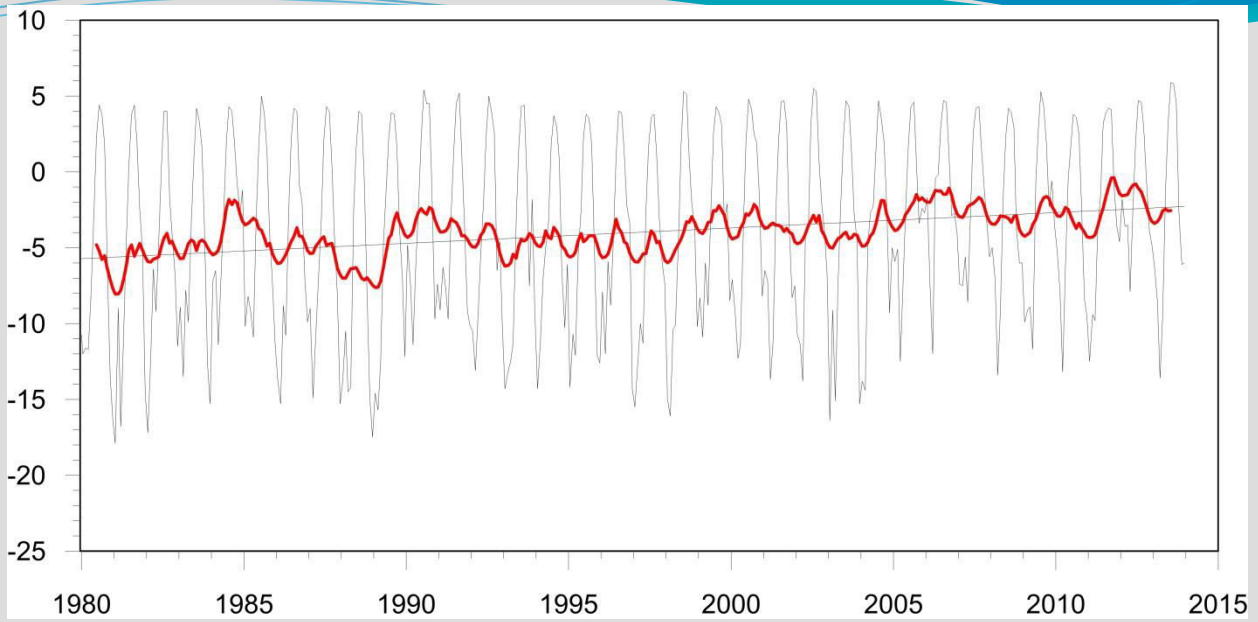


The oceanic heat transported with AW by the northward baroclinic currents across the 73°30' parallel diverges:

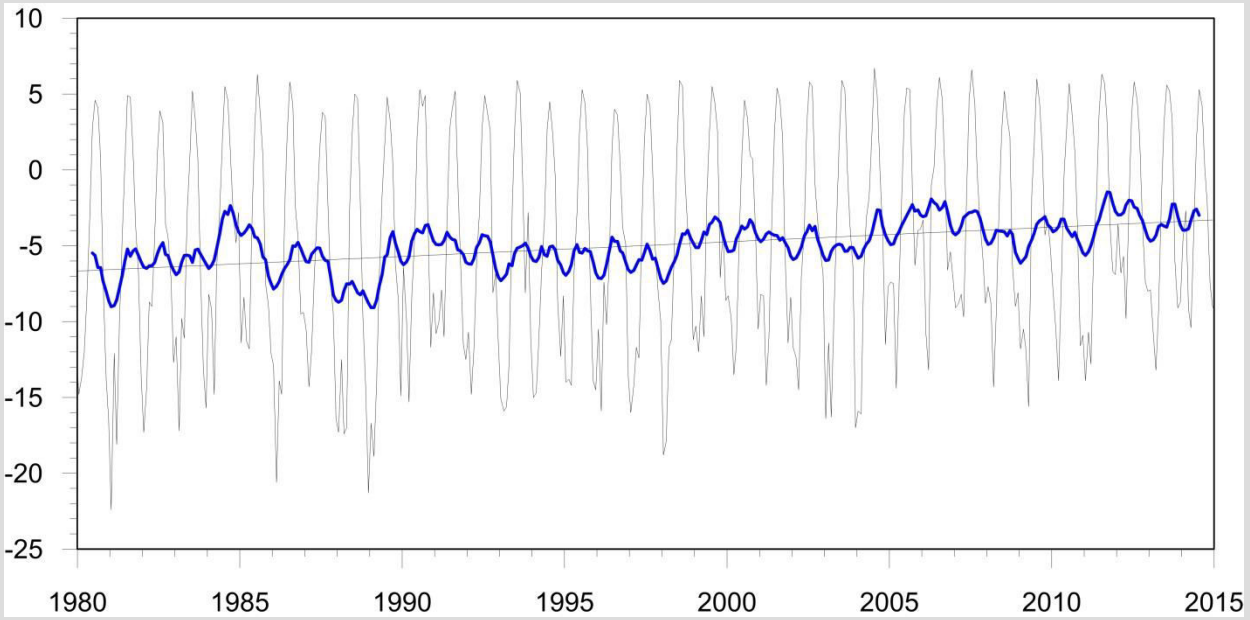
- 22% of heat flows the Arctic Ocean through the Fram Strait;
- 53% goes westward to the western Greenland Sea
- <u>25% of heat is transferred to the atmosphere.</u>

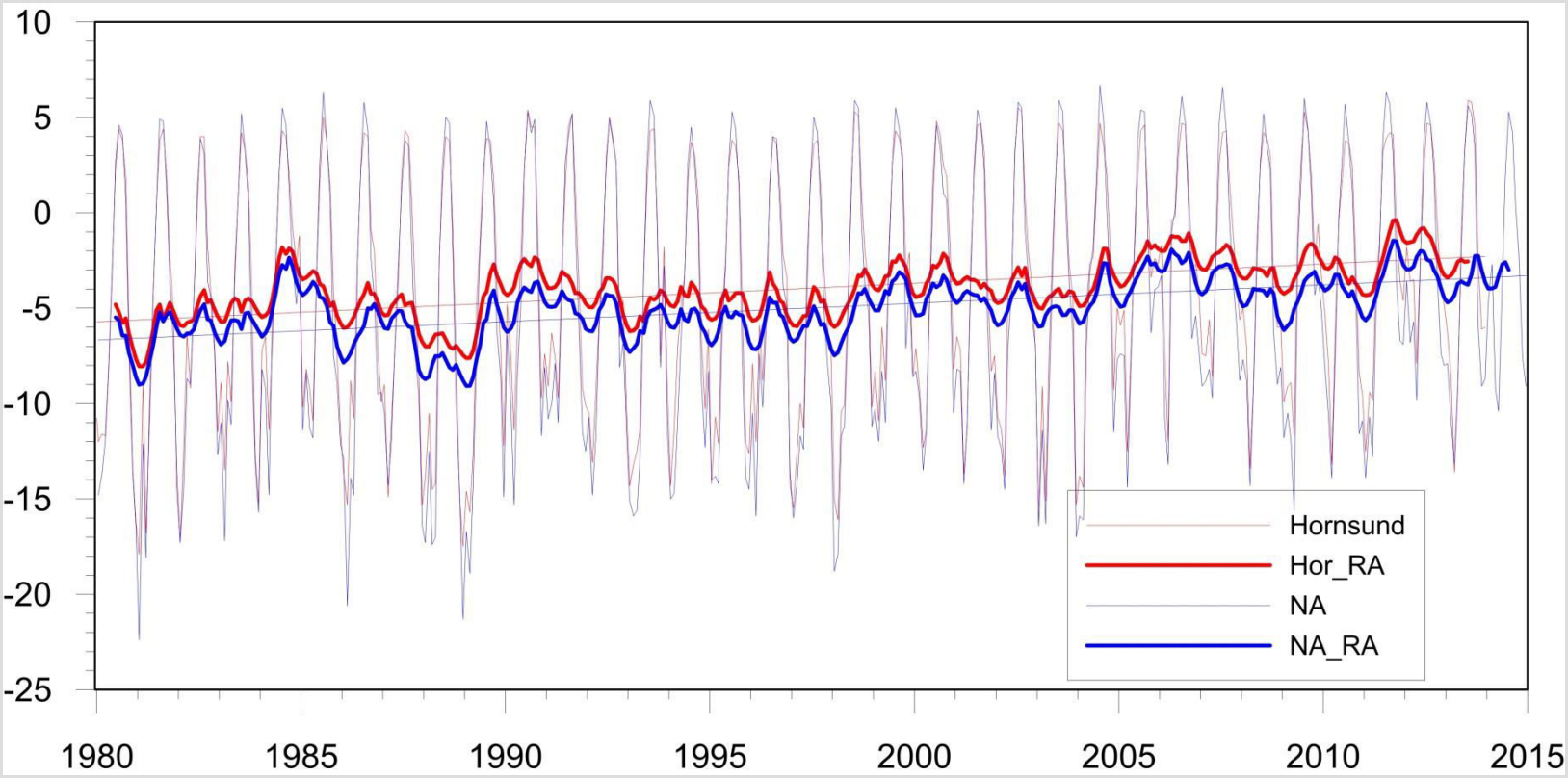
It creates 90 W·m-2 of yearly mean heat flux between ocean and atmosphere

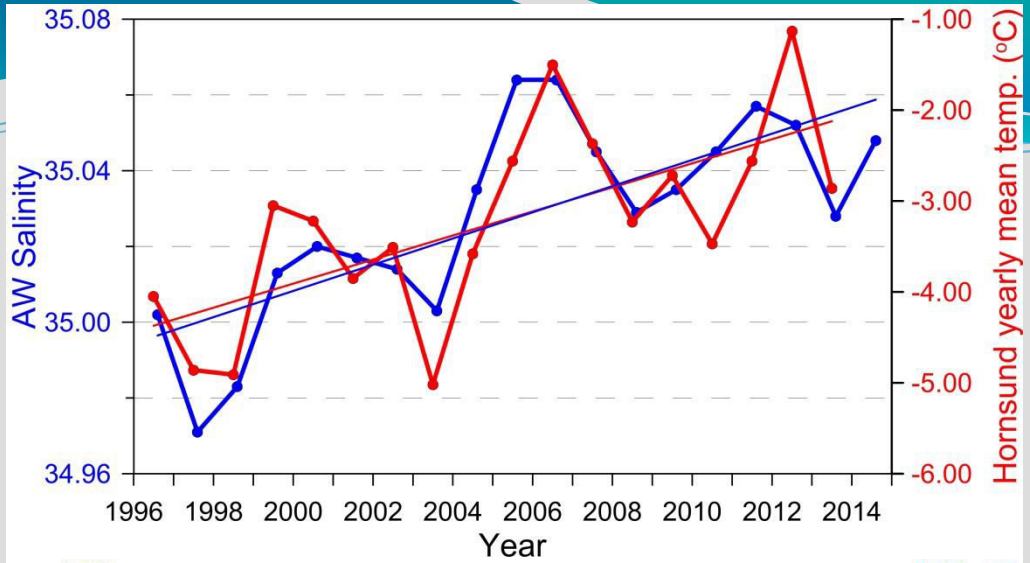
Hornsund

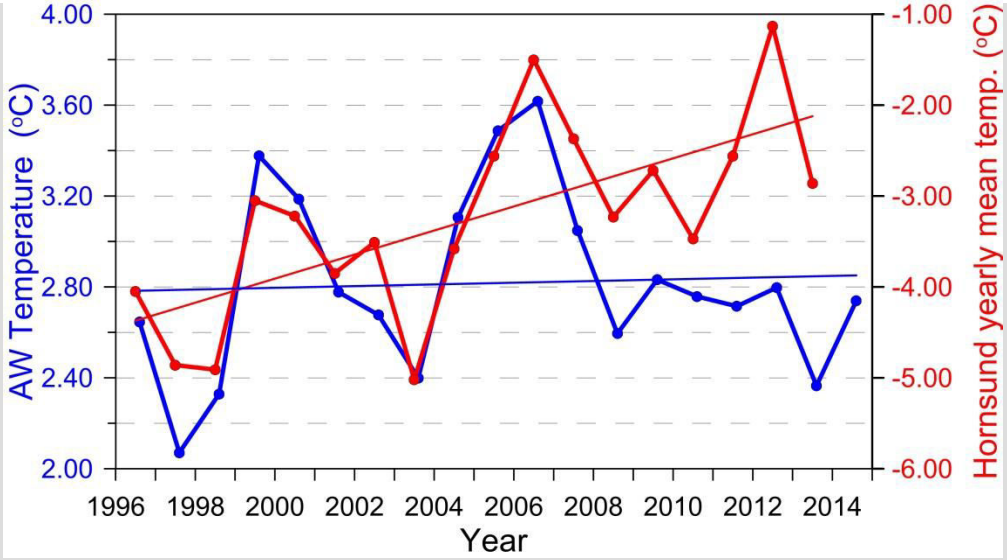


Kongsfjorden



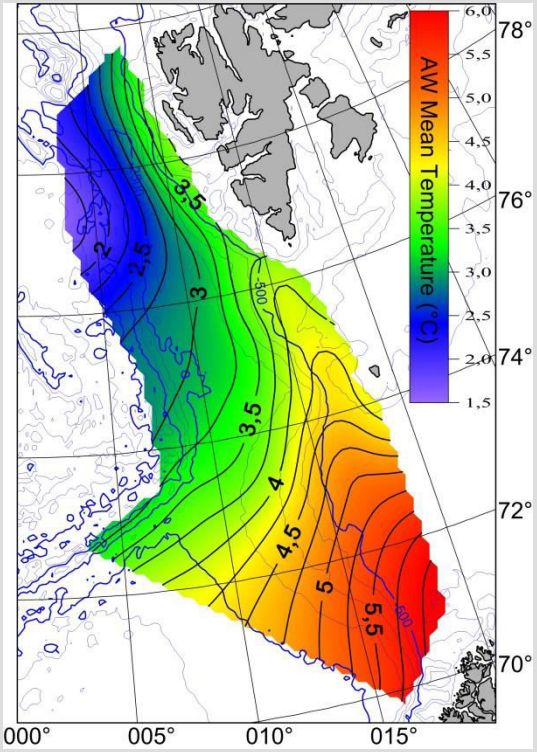

10
5
0
-5
-10
-15
-20
-25
1980
1985
1990
1995
2000
2005
2010
2015
Hornsund
Hor_RA
NA
NA_RA

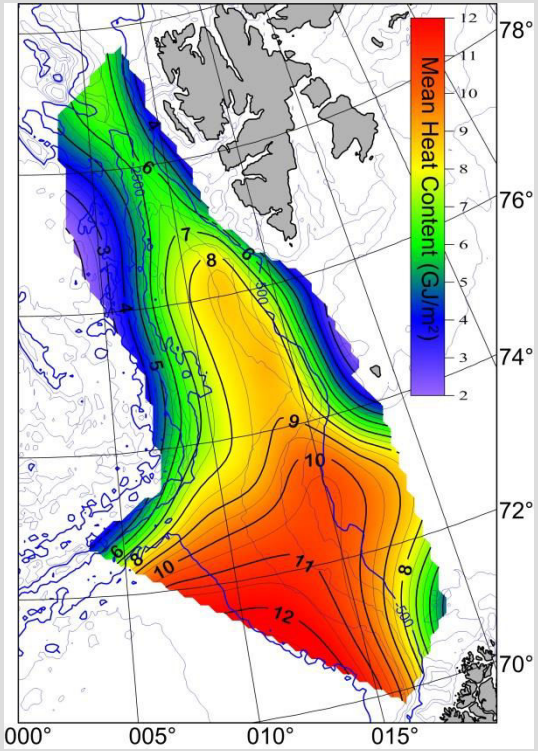


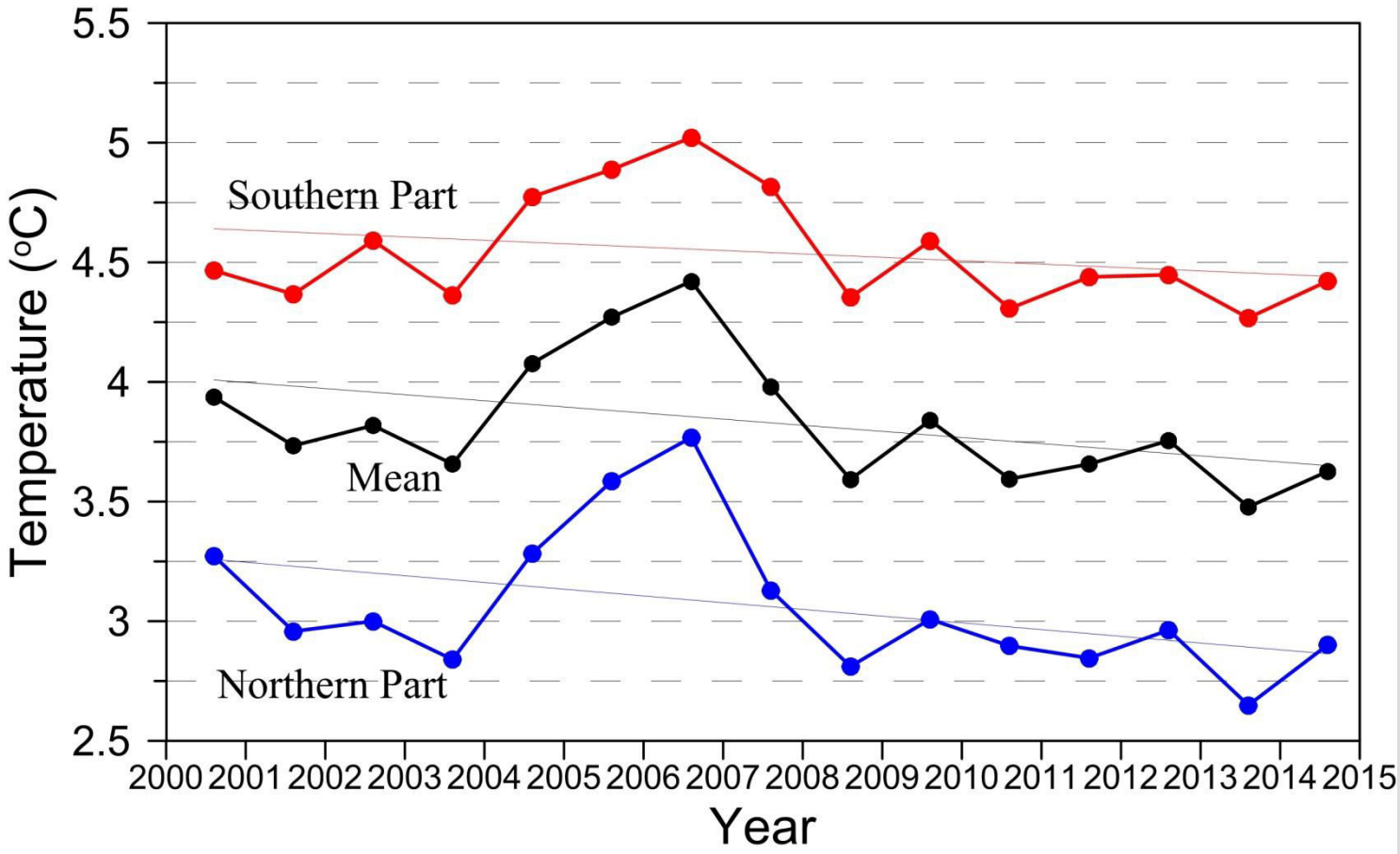


Zasolenie (a) i temperatura (b) AW (linia niebieska) na przekroju ‘N’ razem z średnią roczną temperaturą powietrza w Hornsundzie.

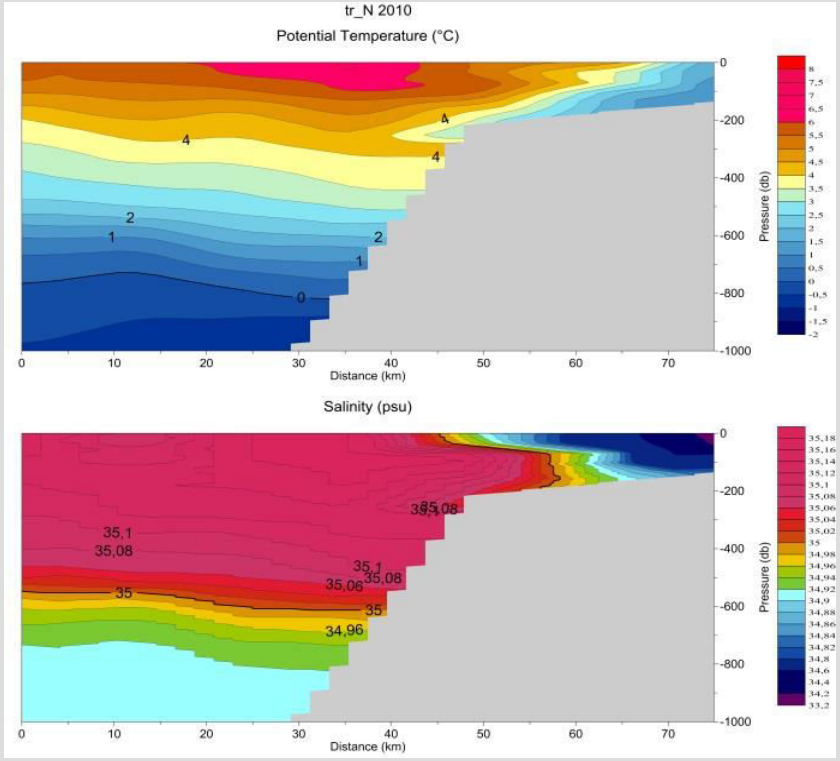
AW (a) mean temperature and (b) heat content for summers 2000-2014.

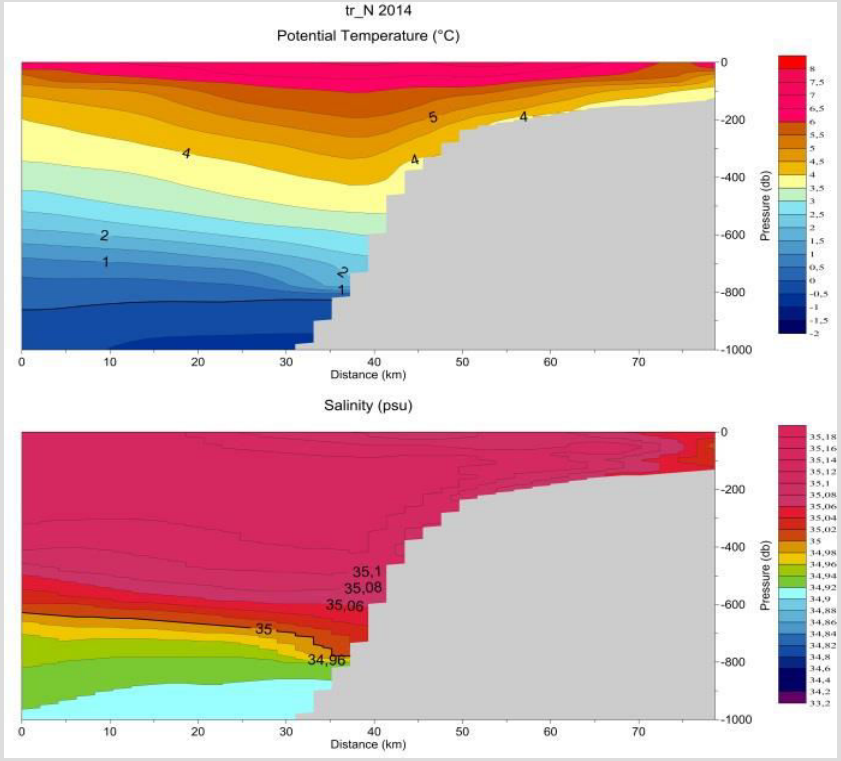




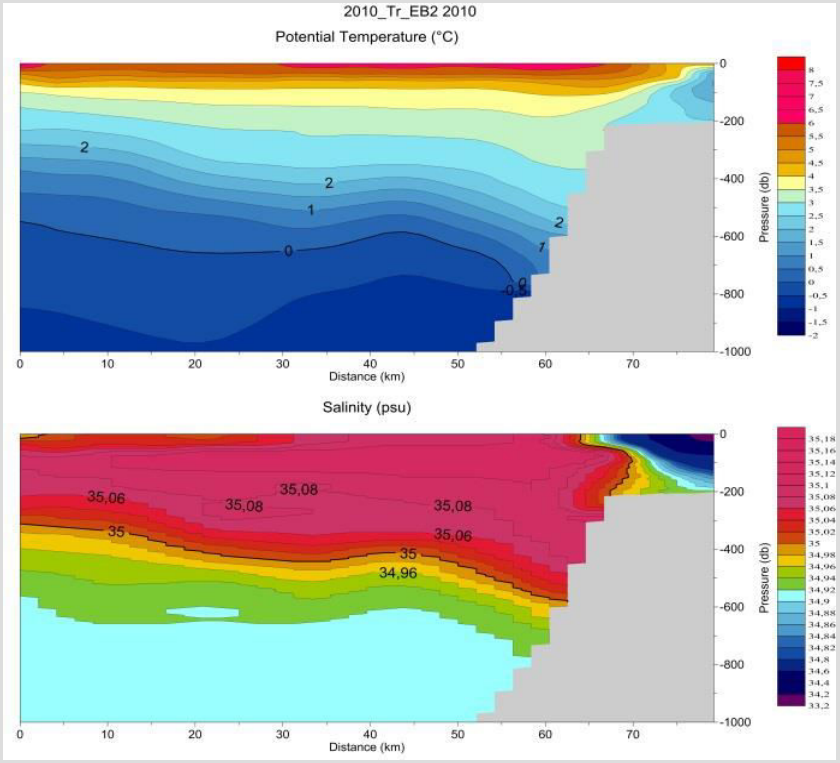

Temperature (°C)
5.5
5
4.5
4
3.5
3
2.5
Southern Part
Mean
Northern Part
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

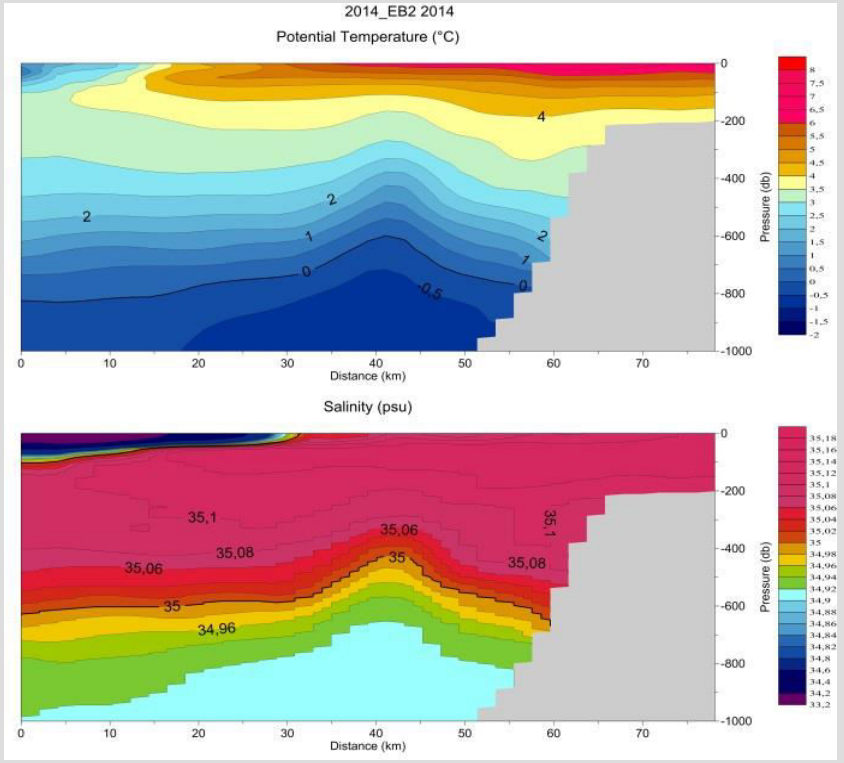
Temperature and salinity of WSC core and shelf waters at section ‘N’ along the 76 30’N in summers (a) 2010 and (b) 2014



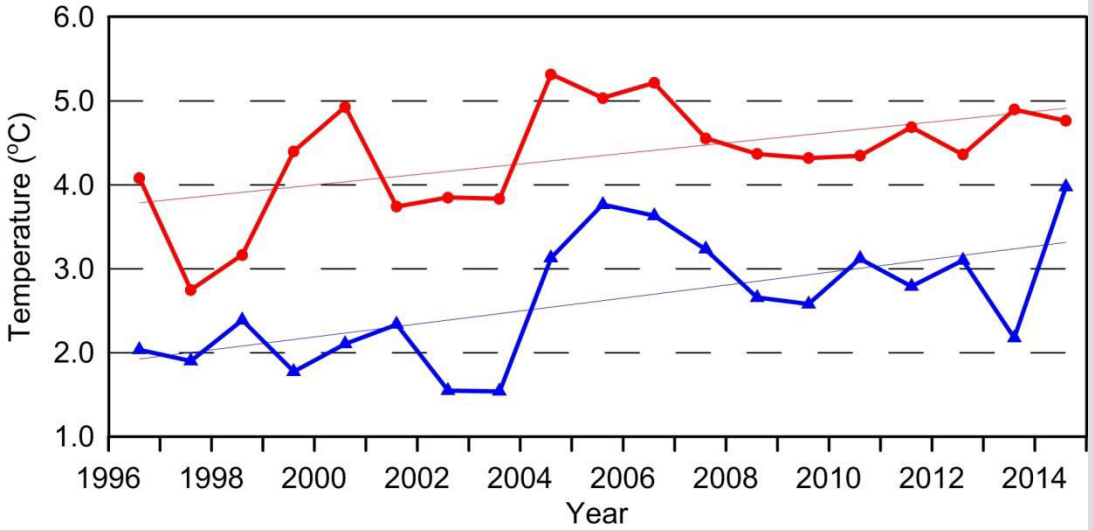


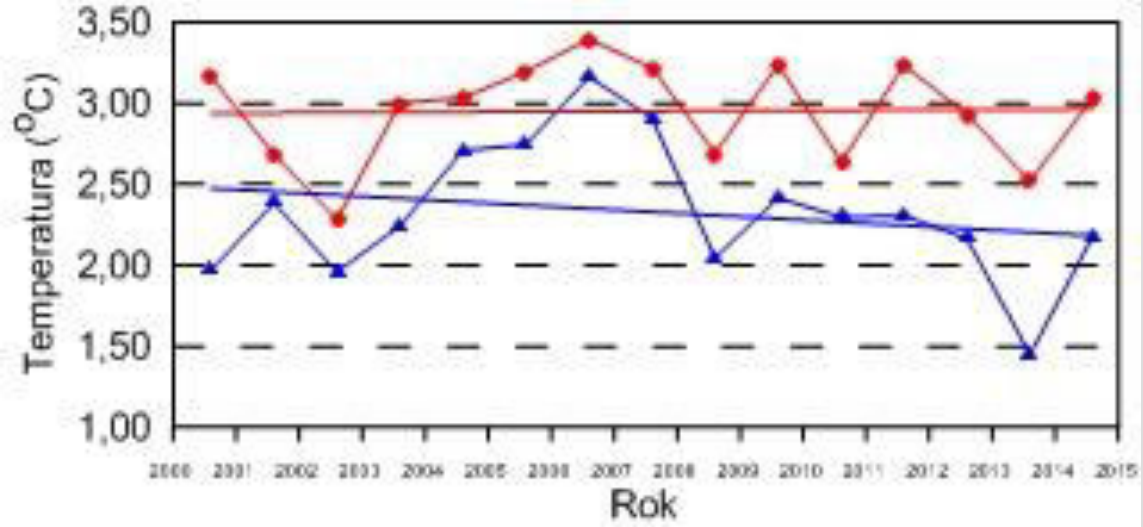
Temperature and salinity of WSC core and shelf waters at section ‘EB2’ along the 79° N parallel in summers (a) 2010 and (b) 2014

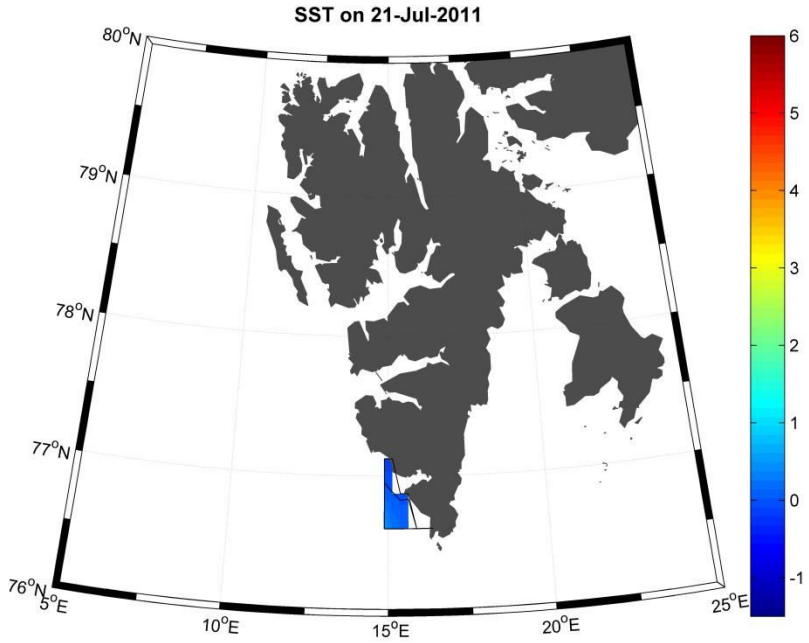


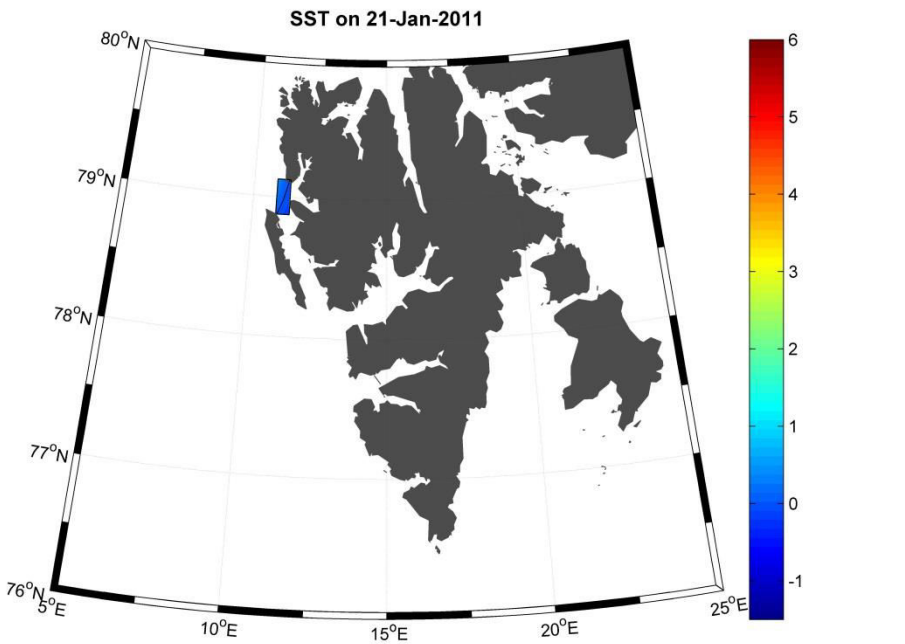


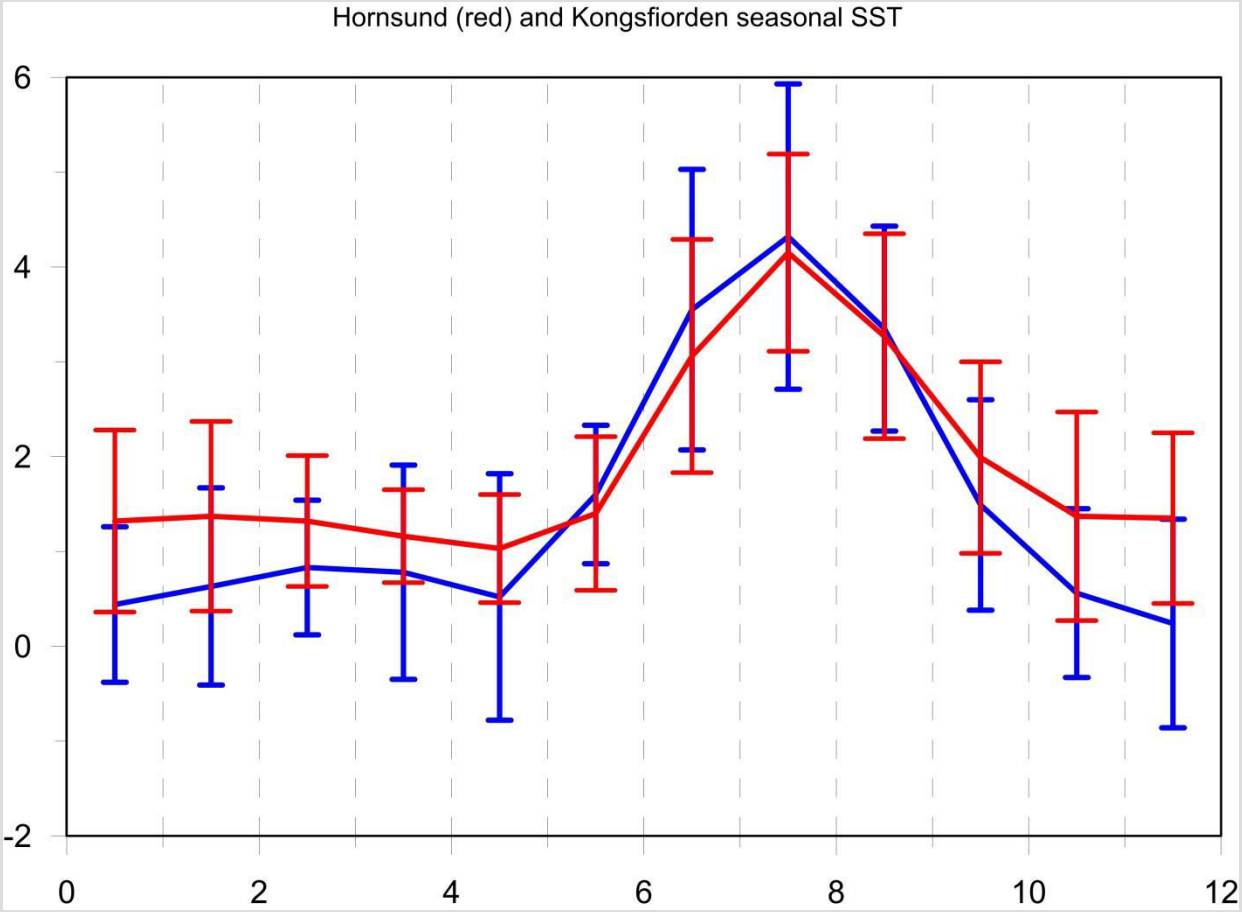
AW te,mperature at section N and EB2

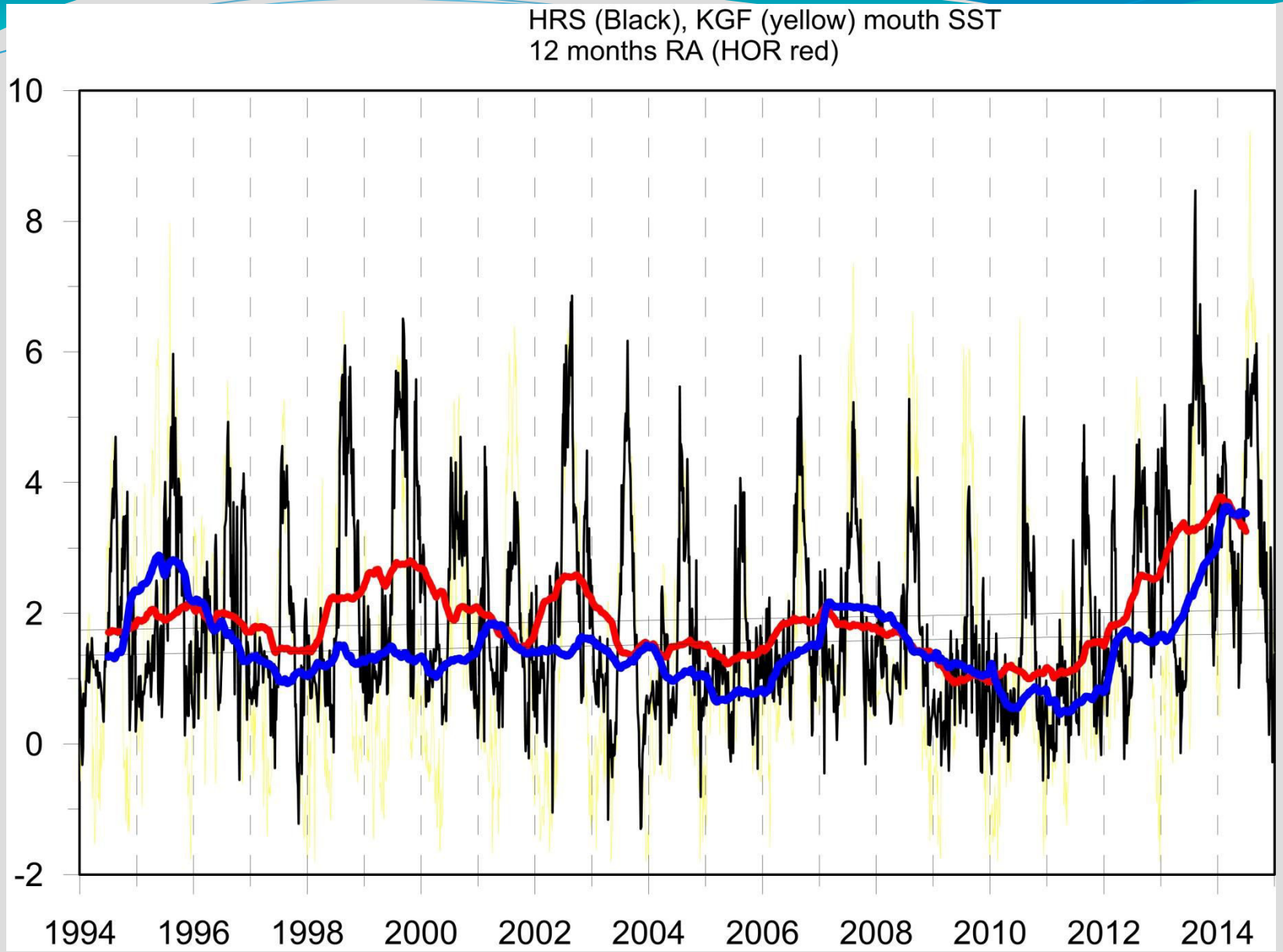


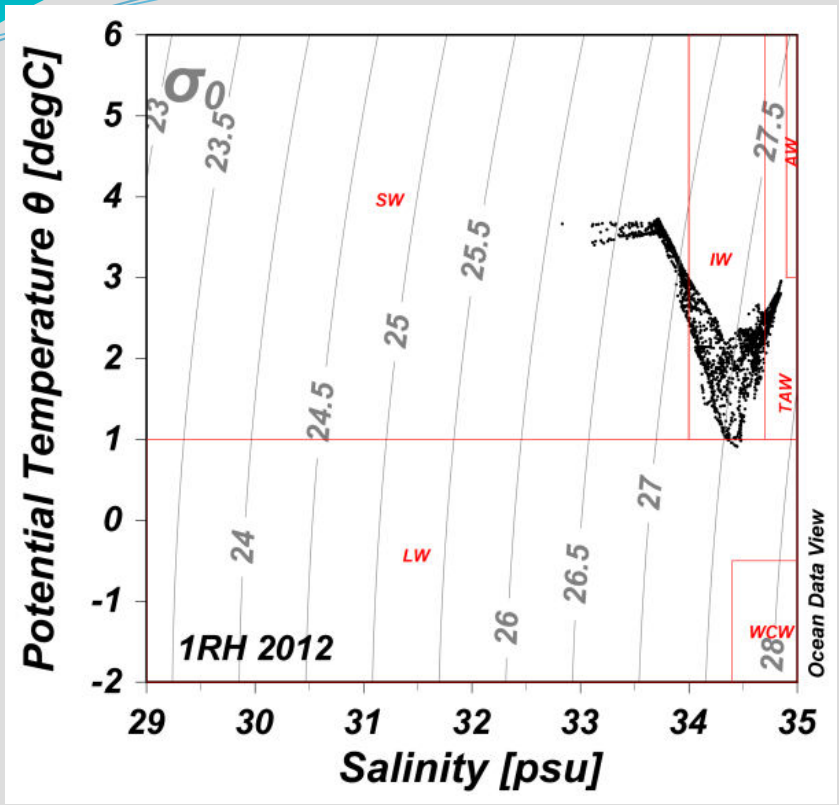


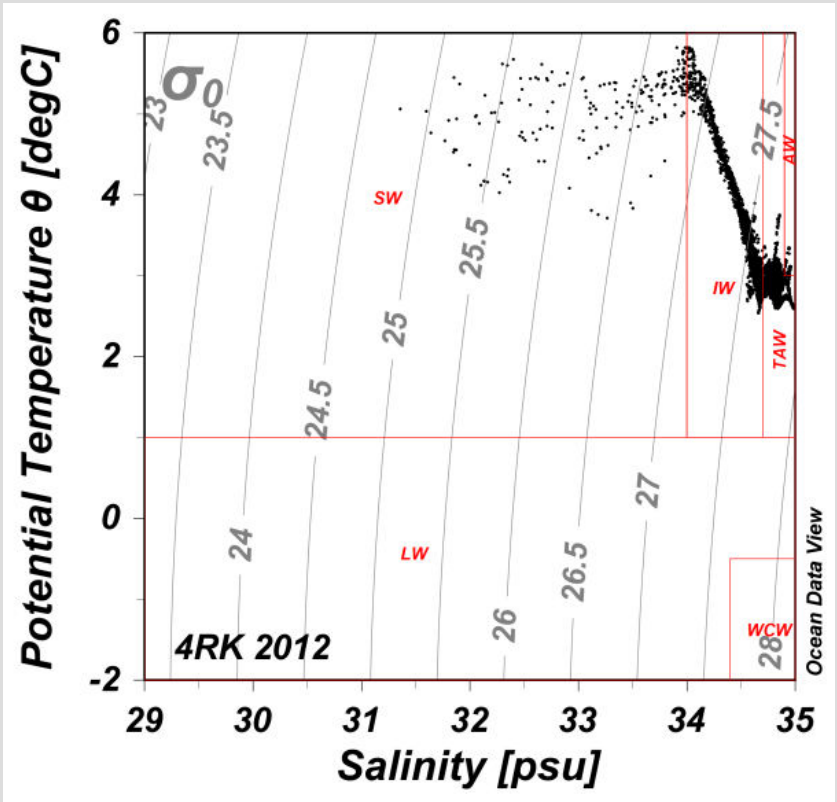

SST on 21-Jul-2011
80°N
79°N
78°N
77°N
76°N
5°E
10°E
15°E
20°E
25°E
6
5
4
3
2
1
0
-1


SST on 21-Jan-2011
80°N
79°N
78°N
77°N
76°N
5°E
10°E
15°E
20°E
25°E
6
5
4
3
2
1
0
-1


Hornsund (red) and Kongsfiorden seasonal SST
6
4
2
0
-2
0
2
4
6
8
10
12

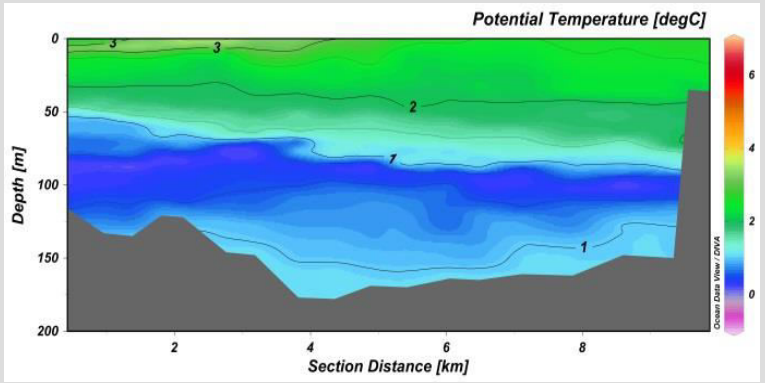

HRS (Black), KGF (yellow) mouth SST
12 months RA (HOR red)
10
8
6
4
2
0
-2
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

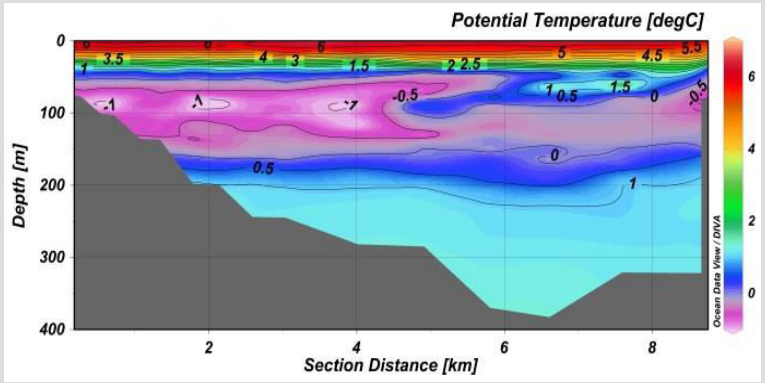


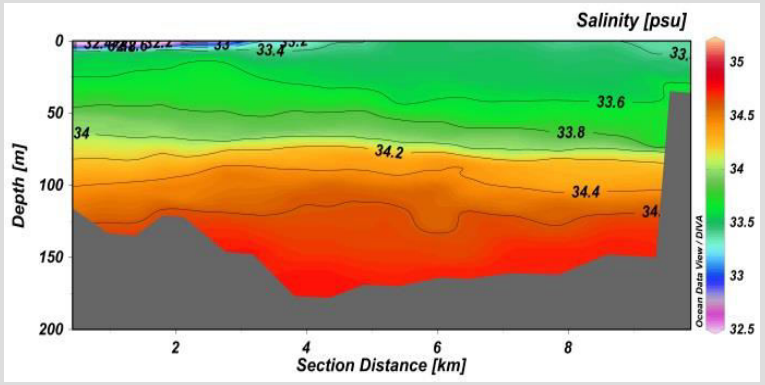


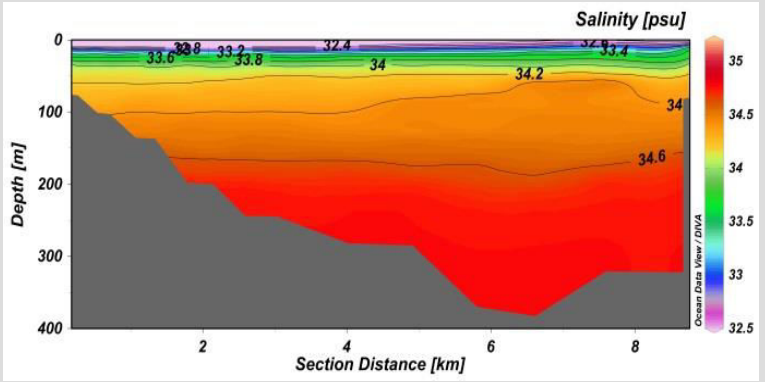
TS diagrams for the sections cross the mouths of (a) Hornsund, (b) Kongsfjorden. Summer 2012

Temperature and salinity at entrances to (a) Hornsund and (b) Kongsfjorden in 2010.

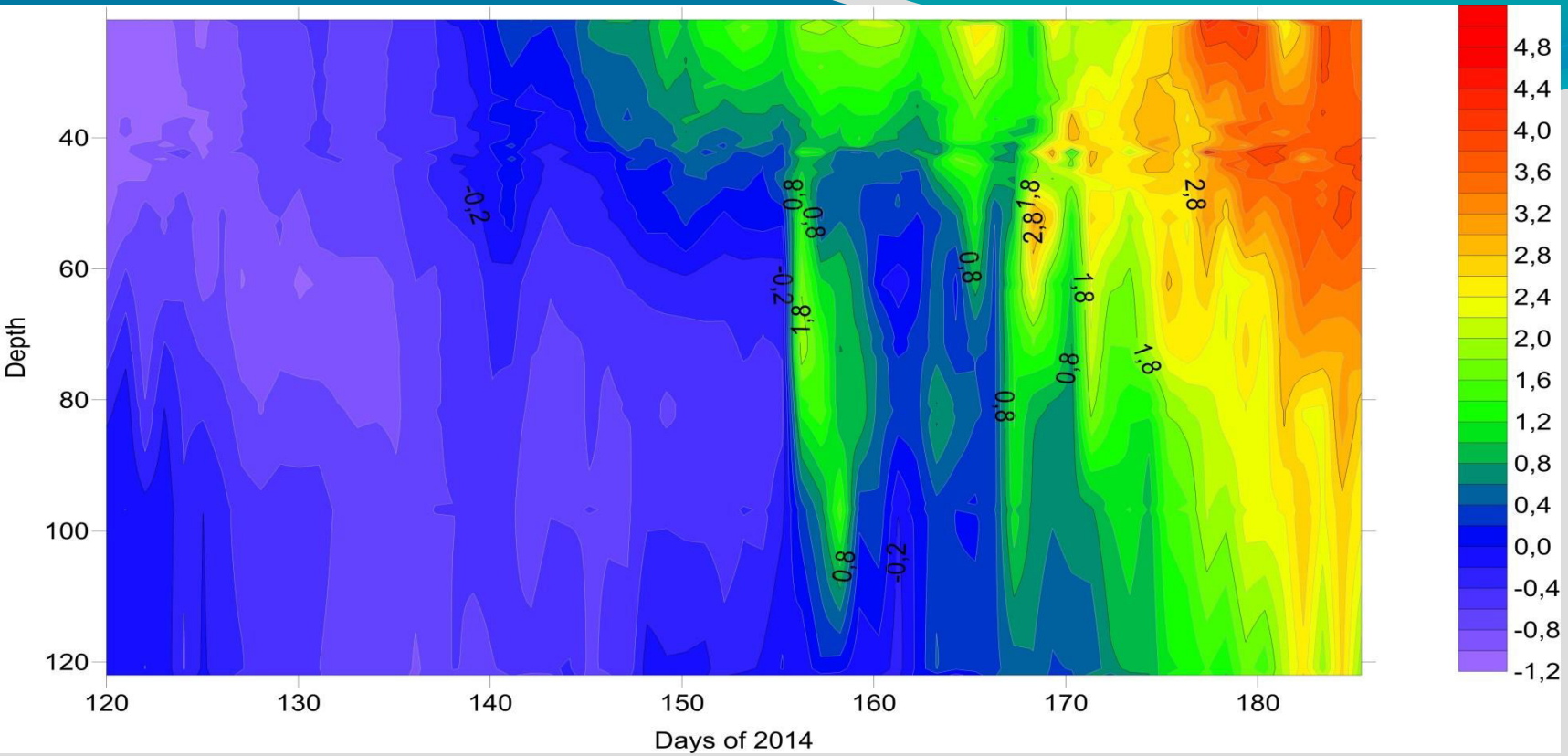




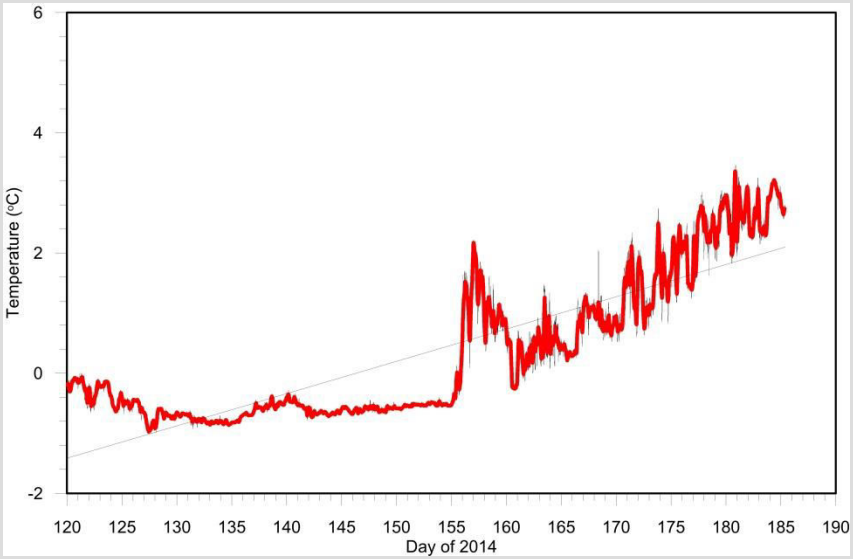




Time series of water properties in Hornsund (blue line) and Kongsfjorden (red line).

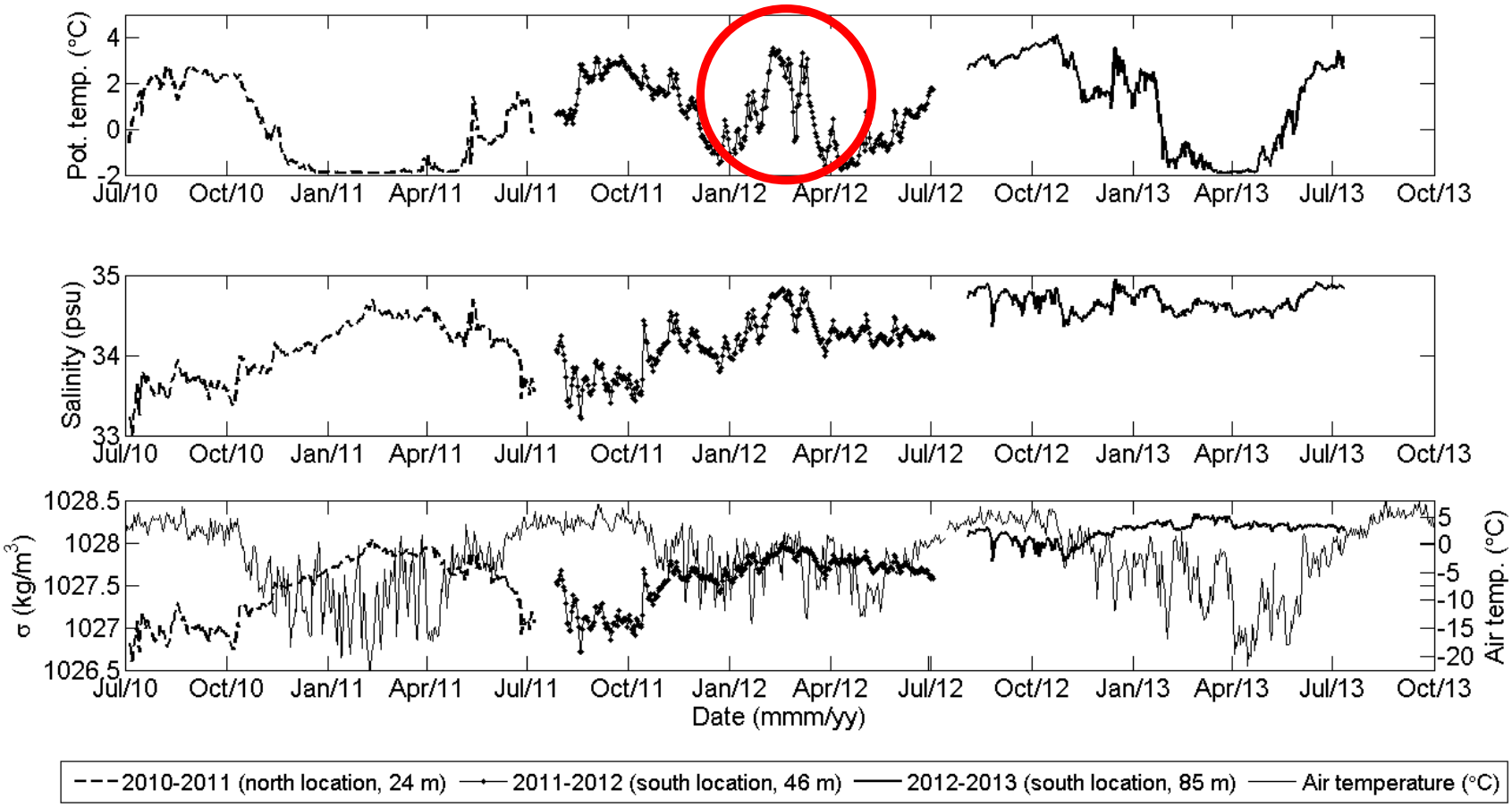


Temperature April-July 2014

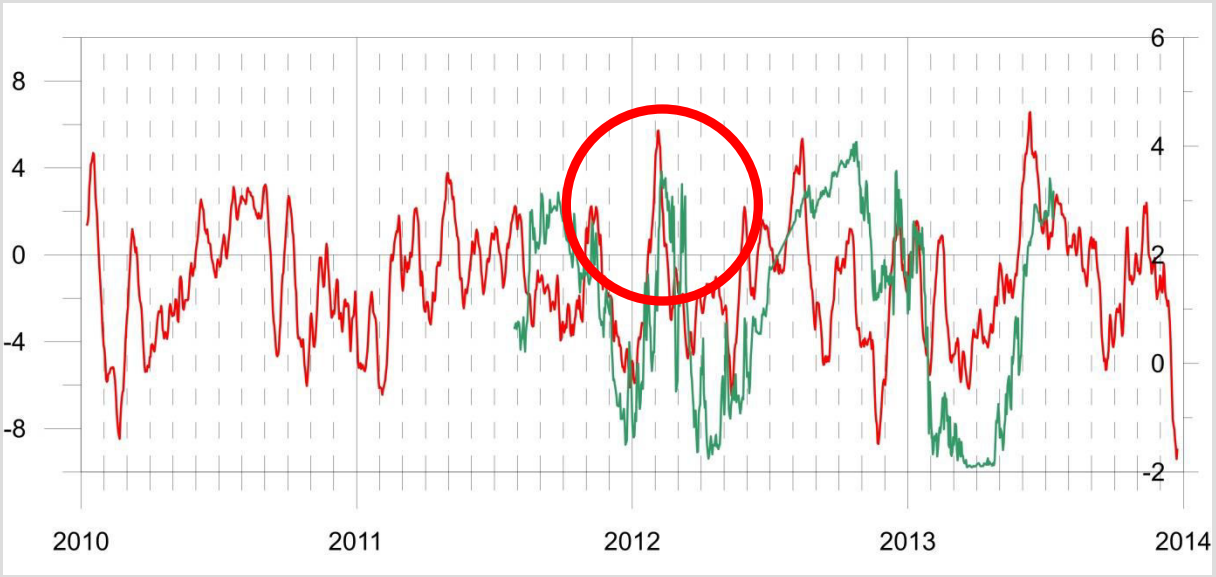


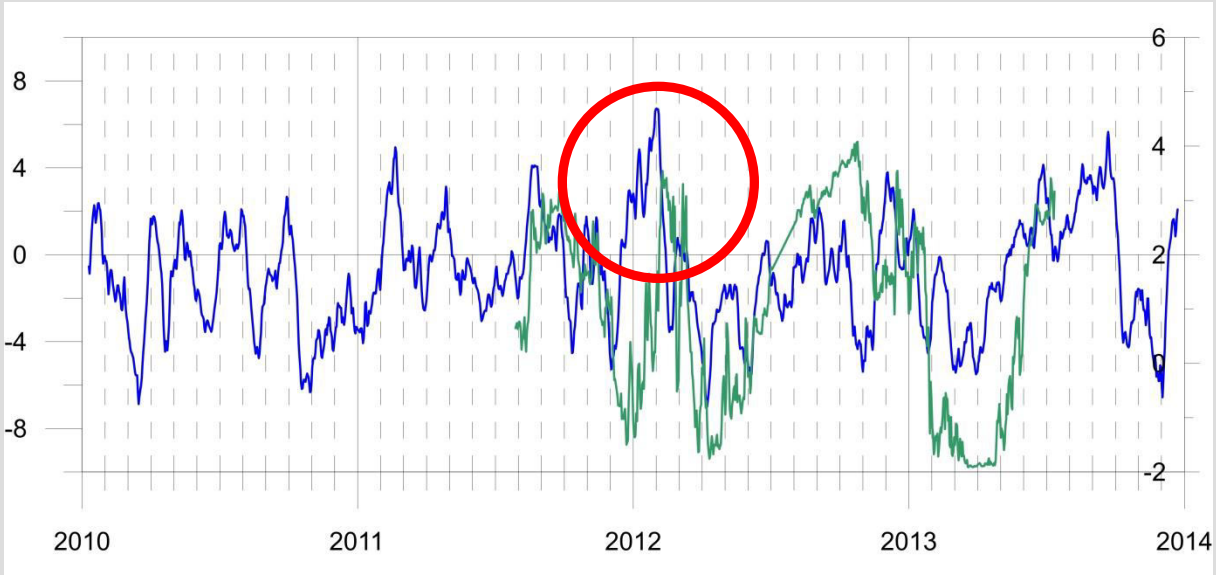
Pulse of warm water at 80 m in May 2014

Temperature, salinity and density of water in Hornsuind mouths

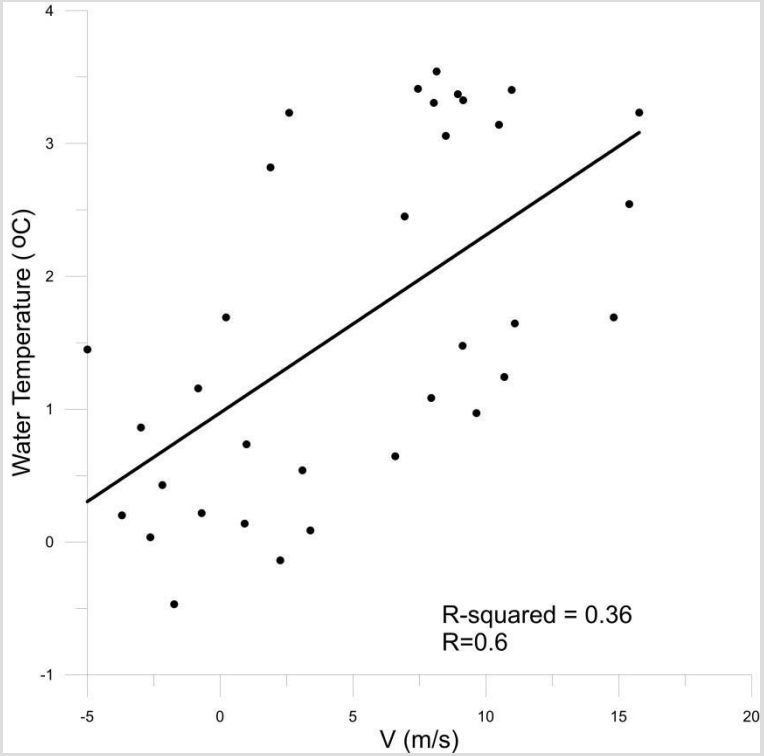


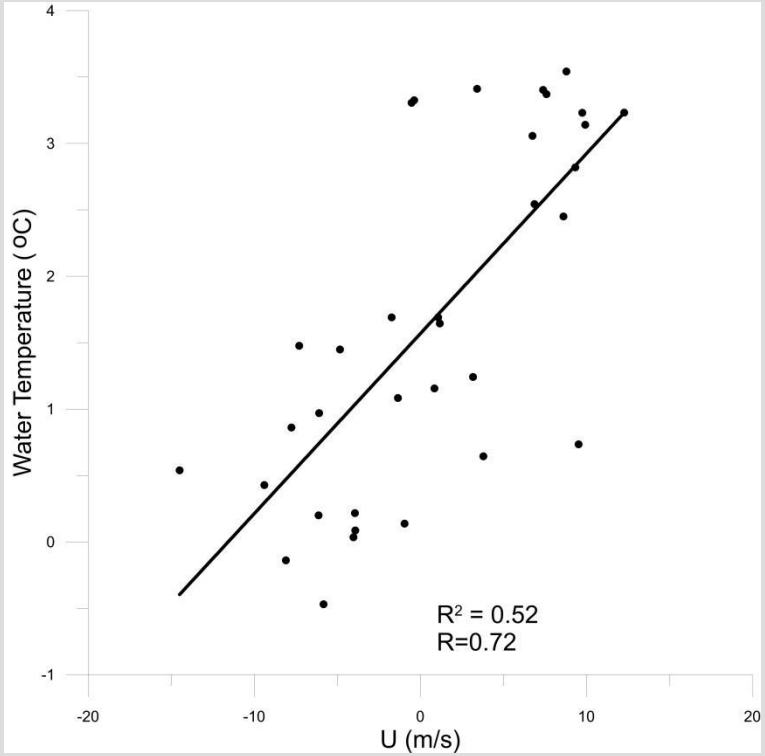
Water temperature (green) and wind (U and V component)





Regression between water temperature and wind V component (left) and U component





Hornsund exchanges

Year	Vol mSv	Vol+ mSv	Vol- mSv	Temp °C	Sal	Heat MW	Heat+ MW	Heat- MW	AW_Vol mSv	AW_heat MW
2001	3.3	18.2	-14.9	2.55	33.93	44	212	-169	-0.1	-1
2002	5.5	21.4	-15.8	3.31	34.43	76	356	-280	0.3	4
2003	-33.8	2.6	-36.4	2.32	34.39	-403	26	-430	-0.1	-1
2010	47.5	64.7	-17.2	1.37	34.08	457	547	-90	0	0
2011	-0.6	21	-21.6	0.83	33.76	-9	58	-67	0	0
2012	-26.3	8.6	-34.8	2.64	34.32	-359	85	-444	0.1	1
2013	-14	12.4	-26.4	3.44	34.56	-261	226	-487	-4.4	-51
2014	20.1	27.7	-7.5	3.78	34.84	345	481	-137	16.2	265
2015	-26.1	11.5	-37.6	2.68	34.15	-285	151	-436	0.4	5
Mean	**-2.7**	**20.9**	**-23.6**	**2.55**	**34.27**	**-43.9**	**238**	**-282**	**1.4**	**24.7**
SD	25.8	18.1	10.8	0.96	0.33	308	186	169	5.7	91.8

Kongsfjorden exchanges

Year	Vol mSv	Vol+ mSv	Vol- mSv	Temp °C	Sal	Heat MW	Heat+ MW	Heat- MW	AW_Vol mSv	AW_heat MW
2002	-10.1	21.7	-31.8	3.05	34.74	-192	310	-501	-2.3	-12
2003	36.5	48.8	-12.3	2.32	34.43	320	586	-266	0	0
2004	-18	31.5	-49.4	2.17	34.26	-335	410	-745	-3.3	-40
2007	10.7	32.8	-22.1	2.85	34.81	133	452	-319	13.6	173
2008	-75.2	56	-131.2	2.79	34.55	-1005	840	-1845	0	0
2009	17.6	27	-9.3	3.08	34.6	361	519	-159	5.4	69
2010	-16.8	26.1	-42.8	1.12	34.35	-262	120	-382	0	0
2012	14.9	30.7	-15.8	3.09	34.73	189	439	-250	7.2	86
2013	57.2	66	-8.8	3.07	34.7	949	1051	-102	25.1	370
2014	-20.3	10.7	-31	4.34	35.02	-349	248	-597	-18.8	-296
2015	37.7	47.8	-10.1	3.68	34.53	604	806	-202	10.9	161
Mean	**3.1**	**36.3**	**-33.1**	**2.86**	**34.61**	**37**	**525**	**-488**	**3.4**	**46**
SD	36.5	16.4	35.4	0.8	0.22	537	277	490	11.2	164

Driving forces

Large scale driving forces

- Atmospheric circulation
- Oceanic currents (WSC)

Local driving forces

- Local winds;
- Local currents (Soerkapp Current);
- Upwelling and other shelf-basin exchanges processes;
- Drifting seaice;

- Statistics of large scale winds for oceanic region west of Hornsund and Kongsfjorden are similar to each other.
- Variability of the WSC in both regions is similar, in Kongsfjorden region AW is colder;
- SST variability in both regions is similar ;

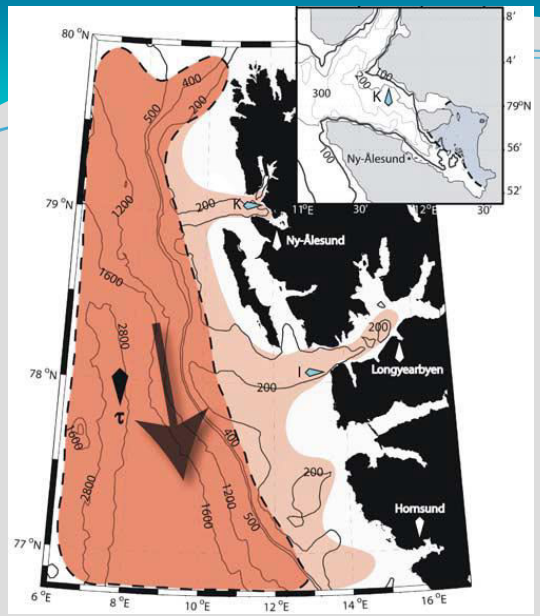
- **Both fjords undergoes the same oceanic and atmospheric large-scale forcing**

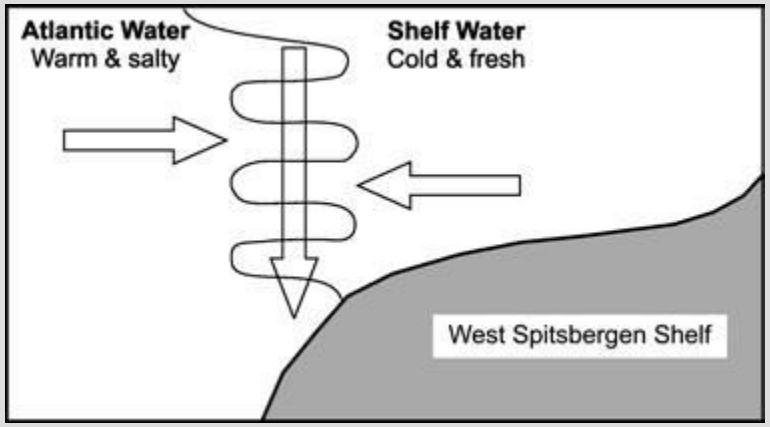
- There is not direct dependence between AW temperature and fjords temperature

- Fjords conditions in cold season may be strongly modified by inflow of AW into the fjord
- During warm season conditions are shaped by AW and glaciers activity

- Kongsfjorden is more accessible for the AW inflow – deeper entrance, weaker Sørkapp Current

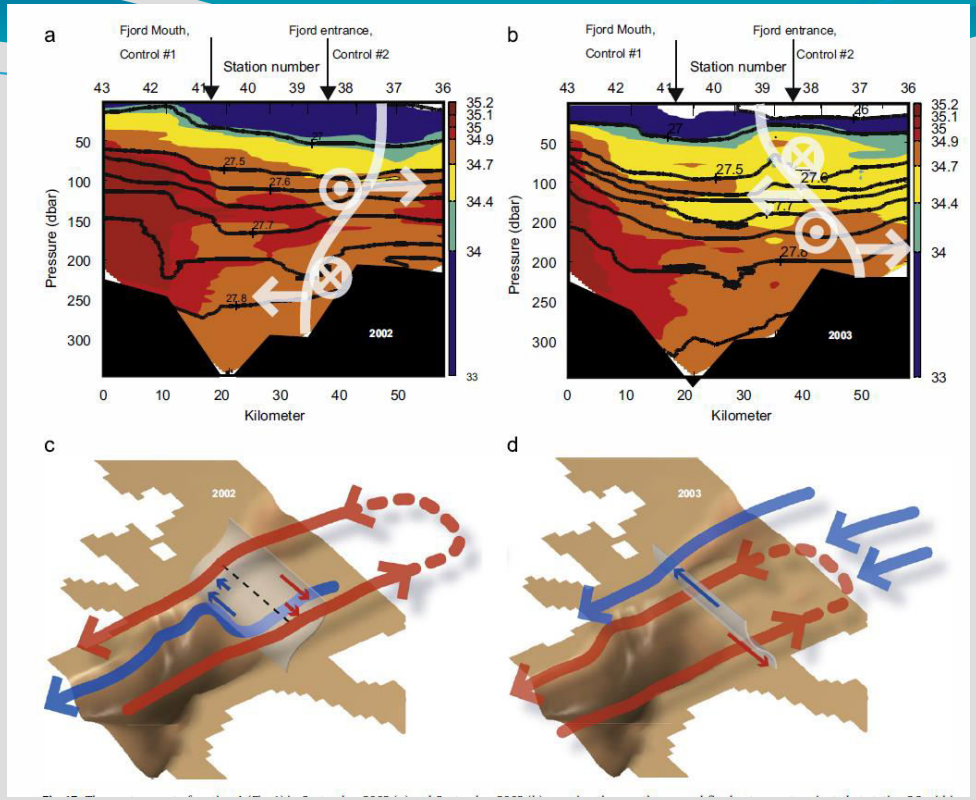
- **AW inflow into Hornsund depends of the AW proximity and local exchanges conditions. Pulse-like inflow**





On the double-diffusive and cabbeling environment of the Arctic Front

F. R. Cottier & E. J. Venables, West Spitsbergen



Fjord– shelf exchanges controlled by ice and brine production: The interannual variation of Atlantic Water in Isfjorden, Svalbard
F. Nilsen a,b,, F. Cottier c, R. Skogseth a, S. Mattsson a

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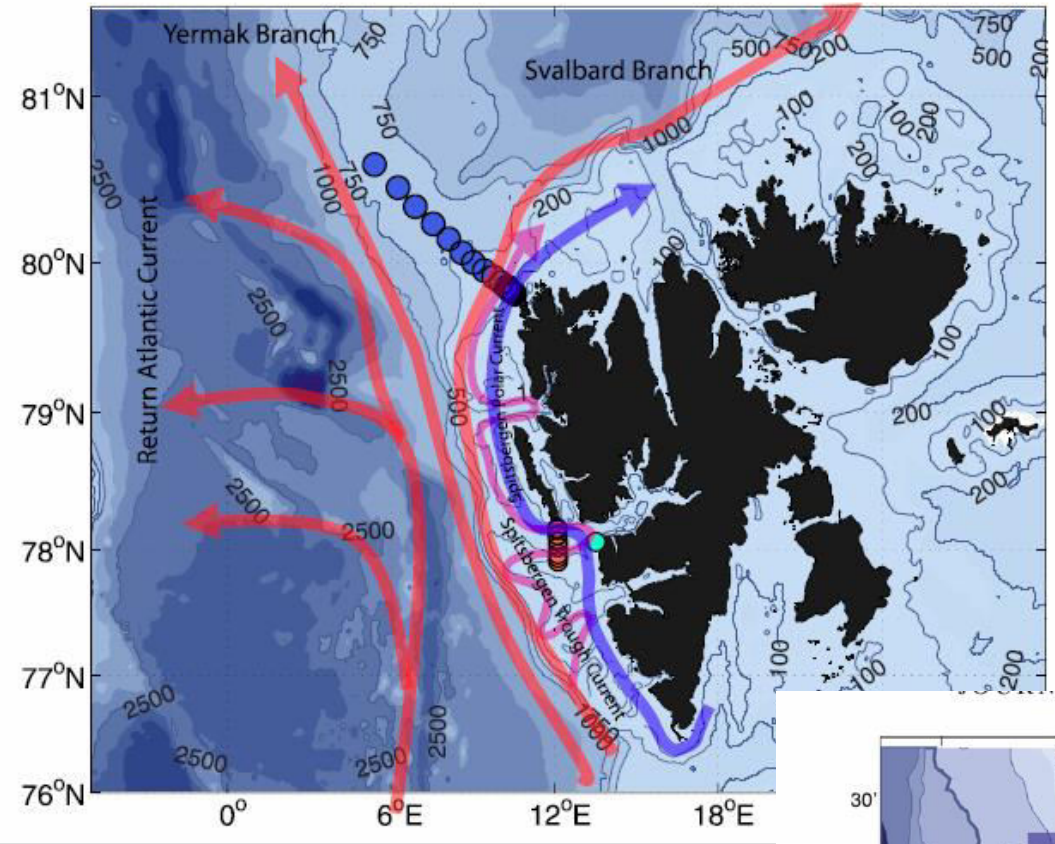
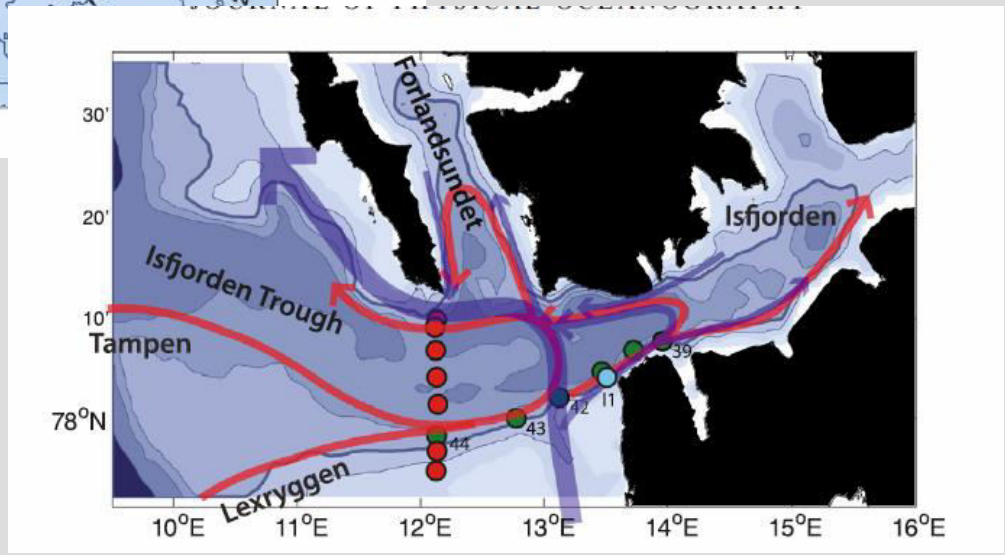


A Simple Shelf Circulation Model: Intrusion of Atlantic Water on the West Spitsbergen Shelf

FRANK NILSEN, RAGNHEID SKOGSETH, AND JUNI VAARDAL-LUNDE




MAGNUS ZAREMBA