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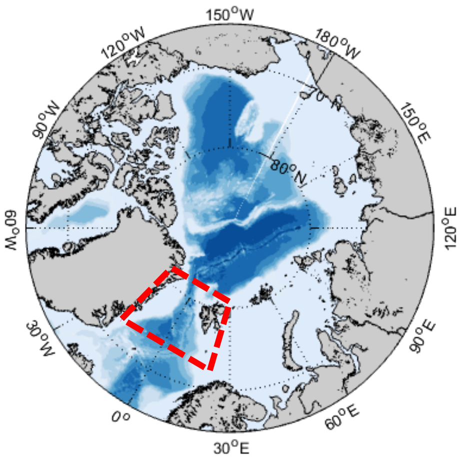


Fig.1 The map of the Arctic Ocean. The red box shows study region.

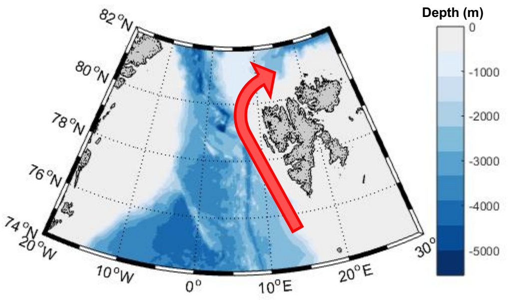


Fig.2 The map of the study region. The red arrow indicates the pathway of the Svalbard of the WSC.

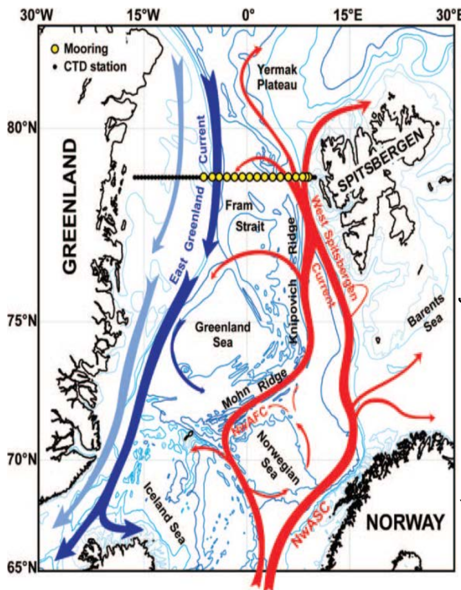
Arctic Seas:

Arctic measurements have been performed since 1987 under the *IO PAS* annual summer Arctic Experiments (AREX) in the Nordic Seas and Fram Strait by the *IO PAS* research vessel *'Oceania'*.

West Spitsbergen Current (WSC):

- structure, dynamics and variability
- Atlantic Water layer conditions
- volume transport, heat and salt content
- geostrophic currents
- interannual variability
- warm impact to the Arctic Ocean through the Fram Strait

THE '*IO PAS*' LONG-TERM MONITORING PROGRAM AREX (1996-2018)



Beszczyńska-Möller et. al., 2012

Fig.3 A circulation scheme for the Nordic Seas and Fram Strait.

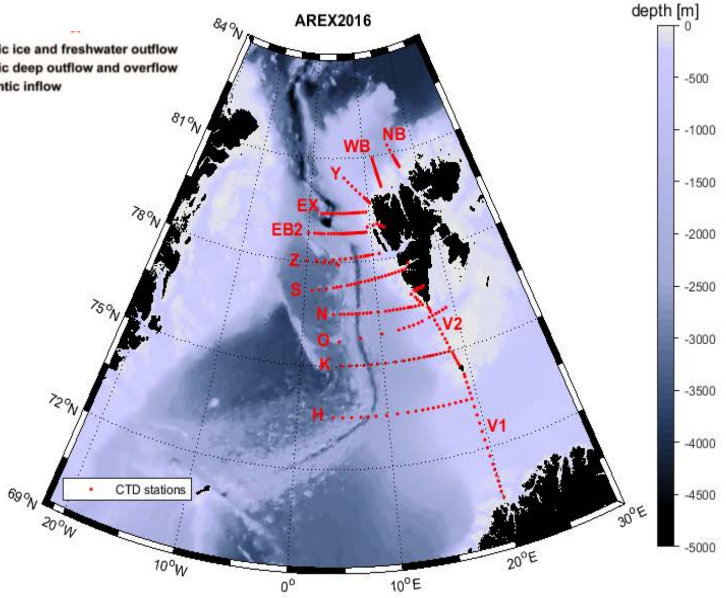


Fig.4 Location of CTD stations measured during the open ocean part of AREX 2016 (June 21—July 24, 2016). Red dots mark CTD stations.

The hydrographic survey carried out during the AREX cruise consists of sections extending from the outer shelf across the slope into the deep basin in order to sample the northward flow of Atlantic water (Fig. 3).

<u>Measurement strategy was based on</u> (Fig. 4):

- performance of cross-sections perpendicular to presumed direction of the WSC
- transects arranged along parallels intersected the most important bottom structures which limit the Atlantic Domain
- two meridional transects closed the entrance to the Barents Sea

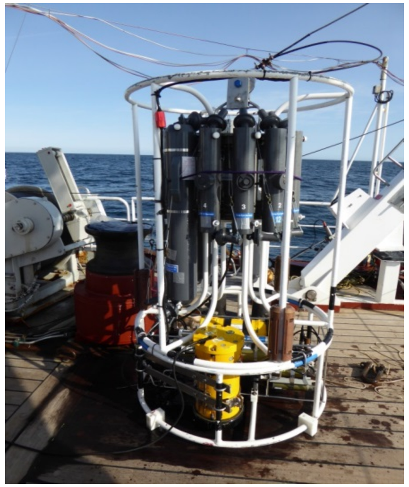


Photo by A. Beszczyńska-Möller

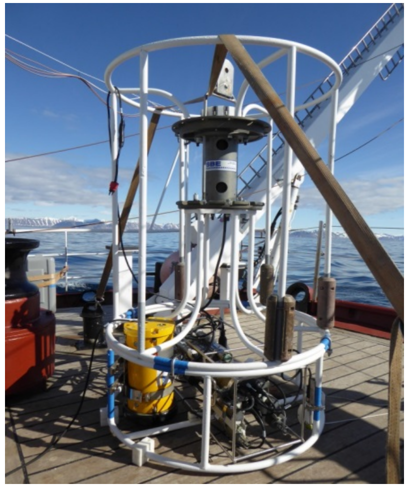


Photo by A. Beszczyńska-Möller

1. System Seabird 9/11+ (24 Hz, 4 cm, 0–3400 m)
   - Double pairs of temperature (SBE3) and conductivity (SBE4) sensors
   - Digiquartz pressure sensor (410K-105)
   - Two dissolved oxygen sensors (one standard SeaBird sensor SBE43 and additional Rinko optode, connected directly to the CTD registration system)
   - SeaPoint fluorescence sensor
   - Benthos altimeter PSA-916
2. *Lower* Acoustic Doppler Current Profiler *LADCP* (150 kHz, 350 m)
3. SeaBird bathymetric rosette (carousel): 9 large Nansen bottles (12 l each) and 3 small bottles (1.75 l each)

PROPERTIES OF ATLANTIC WATER IN SUMMER AND THEIR LONG-TERM VARIABILITY

Following oceanographic measurements were carried on during the open ocean part of the AREX cruise:

- Full-depth measurements of temperature, salinity and ocean currents in the Norwegian-Atlantic and West Spitsbergen currents (CTD, LADCP)

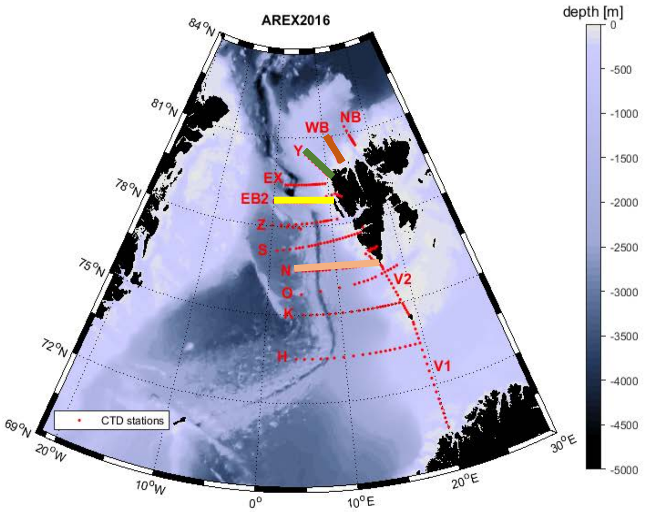


Fig.4 Location of CTD stations measured during the open ocean part of AREX 2016 (June 21—July 24, 2016). Red dots mark CTD stations.

The longest observation record from the **section N** along 76°30’N reveals a steady **increase of Atlantic water salinity**, while temperature trend depends strongly on parametrization used to define the Atlantic water layer. However spatially averaged temperature at different depths indicate an **increase of Atlantic water temperature** in the whole layer from the surface down to 1000 m.

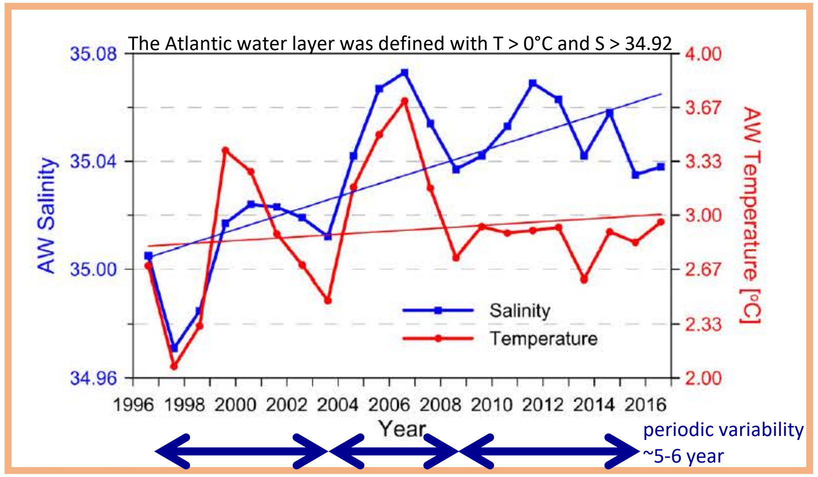


Fig.5 Time series of the vertically averaged temperature and salinity of the Atlantic water layer at the section N measured in summers of 1996—2016.

Walczowski, W., A. Beszczynska-Möller, P. Wieczorek, M. Merchel, A.Grynczel (2017) Oceanographic observations in the Nordic Sea and Fram Strait in 2016 under the IO PAN long-term monitoring program AREX, Oceanologia 59, 187—194

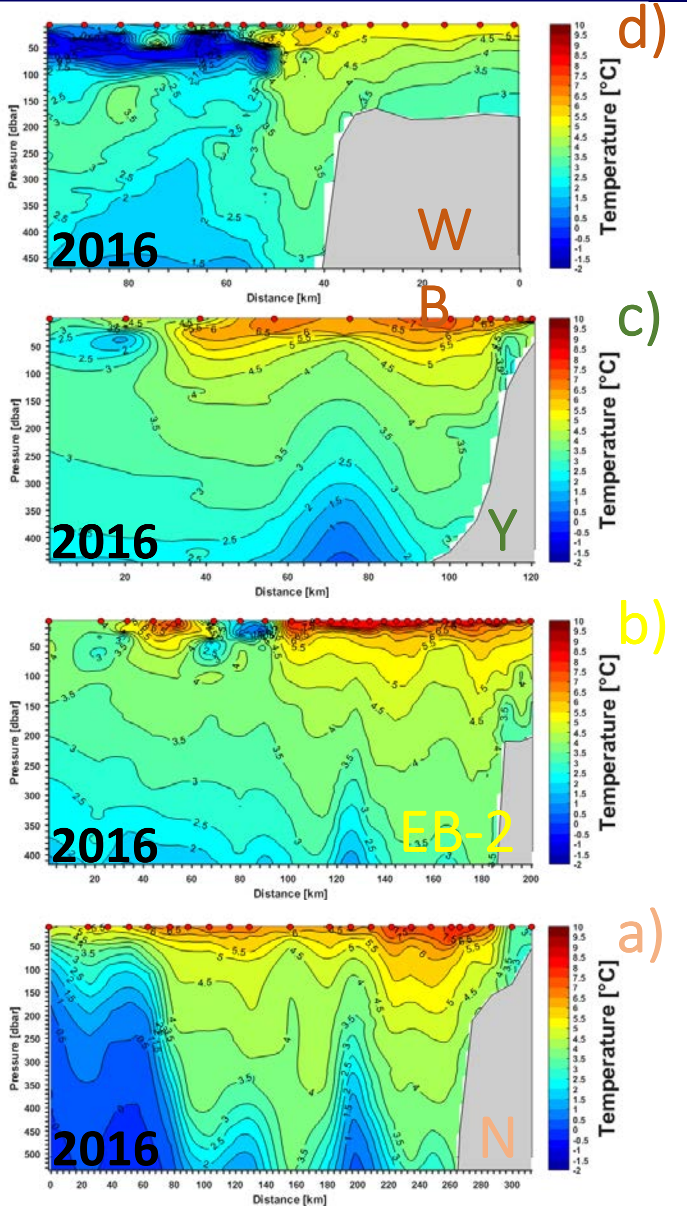
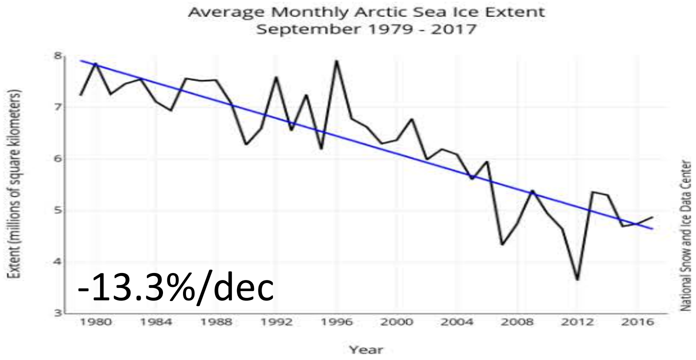


Fig.6 Vertical distributions of AW temperature in section N **(a)**, section EB-2 **(b)**, section Y**(c)** and section WB **(d)** in 2016 .

Observations of Atlantic water variability during the AREX summer campaigns: impact on sea ice concentration north of Svalabrd



- The northernmost polar region is most sensitive to global climate change.
- Climate change is faster and more severe in the Arctic, which is warming at a rate of almost twice the global average (*Cohen et al., 2014; Serreze et al., 2009*).
- While many complex feedback processes contribute to the enhanced warming of the Arctic region called *Arctic amplification*, it`s largely driven by the loss of the sea ice cover (*Overland, 2016*).

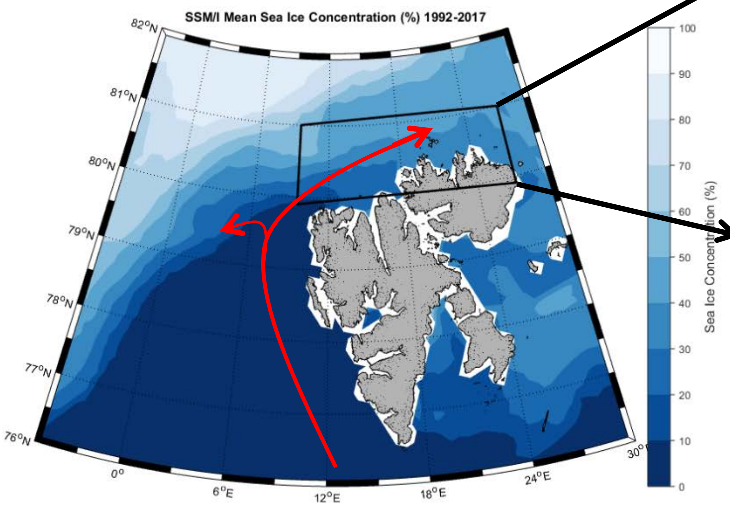


Fig.7 Mean ice concentration (percentage of ocean area covered by sea ice) field from 1992 to 2017 (39.4%). The solid black box shows the study region north of Svalbard. The red arrow indicates the pathway of the Svalbard Branch of the WSC and RAC.

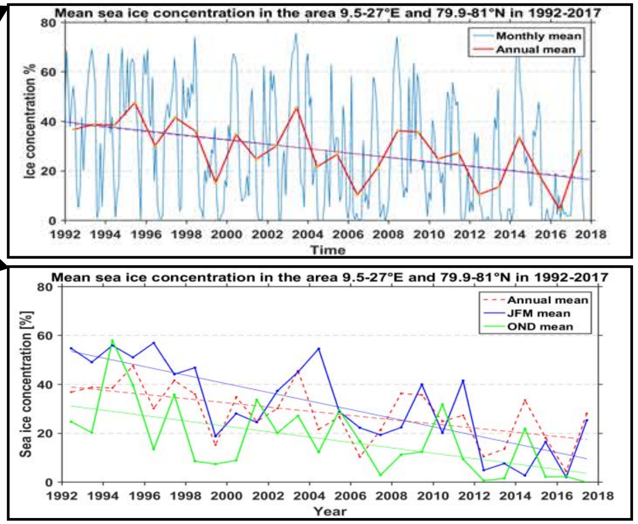


Fig.8 Time series of the annual and monthly means in the study regions north of Svalbard between 1992-2017.

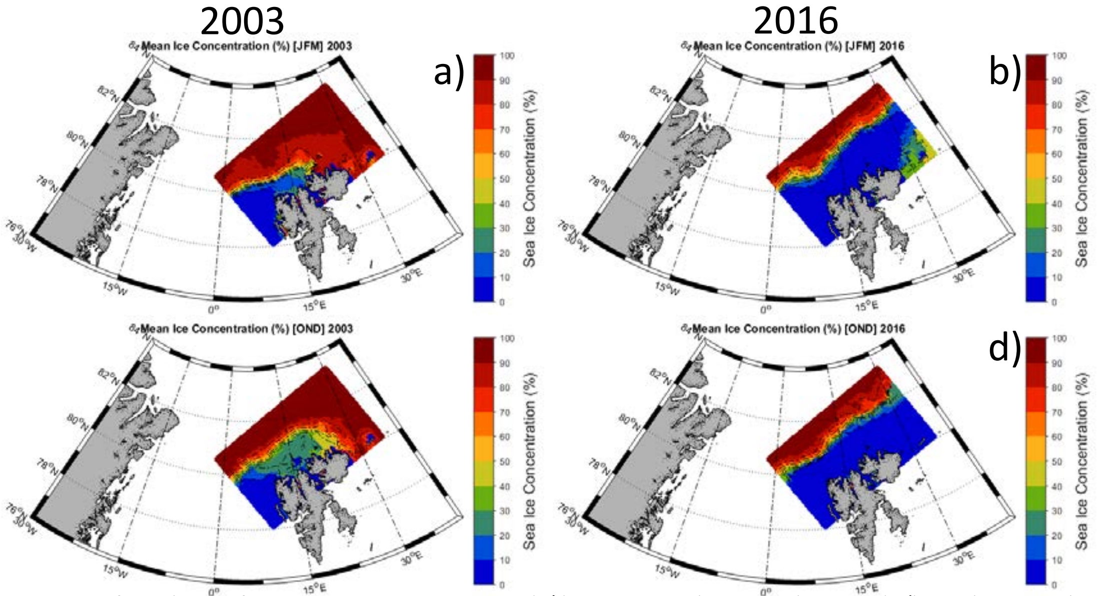


Fig.9 Specific evolution of sea ice concentration in winter (**a,b**): January-March [JFM] and autumn (**c,d**): October-December [OND] in 2003 and 2016.

Table.1 Correlation coefficients for AW temperature for the whole transect N', EB-2', WB' and the sea ice concentration area north of Svalbard in winter [January-March (JFM)], spring [April-June (AMJ)], summer [July-September (JAS)] and autumn [October-December(OND)].

NORTH OF SVALBARD	summer [July-September] (JAS)	autumn [October-December] (OND)	winter [January-March] (JFM)	spring [April-June] (AMJ)
Section 'N' (1996-2017)	-0,30	-0,51	-0,62	-0,40
Section 'EB-2' (2001-2017)	-0,16	-0,55	-0,70	-0,33
Section 'WB' (2013-2017)	-0,35	-0,70	-0,83	-0,50

- The study region north of Svalbard (black box) has an annual mean ice concentration of 39.4% between 1992 and 2017.
- During the last three decades, the sea ice concentration has decreased north of Svalbard, with record low annual minimum in 2016.
- The winter [JFM] and autumn [OND] mean ice concentration demonstrate the biggest reductions of sea ice.

RESEARCH OBJECTIVE

MEAN SEA ICE CONCENTRATIONS IN WINTER [JFM] SEASON IN THE NORTH OF SVALBARD

Mean sea ice concentrations in winter [JFM] season 2004

Mean sea ice concentrations in winter [JFM] season 2006

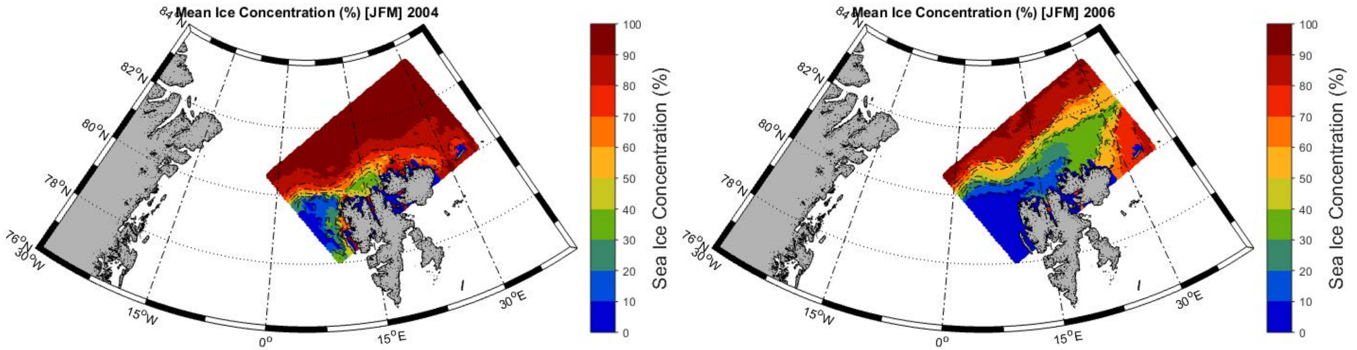


Fig.10 Specific winter evolution of sea ice concentration in the Atlantic section in winter: January-March [JFM] and autumn: October-December [OND] in 2004 and 2006.

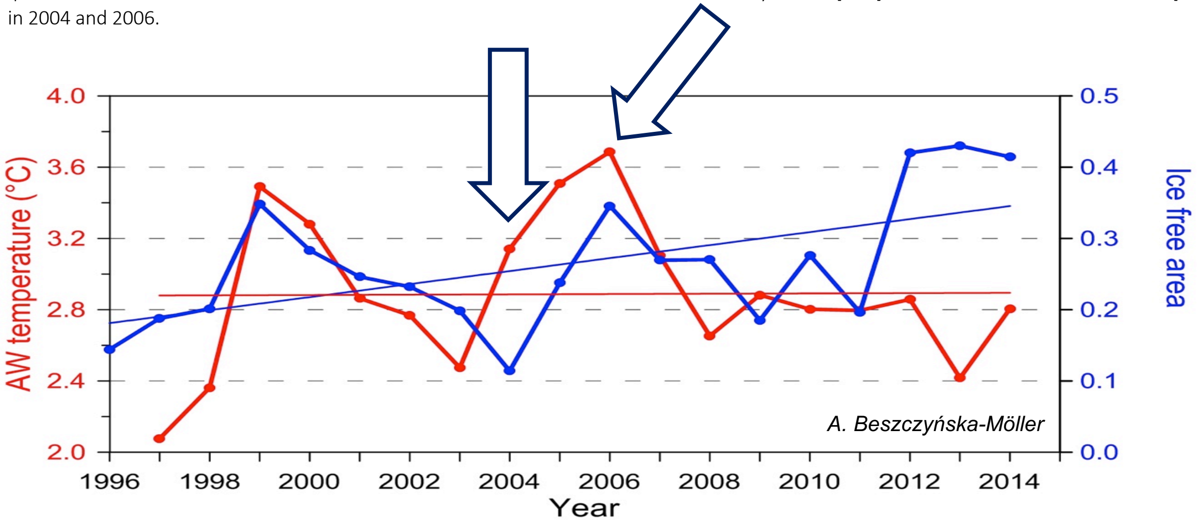


Fig.11 Time series of the vertically averaged temperature of the AW layer at the section N measured in summers and ice free area in 1996—2014.

- The spatial winter [JFM] season sea ice loss north of Svalbard illustrates an ice retreat above the pathway of the AW.
- Lower ice concentrations are gradually moving northeastward along Svalbard's northern coast.

A steady temperature increase, observed both in the atmosphere and in the ocean, has a profound impact on the sea ice cover in the sub-Arctic seas and Arctic Ocean (e.g. Polyakov et al., 2012; Stroeve et al., 2012).

- What is the influence of different branches of the Atlantic water inflow on the local ice coverage in Fram Strait and north of Svalbard?
- What mechanisms causing the reduction of the sea ice cover in the Fram Strait and north of Svalbard?

RESEARCH OBJECTIVE