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Structure and transport of Atlantic Water north of Svalbard from observations in summer and fall 2018

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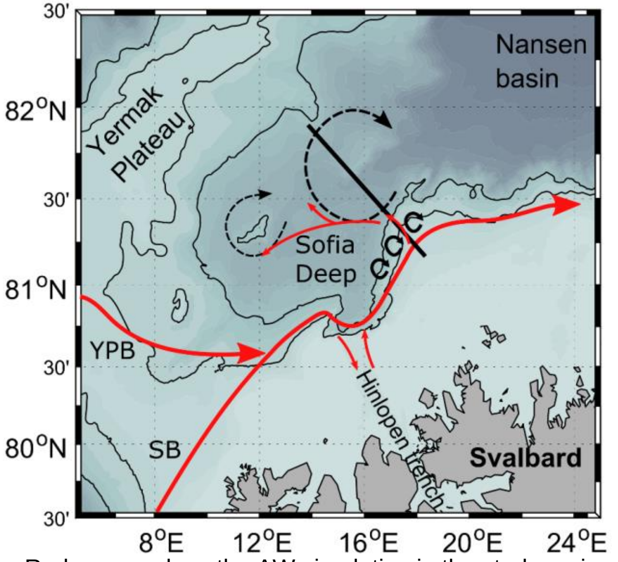
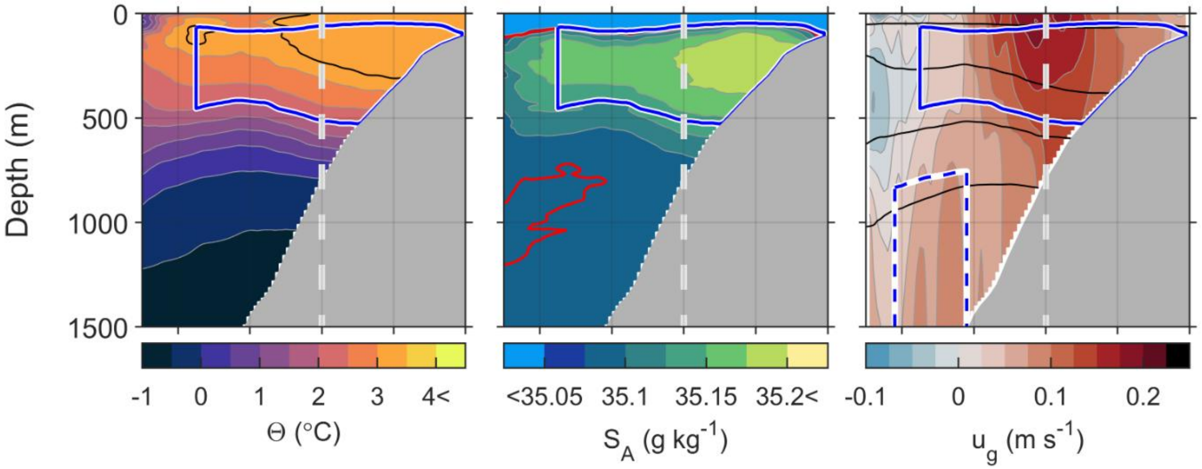
A counter current in the Sofia Deep transports Atlantic Water westward



Red arrows show the AW circulation in the study region. Black dashed arrows show possible anticyclonic circulation in the Sofia Deep. Small black arrows mark the possible generation site for eddies.

A deep, bottom-intensified current on the lower continental slope carries cold waters into the Arctic



White dashed line indicates the location of the 800 m isobath. Blue line envelops the Atlantic Water with $U_g > 0$. Blue dashed line envelopes the bottom-intensified current. Black line in the Θ plot is the 3.3°C isotherm. Red line in the *SA* plot is the 35.08 g kg^{-1} isohaline. Black lines in the u_g plot are isopycnals.

This research is currently under consideration at JGR – Oceans, and will be made open access upon acceptance.

EGU2020 OS1.11: Changes in the Arctic Ocean, sea ice and subarctic seas systems: Observations, Models and Perspectives

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Motivation

Why is it important?

The **transport of warm Atlantic Waters** (AW) north of Svalbard is one of the **major heat and salt sources** to the Arctic Ocean. The circulation pathway and the associated heat transport **influence** the variability in the Arctic **sea ice extent**, the **onset of freezing**, and **marine ecosystems.**

Research gaps:

The **fraction of AW** that **enters** the Arctic Ocean is **not accurately known**.

The observed **along-path cooling rate of AW** is larger than that indicated by vertical heat fluxes. It is not clear which processes can sustain such along-path cooling rates.

Our contributions:

Volume transport and **circulation patterns** north of Svalbard, from high resolution observations summer and fall 2018.

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Methods

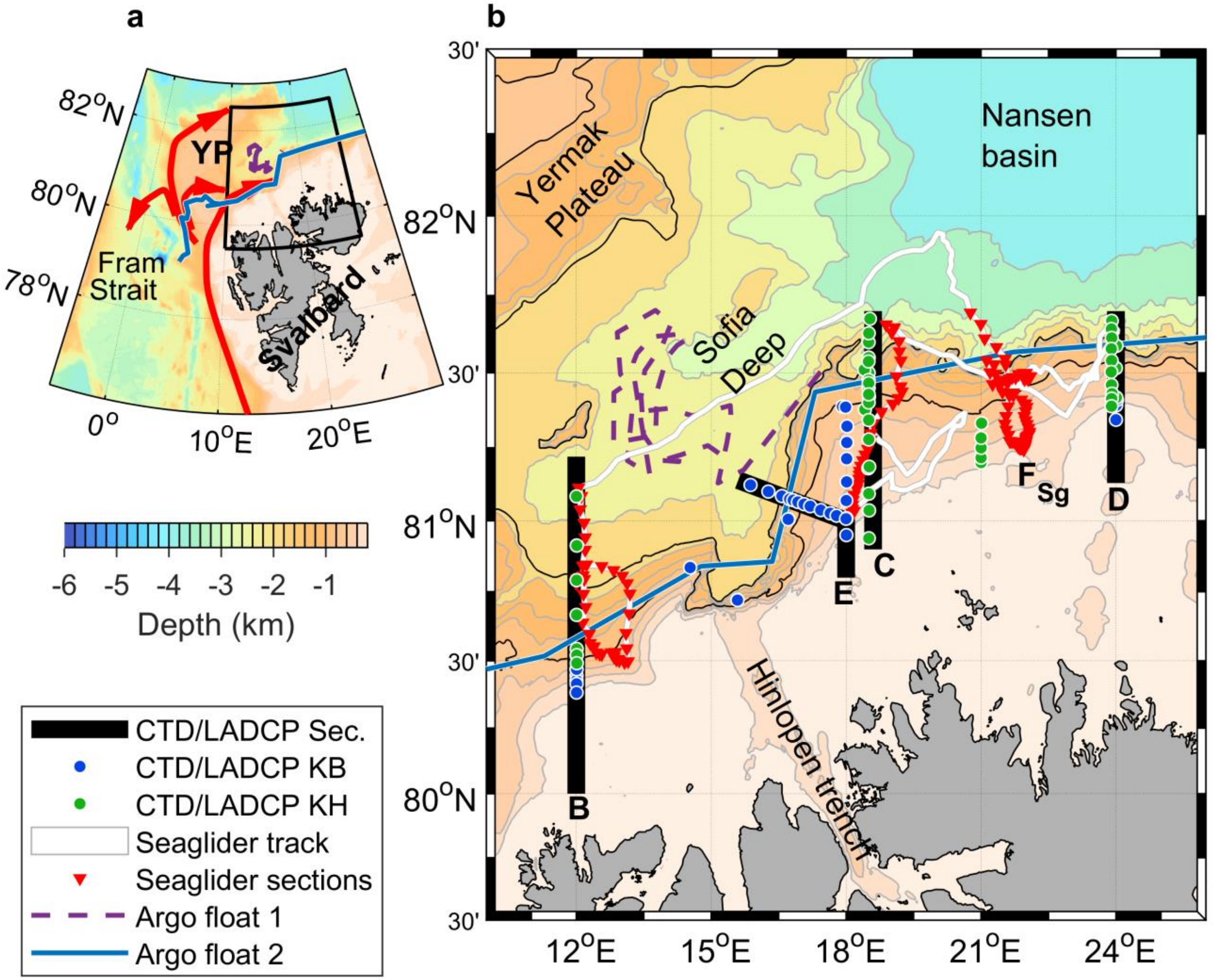
- We present hydrographic observational data from two research cruises, one Seaglider mission and two Argo floats, summer and fall 2018.

- Atmospheric forcing was extracted from the Norwegian Reanalysis Archive (NORA10).

- Composite sections are constructed along a representative, average bathymetry across the shelf break, using all available observations.

The composite sections enable us to compare data collected across different platforms and different locations

- All current measurement are de-tided using the inverse tidal model AOTIM-2018.



Station map with CTD sections B to E (blue: June/July, green: September, red: Seaglider Oct-Nov). CTD stations used for composites are marked with circles. Black isobaths are at 800 m and 1500 m. Grey lines are isobaths from 200 m to 1400 m depth at every 200 meters, and 2000 m to 6000 m at every 500 meters.

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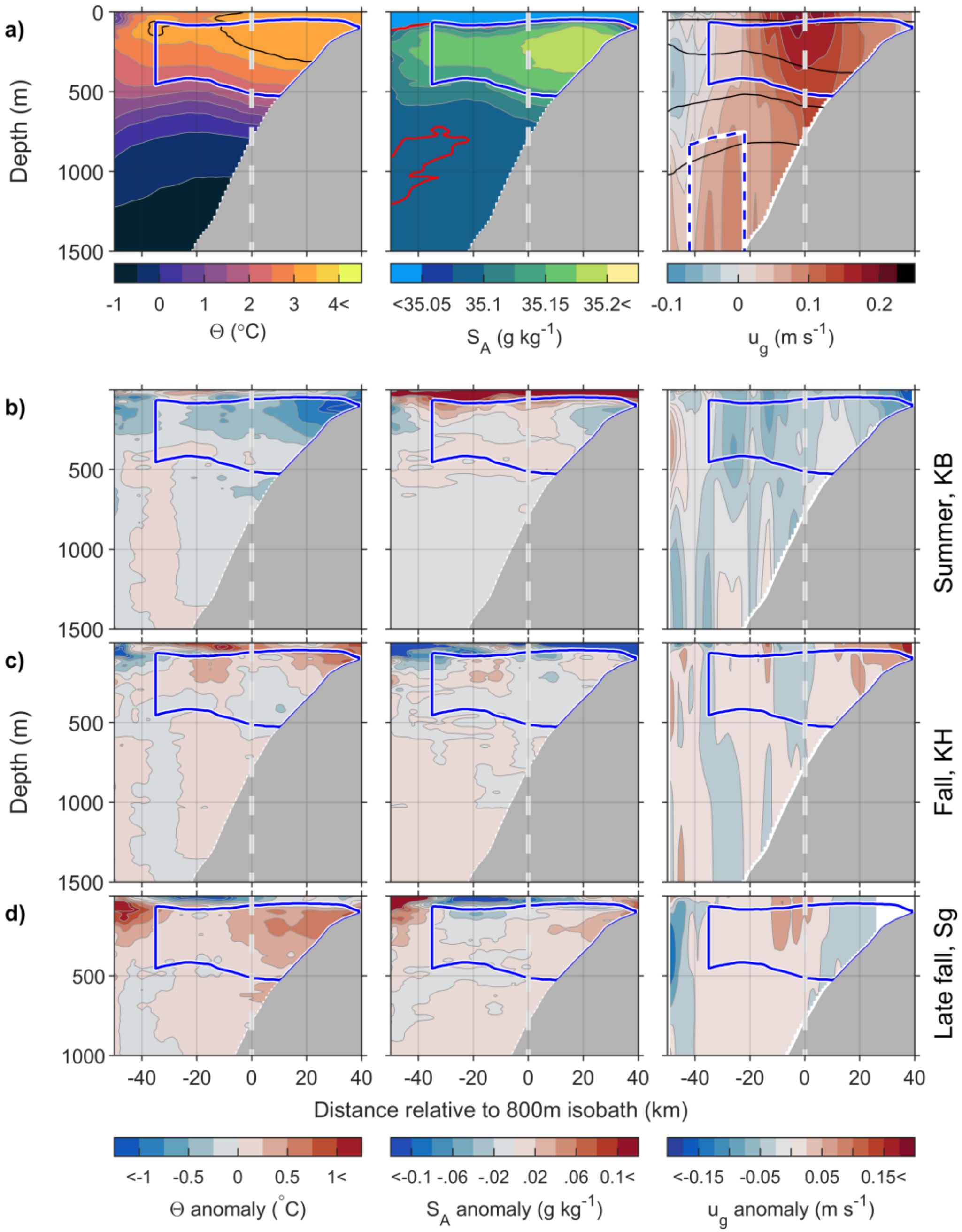
Results

- AW boundary current with average transport of 2.6±0.2 Sv, and associated heat transport of 35 TW

- From summer to fall the average AW transport into the Arctic increased from 2.0±0.1 Sv to 3.0±0.2 Sv, with a maximum in October.

- North of the AW boundary current we observed a return flow containing a separate patch of AW, overlaying an eastward flowing bottom-intensified current



a) Average composite sections for Θ, S_A and u_g, based on cruise data and Seaglider data.

b) Summer anomalies for Θ, S_A and u_g (mean subtracted from individual season). **c)** Shows fall anomalies, and **d)** shows late fall anomalies.

White dashed line indicates the location of the 800 m isobath.

Blue line envelops the Atlantic Water with $U_g > 0$.

Blue dashed line envelopes the bottom-intensified current.

Black line in the Θ plot is the 3.3°C isotherm. Red line in the S_A plot is the 35.08 g kg^{-1} isohaline. Black lines in the u_g plot are isopycnals.

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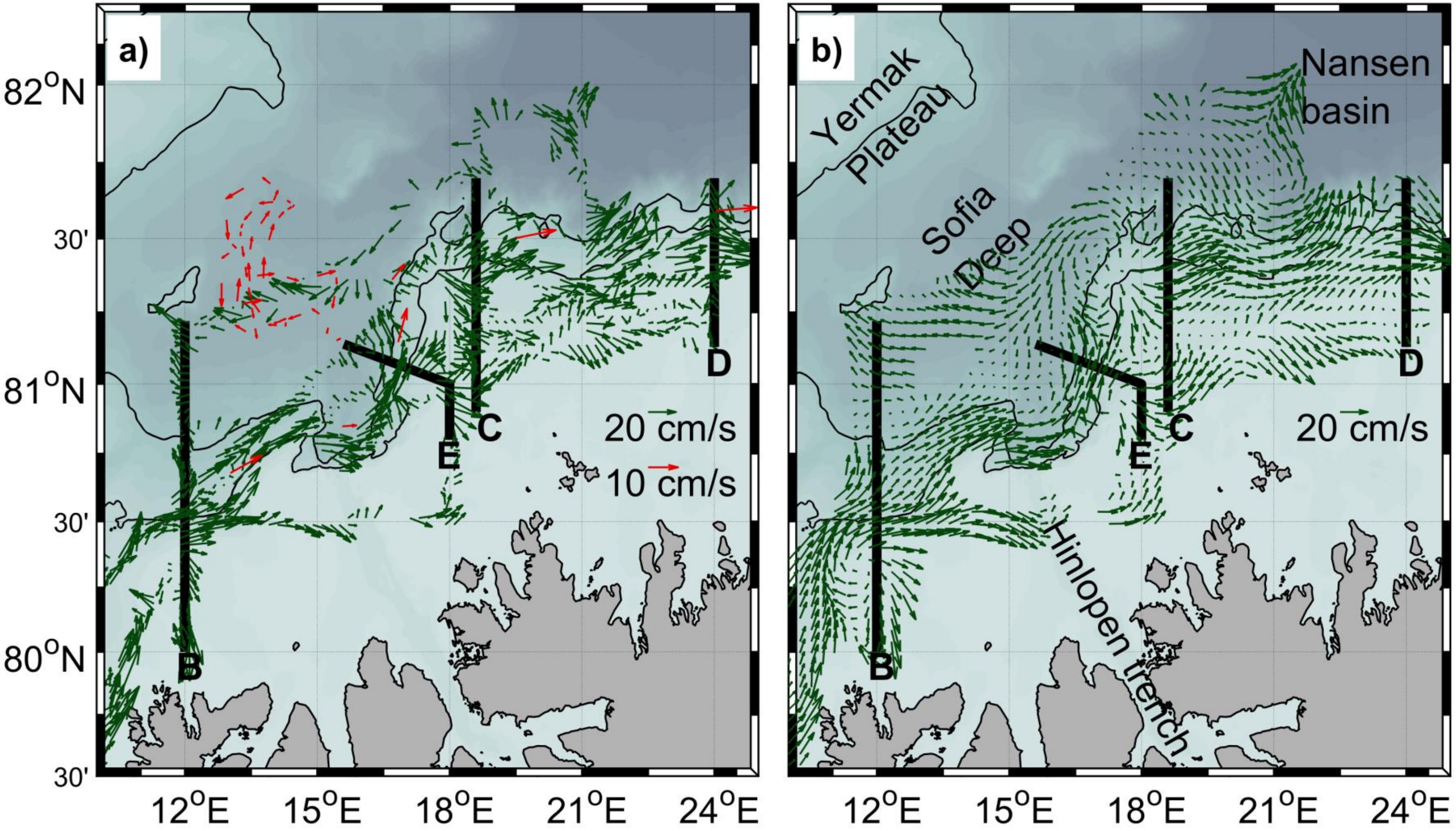
Results

Mean currents between 0-1000 m support a return flow in the Sofia Deep.



a) Green arrows show 0-1000 m mean currents, bin-averaged over 3km by 3km horizontal bins, from Acoustic Doppler current profilers and Seaglider depth-averaged currents. Red arrows show drift trajectories from Argos.
b) Objective interpolation of average currents in (a). Thick black lines show predefined sections. Black contours show the 800 m and 1500 m isobath

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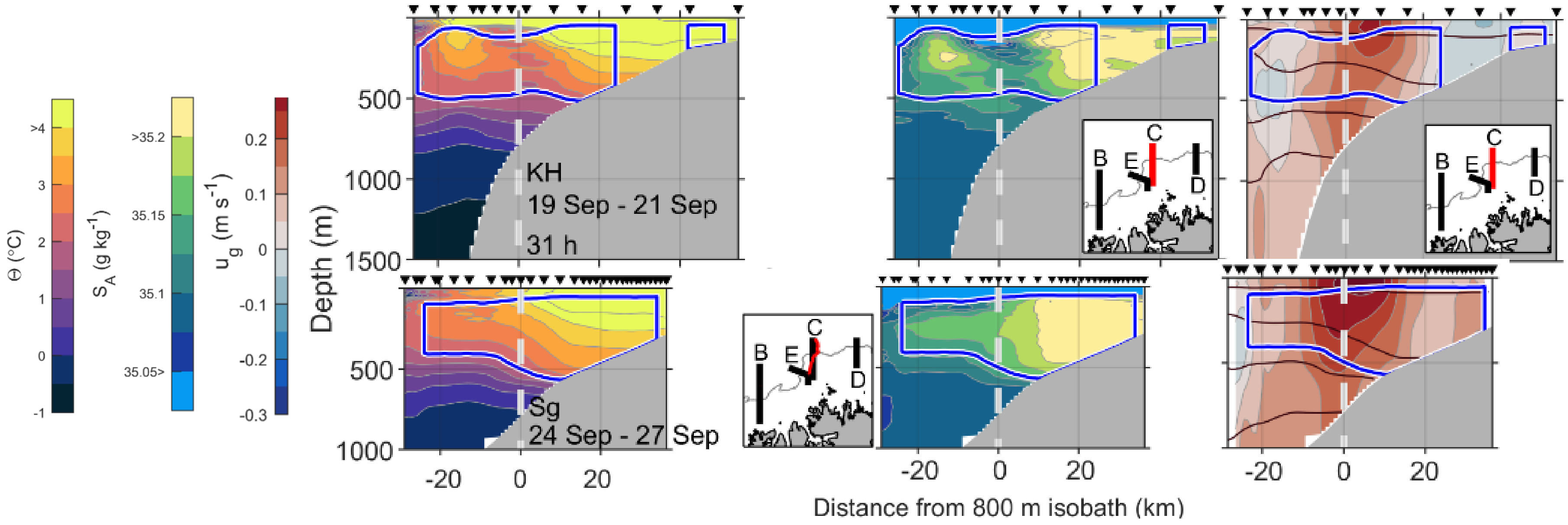
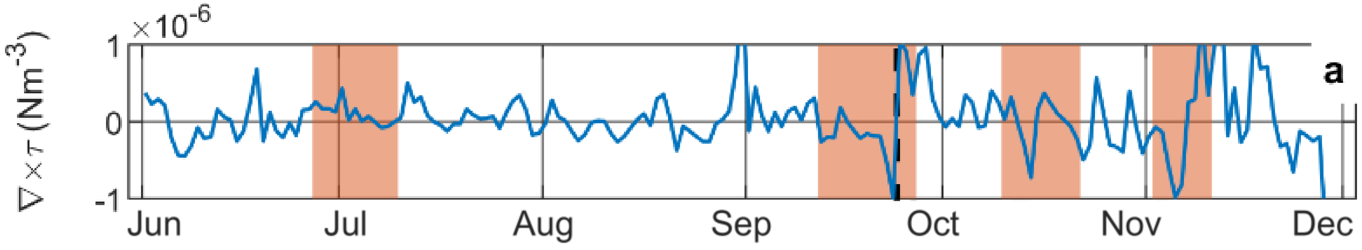
Results

Two transects along the same section, only five days apart, showed an increase in AW transport from 1.9 Sv (upper panel) to 3.5 Sv (lower panel). This increase was caused by a change in wind stress curl from negative to positive in the Sofia Deep, strengthening the AW boundary current.



Conservative Temperature, Θ, Absolute Salinity, S_A , and geostrophic velocity, u_g, for synoptic sections. The section displayed in each row is indicated by a red line in the respective overview figure. The white dashed line at 0 km, and the isobath marked in the overview figure, show the location of the 800 m isobath. Blue line envelopes AW. Black triangles at the top of each panel show cruise profile location and Seaglider surface location. KH = RV Kronprins Haakon, Sg = Seaglider



Daily mean wind stress curl averaged over the region of interest. Highlighted time periods indicate the times of the cruises and the Seaglider transects. Dashed black line separates the fall cruise from the Seaglider transect, shown in the figure above

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Conclusions

- The AW boundary current following the 800 m isobath has an average transport of 2.6±0.2 Sv, and associated heat transport of 35 TW.

- From summer to fall the average AW transport into the Arctic increased from 2.0±0.1 Sv to 3.0±0.2 Sv, with a maximum in October.

- The short term variations were even larger, we observed an increase from 1.9 Sv to 3.5 Sv in less than five days, caused by a transition from strongly negative to strongly positive wind stress curl over the Sofia Deep.

- North of the AW boundary current we observed a return flow containing a separate patch of AW, overlaying an eastward flowing bottom-intensified current. The strength of the return flow and the bottom-intensified flow is likely affected by the wind forcing, similar to the boundary current.

- With a decreasing Arctic sea-ice cover, we suspect the wind stress will play an increasingly important role in modifying the AW inflow and circulation patterns.

- Signatures of multiple eddies were found in the Sofia Deep. Section C is a likely generation site for these eddies, yet this needs further investigation.