Understanding circulation in the eastern Arctic Ocean from NABOS observations

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RESULTS:

- **"Atlantification" of the eastern Arctic Ocean associated with greater roles of Atlantic inflows on sea-ice loss**
- **Stronger upper-ocean currents and their vertical shear and increasing coupling between the wind and sea ice with upper ocean currents and shear.**

1. Background

A series of moorings has been deployed in 2013 for two years in the eastern Arctic Ocean as a part of Arctic Observing Network (AON) funded by the National Science Foundation (Fig. 1). All these moorings delivered critical information about changes in this part of the Polar Basin.

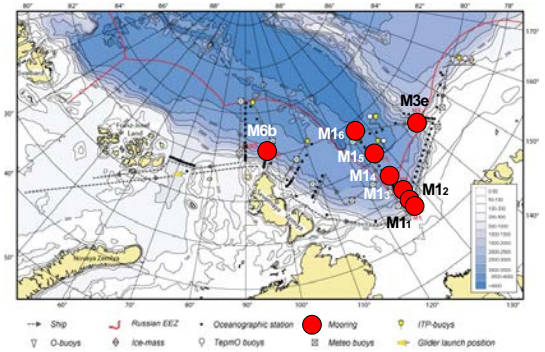
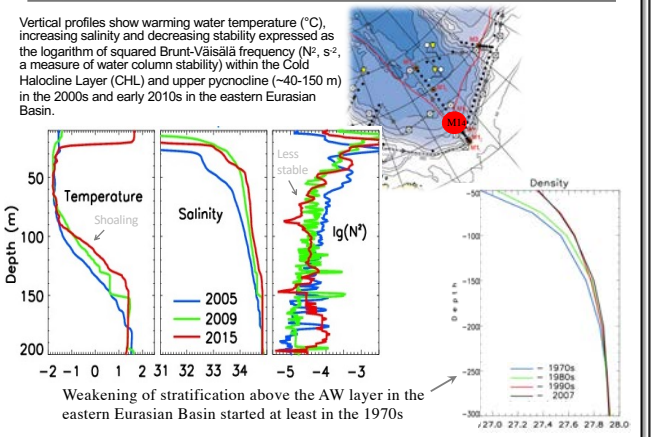


Figure 1. Map showing locations of moorings deployed in 2013-15 in the eastern Eurasian Basin of the Arctic Ocean. Information provided by these moorings is critical for understanding dramatic changes in this part of the Arctic Ocean.

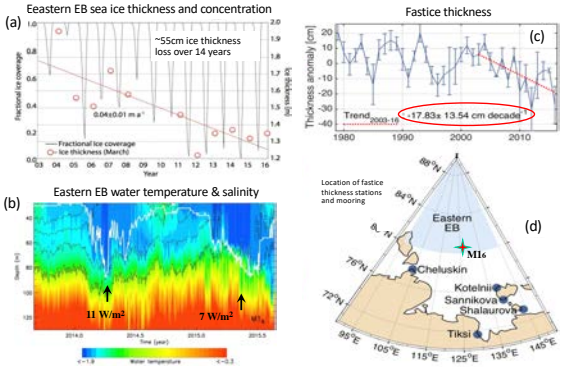
2. Weakening of stratification in halocline and AW shoaling

Vertical profiles show warming water temperature (°C), increasing salinity and decreasing stability expressed as the logarithm of squared Brunt-Väisälä frequency (N^2, s^{-2}, a measure of water column stability) within the Cold Halocline Layer (CHL) and upper pycnocline (~40-150 m) in the 2000s and early 2010s in the eastern Eurasian Basin.



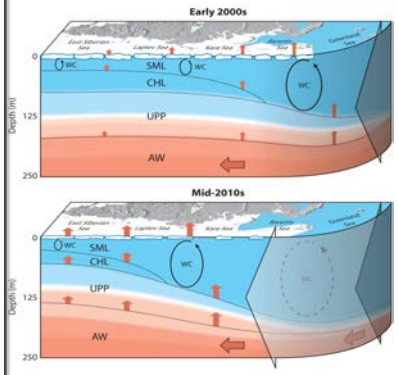
Weakening of stratification above the AW layer in the eastern Eurasian Basin started at least in the 1970s

3. Increased oceanic heat fluxes explain most of sea ice reduction in the eastern Eurasian Basin in recent years



(a) Satellite-based estimates of sea ice thickness loss, (b) oceanic heat fluxes derived from mooring records are equivalent to 18-40cm anomalous sea ice thickness loss, (c) estimate of sea-ice thickness decrease due to atmospheric thermodynamic forcing and (d) locations of fast-ice thickness stations and mooring $M16$.

4. Atlantification of the eastern Arctic Ocean

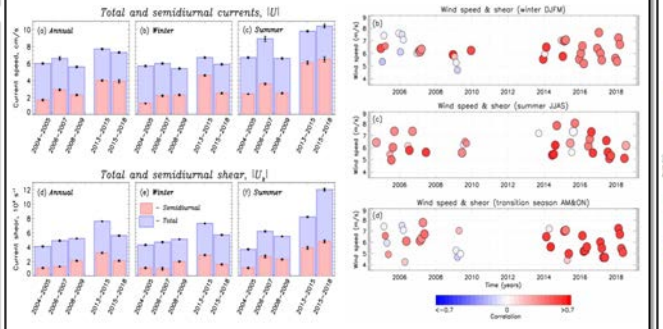


Winter convection (WC) penetrated through the weakly stratified Cold Halocline Layer (CHL) in the eastern Eurasian Basin in recent years releasing AW heat upward and making sea ice weaker.

This is similar to what was observed in the past in the western Nansen Basin. We call this eastward progression of the western EB conditions the "atlantification" of the Eurasian Basin of the Arctic Ocean.

Entrainment below the Surface Mixed Layer (SML) and delivery of AW heat across the pycnocline to the SML and ice by double-diffusive mixing are two big unknowns in this complex picture.

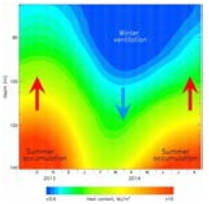
5. Enhanced currents and shear in the upper ocean



Weakening of stratification has been accompanied by stronger upper-ocean currents and their vertical shear (left) and by increasing coupling between the wind and sea ice with upper ocean currents and shear (as indicated by their increasing in time correlation – right). Most of this enhanced energy and shear is in the semidiurnal band, which includes baroclinic tides and inertial oscillations. The increased shear together with the weakening stratification indicate a greater potential for shear-driven turbulent mixing.

6. Strong need for additional observations

The prior measurements identify the strong seasonality of upward heat fluxes but cannot identify the responsible processes. This prevents us from developing reliable ways to include these ocean fluxes in the fully coupled models required to predict the future of the Arctic system. New, targeted measurements are urgently needed.



A 2013-2014 part of the eastern Eurasian Basin (EEB) $M13$ mooring record showing annual component of heat content and winter halocline ventilation which goes well below the SML. Red arrows show summer accumulation of Atlantic Water heat and blue arrow shows penetrative winter ventilation to the depths exceeding 140m. Adapted from *Polyakov et al.* (2020).

We propose to address this knowledge deficit through a targeted field program to obtain the necessary process data during the season (late winter to early spring) when existing measurements of water mass changes indicate that strong upward heat flux into the SML must occur. We have determined that the optimum approach to obtaining the required data set is through a ship-supported ice camp, plus augmentation of the NABOS mooring array.

Acknowledgements

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