Bottom melting of Arctic Sea Ice in the Nansen Basin due to Atlantic Water influence

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The project

Between January and June 2015 the R.V. Lance completed four drifts in the Arctic sea ice north of Svalbard (Fig. 1). On each floe, an ice camp was set up and oceanographic, atmospheric, sea ice, snow, and biologic observations were collected (Granskog et al., 2016).

N-ICE2015 is a research project with the goal to understand the effects of the new thin, first year sea ice regime in the Arctic on energy flux, ice dynamics, and linking AW heat to ice and the associated ecosystem and global climate.

N-ICE2015
NORWEGIAN YOUNG SEA ICE CRUISE

Background

Atlantic Water (AW) is present below the Arctic sea ice cover, but the depth varies by region and over time. Usually AW heat is separated from the ice due to strong stratification. Efficient melting of sea ice is expected when AW is close to the surface. Near Svalbard, AW depth is determined by a combination of:

- local: topography (Yermak Plateau), sea ice growth, sea ice melting and tidal mixing,
- volume and characteristics of imported sea ice,
- changes in AW inflow characteristics.

Hypothesis:
The inflow of AW on the Yermak Plateau is warming and further downstream it is shoaling. This shoaling and warming melt and limit sea ice growth in the area.

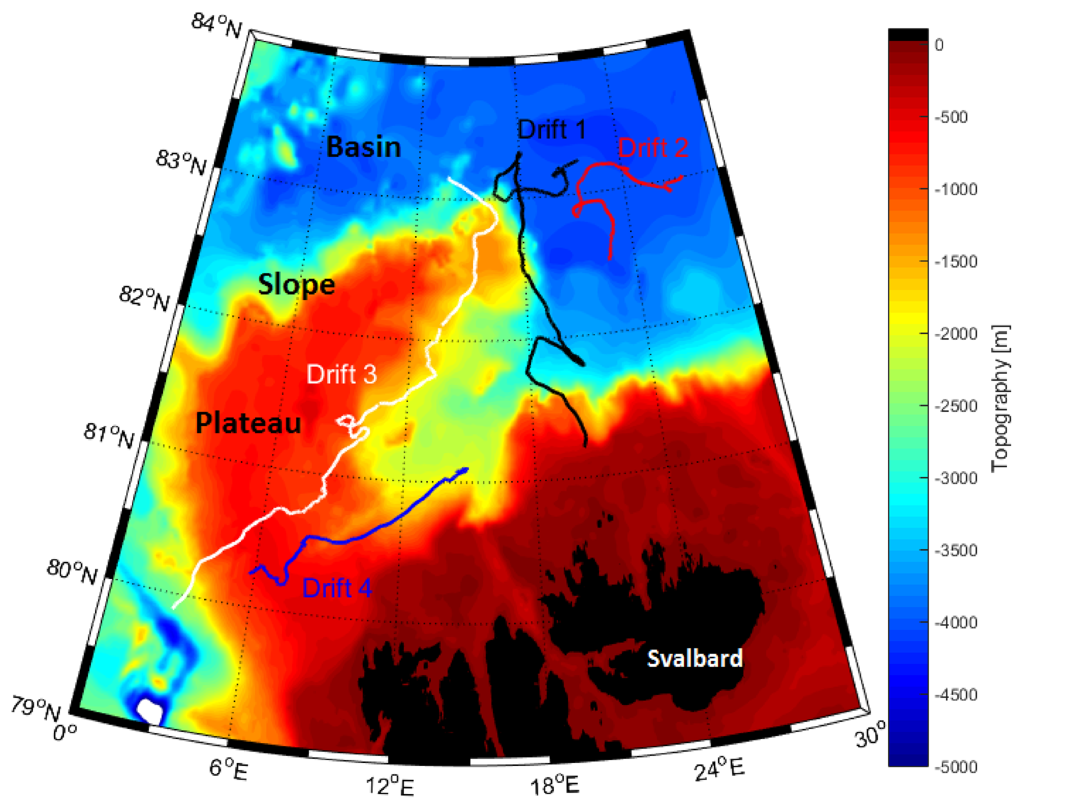

Figure 1: Trajectories of the four N-ICE2015 drifts overlaying topography in color scale ranging from 0 m to 5000 m depth.

N-ICE2015 Hydrography

Hydrographic observations show mostly an absence of the cold Arctic Halocline in the N-ICE2015 area. There is a mixed layer at the freezing point created by sea ice formation during winter. Below the mixed layer Atlantic Water (AW) is found with a mean depth of the upper interface at 107 m in winter.

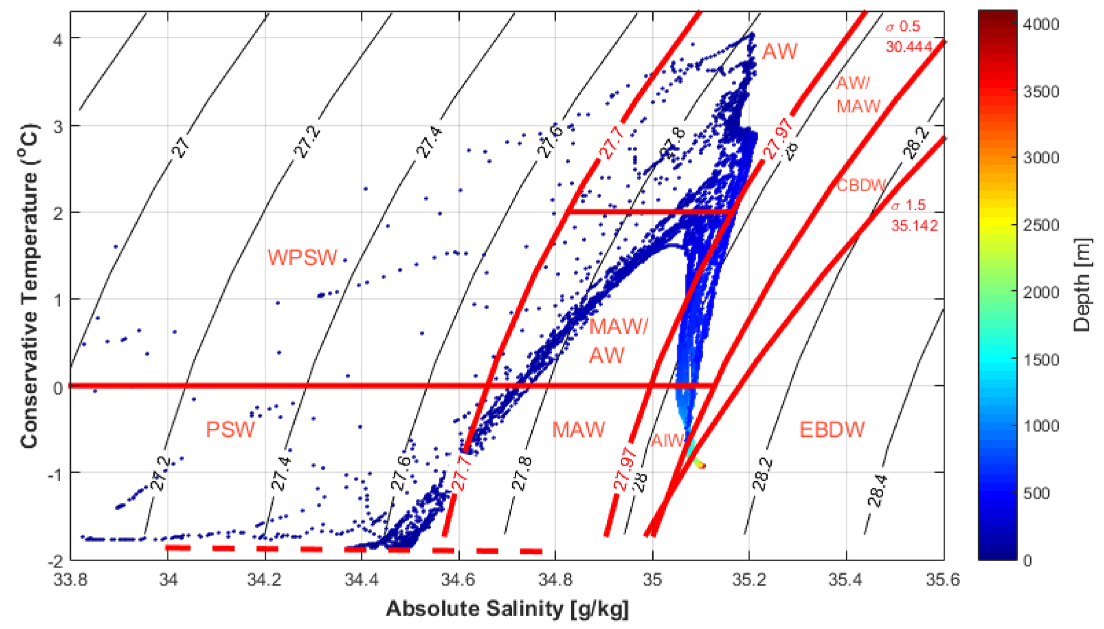

Figure 2: TS-plot from all ship CTD-profiles. Water mass distribution is boxed following the definitions of Rudels et al. (2000). The dashed line represents the freezing point.

Mean:	AW depth	AW core temperature	Mixed layer depth	Mixed layer temperature	Mixed layer salinity
Winter	107 m	2.03 °C (max: 3.27 °C)	66 m	-1.83 °C	34.37 g/kg
Spring	56 m	3.22 °C (max: 4.05 °C)	21 m	-1.19 °C	33.71 g/kg

Table 1: Mean AW and mixed layer characteristics.

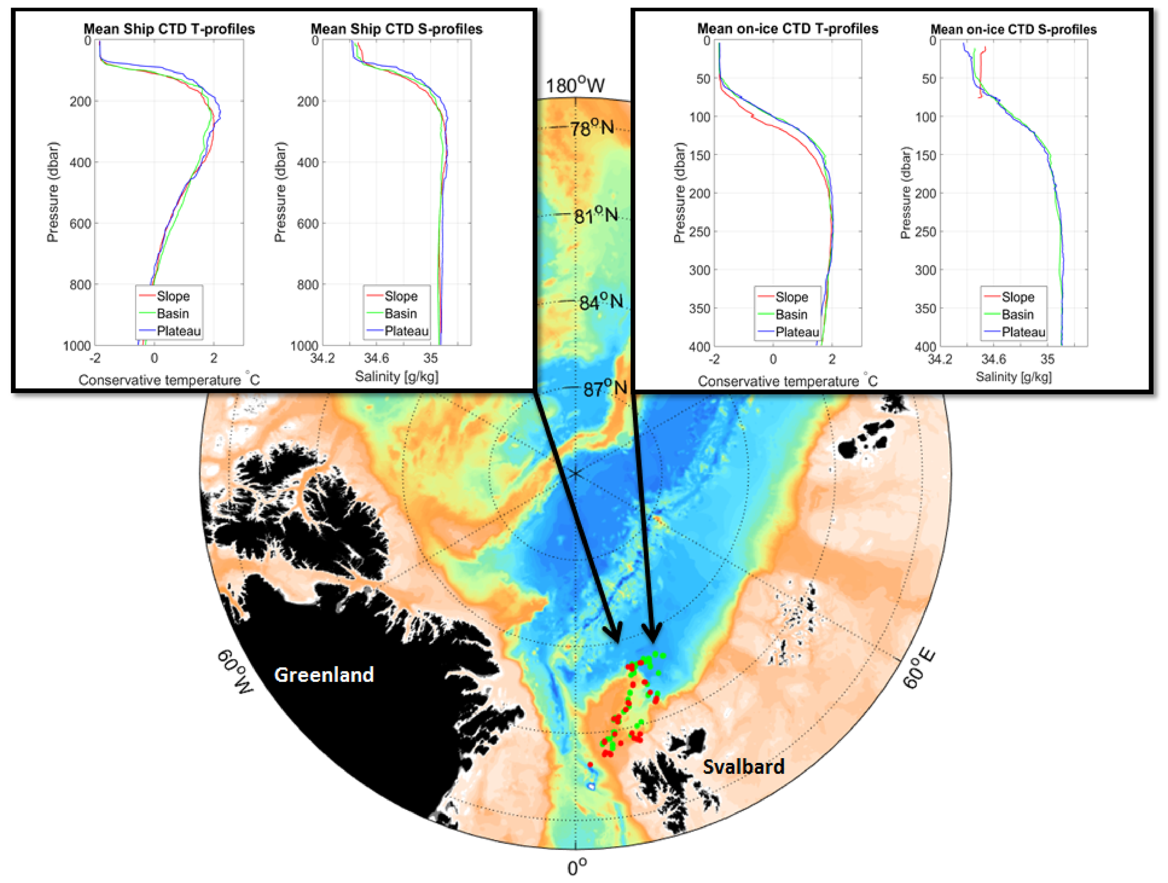

Figure 3: Map showing ship CTD stations (red) and ice-based CTD stations (green) with corresponding mean salinity and temperature profiles.

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The N-ICE2015 observations show that AW tends to be warmer and nearer to the surface over the Yermak Plateau and the slope, than in the deep basin (Fig. 4). AW properties in the Norwegian Earth System Model (NorESM) are similar to observed values for temperature and depth. As expected bottom melting occurs all over the Arctic Ocean during spring and summer (Fig. 5). **During winter there is extensive bottom melting in the region of AW inflow, likely due to upward heat flux from AW driven by turbulent mixing.** Fig. 9 shows the spatially varying correlation between AW temperatures at the inflow and bottom melting.

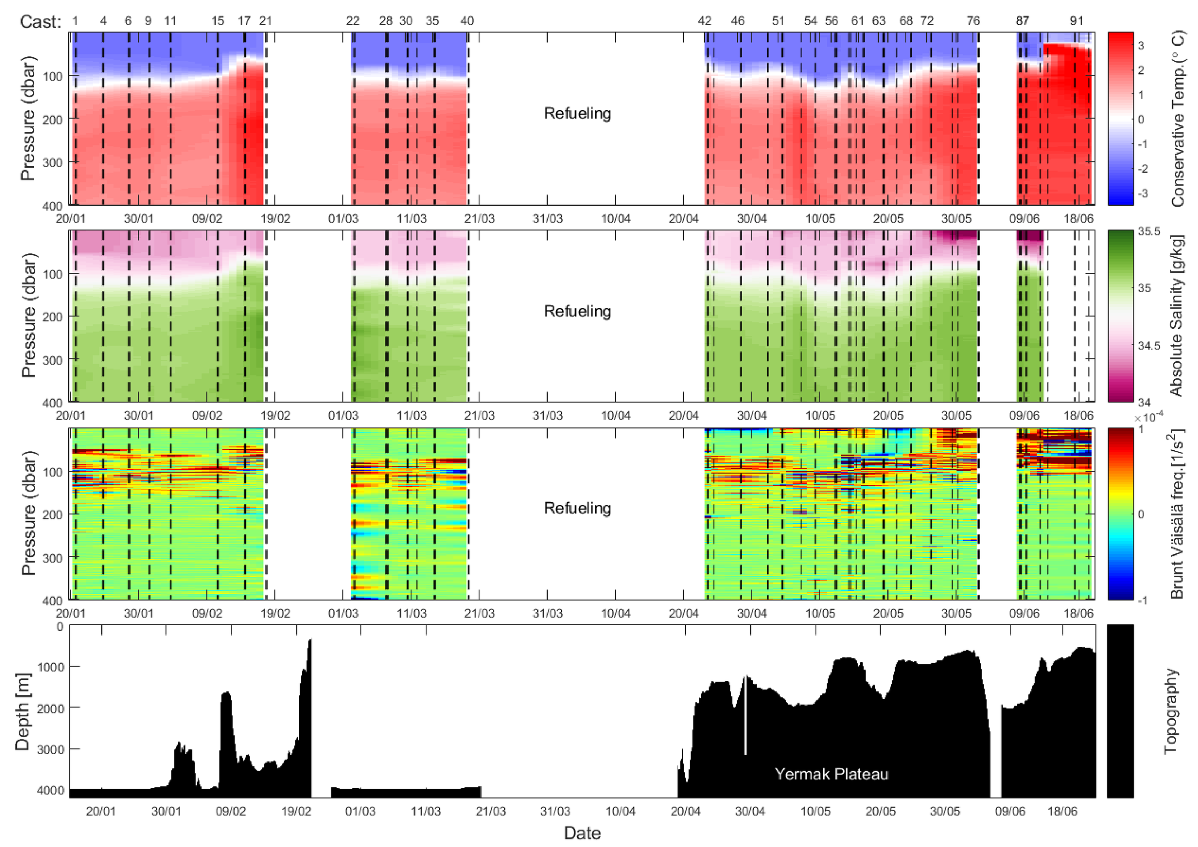

Figure 4: Temperature, salinity and buoyancy frequency (N2) sections for the four drifts from ice-based CTD.

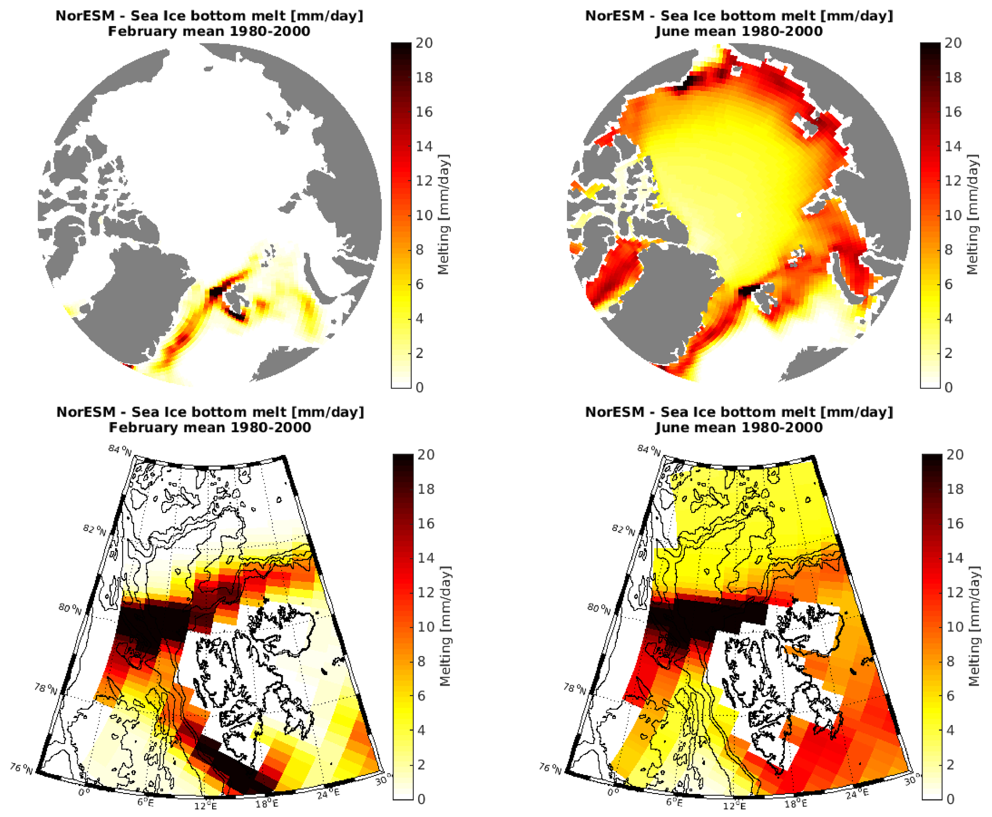

Figure 5: Spatial distribution of mean sea ice bottom melting from NorESM model for February and June (1980-2000).

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References: Granskog et al. (2016), Arctic research on thin ice: Consequences of Arctic sea ice loss, EOS, 97.
Rudels et al. (2000), Water mass distribution in Fram Strait and over the Yermak Plateau in summer 1997. Annales Geophysicae, 18(6):687-705.

Historical data comparison

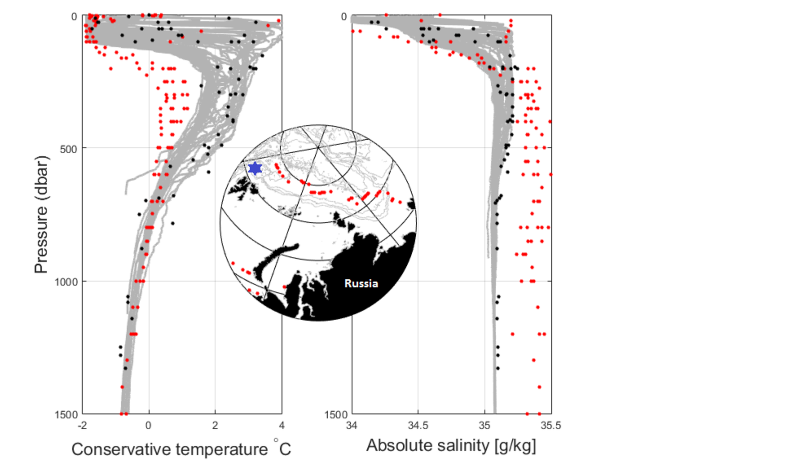

Figure 6: All N-ICE2015 temperature and salinity profiles compared with observations from Nansen's Fram expedition (1895-1897) (red dots) and Sverdrup's measurements from the Nautilus 1931 expedition (black dots).

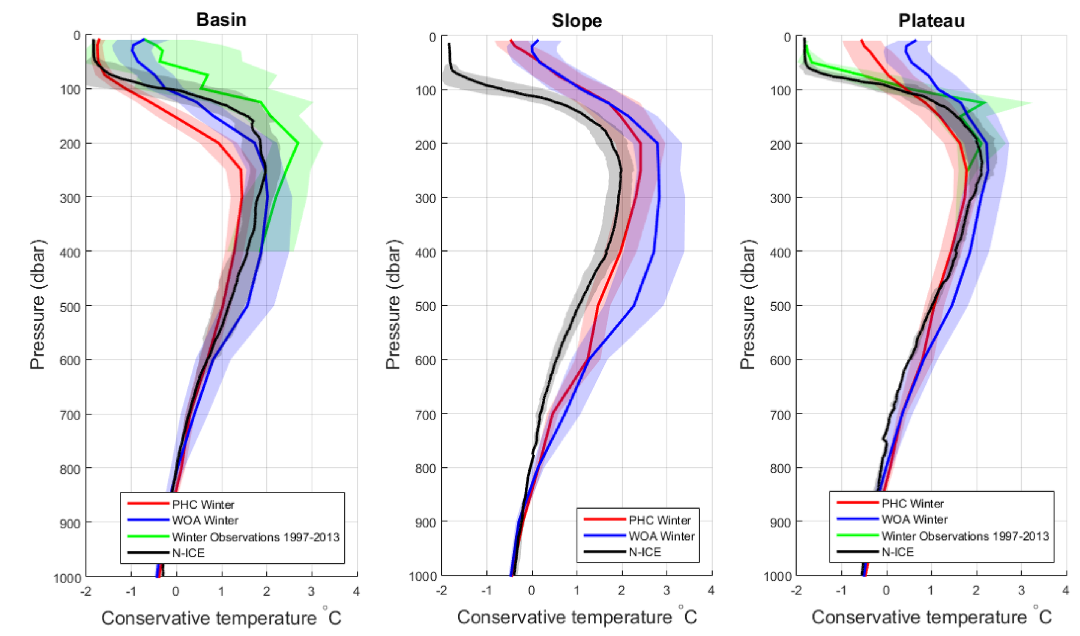

Figure 7: Regional mean temperature profiles from N-ICE2015 compared with PHC3.0 climatology, World Ocean Atlas 2013 climatology, and other available temperature observations in the "N-ICE2015 area" from 1997 to 2013.

Atantic Water Warming

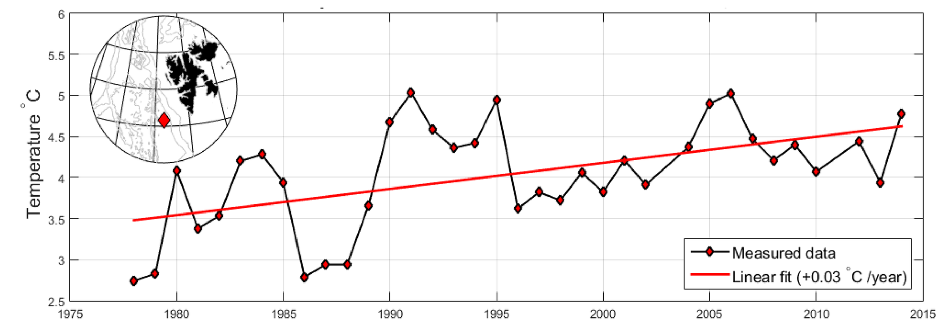

Figure 8: AW core temperature measured in the West Spitsbergen Current (August snapshot 1978-2015), data courtesy of Norwegian Institute of Marine Research (IMR).

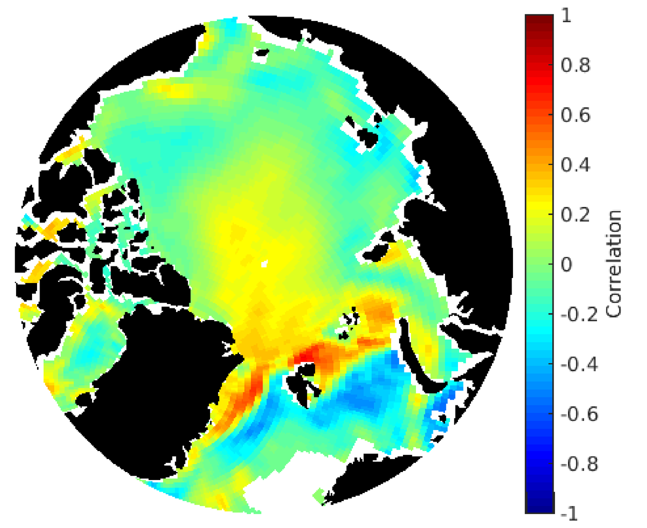

Figure 9: Spatial correlation between changes in annual Fram Strait AW temperatures and sea ice bottom melting simulated by NorESM model between 1954 and 2000.