Field observations of the temporal evolution of meltwater and false bottoms for level ice during MOSAiC expedition

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Abstract

There are a limited number of studies covering the temporal evolution and spatial distribution of under-ice meltwater and false bottoms for Arctic sea ice. At the same time, they both have a significant effect on the desalinization of sea ice and the ice bottom melt rates. Additionally, these observations are an important part of the meltwater budget. The MOSAiC drifting expedition was aimed to collect field data of coupled processes between ice, ocean, and atmosphere. During the melt season ice cores were collected every week from the unponded first- (FYI) and second-year level ice (SYI) of the investigated ice floe. In addition, ice mass balance buoys were installed in the vicinity of two coring sites, but in ponded areas. This allowed for the comparison of snow, ice, melt pond, under-ice meltwater layer, and false bottom thickness evolution, as well as ice and water physical parameters. Despite the 130 m distance between unponded and ponded FYI sites, the thickness of both under-ice meltwater layer and false bottoms was almost identical. For the SYI, the thicker unponded area had a draft below the meltwater layer and experienced only an ice bottom temperature rise to -1.2°C, while for thinner ponded SYI under-ice meltwater layer was observed. The depth of the seawater and under-ice meltwater layer interface was similar for FYI and SYI. The temperature of under-ice meltwater was close to 0°C, above its freezing point with pronounced diurnal cycles. The under-ice meltwater layer formed three weeks earlier below SYI than below FYI. Due to presence of under-ice meltwater, the FYI bulk salinity decreased from both top and bottom to bulk values below typical for multiyear ice due to only top surface flushing. The thickness of under-ice meltwater layer was stable, around 47 cm for FYI and 26 cm for SYI, in contrast to gradually increasing water equivalent of melted snow and ice. This imbalance indicates a significant horizontal transfer of meltwater.

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There is a limited number of studies covering the temporal evolution and spatial distribution of the under-ice meltwater and false bottoms. At the same time, they both have a significant effect on the desalinization of sea ice and the ice bottom melt rates. Additionally, these observations are an important part of the total mass balance of the melt water.

The MOSAiC drifting expedition was aimed to collect field data of coupled processes between ice, ocean, and atmosphere. During the melt season ice cores were collected every week from the unponded first- (FYI) and second-year level ice (SYI) of the investigated ice floe. In addition, ice mass balance buoys were installed in the vicinity of two coring sites, but in the ponded areas. This allowed to compare snow, ice, melt pond, bottom meltwater, and false bottom thickness evolution, as well as ice and water physical parameters.

Despite the 130 m between unponded and ponded FYI sites, the thickness of both under-ice meltwater and false bottom was almost identical. For the SYI, the thicker unponded area had a draft below the meltwater layer and experienced only a warming at the ice bottom up to -1.2°C, while for thinner ponded SYI under-ice meltwater was observed. The depth of the seawater and under-ice meltwater interface was similar for FYI and SYI. The temperature of under-ice meltwater was close to 0, above its freezing point with pronounced diurnal cycles. The under-ice meltwater formed under SYI three weeks earlier than under FYI. Due to presence of under-ice meltwater, the FYI bulk salinity decreased from both direction until values below typical for multiyear ice due to top surface flushing. The thickness of under-ice meltwater layer was stable, around 47 cm for FYI and 26 cm for SYI, in contrast to gradually increasing water equivalent of melted snow and ice. This imbalance indicates a significant horizontal transfer of meltwater.

3 minutes = 450 words

AGU eLightning 3-minutes poster talk

[intro]

Hi everyone. This poster presents a study about the temporal evolution of under-ice meltwater and false bottoms. It is based on the field investigations during May-July 2020 during the MOSAiC expedition. This analysis use data from the ice coring and ROV multibeam sonar.

[left figure]

During the summer season, the meltwater is accumulating above, inside, and underneath sea ice. The under-ice meltwater may form an additional layer of ice at the interface with colder seawater, and this ice layer is called a false bottom. Weekly coring program allowed us to collect physical parameters of first-year ice, meltwater, and false bottoms. On the left image you can see the temporal evolution of salinity and thickness of those three layers. During the melt season the first-year ice salinity decreased from 5 to 1, and the presence of under-ice meltwater doubled loss of ice salt.

While sea ice was melting gradually, this under-ice meltwater appeared instantly reaching its mean thickness of 50 cm. This indicates a significant horizontal transfer of meltwater. The salinity of that meltwater was changing between 4 and 10 with a strong input from the brine flushing.

[central figure]

It is important to know how the presence of this meltwater affects the ice melt. As you can see in the central figure, we had 3% lower ice draft decrease for the ice with false bottoms. Additional 5 % difference can be added from the final thickness of false bottom.

From the sonar measurements of the ice draft, we can see the strong draft increase in the areas with false bottoms, shown here as a black dashed line.

[right figure]

This pronounced draft change allowed us to estimate the areal coverage of false bottoms, which you can see in the right figure as blue-shaded areas. The estimated areal coverage of false bottoms was 21%, which is larger than in most previous observations. We also confirmed an importance of small ridges for keeping this meltwater under the ice. Areas not surrounded with ridges, like the unponded ice in the left bottom corner of the map, didn't have any false bottoms.

[summary]

As a summary, we presented an overview of the temporal evolution of under-ice meltwater and false bottoms. This meltwater appeared instantly and had a stable thickness, defined by the draft of the surrounding ridges.

It also doubled rates of the ice desalinization and slightly decreased ice melt. The areal fraction of false bottoms was defined as 21%.

Thank you.