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Interactive comment on "Combining physical and geochemical methods to investigate lower halocline water formation and modification along the Siberian continental slope" *by* Matthew B. Alkire et al.

Anonymous Referee #2

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This manuscript addresses the Arctic Ocean halocline, its formation and evolution in the eastern Nansen and Amundsen basins. By the use of oxygen-18 data in combination with standard ctd measurements a front in the halocline characteristics is identified north of Severnaya Zemlya. West of the front sea ice melt water dominates in the halocline, while east of the front a stronger presence of meteoric water (runoff & precipitation) is observed. The stronger influence of meteoric water is due to vertical mixing with overlying, less saline water, but I am not sure if the authors also claim that the presence of meteoric water indicates major different sources of the halocline water.

Instead of discuss this issue here, I will first go through the manuscript from the top and then return to this question below.

Specific points: Page 1,lines 26-27: The halocline is not just the "kink" but also includes the water of different TS slope (stronger salinity change) up to the level of the seasonal deepening in winter, if lucky to be identified by a temperature minimum. It should perhaps also be stated that the lower halocline water was introduced by Jones and Anderson (1986) to distinguish it from the nutrient rich upper halocline with salinity around 33.1.

Page 2, lines 6-8: In this scenario the upper layer is formed by melting sea ice and mixing the melt water into the upper part of the Atlantic water creating a fairly saline, cold upper layer. As the upper layer is advected eastward seasonal sea ice melt creates a summer halocline, which is removed by ice formation and brine release in winter, creating a winter mixed layer above the Atlantic water. AS a general remark, I think that the use of an advected halocline versus a convective halocline complicates the picture. The winter mixed layer is advected and homogenized until it becomes covered by an outflow of less saline shelf water. If the shelf water is more saline and denser than the surface layer, it is injected into the water column below the upper layer. In both cases advection as well as convection are involved.

Page 2, lines 11-13: As this description stands, it does not differ from the mechanism described in the paragraph above. As I interpret the schematics in Steele and Boyd (1998) the advective contribution comes from the northern Barents Sea and the northern Kara Sea.

Page 2, lines 13-16: The description of the process proposed by Kikuchi et al. (2004) cannot be correct. Freezing on the Atlantic water at its entrance, should that be possible, would lead to convection and homogenization of the Atlantic layer and perhaps convection to the bottom. A low salinity upper layer must exist for this mechanism to work, creating the bent TS curves.

Page 2, lines 18-23: Rudels et al. (2004) claim that the water from the Barents Sea that eventually contributes to the Barents Sea branch halocline water also is formed by sea ice melting on Atlantic water. The higher salinity compared to the Fram Strait branch halocline water is due to the lower temperature of the Atlantic water when it encounters the sea ice in the eastern Barents Sea.

Page 2, line 29: The Barents Sea branch halocline is initially more saline and eventually it also becomes warmer and thicker due to mixing with underlying Atlantic water.

Page 4, first paragraph: There is no halocline water mass in the Nansen Basin west of Severnaya Zemlya and the thermocline and halocline coincide.

Page 4, line 9: In the supplementary material the depth of the winter mixed layer with salinity >34 ranges between 30m to 94m (L1) and between 42m and 58m (L2). Most of the depths were larger than 50m. (There were also two stations with depths close to 200m on L2 but the temperatures were close to 0C and the salinities >34.8. Should these observations be correct we would have winter mixing into the Atlantic water. This shows that the temperature minimum as a limit for winter convection should be used with care. However, in general it underestimates the winter mixed layer depth.)

Page 5, lines 19-21: Freezing shifts the mixing line between Atlantic water and meteoric water to the right, making it steeper. The Laptev Sea shelf input would then contain more brine than the East Siberian Sea input.

Page 5, last paragraph: Here I am not sure that I follow the authors thinking. As the water from the Nansen Basin (the sea ice melt water branch) becomes covered by les saline shelf water with larger content of meteoric water, vertical mixing with the overlying water will lead to a mixing line with the observed slope. However, the bulk of the halocline water mass is derived from the winter mixed layer advected towards the Laptev Sea. The mixing changes slightly the properties of the halocline, but it does not provide any significant volume. Is this what the authors mean, or do they claim that here exits a major different source of the halocline water containing initially more meteoric water?

Page 6, lines 10-14: Once the low salinity polar mixed layer is formed, any shelf contribution having higher salinity than the polar mixed layer will contribute to the halocline. The question is, how large are these contributions compared with the initial Fram Strait branch and Barents Sea branch contributions?

Page 6, lines 26-28: This description is essentially correct, but why not state explicitly that to create an halocline water mass from the winter mixed layer, this layer has to be capped by a water mass with lower salinity advected from the Laptev Sea shelf?

Page 6, lines 30-32, Page 7, lines 1-5: These mixing examples are interesting, but I think that it would be simpler to think of the winter mixed layer being capped by low salinity water. The initial thermostad and halostad would then be freshened by mixing with the low salinity layer above and heated and become more saline by mixing with the Atlantic water below. This would create the vertical gradients in temperature and salinity that characterize the halocline. Furthermore, I thought that freezing does not fractionate the oxygen isotopes. Brine rejection would then not change the oxygen-18 value. What is the reference for the adopted slope? On page 8, line 13 brine rejection is characterized as “negative sea ice melt”. Would that not give a slope that increases the delta-oxygen-18 value as well as the salinity?

Page 7, lines 6-7: To me the lower halocline water and the cold halocline layer are the same, at least in this location. Once we enter the Canada Basin with Pacific inflow through Bering Strait the situation is different.

Page 7, lines 23-24: I agree with this statement.

Page 8, lines 10-11: Why does the delta-oxygen-18 decreases? A reference is needed.

Page 8, lines 17-21: Does this mean that there are two separate branches of halocline water, or only that when the Fram Strait and the Barents branches cross the front, their upper parts are changed from being homogenized by brine rejection and convection to evolve by mixing with overlying low salinity and underlying Atlantic water?

Figure 1: I would have appreciated to see not only TS curves but also profiles from the different sections.

Summary: My concern about this manuscript should be clear after the comments above. If the authors mean that there are two distinct branches, one sea ice melt branch and one meteoric water branch, they have to argue their case better. If it is only a transition between the two branches across the front, the manuscript does not bring much new information. However, the use of the oxygen-18 data is interesting, but some of the adopted slopes have to be explained better.

The manuscript might be published after major revisions, some based on my comments given above.

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