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Discussions

Interactive comment on "Observations of brine plumes below Arctic sea ice" *by* Algot K. Peterson

Anonymous Referee #2

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Overall, this is a nice dataset that has been carefully analyzed, but the presentation and arguments could use some improvement. The ability to compare salinity changes in the ice, due to melting of the ice or changes in storage / drainage, and the turbulent salt fluxes in the ocean is novel, and a revised version should be published in the literature. My suggestions below are primarily asking for clarification and expansion of some of the points made in the paper, and I recommend it be published after major revisions.

Major comments:

Anti-correlated fluxes: As presented, I am left wondering about other processes besides brine from the ice that would result in correlated fluxes. The results section should begin with an overview of the salinity changes to the ice. Otherwise, the assertion (page 4 paragraph at line 19) that salinity fluxes are due to brine drainage is simply an assertion. There is a consistent story here, but it is somewhat confusing as

presented. In addition, the following two points may warrant a brief mention:

- Anti-correlation of heat and salt fluxes could also result from entraining water from beneath the mixed layer base during the June 13 storm. But if the water beneath the mixed layer is warm (shown in Fig 3) and salty (?), it would not explain the negative salt fluxes. This should be explicitly stated (that entrainment from below cannot explain the correlated fluxes), and Figure 3 should be altered to show salinity profiles/transects.

- Anti-correlation could also result from a mixed layer at the freezing temperature, for which salty water is cold. If a parcel of salty water at the freezing temperature moves downwards, then it will have negative salt fluxes and positive heat fluxes (e.g., Cole et al., 2014; Randelhoff et al. 2014). Figure 5a shows that maximum heat fluxes are associated with water very close to the freezing temperature for the plumes, is this also true for the 15-min or 3-hour timescale? A correlation between T and S is a simple explanation for the correlated fluxes.

Cole ST, Timmermans M-L, Toole JM, Krishfield RA, Thwaites FT, 2014: Ekman veering, internal waves, and turbulence observed under Arctic Sea Ice, J. Phys. Oceanogr., 44, 1306-1328.

Randelhoff A, Sundfjord A, Renner AHH, 2014: Effects of a shallow pycnocline and surface meltwater on sea ice-ocean drag and turbulent heat flux, J. Phys. Oceanogr., 44, 2176-2190.

The uppermost meter of the ice: The assertion seems to be that the uppermost meter of the ocean is stratified with fresh meltwater remaining shallow while the brine plumes are able to penetrate through this fresh layer (Page 13, line 17-18 'Such plumes...'). Is this correct? And how is the uppermost meter of water not a) fresh, and b) well mixed due to the turbulence and large ice speeds?

Brine salinity: More careful treatment of the bulk salinity of the ice (5, fresh to the ocean), versus the salinity of the brine (presumably of higher salinity than the ocean) is needed. Overall, how does drainage of water with a salinity of 5 (ice+brine on average?) cause a negative salt flux? The ocean should 'see' it as fresh water flowing downwards, which is a positive salt flux. Are the plumes 'visible' to the ocean only when there is no active melting during those 10 second bursts?

The link between the turbulent scale processes and larger-scale picture is not complete:

- What does averaging Figure 4 in a distance framework look like? What is the characteristic horizontal scale of the plumes? Roughly, 10 s x 0.23 cm/s = 2 cm width. There is a missing link between some of the arguments about turbulent features at these small scales (2 cm) and the larger scale arguments regarding salty water dragging over fresher water in a marginal ice zone. The later would suggest a much larger-scale instability.

- Salty plumes are observed for a wide range of 15-min or 3 hour salt flux values. Are plumes of salty water traveling upwards observed? What about freshwater traveling downwards? To what extend are these 10 s plumes dominating the 15 minute or 3 hour average?

Additional comments:

- Consider a more descriptive title, e.g., Observations of sea ice desalination and turbulent brine plumes beneath melting Arctic sea ice.

- Why aren't the other TIC measurements discussed here? Is there something unique about this ice floe (floe 4) that leads to brine plumes, or was it simply more heavily instrumented / sampled?

- page 2, line 12: is this really the first observation? What makes it so?

- page 3, lines 7-12: a reference to Section 6, which has some additional details on processing would be useful.

- Page 9, line 19: is the net change in salt content (2.8 kg/mˆ2) a decrease?

- Page 9, line 18 to page 11 line 7: reading this paragraph, it would be useful to refer to Figure 2, and to have Figure 2 show the two estimates of salinity loss (ice cores and salt fluxes).

- Page 14 line 4-10: how much data was excluded from analysis due to the various processing procedures? Some detail here is warranted even if it is described elsewhere.

- Page 15 line 25-26 ('In the interior...'): Why? There is still seasonal melting in the interior that melts ice. Isn't the brine release related to the volume of ice melted? I am missing the connection to processes that happen in the marginal ice zone.

- Section 7: What are the specific conclusions of this work? I find it difficult to state this explicitly, and would like to see the final section expanded with such a statement.

- Figure 1: Please indicate the start location for the drift. Consider also just showing the floe 4 drift track.

- Figure 3: Yellow lines are difficult to see. Add in something that indicates mixed layer depth (panel a and/or b), and a salinity section or salinity profiles.

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