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The Cryosphere Discussions

Interactive comment on "Interannual variability in Transpolar Drift ice thickness and potential impact of Atlantification" *by* H. Jakob Belter et al.

Anonymous Referee #1

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Overall comments

Belter et al provide a timely study on summer sea ice thickness (SSIT) in the Transpolar Drift given the rapid changes of Arctic sea ice. This will certainly be relevant for the readership of the Cryosphere. It is generally well written and provides a interesting analysis of existing SIT data, however there are few critical points that should be addressed before this work can be published. Most critically this does now provide a biased examination of all the factors that could contribute to changes in SIT, namely ice growth (snow insulation or snow-to-ice transformation or ocean heat flux or larger solar heat accumulation in the ocean prior to ice growth) or ice melt (solar and longwave heating and surface ice melt or variable ocean heat). Especially the year-to-year variations of all these factors can be large now many set constant. Further quite some pertinent studies in different parts of the Transpolar drift are not referred to in the text and this needs to be corrected. Thus I can only recommeed this paper for publication after major revisions when the below major and minor points have be taken into account appropriately.

Major specific comments

There has been earlier work in parts of the Transpolar Drift, and I think the authors should ackowledge these earlier works better than only refer to own work. This includes work from the NPEO (e.g. McPhee et al. 2003, Perovich et al. 2014) and more recently from N-ICE (e.g. Merkouriadi et al. 2017, Graham et al., 2019). e.g. Perovich et al 2014 did comprehensive work with IMBs and this should be used to validate the simplied modeling of the ice growth and melt, especially when surface melt can be as important as bottom melt and vary significantly year to year, and this is not properly taken into account in the model that is used?

Provide a detailed comparison to SIT observations from ULS in Fram Strait. Although airborne data has been collected over several years, these data also suffer from covering only a shorter period and also somehwat at different times of year which SIT observations can be sensitive to. The consistent time series over several decades of ULS sea ice thickness in Fram Strait should to validate/corroborate the findings from airborne observations used in this paper. I believe it is a valuable analysis how representative the continuous ULS observations in the Fram Strait are for SIT in the Transpolar Drift. A recent update to the ULS SIT time-series was recently published by Spreen et al. (2020) which should be critically compared to the SIT data from AOI. This data also gives better temporal resolution to indicate possible periods of SIT change.

The role of snow. Several recent studies have pointed to the importance of snow, and large gradients exists in the snowfall in the Transpolar drift, and also the timing of sea-ice freeze-up, relative to timing of snow precipiation, greatly affects to growth of both FYI (new ice) and SYI/MYI. The studies by Merkouriadi and co-workers (2017, and

2020 GRL and 2020 Ann. Glac.) analyse aspects of effects of the snow cover in parts of the Transpolar drift, that should at least be discussed in this paper (Introduction and Discussion). Also Rösel et al. (2018) shows that at the "end" of the transpolar drift snow depth can be much larger than the Warren climatology (and especially much larger than 50% of Warren climatology that is used in this study), this will evidently affect ice growth.

In a similar manner the choice of a constant ocean heat flux value can be very importnat for the ice growth but also melt in summer, again some observational data in the Transpolar Drift are not taken into account. Using values from previous studies does not make it right. At least a sensitivity study should be made with using seasonal ocean heat fluxes (see e.g. Merkouriadi et al. 2017, based on McPhee et al 2003).

When you have kept the ocean heat flux and surface melt constant does this not mean that the only driving force for variation is FDD and it is partly an autocorrelation that SIT and FDD follow each other? By using constant values for some factors does not mean they are non-important in real world. Discussion needs to include a more balanced view on the different factors that can affect the SIT, given the approach used it is almost given the only allowed to induce year-to-year variation is FDD.

Detailed comments

To numerous to be listed here.

These are provided in the annotated pdfs of the manuscript and the Supplemntary materials, which also provide more details on what needs to be clarified and what needs to be added to satisfy my first order concerns.

Note that comments to the Sup Mat are at the very end of the pdf.

The above comments requires inclusion and discussion of these relevant studies for understanding sea ice in the Transpolar drift, including;

Graham, R. M., Itkin, P., Meyer, A., Sundfjord, A., Spreen, G., Smedsrud, L. H., et al. (2019). Winter storms accelerate the demise of sea ice in the Atlantic sector of the Arctic Ocean. Scientific Reports, 9(1), 9222. https://doi.org/10.1038/s41598-019-45574-5

McPhee, M. G., Kikuchi, T., Morison, J. H., & Stanton, T. P. (2003). Ocean-to-ice heat flux at the North Pole environmental observatory. Geophysical Research Letters, 30, 2274. https://doi.org/10.1029/2003GL018580

Merkouriadi, I., Cheng, B., Hudson, S. R., & Granskog, M. A. (2020). Effect of frequent winter warming events (storms) and snow on sea-ice growth – a case from the Atlantic sector of the Arctic Ocean during the N-ICE2015 campaign. Annals of Glaciology, 1–7. https://doi.org/10.1017/aog.2020.25

Merkouriadi, I., Liston, G. E., Graham, R. M., & Granskog, M. A. (2020). Quantifying the Potential for SnowâĂŘIce Formation in the Arctic Ocean. Geophysical Research Letters, 47(4), e2019GL085020. https://doi.org/10.1029/2019GL085020

Merkouriadi, I., Cheng, B., Graham, R. M., Rösel, A., & Granskog, M. A. (2017). Critical Role of Snow on Sea Ice Growth in the Atlantic Sector of the Arctic Ocean. Geophysical Research Letters, 44(20), 10,479-10,485. https://doi.org/10.1002/2017GL075494

Perovich, D., Richter-Menge, J., Polashenski, C., Elder, B., Arbetter, T., & Brennick, O. (2014). Sea ice mass balance observations from the North Pole Environmental Observatory. Geophysical Research Letters, 41(6), 2019–2025. https://doi.org/10.1002/2014GL059356

Rösel, A., Itkin, P., King, J., Divine, D., Wang, C., Granskog, M. A., et al. (2018). Thin Sea Ice, Thick Snow, and Widespread Negative Freeboard Observed During N-ICE2015 North of Svalbard. Journal of Geophysical Research: Oceans, 123(2), 1156–1176. https://doi.org/10.1002/2017JC012865

Spreen, G., Steur, L., Divine, D., Gerland, S., Hansen, E., & Kwok, R. (2020). Arctic Sea Ice Volume Export Through Fram Strait From 1992 to 2014. Journal of Geophysical Research: Oceans, 125(6). https://doi.org/10.1029/2019JC016039

Wang, C., Granskog, M. A., Hudson, S. R., Gerland, S., Pavlov, A. K., Perovich, D. K., & Nicolaus, M. (2016). Atmospheric conditions in the central Arctic Ocean through the melt seasons of 2012 and 2013: Impact on surface conditions and solar energy deposition into the ice-ocean system. Journal of Geophysical Research: Atmospheres, 121(3), 1043–1058. https://doi.org/10.1002/2015JD023712

Please also note the supplement to this comment:
https://tc.copernicus.org/preprints/tc-2020-305/tc-2020-305-RC1-supplement.pdf

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