The paper describes assimilation of Cryosat-2 winter sea ice thicknesses (SIT) in the Met Office sea ice analysis system. The paper's main novelty is that Cryosat-2 CPOM along-track observations were used as opposed to averaged gridded and temporally-averaged products, and modelled snow thickness values were employed to convert ice freeboards to ice thicknesses as opposed to the conventionally used Warren's snow thickness climatology. Verification of the control (no SIT assimilation) and SIT assimilation experiments against various SIT observations is presented. The paper claims that there is some indication of the usefulness of assimilating Cryosat-2 winter SIT observations in sea ice numerical systems, but the results are mixed and not convincing. I believe that the paper is currently not suitable for publication and the following comments should be addressed before the paper can be considered for publication again.

General Comments:

My main concern is that the paper does not contain a clear evidence that assimilation of CPOM Cryosat-2 retrievals helps to bring modeled SIT closer to the reality. The large improvement in SIT analysis is observed when compared against Cryosat-2 biased data themselves (although not yet assimilated), and I think this improvement simply comes from the memory of the previously assimilated Cryosat-2 SIT observations. But such a result is expected regardless the quality of the assimilated Cryosat-2 observations. Thus, how are the authors confident that assimilation of Cryosat-2 observations does actually bring modeled SIT closer to the reality? Particularly, given the fact that degradation is observed when compared against ULS and EM induction data. There is some improvement with respect to Ice Bridge data, but the amount of data is limited. Overall, the paper presents mixed results which do not allow one to conclude that the currently used Cryosat-2 retrievals could be considered ready for data assimilation purposes. I believe, that much more work needs to be done to improve the quality of Cryosat-2 ice thickness retrievals before considering them appropriate for assimilation.

The authors should consider improving the Cryosat-2 freeboard retrievals by taking into account various sources of uncertainty due to various effects including:

(1) the effect of brine-wetted snow reported and quantified in (Nanden et al. 2017)
(2) the effect of surface roughness described and quantified in (Landy et al. 2020)
(3) the effect of ice type, i.e., increased Ku-band signal penetration in multi-year ice (MYI) compared to the first-year ice potentially leading to freeboard underestimation for MYI (Xia and Xie, 2018)

The authors could also consider using additional independent data sources for verification SIT analyses such as ice charts.

The authors report that the sea ice model retains improvements to the SIT field throughout the summer months, due to winter SIT assimilation. However, (Bushuk et al., 2020) investigated a so-called "Arctic spring predictability barrier", and they found that initializing sea ice models with SIT observations prior to May/June is not beneficial for

predicting summer sea ice, and, therefore, summer ice thickness observations are strongly required. The authors should discuss in the paper how their results correspond to the previous findings in (Bushuk et al., 2020, Bonan et al., 2019).

References:

Nandan, V., Geldsetzer, T., Yackel, J., Mahmud, M., Scharien, R., Howell, S., et al. (2017). Effect of snow salinity on CryoSat-2 Arctic first-year sea ice freeboard measurements. Geophysical Research Letters, 44, 10419– 10426. https://doi.org/10.1002/2017GL074506

Landy, J., Petty, A., Tsamados, M. & Stroeve, J., 2020. Sea ice roughness overlooked as a key sourceof uncertainty in CryoSat-2 ice freeboard retrievals. J. Geophys. Res. Oceans, 125(5), p.e2019JC015820.

W. Xia and H. Xie, “Assessing three waveform retrackers on sea ice freeboard retrieval from CryoSat-2 using operation IceBridge Airborne altimetry datasets,” *Remote Sens. Environ.*, vol. 204, pp. 456–471, Jan. 2018.

Bushuk, M., Winton, M., Bonan, D., Blanchard-Wrigglesworth, E., & Delworth, T. (2020). A mechanism for the Arctic sea ice spring predictability barrier. Geophys. Res. Lett., 47(13). doi:10.1029/2020GL088335

Bonan, D., Bushuk, M., & Winton, M. (2019). A spring barrier for regional predictions of summer Arctic sea ice. Geophys. Res. Lett., 46(11), 5937-5947. doi:10.1029/2019GL082947

Specific Comments:

Line 1 and throughout the text. Usually, abbreviation is given in parentheses, i.e., “SIT (sea ice thickness) → “sea ice thickness (SIT)”.

Line 51. “from retrievals of brightness temperature” → “from L-band brightness temperature measurements”.

Line 100. “Temperature profiles are also obtained from marine mammals.” What does this actually mean?

Equation (3). Please define *e*

Tables 2, 3, and 4. Please add dimension (m) where appropriate to the first column of the table.

Line 420. “may indicate spatial noise” → “may indicate that spatial noise”