The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-215-AC1, 2020

The Cryosphere Discussions

Interactive comment on "Long-term variation of sea ice and its response to thermodynamic factors in the Northwest Passage of the Canadian Arctic Archipelago" *by* Xinyi Shen et al.

Xinyi Shen et al.

xyshen9676@163.com

Received and published: 24 September 2020

Responses to Reviewer #1

General comment The first problem is the quality of the data used in this study which has major implications for the results they present and the conclusions they draw. 1. The quality of AO-FVCOM sea ice thickness estimates within the CAA has not been assessed/validated and therefore it is unknown how much uncertainty there is and how much the results can be trusted. I looked at the Zhang et al. (2016b) JGR paper and I noticed all the in situ measurements were outside the CAA so in fact, there was no sea ice thickness validation done in the CAA. There are in fact in situ measurements of

ice thickness as well as airborne EM induction data which could be used for validation (e.g. Haas and Howell, 2015; Howell et al., 2016). Furthermore, there have been major recent assessments of model performance in the CAA which have not been cited (e.g. Howell et al., 2016; Kushner et al., 2018; Laliberté et al., 2018). These uncited studies the authors have missed relate the problem with state-of-the-art climate models having difficultly resolving sea ice thickness within the CAA (Howell et al., 2016; Laliberté et al., 2018). In short, the authors have not provided enough evidence to state that the AO- FVCOM is any better than other models whereby large over estimation in the trends was found to be problematic in the CAA.

Answer: - We appreciate the reviewer's helpful comments. We have revised the manuscript to add the new validation using the observed sea ice thickness of Canadian Ice Services (CIS) the reviewer recommends from Howell et al., 2016. There are two sites in our study region which is Cambridge Bay and Resolute. We did the detailed comparison between the simulated results and these two observed sites. The results are shown below. - From 1979 to 2017, AO-FVCOM captured the seasonal variation feature of sea ice thickness in the Cambridge Bay and Resolute (Figure 1). Howell et al., 2016 suggested that some other models overestimated the sea ice thickness in these two sites. For example, the root mean square error (RMSE) between PIOMAS and observed sea ice thickness was 0.29 cm at Cambridge Bay and 0.68 cm at Resolute. The value of our simulated sea ice thickness was also larger than the observed data. However, compared with other models, the RMSE between our simulation and observations was reduced to 0.18 m at Cambridge Bay and 0.52 m at Resolute (Figure 2, Table 1). The seasonal variation of sea ice thickness was also captured well by the simulation. In addition, Howell et al., 2016 compared the trend of maximum sea ice thickness and found that the simulated result showed larger trend. We also did the same analysis and the results was reasonable (Table 1). In the Resolute, both observation and simulation showed very close decreasing trend of maximum sea ice thickness with the value of -0.07 m/10a and -0.06 m/10a. In the Cambridge Bay, maximum sea ice thickness exhibited observed and simulated decreasing trend of -0.07 m/10a and

-0.12 m/10a, respectively. This difference was also smaller than the models Howell et al., 2016 mentioned.

2. Another data quality problem not discussed by the authors is from altimetry sea ice thickness estimates within the CAA. Sea ice thickness retrievals from satellite altimetry are highly uncertain within the majority of the CAA (certainly the NWP) because there no leads (see Landy et al., 2017).

Answer: - We agreed with the reviewer's comment and we will revise the manuscript to add the discussion and related reference about the quality problem and uncertainty of satellite altimetry sea ice thickness. This would help the readers to further understand the satellite data.

The second problem is the lack of new information on sea ice conditions within NWP. 1. For example, the authors are incorrect to state that "only a few studies have focused on the sea ice conditions in the NWP", "sea ice conditions in the NWP rarely have been examined based on subregional divisions" and "only sea ice concentration has been taken into account in most previous research." Almost every study the authors cite and the numerous they do not cite (because they missed a lot) all do this (e.g. Howell et al., 2008; Tivy et al., 2011; Derksen et al., 2012; Haas and Howell, 2015; Mudryk et al., 2018) and as a result, the justification for this study very weak and then when I got to the results I found that there was not really any new information that is not already known. For example, they boldly state that "Furthermore, exploration of the driving mechanisms that influence the sea ice variation in the NWP was insufficient in prior research because atmospheric and oceanic thermodynamic factors exert significant effects on the sea ice conditions." I do not think the author's have immersed themselves in the literature sufficiently to make this bold statement and their results are certainly less rigorous than previous studies (see Tivy et al., 2011 for links to SAT). Moreover, there is not one reference to previous studies in Section 3-4 of this manuscript and there is a vast body of work on CAA trends/variability which should have at least been compared to. Another is example of a lack of understanding is evident when discussing

why the correlation between SAT and sea ice thickness is low. The author's completely ignored (or missed) that the reason is because snow thickness has been found to be the primary driver of ice thickness within the CAA not SAT (see Brown and Cote, 1992 and Howell et al., 2016).

Answer: - We apologize some statements cause the misunderstanding for the reviewer. For the statements reviewer mentioned, the original purpose is to suggest that only a few studies selected the NWP as the only research domain. The references the reviewer recommended cover the whole CAA and the NWP is only one of their research domains. That is the reason why we did not cite these references. We appreciate the reviewer's helpful comment and we will add the references, remove the inappropriate words and revise the manuscript to avoid the misunderstanding. - Due to the limit of observed sea ice thickness in the NWP, the understanding of temporal and spatial variation of sea ice thickness needs to be enhanced. Since this study is only focused on the NWP, it provides a more detailed study of long-term variation of sea ice condition by dividing the NWP into ten major subregions. The results of sea ice thickness in these subregions including the completed temporal and spatial variation, the distribution of seasonal change rate and the relation with sea surface temperature and surface air temperature were introduced and discussed separately. Additionally, the specific shipping routes along the northern and southern routes were evaluated and selected with the consideration of both sea ice concentration and thickness data. These findings could give us further insight into the understanding of sea ice condition in the NWP. - In addition, we followed the reviewer's suggestion that we will add the references and compared the previous studies of CAA trends/variability with ours. - For the correlation between sea ice concentration and thickness with SAT and SST (section 4), we will add more discussion to explain the reason why the correlation between sea ice thickness and SAT is low.

We are working on the revised manuscript and we will attach a draft revision and highlight the revised places. After getting the comments from other reviewers, we

will make further revision. Hopefully, these answers and revisions could meet the reviewer's requirement.

Please also note the supplement to this comment:
https://tc.copernicus.org/preprints/tc-2020-215/tc-2020-215-AC1-supplement.pdf

---

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-215, 2020.

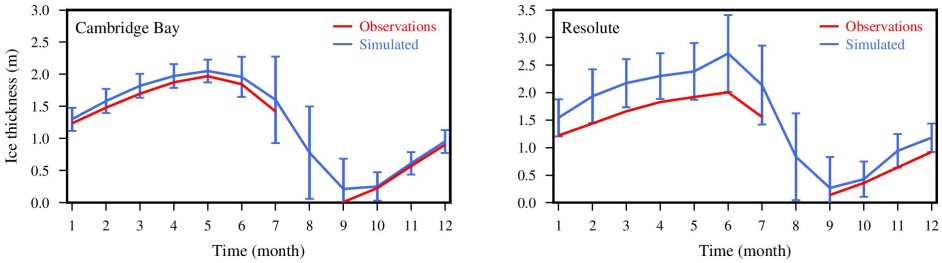

Fig. 1. Figure 1. Seasonal variability of the sea ice thickness from CIS (red curve) and AO-FVCOM (blue curves) over the period 1979–2017.

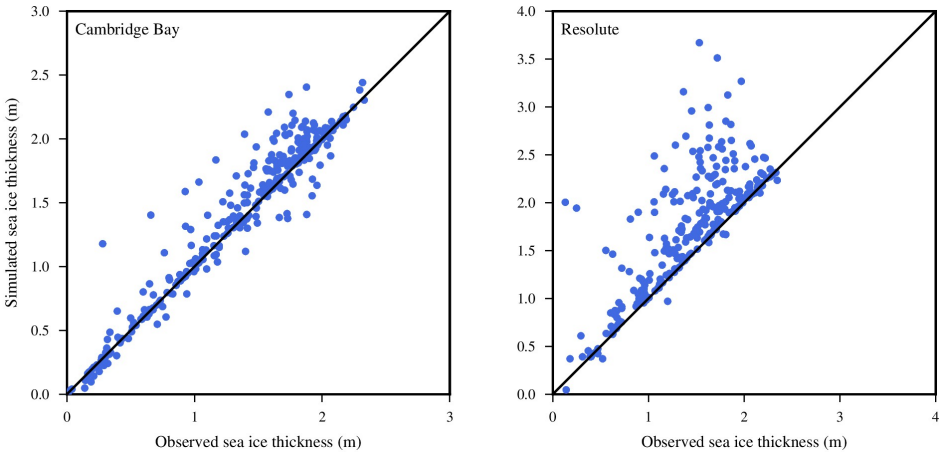

Fig. 2. Figure 2. Comparison of AO-FVCOM sea ice thickness with sea ice thickness observations over the period 1979–2017.

	Cambridge Bay		Resolute	
	Observations	Simulation	Observations	Simulation
Mean sea ice thickness (m)	1.32	1.38	1.41	1.73
Trend of sea ice thickness (m/10a)	-0.07(p<0.05)	-0.12(p<0.01)	0.03	0.00
Trend of maximum sea ice thickness (m/10a)	-0.07(p<0.05)	-0.12(p<0.01)	-0.07(p<0.05)	-0.06
Mean absolute differences (m)	0.10		0.33	
Correlation coefficient	0.96(p<0.01)		0.77(p<0.01)	
RMSE (m)	0.18		0.52	

Fig. 3. Table 1. Mean sea ice thickness, trend and maximum sea ice thickness trend of observations and AO- FVCOM in the Cambridge Bay and Resolute, and mean absolute differences, correlation coefficient, RMSE