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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.

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Major comments

1. Long-term variation of sea ice and its response to thermodynamic factors in the Northwest Passage of the Canadian Arctic Archipelago author by Shen et al. The manuscript (MS) is interesting and fits with the scope of the journal but unfortunately, the data and the interpretation are not well presented. As the authors have highlighted in the MS title "response to thermodynamic factors", but fail to justify the factors. The authors have discussed only the relation with SST and SAT. To understand thermodynamics, we should know the mixed layer depth (MLD), then only we could know the

ocean heat transport. In my opinion, the article cannot be published in that form needs a lot of substantial improvements and modifications: I, therefore, suggest the article cannot be accepted in the present form.

Answer: We apologize our title of "thermodynamic factors" cause the misunderstanding for the reviewer. The reviewer suggested us to add other two thermodynamic factors including MLD and ocean heat transport into the manuscript. Based on the original title, the study should cover more thermodynamic factors including heat flux and MLD. Since the complicated interactions between sea ice and different thermodynamic factors, the study of each factor needs a lot of analysis, experiments and data support before getting some valuable conclusions. The research of each factor could be discussed in detail as a separated paper. This study mainly focused on the detailed relation of surface atmospheric temperature (SAT), sea surface temperature (SST) with sea ice concentration and thickness in the NWP which examined the spatial difference of impact of SAT and SST on sea ice condition. To make the content clear, we will modify the title to "Long-term variation of sea ice and its response to surface atmospheric temperature and sea surface temperature in the Northwest Passage of the Canadian Arctic Archipelago". Considering the length of article, we will do the study of other thermodynamic factors including MLD and ocean heat transport in the future study.

2. The abstract is very simple and doesn't show the novelty of the pertaining long-term sea ice and its response to thermodynamic factors. After reading the abstract I could see authors have just given the decadal observation of SIC and their correlation with SST and SAT. This section is drafted very poorly with the unfocused aim and finding highlights. Although the approached techniques are good but not justified by the authors in their explanations. Suggested to be more focused and rewrite the abstract. This section is lacking with clear aim and objective of the work as well as the concluding remarks/novelty of the work. Need to be more specific about the computational and processing techniques. The sea ice thickness data for the Canadian Arctic Archipelago were utilized from for the model output of the AO- FVCOM. I could not see any data

validation and any specific reasons for choosing this model. If any such study may be given. Data and methods are not complete need to be elaborated properly. I could not find any analysis details. Sea ice extent data details and analysis are missing how SIE was calculated? How the authors have divided the NWP into 10 subregions? What was the criteria or reference have been considered to divide the CAA? Materials and methods are poorly written and incomplete.

Answer: We appreciate the reviewer's suggestion and have revised the manuscript. We will revise our abstract with more focused aim and finding highlights. For the comment about computational and processing techniques, we have added more detailed descriptions of the analysis methods. The ice extent was calculated by the ice concentration and the control area of each grid. The ice extent was the sum of areas with sea ice concentration greater than 0.15 in the NWP. We will add the formula in the manuscript. For the comment about the validation of model result, we have added the new comparison with observed sea ice thickness of Canadian Ice Services (CIS) and provided exact measure of mean absolute differences, correlation coefficient and RMSE (Table 1, Figure 1). Both the comparison with CIS and CS2SMOS all showed the AO-FVCOM could reasonably reproduce the sea ice thickness in the NWP and the error was less than other models. In addition, the reason we divided the NWP into 10 subregions is based on the map of CAA (Sou and Flato, 2009) and the route of NWP. The NWP was divided into ten subdomains. Reference: Sou, T., & Flato, G. (2009). Sea ice in the Canadian Arctic Archipelago: modeling the past (1950-2004) and the future (2041-60). Journal of Climate, 22(8), 2181-2198.

3. Authors have represented their results in just quantitative way in terms of spatial and temporal changes of SIC, SIE and SIT although sea-ice parameters have been published earlier by several authors sector-wise of whole Arctic regions. The MS is lacking with process and mechanism. Authors have attempted to explain the variations with only SST and SAT, this study needs to be extended by considering ocean heat transport and budget. The sea ice declining processes and their forcings are must be

highlighted. In this present form, the paper is not recommended for publication.

Answer: Similar answer with major comment 1. Through modifying the title to make the present manuscript focus on SAT and SST, we will do further study of other thermodynamic factors in the future work. Hopefully the reviewer could reconsider our manuscript based on the work we have done.

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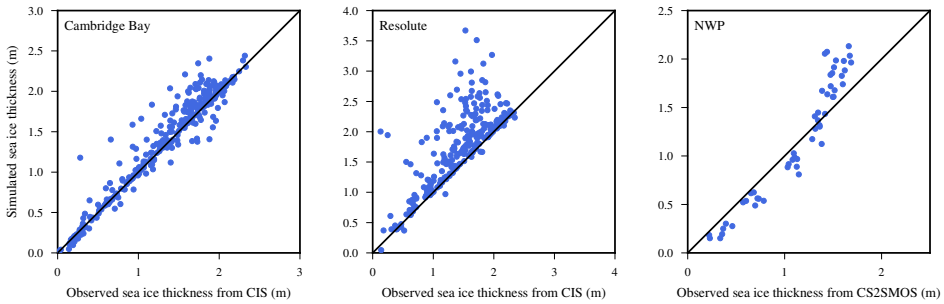

Fig. 1. Comparison of AO-FVCOM sea ice thickness with sea ice thickness observations over the period 1979–2017.

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 between observations and AO-FVCOM.

	Cambridge Bay		Resolute		NWP	
	Observations	Simulation	Observations	Simulation	CS2SMOS	Simulation
Mean sea ice thickness (m)	1.32	1.38	1.41	1.73	1.13	1.19
Trend of sea ice thickness (m/10a)	-0.07 (p<0.05)	-0.12 (p<0.01)	0.03	0.00	-0.02	-0.09
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	-0.15	-0.15
Mean absolute differences (m)	0.10		0.33		0.20	
Correlation coefficient	0.96 (p<0.01)		0.77 (p<0.01)		0.96 (p<0.01)	
RMSE (m)	0.18		0.52		0.25	

Fig. 2.