Response to the reviews of "An improved regional coupled modeling system for Arctic sea ice simulation and prediction: a case study for 2018" by Chao-Yuan Yang, Jiping Liu, Dake Chen

Response to comments by Reviewer #2

We would like to thank the reviewer for the helpful comments on the paper.

General comments:

This is my second time to review this manuscript. Comparing to the previous version, the authors have done a lot of works to address my major concerns and those of the other reviewer. Specifically, many details relating to the involved parameterizations in WRF, ROMS and CICE, the changes in ice, atmospheric and oceanic states, and the ice mass budget analysis in CICE have been added into the revised manuscript. Based on my evaluation, now the manuscript could be done as a minor revision.

Specific comments:

Line 204-208: The description of "ice mass budget analysis" in CICE is quite brief. The authors should introduce it in details because of that lots of the following paragraphs relate to the method.

Response: Thanks for the reviewer's suggestion. In this revision, we added more descriptions of the sea ice mass budget analysis. Now it reads "In order to understand physical contributors that drive the evolution of Arctic sea ice state (the standard variables of the ice concentration and thickness), the mass budget of Arctic sea ice for all experiments is analyzed in this study as defined in Notz et al. (2016, Append. E), including:

- **sea ice growth in supercooled open water (frazil)**
- **sea ice growth at the bottom of the ice (basal growth)**
- **sea ice growth due to transformation of snow to sea ice (snowice)**
- **sea ice melt at the air-ice interface (top melt)**

- **sea ice melt at the bottom of the ice (basal melt)**

- **sea ice melt at the sides of the ice (lateral melt)**

- **sea ice mass change due to dynamics-related processes (e.g. advection) (dynamics)**

These diagnostic variables are determined by saving the ice mass tendency of above processes separately every time step and integrated to output the daily-mean value."

Line 262: the authors should notice that Y21_CTRL generates colder bias (worse result) than Y20_MOD in the central Northern Atlantic in August, as a complementary to the better result of "especially over eastern Siberia and the Atlantic sector in July to September"

Response: Thanks for the reviewer's comment. In this revision, we modified the text to reflect this. "The Y21_CTRL experiment with the RAP physics tends to reduce the prediction errors in Y20_MOD, especially over eastern Siberia and the Atlantic sector in July to September (Fig. 2g-i). However, Y21_CTRL results in larger bias in the central Northern Atlantic in August than that of Y20_MOD (Fig. 2h)".

Line 297: change Y20_CTRL to Y21_CTRL and Y21_MOD to Y20_MOD

Response: Thanks. We corrected them.

Line 321-323: This is a comment (NO need to reply). Atmospheric heat flux at ice surface and oceanic heat flux at ice bottom contribute more "directly" to sea ice area and sea ice thickness change, rather than sea ice extent change, as sea ice extent change is also affected by wind forcing and ocean currents.

Response: We agree with the reviewer.

Line 393: why there is frazil ice formation in July? This is quite anti-intuitive. Line 396-408 give some explanations on it, but I would like to say that it is a "purely" model adjustment, I am not sure whether this will happen in the real ocean.

Response: We agree with the reviewer that frazil ice formation in July is more likely to be the results of model adjustment and/or numerical error. We added this in the revised manuscript. Besides some explanations on L396-408, we also provided extended discussions for the spurious frazil ice formation in section 5. In L539-L558, we mentioned

that the treatment of ice-ocean heat flux parameterization may play a role in the spurious frazil ice formation if the ice-ocean heat flux reaches the limit imposed by the melting potential. This implies the ocean surface layer will be close to the freezing temperature. The ice-ocean heat flux combined with the oscillatory behaviors of advection schemes will further increase the amount of frazil ice.

Line 468-486: the description of Y21_MAR-7 experiment does not present useful information or novelty to the manuscript. I suggest the authors to consider removing the part.

Response: Based on the reviewer's suggestion, we removed the description related to the Y21_MAR-7 experiment in the revised manuscript.

Response to comments by Topical editor

We would like to thank the editor for the helpful comments on the paper.

Comments to the author:

The reviewer is happy with your revision and has a few minor comments. In addition, I have two minor comments:

(1) Please revise the figure captions so that readers can largely understand the figures without reading the paper text and without searching/guessing the meaning of the experiment names in the captions.

Response: Thanks for the editor's helpful suggestions. We modified the figure captions by briefly describing changes made in each experiment. For example:
Figure 4 Top panel: Time-series of Arctic sea ice extent for the observations (black line) and the ensemble-mean of Y20_MOD (blue line, the original CAPS), Y21_CTRL (yellow line, changes in the atmospheric physics), Y21_VT (red line, changes in the ocean vertical coordinate), Y21_RP (green line, changes in the oceanic advection), and Y21_MUSHY (pink line, changes in sea ice thermodynamics). Dashed and dotted lines are the climatology and the damped anomaly persistence prediction. Bottom panel: Time-series of the observed (black line) and the ensemble-mean of regional sea ice extents for Y20_MOD (blue line), Y21_CTRL (yellow line), Y21_VT (red line), Y21_RP (green line), and Y21_MUSHY (pink line) for (a) Beaufort-Chukchi Seas, (b) East Siberian-Laptev

Seas, and (c) Barents-Kara-Greenland Seas.

(2) Please do a thorough English check. Here I just provide a few examples of English issues in the "abstract":

L16 by--> using

L17-20, , which ... --> . CAPS is built on ...

L20 process --> processes

L23 improved simulation in --> an improved simulation of

L25 reduces --> reduce, changes --> change

L30 have --> has

L32 making --> to make

Response: Thanks for the editor's comments. We changed them and did a thorough English check in the revised manuscript.