Reviewer #1:

The revised version of this manuscript addresses the primary concerns of my first review. The addition of long names in the text for the primary parameters is particularly helpful and makes this much easier on the reader. I also find the colors in Figure 10 much improved as well.

Thank you for the constructive comments. We have revised manuscript accordingly. Please see below our response (blue text) to each specific comment point by point.

I have a few relatively minor suggestions.

I believe that there may be a couple different "audiences" for this paper: model developers (particularly sea ice in within the context of global climate models), and climate model users. The extensive details and figures along with the results will serve the former community particularly well. I also believe the paper will be of benefit to the latter group as well (of which I consider myself a member) and to that aim I suggest adding to the abstract two important conclusions (in my opinion) that are currently found in the "recommended parameters" and "conclusion" sections are worth highlighting up front for the benefit of the larger modeling community:

1. "key to reproducing a realistic SIC budget of an ice-ocean coupled model driven by atmospheric analysis is to simulate realistic sea ice velocities" (lines 565-566)
2. "accurate modelling of the SIC budget does not appear to be possible by simply changing the atmospheric forcing product or tuning ocean model's parameters, as the atmospheric forcing itself is systematically biased" (lines 514-518)

These are really important points to bear in mind when using climate models to explore polar region dynamics, mechanisms, change, etc.

We agree with the reviewer that including these two conclusions in the abstract would help the audience for this paper. We have now added the following sentence to Line 21 to highlight these two points: "This implies that a more accurate calculation of ice

velocity is the key to optimising the SIC budget simulation, which is unlikely to be achieved perfectly by simply tuning the model parameters in the presence of biased atmospheric forcing."

And the last sentence in the abstract has also been changed to "Nevertheless, ten combinations of NEMO4.0-SI^3 model parameters were recommended as they could yield better sea ice extent and SIC budgets than using the standard values." to make the text read more smoothly.

I suggest adding 1-2 sentences summarizing your paragraph that response to my question about how these parameter set recommendations might change optimal values in a warming world (to paragraph that ends at line 159). I found the response in “response to reviewers” quite helpful, for example, in that I didn’t imagine how air-ice drag coefficient might change due to changing surface roughness and atmospheric stability in a warming world. Essentially what I would like in the paper, if possible, is a couple sentences summarizing how different conditions may result in different optimizations and whether or not the impacts would be "large". I don’t expect detailed answer here to this complicated question – clearly beyond the scope of this work – just something to help what I consider "climate model users" (not sea ice model developers per se) understand how or which parameters might change and how large of change – i.e. should I still be able to trust sea ice component of a climate model that has parameters optimized from current conditions to help me understand future polar climate change? Or not? Or what should I bear in mind when using sea ice model in somewhat different climate states? Or even how or why they might change but no idea exactly how much or if it will be of impact on a larger scale? Just a summary sentence or two that would help the reader in the same way your response to my review helped me…

Thanks for the suggestion, and we agree that add some discussion on this topic would be helpful to climate model users. The Line 159 correspondings to Gaussian process emulator formulation, which we do not think is where the reviewer was referring to.

We have now added one sentence at the end of the paper (Lines 573-575):
"The recommended parameter sets are determined based on the current climate scenario, and their optimal values are expected to change to some extent when applied to simulate sea ice in a warming world. In general, one might expect the global or hemispheric optimal parameter values to change little because even now global sea-ice models can reasonably reproduce regional sea ice characteristics, ideally associated with a wide range of optimal parameter values."

In addition to the above general comments I have some specific minor suggested changes outlined below. I also recommend if possible to have a good editor go through the manuscript for editorial changes – I've found some myself but am not skilled per se in this arena and have most likely missed some others.

Line

30 two Notz articles referenced are not in reference list
Thanks for your reminder, both references have now been added, and we have checked the reference specification again.

87 add "thick" (m thick) as a little confusing as written
Revised.

90 add "scheme"
Done.

135 replace "divide" with "divides"
Corrected.

147 replace "practivally" with "practically"
Corrected.

203 replace "with" with "while"

Done.

217 replace "observation" with "observations"

Corrected.

235 "detached" ? huh? Tails of distribution larger in winter than summer?

We have revised this sentence to "Additionally, the SIV cycles show a larger spread in winter than in summer, which is opposite to that of SIE cycles" to make it clearer.

253, 254, 258 replace "observation" with "observations"

Thank you for the correction. We have used several SIC observations to verify the SIE/SIA results, so changing "observation" to "observations" in line 217 is necessary. However, only one observational SIC budget product (i.e., calculated by CDR SIC and KIMURA ice drift) was used to diagnose the modelled SIC budget results in Section 3.2, so we replaced "observation" with "observational data" in these lines. Other places where "observation" was used have also been changed to "observational data" or "observations" accordingly (e.g., Line 188, 285, 383, 405).

281 "very little different".....rephrase

We have rephrased this sentence to "The spatial pattern of the divergence of SIV does not differ much from that of SIC".

303. delete "a" in "implement a method"

Revised.

389. rn_beta and rn_dmin – suggest helping reader with long names…

We have added their long names afterwards to help readers.

458 "weaker ice is more easily to deform and increase ice thickness" ? doesn’t make sense

Docquier et al. (2017) carried out a detailed study of the relationship between Arctic sea ice drift and ice strength modelled by NEMO-LIM3.6, and shows that "higher values of P* generally lead to lower sea ice deformation and lower sea ice thickness", and the results of our sensitivity analysis (Fig. 12a) support that this conclusion also holds in the Antarctic. We have now cited this paper to make the statement in the text more convincing (Line 462).

469-470 "always shows a similar high sensitivity to …and…. " to "show similarly high sensitivities to …"

Revised.

483 delete "question"

Done.

Reference:

Docquier, D., Massonnet, F., Barthélemy, A., Tandon, N. F., Lecomte, O., and Fichefet, T.: Relationships between Arctic sea ice drift and strength modelled by NEMO-LIM3.6, Cryosphere, 11, 2829–2846, https://doi.org/10.5194/tc-11-2829-2017, 2017.