The Cryosphere Discussions

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Comment on tc-2022-84

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Referee comment on "Arctic sea ice and snow from different ice models: A CICE–SI3 intercomparison study" by Imke Sievers et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-84-RC2, 2022

The manuscript is a nice summary of a comparison study between two sea-ice models coupled to the same ocean model and forced the same way. The main conclusion is that the two models perform relatively close (which conclusively puts SI3 on par with a well-known model as CICE) and the remaining differences can be accounted by different implementations of snow/albedo and the presence/absence of form drag in respectively CICE/Si3. On the latter, one can regret that the drag scheme was not tested in isolation of the rest, as it is discussed to be an important contributor while it is not clear whether the single experiment reported here can decipher the interconnected results. So the authors should either run another NEMO-CICE experiment without the form drag or make more cautionary statements about the impact of the drag. I particularly like the analysis and conclusion about the snow contribution, as the snow impact tends to be too easily ignored in climate studies. The authors should revise the grammar and spelling of the text as I have found too numerous inconsistencies.

1. “Wang, C., Graham, R. M.,Wang, K., Gerland, S., and Granskog, M. A.: Comparison of ERA5 and ERA-Interim near surface air temperature and precipitation over Arctic sea ice: Effects on sea ice thermodynamics and evolution, in: AGU Fall Meeting Abstracts, vol. 2018, pp., C33F–1626, 2018.” Is only a abstract and should be replaced by the full paper:

Wang, C., Graham, R. M., Wang, K., Gerland, S., & Granskog, M. A. (2019). Comparison of ERA5 and ERA-Interim near-surface air temperature, snowfall and precipitation over Arctic sea ice: effects on sea ice thermodynamics and evolution. The Cryosphere, 13(6), 1661-1679.

2. Dupont et al. (2015) may not be proper for discussing short-term forecast (although it is the base for the ECCC regional 2-day prediction configuration). Lemieux et al. (2015)

would be better:

Lemieux, J. F., Beaudoin, C., Dupont, F., Roy, F., Smith, G. C., Shlyaeva, A., ... & Ferry, N. (2016). The Regional Ice Prediction System (RIPS): verification of forecast sea ice concentration. Quarterly Journal of the Royal Meteorological Society, 142(695), 632-643.

3. Line 38 "grid" misspelled

4. Same place, "[Kiss et al. (2020)] compares three global ocean-sea-ice models on three different fine grid resolutions and finds that different resolutions favor the representation of different process. They for example find that models run on coarser girds miss certain sea ice characteristic features as for example leads": the latter conclusion of Kiss et al. (2020) has to do with explicit vs statistical representation of the linear kinematic features in open leads (they prefer the former at the end of their section 4.3.1) than truly identifying particular processes at play at different resolutions. As I do not see any firm conclusion in terms of "processes" in this reference, I would suggest modifying the "different resolutions favor the representation of different process" statement.

5. L36 "Kiss et al. (2020) compares … and finds", should the verb uses plural? Same for "Losh et al. (2010) compares"

6. Line 61 "LEOGS" might be misspelled, did you mean LEGOS?

7. L79, "hind casts" in one word would make more sense

8. L132 "utilise" -> "utilizes" if it goes with the subject "combination" (the "z" is due to my North-American auto-corrector).

9. Percentage changes in L151-156, are there as a ratio (new=(1+%)*ref) or the difference (since SIC can be given in percentage itself)? The figure leads me to think it is the simple difference, but maybe a statement might be needed to clarify this.

10. L160p6, "not SMOS" -> "neither SMOS"?

11. L164 "In most years, when the freeze up begins CICE models the sea ice cover to be thinner than the ice cover from SI3", maybe rephrase that sentence?

12. Fig5: is there a reason that fig5 shows model-obs but fig2 the opposite (i.e., obs-model)?

13. L174: "This difference is strongest pronounced" sounds a bit weird but I get the idea

14. L175, maybe add the mention "(not shown)" when describing SI3 for all month.

15. L180: "over all" should be one word here, further to the right, you can remove the "s" in "SI3s"

16. L181: Missing "Fig." in front of "6" +L183.

17. I would capitalize the first letter of each "Figure" in general.

18. L182 Missing "to" in "SI3 is up 1m thicker than CICE" or remove "up"

19. Fig7: in Fig5 "turquoise" was referred as "light blue". Please harmonize. Also, there seem to be missing the two rows if the legend is correct. Only one is presented.

20. L195 "Overall, the models show a more noisy distribution than the observations" … or the observations are smoother (i.e., due to whatever processing was used to obtain them)?

21. 8: September seems a bit dull to show. You could maybe stick to the first row (March).

22. L207, not sure why in "(Snow blue, Ice turquoise)" the first letter is capitalized. The whole bracket might be removed as this level of details is given in the legend anyway.

23. Ndte is the same for both models, which value is that (sorry, I had not time to check the supplementary material)?

24. L225 « The ice volume peaks… » maybe recall here that you mean "the ice volume difference". I know it sounds a bit repetitive with the previous sentence, but since you switch from snow difference to ice, it is ambiguous if you are using the same comparison convention.

25. L236 "In March the both the atmosphere and ocean drag in SI3 exceeds CICE drag coefficient in most regions", could you rephrase that please?

26. L237 "s" at the end of "CICEs" and "SI3s" come back for no clear reason.

27. L239 "the ice is more vulnerable to the external forcing", do you rather mean that the ice will be more responsive to wind? Secondary effects would be turbulent heat fluxes but I am not sure whether you meant those.

28. L241, missing comma after "same data".

29. L242 "… the models numerical formulation differ" you want to check the grammar here

30. L248 "models sea ice extent": check grammar and do you mean the CMIP6 models or the 2 presented here.

31. In general, I would hyphen over/under-estimate or even merge them. There are a mix of both separated with no hyphen or merged in the text. Please harmonize.

32. L263p15 please replace "which" by "this", you need a subject in this sentence

33. L292 "cost" I think you meant "coast"

34. L307: "The regions with more SIC in March in figure 3 coincides well with the regions with a significantly higher drag coefficient in CICE located at the ice edge (see figure 10)." I guess this is cautionary statement as

35. L318: "grows", you mean "growth"? then "is" -> "are"

36. L318-319: “The remaining difference between the models could be explained by differing formulations for grounded and land fast ice” is a repetition of L315 “The Russian shelf region is shallow and both models calculate grounded ice differently” with no more details. Were you intenting in providing that detail there?

37. L324 “force” -> “forced”

38. Fig10: Because it is difficult to estimate when the wind forcing is stronger than the ocean breaking, you may want to map the ratio of the air drag over ocean drag (i.e. the Nansen number), and maybe their difference too between the two models since the ratio is considered more informative (see de Vos et al., 2021) than just the difference drag. It might facilitate the discussion in general in Section 4.

de Vos, M., Barnes, M., Biddle, L. C., Swart, S., Ramjukadh, C. L., & Vichi, M. (2021). Evaluating numerical and free-drift forecasts of sea ice drift during a Southern Ocean research expedition: An operational perspective. Journal of Operational Oceanography, 1-17.

39. In L334: missing verb in last sentence.

40. L337: I think you mean “Over all” in one word. And you may want to revisit the sentence because of the repetition of “form drag” at the end of the sentence and “overall” with the beginning of the paragraph.

41. Nice analysis in L345-348

42. L362 “link” -> “linked”

43. L337-363 “formdrag” might be better split in two.

44. L364: what is “an overestimation of the ice edge”? maybe “extent”?

45. L337:365: The reference to Castellani et al. (2018) seems valid although the magnitude of the SIT difference is quite different. Their Fig.7 middle panel saturates at

+-0.5m while at Fig.6 yours saturates at +-1m. So qualitatively, I would say that your difference is much larger and could be explained by other processes (you already mentioned the contribution of the larger snow insulation in your CICE experiment). Moreover, given that the implementation of the form drag is quite different in Tsamados et al. (2014) and Castellani et al. (2018), I would recommend to be a little cautious here. You may also refer to Chikhar et al. (2019) which also shows a smaller ice volume with form drag and an acceleration in summer and use the same CICE form drag. Tsamados et al. (2014) found a summer deceleration but since their model is stand-alone, it does not represent the increased momentum directly passed to the ocean through leads and the subsequent feedback to the sea-ice. The best would be to repeat the NEMO-CICE experiment with constant drag as in Castellani et al. (2018) and Chikhar et al. (2015) so as to give more weight to your argument.

Chikhar, K., Lemieux, J. F., Dupont, F., Roy, F., Smith, G. C., Brady, M., ... & Beaini, R. (2019). Sensitivity of ice drift to form drag and ice strength parameterization in a coupled ice–ocean model. *Atmosphere-Ocean*, *57*(5), 329-349.

46. Tsamados et al. (2014) showed that their form drag tends to emphasize the contribution of the ice floe edge drag in summer (and year round at the ice edge), which may explain the results in Fig.10: higher velocity and Ekman convergence closer to the ice edge and marginal ice regions. However, you may note that in none of these references and, for that matter, your experiments, the atmosphere is responding to the change in surface drag.