

**Review of: “The sensitivity of landfast sea ice to atmospheric forcing in single-column model simulations: a case study at Zhongshan Station, Antarctica”, by Fengguan Gu et al.**

**General comments**

This manuscript uses a single column sea ice model to investigate the impact of atmospheric forcing on the simulation of snow and sea ice at Zhongshan Station in Antarctica during the 2016 austral winter. The model is forced both with in-situ observations and interpolated data from a reanalysis (ERA5), and the results are compared with in-situ observations of ice and snow thickness. The authors find that the forcings having the largest impact on the simulation of the ice and snow thickness are precipitation and wind speed. Biases in precipitation can have different impacts on the ice thickness, depending on how thick the snow is.

In terms of the originality, scientific quality, and significance I assess this manuscript as good. This is an interesting and useful study: atmospheric reanalyses are widely used to force ocean-ice and sea ice models, and so a detailed understanding and quantification of how the inevitable biases in a reanalysis can impact the model simulation is very valuable, albeit it over a very localised region. In terms of presentation I assess this manuscript as fair and would recommend some re-writing so that the manuscript is easier for the reader to follow, and the conclusions more clearly expressed.

Overall, I feel the paper could benefit from

- A more careful explanation of some of the details of the study – especially the differences between Obs and Sim\_Obs.
- More care when referencing the figures
- A better structuring and bringing together of conclusions in the discussions – I felt there were some interesting results here, but that they could have been expressed more clearly

I hope these comments will prove useful.

**Specific comments**

P2 L33-35 Although the manuscript mentions that the ICEPACK model may overestimate the snow-ice formation, I don't think that potential differences in the flooding process between landfast sea ice and pack ice are discussed?

P3 L64-64 Re-word this sentence to be clearer.

P3 Line 83 Perhaps mention the insulating impact of the snow here as well.

P4 Section 2.1 The information provided about the different observations seems rather inconsistent: compared to the meteorological data, the frequency of measurement of the SW and LW is not mentioned, but there are extra details about the equipment used, plus the uncertainty in SW and LW is mentioned, whereas it is not for the other observations.

P5 L138-140 Maybe a little more about the interpolation – linear? How many grid points used?

P5-6 ICEPACK description. It would be good to be more explicit about the processes that are and are not included here, in particular for processes that are mentioned later in the manuscript such as snowdrift and the impact of melt ponds.

P56 L156 (Table 1) How were the initial ice and snow thickness chosen?

P6 L165 – P7 L171 This paragraph seems out of place in a section describing the ICEPACK model. Consider moving to the introduction, or even the discussion. Also, the sea ice response to climate change is mentioned here, but that is not a part of this study. It would be good to be more explicit about this point – I agree that understanding the impact of uncertainties in the forcing in future sea ice changes is important, but I'm not sure whether you are suggesting using a similar methodology to that used in your study to investigate this?

P7 L182-183 Could you be clearer about what you mean here by the relative deviations, and perhaps include them in Table 2.

P7 L188 It would be good to be more explicit about why these 3 variables are chosen. I think it is for these reasons, but this could be expressed more clearly:

- A previous study has shown that these are (the most?) important factors affected the ice thickness
- $U_a$  may also affect the snow thickness
- In this study,  $P$  and  $U_a$  from the analysis have the largest relative deviation from the in situ observations (and the smallest correlation coefficients compared to the in situ observations)

P8 L201 relative deviation? Ties in to point for P7 L182-183.

P8 L210-212 I'm not sure of the relevance of this point to this discussion about the forcings, although it is clearly an important point in terms of the modelled snow thickness.

P8 L212 Deviation in what, and relative to what?

P9 L222 Add (Figure 2c)

P9 L231 The measurement details don't need repeating here – could just say drill hole sea ice thickness measurements or similar, to avoid distraction.

P9 L264 onwards: sections 3.2 and 3.3. I wonder if making more use of the notation in figure 3 (Obs, Sim\_Obs etc) would help make the discussion in these sections easier to follow.

P10 L242 add (Figure 3b) to end of sentence

P10 L244-245 This description does not seem to match the plot, or perhaps it is just unclear what period the seasonal mean covers. I have suggested below that the seasonal mean could be added to figure 3b to clarify things. I was assuming it referred to the entire period, in which case it does not look to me like the snow depth reduces to below the seasonal mean before the secondary peak on 2<sup>nd</sup> August as described in the text, but it may be that this was intended to refer to the peaks in September and October.

P10 L245 onwards: I would suggest starting a new paragraph when discussing the comparison between Obs and Sim\_Obs. I don't think the current description of the figure fully captures what is happening – for example Sim\_Obs tracks Obs closely until the 11<sup>th</sup> July precipitation event, but does not capture the magnitude in the increase in snow thickness seen in Obs. It is mentioned that the lack of snowdrift in Sim\_obs means that the snow thickness does not decrease again after the precipitation events in the way it does in Obs, but I am not clear why Sim\_Obs does not show *increases* of a similar magnitude to Obs, instead producing a more gradual increase in snow thickness.

P11 L265 Mention that the deviation is w.r.t. Obs and Obs\_TV

P11 L270 refer to figure 3b in this sentence.

P11 section 3.3: While section 3.2 discussed some reasons for the difference between Sim\_Obs and Obs, this section is purely descriptive of the differences. I presume this is because the reasons for the differences are explored in the sensitivity experiments that follow, but some mention of this and a link into the following sections would be beneficial. Also, it would be good to be more explicit about whether differences described are relative to Sim\_Obs or Obs.

P12 Section 3.4: there are several places where the figure references are incorrect. I have highlighted some but can this be checked carefully in the revised manuscript.

P12 L291-292 I think this was mentioned earlier in the paper but can the way this is assessed be clarified.

P13 L299 should read Figure 4d?

P13 L308 Figure 4e?

P13 L319 4a?

P13 L325 4d?

P15 L342 This sentence needs re-wording. Also I'm not sure where the  $-5.1 \text{ W m}^{-2}$  comes from – from figure 5b it looks like the difference reaches about  $-2.5 \times 10^4 \text{ W m}^{-2}$ . Can this be clarified.

P17 L369 Add ref to figure 7

P17 L375-378 I struggled to understand this discussion – re-draft to be clearer.

P17 L378 – P18 L380 If figure 8 is to be included I feel it needs more explanation in the text (see also comments in the figures section). I presume it is to illustrate point (4) in the conclusions, but that is not brought out clearly here.

P18 Discussions section: This section seems to be primarily about model limitations, so consider renaming to make this clear.

P18 L388-395 As superimposed ice is mentioned as an important process, it could perhaps be mentioned earlier in the manuscript – maybe in the introduction and the model description (as a missing process).

P19 L419-420 Include reasons for this.

P19 L 431-432 clarify this is for changes in the ice thickness.

## **Figures**

Figure 3b: The text makes frequent reference to the seasonal mean snow depth, so consider adding this as a line on figure 3b.

Figure 4: The caption is incorrect – surf heat flux and snow depth need to be swapped. Does Sim\_Obs have zero flooding? Can this be mentioned and explained in the text (if it is already there somewhere I missed it).

Figure 6: This figure does not seem to be mentioned in the text.

Figure 8: I was unclear what this figure is intended to show. (b) has a number for heat flux whereas (a) does not – I did not understand why. If this figure is retained, it would be good to be more explicit about the points it illustrates by expanding the text and/or adding more labelling to the figure - I presume it's about point (4) in the discussion.

## **Technical corrections**

P3 L83 New paragraph for paper outline.

P4 L91 observations

P5 L125 delete 'temperature'? I think this refers to both temperature and salinity.

P6 L152 no capital needed for initial

P6 L154 categories

P6 L168 remove etc.

P7 L193-194 Move the citations forward to the end of this sentence.