Review response on

"From snow accumulation to snow depth distributions by quantifying meteoric ice fractions in the Weddell Sea" by Stefanie Arndt et al.

Anonymous Referee #1 (2nd review round)

Received: 11 March 2024

We thank the reviewer again for the critical questioning of our manuscript. In particular, we agree that the added figure on the sea ice thickness evolution in the appendix adds to the credibility of the study – and having it placed in the appendix it is also not destructive for the overall manuscript.

In addition, one (hopefully) last issue with the SNOWPACK code could be solved: During the analysis of the SNOWPACK simulations, we noticed that there was a bug in the SNOWPACK's model code when calculating the sea ice density. We have reported this bug to the SNOWPACK developers and it has been fixed on 5 March 2024 and we repeated all simulations with the latest SNOWPACK version including this correction.

Detailed comments

Since detailed comments and suggestions are provided in the annotated manuscript, we will only reference the line numbers from the commented tracked change document from the previous review round here. Language corrections suggested in the manuscript have been implemented (visible in the tracked change document) but are not explicitly mentioned here.

L.19	Thanks for pointing out this potential misunderstanding. We therefore added that the superimposed ice parts adds on top of the snow ice. *In addition, we simulate the evolution of internal snow properties along the drift trajectories with the more complex SNOWPACK model, which results in superimposed ice thicknesses between 0 and 16 cm on top of the snow ice layer.*
Figure 1	Thanks a lot for pointing out the misplaced region label; we corrected that in the figure.
Section 2.4	Yes, indeed, we now state explicitly that superimposed ice and snow ice are simulated in SNOWPACK and added therefore the sentence: *For sea ice applications, snow layers below sea water level are immediately flooded in the simulations and refreeze to form snow ice.*
L.190ff	Sorry, this sentence was accidentally placed in the wrong position. It belongs to the explanation how we distinguish snow ice and superimposed in the model output. As we had to re-run the SNOWPACK simulations (due to the bug in density calculation as stated above) and to change how we determine the fractions of snow ice and superimposed ice, we changed the text accordingly and it reads as follows: *To extract the fraction of snow ice from the simulations, we do the following for each simulation time step: In SNOWPACK each layer is marked as (different types of) snow or ice. A layer is marked as ice when its volumetric ice content is > 0.763, this corresponds to a dry ice density > 700kg/m3 (i.e. if the remaining volumetric content is air, the layer's bulk density is slightly higher than 700kg/m3, and even higher if the layer contains a nonzero water fraction). Once a layer is marked as ice, it will stay to be ice even when the volumetric ice content decreases below the above mentioned threshold. In each simulation time step, we sum up the heights of the layers marked as ice that are located above the initial Snow Buoy's installation height (i.e. the initial*

snow-ice interface) but below sea water level. This is classified as snow ice. In addition, when there is ocean water flooding simulated in SNOWPACK, the saline water can be transported into the snow above sea water level, which leads to melting and re-freezing of the snow. The resulting saline ice is also considered to be snow ice, and we use a salinity threshold of 1kg/kg to count these layers as snow ice. Once snow ice has formed, it can rise above sea water level (following the hydrostatic equilibrium of the ice floe) or become less saline and it will still count as snow ice. All other layers above the initial Snow Buoy's installation height that are marked as ice in SNOWPACK are considered to be superimposed ice.

L.416 Thank you for highlighting this crucial consideration regarding the perspective of floe size versus point measurements. To address this, we have incorporated the suggested paragraph accordingly:

Additionally, the hydrostatic balance appears to be primarily determined at the scale of individual floes, whereas the measurements obtained from Snow Buoys represent specific points and may not fully capture the heterogeneity of the entire ice floe. Consequently, this discrepancy could result in elevated freeboards and subsequently reduced occurrences of flooding and snow ice formation.

L.519 We acknowledge that drawing conclusions without presenting sea ice thickness evolutions can be speculative. Consequently, we have included a figure in the Appendix depicting the thermodynamic sea ice growth evolution for both the 1D model and SNOWPACK. Additionally, a corresponding sentence has been added to section 3.3.1 addressing the insulating effect of the snow ice and snow layer on sea ice growth. As a result, the need for the "new" reference in the conclusion section is no longer necessary. The additional sentence within the results section reads as follows:

The substantial layers of snow ice in the eastern Weddell Sea, along with the insulating snow cover on top, contribute to a notable reduction in thermodynamic growth during winter months (see Figure A2). This highlights the crucial role of the Antarctic snow cover in shaping the sea ice mass budget within this area.

L.532 We agree that the statement of Antarctic-wide melt pond formation might be rather extreme, which is why we rephased the sentence accordingly:

This metamorphic and wet snow reduces the albedo, ultimately initiating an ice-albedo feedback due to conditions resembling those observed in the Arctic, which is referred to as "Arctification" of the Antarctic sea ice (Arndt et al., 2021).