General Comments:

The overall objective of the study is to *quantify the independent effects of meltwater and ice-albedo feedbacks on the Arctic ice-ocean system*. Specifically, the work proposes to anser three questions:

- *To what extent do the meltwater and ice-albedo feedbacks influence ice melting during summer?*
- *What is the contribution of the meltwater (ice-albedo) feedback if the ice-albedo (meltwater) feedback is not involved?*
- *What are the regional differences in the impact of meltwater on the ice-ocean system?*

These research objectives are within the scope of The Cryosphere and, to the best of my knowledge, are novel. The difficulty of the research arises from the strong coupling between the feedbacks of meltwater and ice albedo, which prevents a clear differentiation of the contribution of each. To solve this problem, the authors propose a methodology based on a series of simulations where feedbacks are selectively activated. Independent contributions are then encoded in feedback factors. I consider the methodology appropriate, implemented in a rigorous way and well documented. The supplementary material reinforces its validity with an extensive comparison between the model and observations. However, I believe that its description would benefit from the inclusion of the 1D dynamic equations either in the main text or in the supplementary material.

The presentation and discussion of the results raised my main concerns with the manuscript. Model results are quantitatively presented but, in main opinion, poorly interpreted from the physical point of view. In some sections (see below), the explanation of some model results would require a qualitative interpretation or a physical hypothesis. The quantities are only indicated and at most justified with references or general assessments. Brief physical explanations would be very informative.

I consider that a revised version of the manuscript could be suitable for publication in The Cryosphere.

Specific Comments:

L 55: *In winter, brine rejection caused by ice formation leads to the upward entrainment of heat from the NSTM and AWW and impedes winter ice formation consequently (Smith et al., 2018; Steele et al., 2011; Timmermans et al., 2017), which is a negative feedback known as the ice production-entrainment feedback (Goosse et al., 2018)*. My understanding is that the ice production-entrainment feedback inhibits vertical heat transfer, promoting more ice production. could you confirm this point?

L 72 *Zhang et al., (2023) demonstrated that the removal of meltwater increases ice melt by 17%* Could you add briefly the physical mechanism proposed by Zhang et al. to justify this effect?

L 75 Indicate the differentiated aspects considered in the work between meltwater and icea albedo feedbacks. There is a strong relationship between both and it is not clear their intrinsic and differentiated components.

L 102 I would suggest to include the mathematical expression of the 1D model.

L 116: A boundary condition is always required to get a particular solution to the differential equation. Please, clarify the sentence *No boundary condition is applied at the bottom of the model.*

L 175 *Based* ON *the feedback factor (γ) framework proposed by Goosse…*

L 177 *Total response* by Total Response

L 179 (Reference Response, RR)

Figure 3. Please define the acronyms in the figure caption. The figure is cited before they are defined in the text.

L 264-265 *the brine rejection process during winter creates higher ocean-ice heat flux, which in turn inhibits ice formation*. Could you briefly clarify the mechanism of this? As I understand it, brine rejection contributes to the formation of the cold halocline that isolates the upper Arctic layers from the warm waters of the Atlantic. It would favor ice formation in this case. Could you clarify the assessment?

L 270 *the removal of meltwater results in a 0.19 m increase in ice formation compared to the CTRL run*. Why? How do you physically interpret this result?

L 273-275 *The noMWIA run also shows less ice formation compared to the noIA run (Figure 5b) in station NS2, NS4 and NS5, but no sea ice melting is observed during winter, further demonstrating the importance of meltwater in weakly stratified regions*. What is the physical explanation for this result?

L 277 *This suggests that sea ice retreat during summer can promote ice formation in winter*. Can you give a physical reason based on your model? Is it just a geometric effect of having more ocean surface available to freeze?

L 291 *the NSTM, because the heat absorbed by the ocean can mix sufficiently within the upper 30 m.* This explanation would disagree with observations. The NSTM layer can be observed at this depth in the Canada Basin (Jackson 2010). Provide an explanation to the discrepancy between the model and observations.

L 297 …agree well with the observed values…

Figure 6.Add month labels to the figures corresponding to station BS5, similarly to those of NS2

Figures 6 a,e,I,m,c,g,k and o. The discontinuity in the MLD seems an artifact of the surface tracking algorith due to the appearance of a new water mass, the meltwater. A gradient tracking algorithm could identify this as the bottom of the mixed layer. There is no discontinuity in the rest of simulations because the meltwater input is cancelled. Could you clarify this point?

L 305 How do you explain this big impact of meltwater in the mixed layer depth during the freezing season? Is there any observational or 3D model result that corroborates it?

L 390 *This is a process similar to the noMW run, where less meltwater entering the ocean accelerates sea ice melting.* Meltwater from ponds, sooner or later, flows into the Ocean. This might slow or delay the formation of a meltwater layer, but probably not inhibit it like in the study. Could you comment?

L 455 *it delays winter ice melting by slowing surface cooling*. Should be warming instead cooling?