Answers to the comments of reviewer 1.

In reviewing this manuscript, I looked at the rationale for the research, the method of study (I did not evaluate the models themselves) and the interpretation of the results.

This is article describes a careful attempt to isolate factors that influence the seasonal cycle of Antarctic sea ice extent and to explain how they do so. The manuscript is well written. The research problem is clearly stated – "what, other than the cycle of insolation influences/controls the asymmetry of the seasonal cycle of Antarctic sea ice extent?". The goals of the study are clear as are the arguments supporting the need for the research and the links to already existing work.

The authors use a series of sensitivity modeling studies to determine the roles of the oceanic and atmospheric processes in the seasonal cycle of Antarctic sea ice. More specifically, they examine the sea ice (extent, volume, timing of advance and retreat and growth/melt rates) responses to changes in the mixed layer depth (and the implied impact on heat storage), sea ice thickness, surface albedo, and ice dynamics. These simulations are short and there are caveats, but these are clearly stated, and results are interpreted within the bounds of these caveats. Even with these constraints, the results allow a better understanding of how the sea ice responds to different processes and the role of the atmosphere.

Overall, this study is immediately valuable to the field. It is, to my knowledge, the first of its kind to try to assess the response of the seasonal cycle to these key processes. Of course, sensitivity studies that involve a longer set of simulations may give more (statistically) reliable results, but these initial results seem physically sound and have great potential for interpreting and understanding the variability seen in observations sea ice extent around Antarctica.

We would like to thank the reviewer for the positive evaluation and the helpful comments. Our responses are in blue, after the comments of the reviewer, which are in italics. The suggestions of modified text in the revised version are in green.

I have only a few minor comments/suggestions to make. They follow.

Line 205/206: How valid is this assumption - biases are small enough to have only a marginal effect on the response to the perturbation?

This is a very interesting point and a question hard to answer. The validity of the assumption may be evaluated by comparing the results of different models or different model versions and determining how the different biases in those models impact the results. This is unfortunately a lot of additional work and, even in this case, isolating the impact of the biases in the results is not easy. This would thus require a specific study. Nevertheless, the sentence included in the submitted version was a bit short. We know that the mean state influences the response to a perturbation (see for instance the discussion in Massonnet et al. 2018) and the evaluation of feedbacks (e.g., Goosse et al. 2018), as mentioned in the first paragraph of section 5. We also discuss in section 4 how the biases in the estimate of summer sea ice extent influences the quantification of atmospheric feedbacks during this season. We thus propose to modify the sentence to expand a bit the discussion on this point:

Each sensitivity experiment will be compared to the reference simulation using the same model configuration and initial state. This standard method implicitly assumes that the biases remain nearly constant in those pairs of experiments and the effect of those biases on the quantification of the response to the perturbation is largely removed by performing the difference between the experiments. However, even with this procedure, the biases can still have in some cases a clear impact on the quantification of feedbacks, as discussed in section 5 for the summer sea ice extent.

Line 229/230 - Are you saying that this (assuming that sea ice salinity is the same as the ocean surface salinity) is what you did in the model? I assume yes. So, make this an active statement.

On a practical point of view, we put to zero the mass fluxes at the sea-ice ocean interface in the sensitivity experiment. This is easier as sea ice and ocean salinities are variables in the model. To make it more explicit, we propose to replace the sentence by:

In practice, we thus set all the mass fluxes at the sea ice -ocean interface to zero in NoMassFlux but this is equivalent to assuming that sea ice salinity is the same as the ocean surface salinity.

Line 237/238 – I had to read several times to make sure that I understood what you meant. This, way of writing makes it a little confusing. Can you redraft for clarity?

We propose to remove the parentheses and change the sentence to:

This is achieved by increasing the thermal conductivities of the ice and snow by a factor of five in ThickIce and by decreasing the thermal conductivities of the ice and snow by a factor of five in ThinIce.

Line 256/257 - This assumption might very well be valid but here the atmospheric feedbacks focus on the heat exchanges. Can you make any comment on the effect that the lack of dynamics associated with atmospheric motion might have on your simulations?

The perturbation of surface conditions obtained in the sensitivity experiment can also have an impact on the dynamics and on the atmospheric circulation simulated by the regional atmospheric model COSMO-CLM. This is included in our evaluation of the atmospheric feedbacks that is based on an overall comparison of a configuration of NEMO that is forced and another configuration in which NEMO is coupled to the regional atmospheric model. However, as the dynamical response is expected to be more difficult to isolate in our short experiments that use boundary conditions that constrain the large-scale circulation, this potential dynamical response is not investigated in detail in the manuscript. We suggest to make this more explicit in the revised version by adding in the text that we will focus on the processes associated with surface heat exchanges but we not investigate in detail the potential changes in the winds and atmospheric dynamics in response to the perturbation:

While the perturbations can potentially influence the atmospheric dynamics, and thus winds for instance, we will focus on the feedbacks on heat exchanges at the surface as they are more directly impacted in the sensitivity experiments.

Lines 375 -383 – It is worth it to include a Figure reference here to aid the reader.

We will add a reference to Figures 4 and 2 in the revised version.