Ashley et al. response to Anonymous Referee #2 (our replies are in bold)

Review of Ashley et al. This study presents a new Holocene record (12 ka to present) from the Adelie basin to infer past changes in meltwater from Antarctica as well as sea-ice changes. Hydrogen isotopes of fatty acids, relative abundance of phytoplanktons, and organic compound composition are measured in the marine sediment core. Other measurements were made (e.g. grain size analysis), but are not shown in the main text. In addition, meltwater experiments are performed with an eddy-permitting ocean model. The study is interesting, presenting a lot of information, which can help in the understanding of the deglaciation of Antarctica. I think in between the main text and Supp. all the information is there. However, the manuscript needs to be significantly restructured as it is currently very hard to follow. The reasoning and result from each analysis/modelling needs to be more clearly laid out.

We thank the reviewer for this constructive review. We will restructure the manuscript in the final submission by moving some information from the supplementary into the main text to make it easier for the reader to follow.

This is developed in the comments below:

1) Numerical modelling: I was quite excited at first to see a series of simulations performed with 1/6deg model. However, the results are only very briefly described in the paragraph L. 261. The motivation behind the modelling experiments should be more clearly explained as well as the limitations/assumptions taken. The volume of ice equivalent to each meltwater input should be given. They have the advantage of being performed with a high-resolution ocean model, however for the problem at hand (understanding the percentage of meltwater coming from the Ross Sea, without the use of water isotopes), they are a bit limited. The paragraph L. 261 surprised me, as the setting of the study is described, and suddenly some results of the numerical simulations are described. Until looking at the figures, it was very unclear to me that you were referring to your own simulations. Please be more specific, or consider restructuring, also because Figures 3 and 4 are (very briefly) described, whereas Figure 2 has not been called yet.

We thank the reviewer for prompting us to improve the organisation of the modelling elements. In our final submission we will describe and explain the reasoning for the modelling study more clearly. As the reviewer points out, the model results are briefly mentioned in L. 261, but we will remove this reference as it is confusing here. We will include a new 'Results' section in the final submission, following Section 4, in which the model results are explained and described in detail. Here we will make it clear that they are our own simulations and explain our reasoning behind them. The simulations will then be described in the context of other data in the Discussion section. In addition, we will swap Fig. 2 and 3 around so that the model results are presented before the other datasets following the order they are described in the main text. The reviewer suggests that the modelling is a bit limited as it does not include water isotopes. However, the main purpose of the simulations is to help understand the pathway of glacial meltwater released from the Ross Ice Shelf and interactions with the Adélie Land coast. We would say that the model simulations are sufficient for this purpose.

The volume of ice equivalent to each meltwater input should be given.

The volume of ice equivalent to meltwater inputs is illustrated, in broad terms, by the grey bars in Fig. 3. E.g. A meltwater flux of ca. 0.1 (Sv) is equivalent to a major circum-Antarctic melting event, as suggested by Golledge et al., (2014; Nat. Comms). Most of this meltwater would have originated from the Ross and Weddell Sea during the Holocene. Higher fluxes (e.g. 0.5 and 1 Sv) are relevant in the context of the supercooled ISW water and freshening of surface waters that occur on the

broad continental shelf the Ross Ice Shelf, that was previously much narrower. This is not meltwater per se, but supercooled waters emanating from cavities can act like meltwater, in terms of buoyancy and pathways. For example, Robinson et al. (2014; JGR) model 0.4 Sv ISW from the McMurdo Ice Shelf which directly passes into surface waters and directly influencing sea ice growth. Determining the exact flux of Ross Sea ice shelf *influenced* surface water proves difficult due to mixing/modification process and sparse observational data. In our revised manuscript we will expand the description in the figure legend and will more clearly cross reference to the main text of the manuscript to clarify these meltwater scenarios.

2) Based on the Methods, a lot of analyses have been made on the sediment core, but i) only d2H of fatty acids, phytoplankton %, and organic compound composition are shown in the main text, ii) only hydrogen isotopes of fatty acids are presented in the "results"(there is in fact no "result" section), iii) most of the other analyses are in fact presented in the "Discussion" section and the supplementary. As reading L. 536 in the Discussion, I realized you were in fact talking about your results (Ba/Ti). Searching through the document I realized this was briefly mentioned elsewhere, but this should be made much more obvious. Methods could be shorter but by going to the point of each measurement that you need for your interpretation. It would be good to have all the necessary/needed sediment analyses and modelling results presented in the "Results" section as well as in the Figures of the main text. The discussion section should then focus on the bigger picture and putting the results within the context of previous studies.

We are not sure what the reviewer means 'only d2H of fatty acids, phytoplankton %, and organic compound composition are shown in the main text'. **In the introduction (L. 69 – 86) we introduce the new measurements made on U1357, specifically: *"Here, we present a new Holocene record of glacial meltwater, sedimentary input and local sea ice concentrations from Site U1357 using compound-specific hydrogen isotopes of fatty acid biomarkers (d2HFA), terrigenous grain size, biogenic silica accumulation, highly-branched isoprenoid alkenes (HBIs) and Ba/Ti ratios (Fig. 2 and S4)."* These new data are shown in the main data Figure (Fig. 2) along with data-sets from the literature. Never-the-less, in our final submission we will include a clearer Results section, following on from Section 4, in which all the new data presented in this paper will be described in more detail. This will help the reader understand which datasets are new. In addition, we will move Fig S2 (displaying sedimentary data from the core) from the supplementary into the main manuscript so that all of our data is displayed in the main text. To make it clear which data we our presenting in the paper, we will also add some additional text to the end of Section 4 explaining the interpretation of our other proxy data, in addition to the hydrogen isotopes.**

In our final submission, we will also try to cut down the methods section. However, as we are presenting a lot of new data, there are a lot of methods to describe and we do not think there is a lot of detail which can be cut out while still keeping enough information so that the reader can see that our methods are valid and reproducible.

Suddenly in the Discussion section (e.g. L. 544, L. 550), conclusions are presented about changes in sea-ice, without knowing where this is coming from. Please clearly state in the results section how you infer the changes in sea-ice and what the main changes across the Holocene are.

We agree that our interpretation of the HBI proxy could be made clearer and in our final submission we will include this interpretation at the end of Section 4. We will also include a brief description of the HBI data in the Results section.

It is not clear to me that all the other proxies (from other marine sediment/ice cores) presented in Figure 2 are consistently discussed in the text. Please make sure to clearly mention what each proxy suggest/represent (i.e. how to interpret changes in MSA, Lithics… might not be straight forward for all readers), and refer to it as Fig. 2f, 2g, with the appropriate reference.

We will include specific reference to each dataset in the main text and refer to the relevant part of the figure where it is displayed.

3) The manuscript is quite well referenced, particularly with respect to the setting of the study, but I am surprised (particularly given the co-author list) not to see any comparison or discussion with previous modelling work on Antarctic deglaciation. Even though these simulations (e.g. Golledge et al., 2014) are associated with significant uncertainties, they might help in discussing the origin and magnitude of Antarctic meltwater.

We refer the reviewer to our Response 1, as the grey bars in Fig. 3 are based on previous modelling work (Golledge et al., 2014). We apologise that this was not properly discussed, in our revised manuscript we will expand this discussion and will include relevant references (e.g. Golledge et al., 2014; Robinson et al., 2014).

4) Minor points and typos:
L.101: "sealed"
L. 191: Please use present tense.
L. 257: Please correct the typo "10ˆ6" and add Sv, so it should read (1 Sv=10ˆ6 m3/s).
We will amend the above typos in the final revised submission.

L. 257: Maybe add a caveat to the "76 Sv", which seems a bit high. In Thompson et al., 2018 (Review of Geophysics on the ASC), they state that Pena-Molino et al., (2016) find a highly variable ASC at 113E from 0 to 100 Sv, but with a mean of 21 Sv.

Agreed, we will add the caveat as suggested.

L. 259: "the gyre transport is around"
L. 268: "of the meltwater input."
L. 347: there is something wrong with that sentence.
Agreed. The sentence should read "A significant shift in FA distributions has been shown to occur within 100 years due to early diagenesis". This will be corrected in the final submission.
L. 597-598: "most models", There are not many transient simulations of the Holocene currently published, and the one you refer to could be the only one. So instead of "most models", simply state the "TRACE21 simulation"
We will amend this in the final revised submission.