Response to reviewers: **Estimating the extent of Antarctic summer sea ice during the Heroic Age of Exploration**

We would like to thank the reviewers for taking the time to carefully read and comment on this manuscript and for their encouraging and positive comments on the paper. In the following we outline our response to their specific comments and describe all changes. In addition to the suggestions by the reviewer we have also made two changes to the text based on comments received from Holly Titchener, to clarify the description of the methods in Section 2.

Reviewer 1:

Page 5 line 7: "...15% threshold in sea ice concentration..." Not entirely clear how the actual threshold concentration was estimated, is it based on a frequency of sea ice occurrence for a specific pixel or a mean concentration over the period of satellite observations for a specific day of year?

It is the latter, so 15% concentration in the mean sea ice concentration field for a given day of the year averaged over the period 1989-2014, which we have calculated for all days of the year. We have adjusted the text to make this clearer.

Page 6 line 14: ... "corresponding contour whose coordinates have been shifted by the calculated change in latitude to give an approximate estimate of the ice edge during..." Again, the procedure is somewhat unclear. Did the authors apply a radial scaling (with respect to latitude) fitting the modern pan-Antarctic SIE for a particular day of year to local sea ice observations available for that day? Such extrapolation should be supported by estimates, for example using the EOF analysis, demonstrating that most of the variance for this day (or period of the season) is represented by a single principal component.

We did indeed apply a simple radial scaling method to estimate a pan-Antarctic mean extent for the period. We have adjusted the text to make the method used clearer. We are not asserting that all variability lies in a single principal component but there is simply not enough data to do anything more sophisticated in terms of estimating extent. The procedure and the scarcity of data used to approximate this means that there is an imprecision to our estimates that certainly warrants further investigation. We fully acknowledge these limitations and discuss these in the revised text. However, we do believe that putting our findings, regarding latitudinal variations of the ice edge, into the context of other estimates of areal extent during this period, such as HadISST, is important for the interpretation of these results.

Table 2: Line "Variance of difference" I wonder how symmetric the derived distributions are and if using a normal pdf (and hence sample variance) is adequate?

The distributions are not normal, which is why we used a non-parametric statistical test. However, we state the variance here as a useful measure for the reader to gauge the variability.

Reviewer 2:

Page 4 lines 21-36: Fortunately, the Worby and Comiso study quantifies average differences in where a human observer would note the ice pack beginning on a voyage south, and where satellite data would put it. The Heroic Age did not have the "trained observers" of the Worby and Comiso study, and the study was only for one sector of the Antarctic, but given the other sources of error and imprecision when comparing satellite extent with that from logbooks, these are minor issues.

This is a good point, which we now mention at Page 6, line 20 of the revised manuscript.

This section includes "They argue that during this time of year, saturated bands of ice and floes, particularly at the edges of the pack ice, may be very localised, resulting in ice concentration below the 15% threshold when averaged over the 25km footprint of the PM instrument. "
The use of "footprint" is incorrect here. The algorithm uses brightness temperature from 37GHz, 22Gz, and 19GHz channels, and for these the field of view is larger. For the 19GHz frequency, it is about 70x45km. Simply replacing "footprint" with "grid cell size" works here though. (Substituting "grid cell" for "pixel" throughout would
be more correct.)

We have replaced 'footprint' with 'pixel' as suggested.

Page 5 lines 3 and 4: The actual data set the authors used needs to be cited properly. This is probably the right one to use:
Comiso, J. C. 2000, updated 2015. Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS, Version 2. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: http://dx.doi.org/10.5067/J6JQLS9EJ5HU. [Date Accessed].

We used the Bootstrap algorithm distributed as part of the NSIDC merged dataset. We have added the correct dataset citation.

Page 5 lines 5 and 6: I'll just note that this way of constructing a mean ice edge for one day may not be optimal, because if the ice edge in some sector occupied a low latitude just a few times, and a high latitude most of the time, say, then the average concentration field from that day's 26 instances might easily have values >15% and place the average edge for that day in a place north of where it is likely to be seen. There are other ways to do it (e.g. the median edge used by the Sea Ice Index, described in https://nsidc.org/data/docs/noaa/g02135_seaice_index/#processing_overview), but for the purposes of this paper I don't think it makes much difference.

We acknowledge this comment by the reviewer. However, because we agree with their assessment that it is unlikely to affect the results, we do not modify the analysis.

Page 6 line 24: missing a "by"

Added as suggested:

Supplementary material:

Figure S2, Scatter Max is not the same as figure S2 within Supplementary Material (later lacks a trend line)

This figure has been replaced.

In addition to changes made in response to reviewers comments, we have made a number of changes to the manuscript following feedback from Holly Titchener, developer of HadISST at the Met Office:

Page 4 line 24: We used ship logbooks with data recorded at frequent time intervals and not fixed regular time intervals.

Page 5 line 25: Clarification about the ice edge points used depending on the direction of travel of the ship.

Figure 4: We have updated our HadISST2.1.0.0 curve to the latest version, HadISST2.2.0.0. We also found that the NSIDC Bootstrap and Heroic Age estimates had been plotted incorrectly and have corrected this. We have also added the NASA Team algorithm sea ice extent.