Answer to RC2:

Dear Reviewer,
thank you for your helpful comments and suggestions. Please find in green our answers in line as well as an overview of structural changes at the end of the document.

The paper provides an observing system simulation experiment performed to assess the potential of the TRACOS (Tropical Atlantic Circulation and Overturning at 11 degree S) array for calculating the geostrophic AMOC transport (AMOCg) from it and to evaluate the remaining uncertainties. To this end, the observational setup is subsampled in a high-resolution ocean model to derive AMOCg and to compare it to the model truth. Results suggest that the currently used observing set up based on bottom pressure recorders (BPRs) can explain only 56% of the seasonal to interannual AMOCg variability and that the seasonal amplitude gets overestimated. Moreover, observations of decadal to multi-decadal variability are very limited due to existing pressure sensor drifts. The paper continues by providing various proposals to reduce the uncertainty by changing the observing strategy.

Principally the presented work is important. However, as written the paper is extremely difficult to read and quasi-impenetrable. In fact, it reads more like a detailed data analysis report, instead of a concise scientific paper. My understanding is that this work is performed by the first author as part her PhD thesis; it certainly is written in this way. I also acknowledge that writing a scientific paper is different from writing a thesis, and that it is hard work that needs to be learned. My main criticism is therefore directed toward the senior co-authors who seemingly failed to revise the text and help tuning it into a real paper. This conclusion is supported by the fact that on page 7 the text suddenly turns to “I will refer to” which clearly was not caught by a careful proof.

My main suggestion is therefore that the paper gets returned for a major revision. It really needs to be condensed to the main points and conclusions, which sometime are not even included. All technical details can be provided as supplementary material. The revision in principle should start with changing the title. Instead of evaluating transport observations, the title should already state that this is an OSSE of a TRACOS setup – actual vs. improved – to estimate transports.

We agree that the paper benefits from being more condensed. The changes we will make are listed at the end of the document. We will not move all technical details into the appendix since the topic of the paper is a method test and quite some technical details are required to be precise and to make results reproducible.

Regarding the title, we refrain from including OSSE in it as readers may not necessarily be familiar with the term and as the term might give misleading associations (see also reviewer 1). Similarly, TRACOS is not a well-known term. However, to stress the approach of the study, we will modify the title to “Evaluating AMOC Transport Estimates at 11°S by Mimicking Observational Methods in an Ocean Model” which relates to the key question of the study “How reliably can the AMOC transport at 11°S be computed based on the TRACOS array, considering currently applied and alternative methods on seasonal to decadal time scales?”.

It should be checked carefully which information is really required and which is obsolete. As an example, are really all tables required including their color coding? Is Fig. 6 required? It has many panels and personally I did not find its relevance for the main conclusions. Is panel c in Fig. 3 really helpful? The content can already be seen from panel f of the same figure.

Thank you for your suggestions how to condense the paper to the main points. The changes we will make are listed at the end of document and include your suggestions.

In addition, rather than just focusing on AMOCg and its uncertainties, I suggest to quatify also the resulting error in terms of full AMOC which should be included in Fig. 2. Giving a 50% error of AMOCg suggest that the AMOC can be observed up to this uncertainty. This is not the case as other components matter as well. It is therefore important to understand what the total uncertainty of the setup is and how much comes from the geostrophic transport part.

We agree that it is an important question how representative the uncertainty of AMOCg is for the full AMOC. We calculated for some of the tested methods the resulting error in terms of the full AMOC and will include a short section for this. This section will include Figure 7 with a comparison of AMOCg + Ekman to the model-true AMOC instead of the current comparison in term of AMOCg. We will include the AMOC time series in Figure 2a. We also adapted the abstract so that the numbers relate to the reconstruction of the AMOC instead of AMOCg. The respective sentences read as "We find that the currently used approach based on zonal bottom pressure gradients explains **67%** of the short-term AMOC variability, whilst it cannot resolve longer-term variability due to pressure sensor drift. Long-term variability is currently only captured by boundary current measurements which explain **64%** of the basin-wide AMOC long-term variability. […] combining bottom pressure with moored temperature and salinity measurements can improve estimates of AMOC short-term variability (to **82%** explained)." Please note that in our study the uncertainty of the AMOC is mainly set by the geostrophic transport part. The AMOC is divided into geostrophic transport, Ekman transport and neglected ageostrophic transport. As the neglected ageostrophic transport is small (see Figure 2) and the Ekman transport is not associated with uncertainties in the model, the total uncertainty is mainly set by the geostrophic part. Sources of uncertainty that go beyond this methodological assessment are already mentioned in the discussion.

Line 740 refers to test against other observing approaches such as RAPID of OSNAP. I don't think I have seen these results discussed in the final chapter which, however, would be extremely important. Instead, all the previously mentioned summaries of the TRACOS results were repeated. In essence I belief the final section – which for this paper will be extremely important – needs to be re-written to put the existing results into the context of (1) the actual TRACOS observations and (2) the other observing strategies. Are they by fare better or of similar quality? Is 11S maybe specifically difficult to observe and not a good latitude to go to? How much can the estimates be improved in the future by implementing different observing strategies? Many important questions that a paper like this one should address.

Thank you for pointing this out. We believe that most of the aspects you mentioned are already included in the discussion; although perhaps not highlighted or expressed clearly enough.

Lines 739 to 784 already address the question of how much AMOC estimates at 11°S can be improved by applying different observing methods. For example, Lines 753 to 760 point out that a RAPID- and OSNAP- inspired method can improve current estimates of AMOCg long-term variability in terms of a strongly reduced root-mean squared error.
The current wording with RAPID- and OSNAP-like approaches might be misleading. This study adapts methods similar to those used for other arrays to the TRACOS arrays setup. Essentially, a RAPID-like approach (as described in section 2.4.2) implies that the boundary current transports are computed from direct velocity measurements while the basin interior transport is derived from dynamic height moorings. We do not test the actual setup of the RAPID array and, for example, do not take the lower AMOC limb into account either. As this study addresses the question of what can be achieved with the TRACOS array, we test 1) strategies that are currently used for the TRACOS array, and 2) strategies that are inspired by other arrays and applied to the setup of the TRACOS array.

Regarding the quality of the TRACOS estimates compared to estimates from other arrays, we find it difficult to make a direct comparison because the OSSEs are based on different models, different degrees of idealisation, and different time periods. However, we agree that this is an important question. Hence, we will include a short paragraph discussing how the ability of current and improved methods for the TRACOS array (as displayed in Figure 7) compares to the ability of other arrays, while stating the limitations of such a comparison arising from the before stated inconsistencies. For example, we could state that the correlation coefficients between the array reconstruction and the model truth of the full time series are similar when comparing our improved method with the numbers of Li et al. (2017) for the OSNAP array.

We will revise the discussion to clarify the points raised above, streamline the text and remove redundant summaries of results. We renamed the section from “Discussion and Conclusion” to “Summary and Discussion” as we think it is important to repeat the main findings, particularly given the length of the manuscript.

Further, we rewrote parts of the introduction to highlight the already mentioned findings of Baehr et al. (2009) and Perez et al. (2011) that 1) 11°S is generally a suitable latitude for an AMOC observing array, although not for every method; and 2) that compared to other latitudes in the South Atlantic, the AMOC variability is best captured at 11°S. This addresses your question of whether 11°S is a suitable latitude or not.

I will defer from providing detailed minor comments which should await a revised version of the text.

List of changes to condense the manuscript:

To condense the manuscript, we re-structured it slightly and moved some paragraphs to the appendix. Specifically:

Moved to appendix:

- Parts of the model validation from section 2.1
- Section 3.1.3 on the sensitivity of AMOCg to the vertical structure for the bottom pressure method including Figure 4; accordingly, legend Table 1 is shortened
- Section 3.2.1 about the reconstruction of density profiles from moored temperature and salinity including Figure 5; accordingly, legend Table 2 is shortened
- Figure 6

Further adaptations:

- Figure 3a-c removed
- Figure 2a AMOC added
- Figure 7 replotted for AMOC instead of AMOCg
- Statistic tables (Tables 3,5, and 6) replaced by bar plots for easier understandability

The paper is **re-structured** to more clearly separate between evaluation of currently used methods and alternative methods and to also account for the resulting error in terms of the full AMOC and not just AMOCg. The adapted structure is:

1 Introduction
2 Data and Methods
    2.1 Ocean model configuration VIKING20X
    2.2 TRACOS array setup
    2.3 Calculating AMOC volume transport
    2.4 Deriving geostrophic AMOC transport from the TRACOS array
        2.4.1 Method based on zonal bottom pressure gradients
        2.4.2 Method with interior based on moored temperature and salinity
        2.4.3 Method based on acoustic round-trip travel times
        2.4.4 Combining bottom pressure and moored temperature and salinity data
    2.5 Evaluating the performance of the array reconstruction
3 Results for model-true AMOC components
4 Results for subsampling observational methods to derive geostrophic AMOC transport
    4.1 Methods used so far
        4.1.1 Based on zonal bottom pressure gradients
        4.1.2 Based on boundary currents
    4.2 Alternative methods
        4.2.1 Based on moored temperature and salinity for the interior
        4.2.2 Based on acoustic round-trip travel times
        4.2.3 Potential of including self-calibrating BPRs
        4.2.4 Potential of combining bottom pressure and moored temperature and salinity data
5 Results for deriving AMOC transport and improving methods used so far
6 Summary and Discussion

Appendix A: Additional information on realisation in model
Appendix A1: Realism of the used model simulation
Appendix A2: Differences between reality and model in instrument depth of the TRACOS array
Appendix B: Overview of all performed method tests
Appendix C: Full version of statistics for the simulated array-reconstruction of AMOCg compared to the model-true AMOCg
Appendix D: Additional information on reconstructing vertical structures
Appendix D1: Sensitivity of Tg to the assumed vertical structure for the method based on zonal bottom pressure gradients
Appendix D2: Vertical structure for reconstructing density profiles for the WB4 and EB1 moorings
Appendix E: Additional information on the potential of acoustic round-trip travel times
Appendix F: Additional information on reconstructing bottom pressure by other variables