Response to general comment by P. G. Myers,

We thanks P. G. Myers for his constructive comments on the manuscript. Below we will give detailed answers to the individual comments.

page 2, Line 18: Would the approach work in a GCM whose AMOC is controlled by the strength of southern hemisphere winds? This is a potential major caveat, that might be worth discussing more at the end of the paper when the authors expand on applications.
Thanks for this question. The usage of this AMOC-emulator to mimic the AMOC behavior in more complex GCMs is based on the assumption that meridional density differences are the first order driver of AMOC changes on long time-scales. If in a GCM this is not the case, the AMOC-emulator should not be used. We agree that this is an important point, and have thus included a comment on this topic in the revised discussion section of the manuscript (lines 22-25 page 12) "...many processes that are known to impact the AMOC are not considered in the AMOC-emulator, for instance the impact of winds, gyre circulation, Southern Ocean upwelling or deep water formation outside of the North Atlantic (see Sect. 1). If such processes would prove to dominate the AMOC response to future climate change, a different AMOC box model should be considered that places emphasis on that particular process."

page 4, line 12: Is it reasonable to assume the wind-driven oceanic meridional fresh-water transport is static. I might expect it to evolve with an evolving climate, especially as high latitude freshwater sources (e.g. GIS runoff) changes.
Thanks for this question. Indeed in the real climate, or in higher complexity climate models for that matter, changes in meridional ocean circulation are most likely not only comprised of changes in the density driven circulation, but also in the for instance the gyre transport. A good example of the complexity of such future North Atlantic circulation changes is given in Swingedouw et al. (2015). By using a box-model that is driven by meridional density differences, such complexities are considered of secondary importance. However, since we tune the box-model to mimic the behavior of fully coupled models that do include such processes, they do influence the sensitivity of the emulator to changes in temperature and GIS melt. To our knowledge, the current understanding of the sensitivity of individual mechanisms that drive Atlantic Ocean circulation changes is not sufficient to be incorporated into a sufficiently simple model to be used in an AMOC-emulator.

Page 5, line 30: algorithm misspelled.
Thanks, it is corrected.

page 6, line 4: Why fixed limits of plus/minus 200%? Why not something based on each variable's variability/range?
The plus/minus 200% range is indeed somewhat arbitrary, but this approach is chosen because for most of the variables a reasonable estimate of the variability or range does not exist, mostly because the parameters do not have a 'meaning' in the real world. The updated manuscript includes a line discussing this topic (lines 14-15 page 7) "The appropriateness of this arbitrary range of initial parameter values is later verified by ensuring that all final parameter values are well within the initial range."

page 6, line 8 - analogous misspelled.
Thanks, it is corrected.

Summary: Way too short. I'd like to see more discussion on how such an emulator could be improved, its limitations, questions it might be best for, etc.

We agree that a more substantial discussion section is called for. We have rewritten it to read (lines 4-25 page 12) "Overall, the predictive power of the AMOC-emulator is reasonable when one considers the simplicity of the AMOC box model, but for forcing scenarios that are increasingly far away from the forcings that are used in tuning the AMOC-emulator, the predictive power decreases. A large advantage of using a physics-based AMOC-emulator that is tuned with large climate forcings, over the use of for instance a statistical AMOC-emulator, is that it projects the point after which the AMOC collapses and switches to an off state, as this is an integral part of the physics of the Stommel model. It is clear that using an AMOC-emulator introduces new uncertainty into AMOC projections, however, for which level of added uncertainty an AMOC-emulator is still useful is a question that is difficult to address. Another important consideration when using the AMOC-emulator is the spread in GCM climate forcing scenarios that is included in the tuning process. When using only a single climate change scenario, a better match can be obtained between the AMOC evolution given by the GCM and AMOC-emulator, however, in this case the reliability of the AMOC-emulator will quickly decrease for different climate forcings. On the other hand, one could use a large number of climate change projections in the tuning process to obtain a lesser fit for individual scenarios, but an AMOC-emulator that is applicable to a much larger range of climate change scenarios. The best strategy to be followed strongly depends on the research question in mind. The assumptions behind the AMOC-emulator presented here, limit it to projecting AMOC changes on multi-decadal and larger timescales. Therefore, the applied GCM-based climate forcings and AMOC strength time series should best be filtered to exclude high resolution variability. Moreover, an AMOC-emulator that is tuned to specific GIS melt experiments is likely not applicable to experiments in which melt water is applied to a different geographical region or with a different seasonal cycle. This is not to say that the presented AMOC-emulator framework cannot equally be applied to other sources of melt water input. Finally, many processes that are known to impact the AMOC are not considered in the AMOC-emulator, for instance the impact of winds, gyre circulation, Southern Ocean upwelling or deep water formation outside of the North Atlantic (see Sect. 1). If such processes would prove to dominate the AMOC response to future climate change, a different AMOC box model should be considered that places emphasis on that particular process."

Table 1: For last 3 entries, dependent misspelled

Thanks, it is corrected.

Figure 1: Why is the atmospheric part squished so much in the vertical compared to the oceanic component?

We have adjusted the figure in order for it to have more appropriate scaling.

Figure 4 caption: relative misspelled.

Thanks, it is corrected.

Figure 8 caption: right misspelled.

Thanks, it is corrected.

Reference:

Didier Swingedouw, Christian B. Rodehacke, Steffen M. Olsen, Matthew Menary, Yongqi Gao, Uwe Mikolajewicz, Juliette Mignot. On the reduced sensitivity of the Atlantic overturning to

Greenland ice sheet melting in projections: a multi-model assessment. Climate dynamics 44, 3261-3279, 2015.