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Geoscientific Model Development Discussions

Interactive comment on "Synthesizing long-term sea level rise projections – the MAGICC sea level model" *by* Alexander Nauels et al.

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Referee 1 General Comment (RC1.00): In this paper, the authors describe the first version of the MAGICC sea level model, a set of sea-level emulators linked to versions 6 and 7 of the MAGICC climate model. They provide a clear description of the algorithms for the different sea-level components and of the model calibration. Accordingly, I believe the paper is worth publishing and have only minor comments regarding the paper itself. I suggest the authors add some discussion placing the MAGICC sea level model in the context of other similar tools, such as the BRICK model, also currently in review at GMD (http://dx.doi.org/10.5194/gmd-2016-303). A comparison of the model results to that of other simple sea-level models (e.g., Kopp et al., 2016, and Mengel et al., 2016) under similar forcing would be helpful – prima facie, the projections for 2100 seem to align well with these simpler models.

Author Response (AR1.00): We would like to thank the referee for reviewing this manuscript and are encouraged by the positive feedback and the overall recommendation to publish the work with minor revisions. We have extended the discussion on alternative sea level modeling approaches and included hindcast information with comparison datasets, as also requested by referee 2 (Figure A.2). Unfortunately, we find it hard to compare our results directly to the BRICK model, because we could not find any suitable sea level projection time series in the BRICK discussion paper. However, we very much support the efforts by the author team to provide a simple and transparent sea level model framework and have now referenced the discussion paper in our introduction (p.3 l.5). It is encouraging that also other simple model frameworks are in line with recent comprehensive reference assessments. Our key objective was to develop a simple but comprehensive sea level model that emulates the process-based reference data from the Fifth Assessment Report of the IPCC. Consequently, mainly IPCC datasets are used for comparison in the manuscript. Please note that we discovered a bug in the MAGICC routine to prescribe annual mean surface air temperature as well as a problem with the Greenland SID functional form, while carrying out additional checks of the calibration routines after the submission of the manuscript. Also, one specific CMIP5 model input had to be removed due to quality issues with the reference data (BCC-CSM1.1M). All issues have been resolved. The revised prescribed temperature routine required the re-calibration of all sea level model components, with all figures now showing the revised sea level model results. The updated optimal parameter sets are provided in the corresponding Tables. For the Greenland SID parameterization, the calibrated constant was removed, because it prohibited the reproduction of lower bound projections (see revised Equation 6). In addition, the routine was adapted to allow for hindcasts without depleting the maximum outlet glacier volume, which was determined based on the year 2000. The code repository has been updated to account for these changes. All revised and additional Figures as well as one additional Appendix Table are provided at the end of this document.

RC1.01: Line 28: I believe the citation here should be to Levermann et al. (2014), not Levermann et al. (2013).

AR1.01: Well spotted, thank you! The citation is updated.

RC1.02: Line 30: Note that an early semiempirical model was introduced by Gornitz et al. (1982) twenty five years earlier. Gornitz, V., S. Lebedeff, and J. Hansen, 1982: Global sea level trend in the past century. Science, 215, 1611–1614, doi:10.1126/science.215.4540.1611.

AR1.02: Thank you for this correct remark. We have revised the text accordingly. The passage on p.2 l.30 now reads: "*In the 1980s, first Semi-Empirical Models (SEMs), which estimate global sea level changes based on the evolution of global mean temperature, were introduced together with early attempts to model thermal expansion based on simplified ocean processes (Gornitz et al. 1982). Generally, SEMs establish statistical relationships between observed/reconstructed global mean temperature or radiative forcing changes and observed/reconstructed global mean sea level changes. Assuming that such relationships stay the same for the future, they are used to estimate future SLR from projected global temperature/forcing changes (Jevrejeva, Moore and Grinsted 2010, Kopp et al. 2016, Rahmstorf 2007, Vermeer and Rahmstorf 2009). As such, these SEMs do not calculate sea level by resolving the underlying physical processes.*"

RC1.03: I also note that the code for the sea level model, while available at the gitlab link provided, does not run without the MAGICC model, for which code is not available. I further note that GMD policy states: "If the authors cannot or do not wish to make the code and/or data public (e.g. copyright or licensing restrictions), the reasons must be clearly stated. Note that, for the purpose of the review, the code and/or data must still

be made available to the editor. Access must also be granted to the reviewers whilst preserving their anonymity, if this is legally possible." I am not sure whether the current code availability – dependent upon code that was not available for the review process, and for whose non-availability no explanation was provided – satisfies this policy.

AR1.03: We acknowledge that the parent MAGICC model is needed to fully reproduce results with the MAGICC sea level model and regret not providing the source code and a test example with the first version of this manuscript. In order to facilitate the review of the sea level model implementation and to fully support the GMD policies for reproducibility, we have now provided a minimum MAGICC model setup including source code to the editor for distribution to the referees. The sea level model presented in this manuscript is available as open source code on a dedicated gitlab repository, in accordance with the GMD code and data policies. Please see Meinshausen, Raper and Wigley (2011a) and Meinshausen, Wigley and Raper (2011b) for a detailed description of the parent model. MAGICC itself has not been designed as an open-source model, as its initial development and application go back three decades to a time when the open source concept wasn't well established in the scientific community. The source code for MAGICC model version 6 is available under a license agreement on request. Unfortunately, we did not make this clear in the documentation on the digital repository. This has been corrected. We hope that these efforts address the concerns voiced by the referees and allow us to provide a first MAGICC model component on an open-source platform.

References:

Gornitz, V., S. Lebedeff & J. Hansen (1982) Global Sea Level Trend in the Past Century. Science, 215, 1611.

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Meinshausen, M., S. C. B. Raper & T. M. L. Wigley (2011a) Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6-Part 1: Model description and calibration. Atmospheric Chemistry and Physics, 11, 1417-1456.

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Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/gmd-2016-233/gmd-2016-233-AC2-supplement.pdf

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Interactive comment on Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-233, 2016.

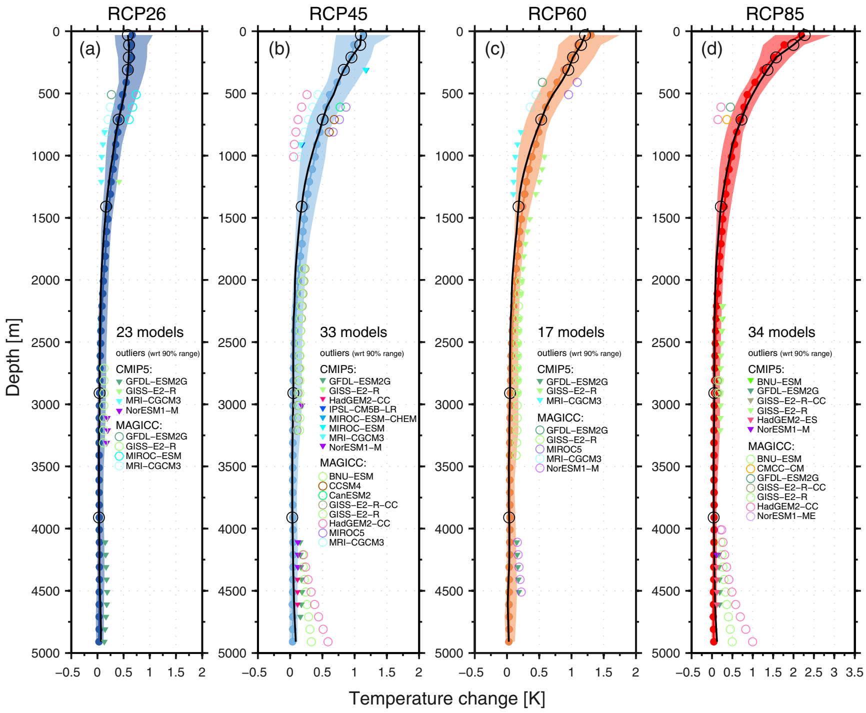

Fig. 1. Figure 2. Potential ocean temperature depth profiles for MAGICC and reference CMIP5 warming under RCP2.6, RCP4.5, RCP6.0 and RCP8.5 scenarios, 2081-2100 anomalies with respect to 1986-2005. [...]

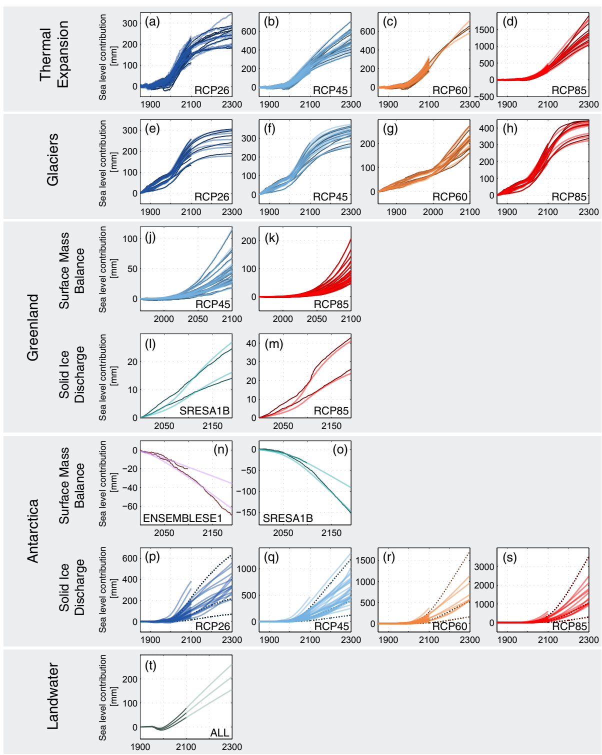

Fig. 2. Figure 3. MAGICC sea level model calibration results for thermal expansion (a-d), global glaciers (e-h), Greenland surface mass balance (j-k) and solid ice discharge (l-m) [...]

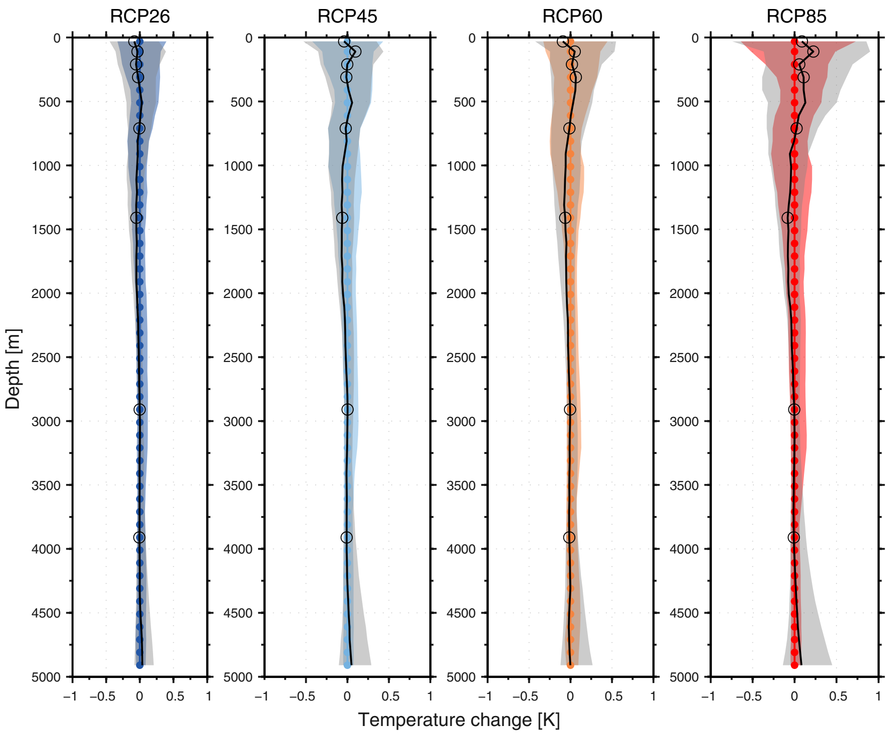

Fig. 3. Figure A.1. Potential ocean temperature residuals for calibrated MAGICC and reference CMIP5 ocean warming under RCP2.6, RCP4.5, RCP6.0 and RCP8.5 scenarios. [...]

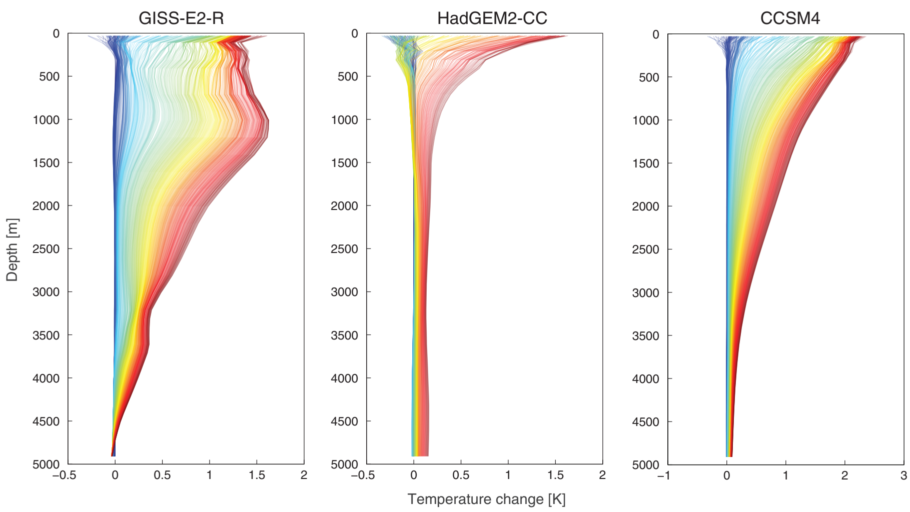

Fig. 4. Figure A.2. Annual RCP4.5 ocean warming anomalies for the CMIP5 models GISS-E2-R (1850-2300), HadGEM2-CC (1850-2100), and CCSM (1850-2300), relative to 1850 and globally averaged. [...]

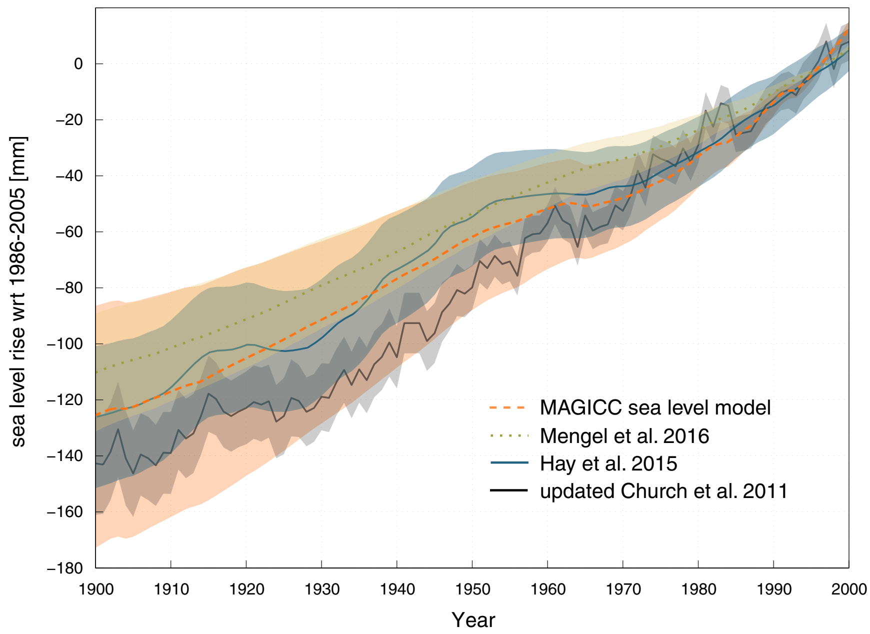

Fig. 5. Figure A.3. Historical modelled and observed SLR from 1900 to 2000, relative to the 1986-2005 mean. Median and 90% uncertainty ranges are shown for the MAGICC hindcast (orange) [...]