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**Geoscientific
Model Development
Discussions**

Interactive comment on "An optimally tuned ensemble of the "eb_go_gs" configuration of GENIE: parameter sensitivity and bifurcations in the Atlantic overturning circulation" *by* R. Marsh et al.

Anonymous Referee #1

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In this paper the GENIE model configuration "eb_go_gs" described in detail in Marsh et al., 2011 GMD, is tuned using the tuning method of Price et al., 2009. Tuning targets are observational 3D ocean temperature and salinity fields and 2D air temperature and relative humidity fields. Additionally, simulations are performed where the effect of small changes of individual tuning parameters on changes of the AMOC state is analyzed, and it is revealed that in the described model version, small parameter changes may lead to large differences in the AMOC solution. This paper neither describes a new model nor a novel tuning method. The main value of the paper is the presentation

of an optimal parameter set that is to be used in future studies that use the GENIE "eb_go_gs" model configuration. Therefore, the manuscript is suitable for publication in GMD.

I have some criticisms concerning the tuning method and some other comments that I wish to be addressed by the authors prior to publication.

General comments

Since the main value of the paper is the recommendation of one parameter set for future studies, this should be better emphasized in the abstract, at the end of Section 4.2, and in the conclusions.

The tuning method does not account for uncertainties of the observational fields. Hence, the observational fields are the optimal solution. Hence, the annual-mean velocity field and stream function calculated from the observational T and S fields should result in an optimal annual-mean circulation (this can be tested by prescribing T and S and let the model calculate the velocities). I believe that this won't be the case, because the overturning circulation is to a great part determined by the density distribution in the deep-water formation zones, and deep-water formation does not occur throughout the year. Additionally, the surface density values at deep-water formation zones might need to be different from observations in such coarse models as GENIE in order to have dense enough surface waters for deep-water formation. The simplest solution to circumvent this problem is to exclude these regions (the Southern Ocean from about 90S to 50S and the North Atlantic from about 90N to 50N) from the tuning metric.

The figure captions are generally too short and do not explain the figures well enough. Extend them such that the figures can be understood without having to read the main text.

Specific comments

p.931, l.10 "The root-mean-squared (RMS) errors defined by these fields and corre-

sponding output fields from “eb go gs” for the last year of a 5000-yr spin-up model integration (sTocn, sSocn, sTatm and sQdry) define four objective functions”. You should take a multi-year mean of the model output to remove numerical inter-annual variability of the model.

p.932, Equations: Add a superscript i to sˆi_Tocn and Sˆi_Tocn and add to the text that N_Tocn is the number of model cells.

p.933, l.3 The process of determining the pareto-optimal solution should be explained in more detail and Deb et al., 2002 should be cited at this point.

Sec.4.1,first paragraph: This paragraph is more a methods discussion than a results discussion and should therefore be moved to the methods section.

Sec.4.1, second paragraph: How are the 90 individuals chosen?

Sec.4.1, third paragraph and Fig. 1: This paragraph and the figure are hard to understand. Improve the explanation of what is shown in the figure and what the interpretation is. What exactly is plotted? If objective function values are plotted, then the axis labels should be “f_Socn”, “f_Tocn”, etc. But these values are a function of the parameter. As I understand there is one cross per individual. So are the crosses some sort of average objective value of one individual? When are runs “successful”? You write that Tocn and Socn are reasonably well correlated. But what about the tail in the figure towards larger Tocn?

p.934, l.28 “Specifically, we have selected points 18, 37, 49, 56, 74, as they were the . . .” Color the crosses of these points in Figure 1 in the same way as it is done in Fig. 3.

p.935, l.4 “Alongside the corresponding Marsh et al. (2011) configuration (using untuned parameters),. . .”. Mention that with “untuned” you mean not tuned by the method described in this paper. I’m sure the “untuned” model version was quite heavily tuned “by eye” or some other method.

p.935, l.24 It should be “normalized” standard deviation. Explain that this is the std. dev. of the model divided by the std. dev. of the observation.

p.936, l.10 and Fig. 4 Here you compare modeled sea ice with observations. It would be helpful for the reader if the observations also appeared in the figure, either as a separate panel, or alternatively, by drawing a line of the annual mean sea ice extent on top of the plots.

p. 936, l.19 “The Antarctic circumpolar flow is strongest, and hence most realistic, on point 74 (Fig. 5e), . . .” Please add a value. It is quite hard to read the values from the figure.

p. 936, l.24ff You compare intensity and depth of the overturning stream functions to observations. However, it is never mentioned to what observations the AMOC depth is compared to. You could base your comparison on nutrient proxies or carbon isotopes (best would be if they were directly simulated in the model). Alternatively, you could compare the AMOC to the AMOC of CMIP5 models.

p. 927, l.2 “. . . we judge point 18 to be marginally most plausible”. Add a sentence such as “We recommend to use this parameter set in future studies using this model configuration.” This is one of the major results of this paper and it should be clear for future GENIE users what parameter set to use in their studies.

p. 939, end of paragraph 1: As above, add a sentence that this one parameter set is recommended for future studies using this model configuration.

Table 3: highlight column of point 18 by bold letters or by a border, since this is the final parameter set.

Figs. 3 and 4: Extend the Figure caption such that the figure can be understood without having to read the paper beforehand: Explain that the reference is the optimum; what are the points?; what is GMD11?

Figs. 5 and 6: I recommend a discrete colorbar with the same increments as in the

figure. This makes it much easier to read the figure.

Fig. 7: Residual of what? Why not write “Objective function value”?

Fig. 8: Dimensions of the parameters are missing. The “x10ˆ6” is confusing, because it is not clear whether it belongs to the upper or to the longer panel. I recommend K_q [10ˆ6 mˆ2/s]

References: See references in the manuscript.

Interactive comment on Geosci. Model Dev. Discuss., 6, 925, 2013.