Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2019-96-RC2, 2019

Geoscientific Model Development Discussions

Interactive comment on "An effective parameter optimization with radiation balance constraint in CAM5 (version 5.3)" *by* Li Wu et al.

Anonymous Referee #2

Received and published: 7 August 2019

This manuscript describes an optimization method to improve the calibration of adjustable parameters in global climate models. This works builds upon previous works by Zhang et al. (2015, 2018). The main difference is the addition of a global constraint to enforce that the net energy imbalance at TOA be less than 1 W/m2. This constraint is incorporated by simply adding a penalty term to the cost function (Eq. 6).

When applied to CAM5.3, the proposed method results in a modest overall improvement of 6.3% in the cost function. Among the fields subject to optimization (LWCF, SWCF, PRECT, Q850, T850), the largest improvements occur for SWCF, Q850, with minor improvement for T850 and minor degradations for LWCF and PRECT (Table 4). Since CAM5.3 is already a well tuned model, it is not particularly surprising the the overall improvement is small.

Overall, the manuscript is clear and easy to read and fits well within the scope of GMD. I would recommend publication after some modifications to further improve it.

* It should be noted that the idea of including a constraint on the global value of net radiation is not new. From Jackson et al. 2008 (J Climate): "We also included a term constraining the global net radiative balance at the top of the atmosphere. We had intended to give this a target of 0.3 W m$-$2"

* Figure 2 and corresponding text. There is a clear separation between optimized results with and without constraint. This is interesting and warrants further discussion. How different are the unconstrained optimized simulations compared to the constrained ones? This could be illustrated by showing a few selected figures. Also, the constraint is applied as a rather brutal all-or-nothing penalty function that may prevent a wider exploration of the parameter space. One wonders whether a smoother penalty function for the global net radiation have led to different (better) constrained solutions? I would recommend exploring alternate formulations for the penalty function (for example quadratic or exponential) to check whether the specific formulation of the penalty function has any impact on the results.

* Table 1 and corresponding text. Under constrained optimization, the final value for 3 out of 6 parameters hit the lowest allowable limit. This should be discussed.

Minor:

* Page 1, lines 17-18: rephrase to make it clear that the constraint is abs(FLNT-FSNT) < 1.

* Page 1, line 20: "under the premise of a profound understanding": delete. I don't see any new "profound understanding" emerging from this work or method.

* Page 1, line 25: "may result in breaking physical mechanisms that models have to address": delete or clarify what is meant by this (i.e. be specific, not vague).

* Page 2, line 13: "by using" → "using"

* Page 3, line 5: “extreme”: delete

* Page 3, lines 10-11: “Qian et al. (2015) indicated that some parameters in cloud microphysics and convection are very sensitive to net radiation flux”: isn’t this the other way around? Net radiation flux is very sensitive to cloud microphysics and convection parameters.

* Page 7, line 1: “The CNTL experiment has excelled in simulating the spatial distribution of SWCF (Fig. 5c)”. With RMSE between 14 and 15 W/m2, neither EXP nor CNTL can realistically be described as excelling in representing SWCF. These are much larger errors than seen in recent CMIP6 models.

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