Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2020-48-RC1, 2020

Earth System Dynamics
Discussions
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Interactive comment on "The Fractional Energy Balance Equation for Climate projections through 2100" *by* Roman Procyk et al.

Anonymous Referee #1

Received and published: 11 September 2020

This manuscript is a very interesting application of a recent model proposed by some of the authors to the problem of climate projections of global temperature. They are using the fractional energy balance equation (FEBE) with realistic forcing of greenhouse gases, volcanic eruptions and solar variability. Their projections are compared with CMIP5/6 projections. The set of parameters of the model is fitted to the observation data in a Bayesian framework. This work is worth publishing in Earth System Dynamics. I have however a few points that I think should be appropriately addressed by the authors:

Figures 9 to 11 show the current and future evolutions of the global temperature as compared with the observations and the CMIP5 simulations. These projections are provided as ensembles in order to cover the range of uncertainties related to the model

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Discussion paper

settings. An observational uncertainty is also provided. It is obvious that the spread of the ensemble is much smaller for the FEBE model than for the CMIP5 ensemble in Figure 9, and very often the observation band is not falling into the range of predicted projections of FEBE, while it is the case for the CMIP5. This suggests that the projections are unreliable in the sense that it does not cover all possible situations that can be observed. In weather and climate sciences, this aspect is key when making forecasts, predictions and projections using ensembles. This unreliability should be first acknowledged in the manuscript. Second this unreliability is maybe related to the use of a weak stochastic forcing. Some experiments with larger stochastic forcing would be desirable in order to clarify the under-dispersion of the ensemble. Stronger stochastic forcing could also maybe lead to larger climate sensitivity. This should be checked too.

At page 20, line 421, the authors claim that the hiatus is better represented in the FEBE than in the CMIP5 ensemble. Well to me this is not true as the observations are most of the time out of the range of FEBE. The CMIP5 looks better at capturing the observations. So I suggest to modify these comments and try to be more objective in the comparison, maybe by using measures of reliability.

One key conclusion of the manuscript is the lower sensitivity of the FEBE model on long time scales as shown for instance in Figure 10. What is happening when the FEBE model is fitted with a stronger noise that could maybe help in increasing the spread of the ensemble and its reliability? The results and the conclusions should then be revisited once these experiments are done and the impact of the stochastic noise clarified.

Minor points:

Equation 14: Please clarify what is the variance of gamma(t)

Figure 6: The response of FEBE is compared with an IPCC two-box model. What is this model? Maybe I missed the place where it is described. Please describe this model in more details in the text

Figure 12: Please correct the colors of the curves. I cannot figure out what is plotted

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