

Interactive comment on “On the increased climate sensitivity in the EC-Earth model from CMIP5 to CMIP6” by Klaus Wyser et al.

Anonymous Referee #2

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The authors present climate sensitivity estimates for different versions of the EC-Earth climate model and attribute the in comparison to the CMIP5 version higher climate sensitivity in the CMIP6 version to the use of a new aerosol climatology and the introduction of aerosol indirect effects. Climate sensitivity is a key metric to describe the global scale response of climate models to CO₂ increase. Therefore, understanding reasons for changes is very important and an absolutely appropriate topic for publication in GMD. This is the more the case as several CMIP6 models show higher climate sensitivities than their predecessor and it is important to understand if that is for similar or very diverse reasons and what can be learned from this. Unfortunately, the analysis presented in the paper seems very superficial to me. I think major modifications will be needed before the paper could be acceptable for publication in GMD. In the following I

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will list three major concerns followed by a list of further minor comments.

The authors present climate sensitivity estimates from a series of simulations including all or subsets of the aerosol related changes between the CMIP5 and CMIP6 versions. Simulation results indicate that as well direct aerosol effects from the new climatology as the inclusion of different indirect aerosol effects contribute to the higher climate sensitivity. However, no attempt is made to understand why and how these effects come about, which I think would be crucial to make this paper useful for readers beyond the notion that differences in climate sensitivities simulated by different EC-Earth version may be related to the treatment of aerosols. There should be an attempt to attribute the changes to different types of climate feedbacks, as well as to identify possible regional patterns and mechanisms that affect the feedbacks. One could e.g. imagine that the modifications affect ECS rather indirectly, e.g. by modifying the climatological cloud distribution which then reacts differently to an increased GHG concentration. It would be important to figure these things out.

There have been other publications on increased or tuned climate sensitivities in CMIP6 models (at least Andrews et al., JAMES, 2019; Gettelman et al., GRL, 2019; Mauritsen et al., JAMES, 2019; Zelinka et al., GRL, 2020, but there may be more I'm not aware of). I find it surprising that the authors ignore all of these publications. Their own work needs to be put into the context of these earlier studies.

To estimate the climate sensitivities in different model configurations the authors deviate from the common approach of branching a simulation with instantaneously increased CO₂ concentration from a control run with a climate in equilibrium. Instead, the authors start control runs with modified configurations at the same time as the runs with increased CO₂ and use anomalies of the latter with respect to the former. The sentence where this is described (L134) cites Andrews et al. (2012) which is a bit misleading as this reference is not appropriate for the use of anomalies. My hypothesis is that likely the use of anomalies is unproblematic, but if there is no reference confirming this I think the authors should show that, e.g. by using other common approaches as

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slab ocean models or +4K experiments which also don't require long spin-up runs. I'm a bit concerned about the applied method because of the strong initial (over five years or so) adjustment due to the change of configuration and the change of sign in the temperature trend afterwards.

Minor comments: L60: The table doesn't show "basic differences" between the different EC-Earth versions but version numbers (and resolutions) of the subcomponents. L67: If the conclusion is that the treatment of aerosols is key for the increased climate sensitivity I think that this paragraph describing it should be expanded, for the reader to better understand key properties and differences. L89: I don't like the use of "tas" for near surface air temperature. I know it is a CMIP variable name, but it looks odd in a written text, isn't used for the global mean in CMIP, and is inconsistent with other names (Qnet). L100 "most important updates are likely those related to the revised aerosols". I guess "most important" is meant in the sense of ECS. Why is that likely? Other authors have e.g. documented that also tuning of model physics may affect ECS strongly. Can this be excluded a priori. L117 "Since models may present a not perfectly closed energy balance ..." Is that the case for EC-Earth? L123 "Therefore we divide ..." This is common practice. L126 Why is a "well-tuned" model a basic assumption of the Gregory method? And how can good tuning be characterized? L134 The new control experiments are no piControl experiments, which are supposed to start after a spin-up. I'd suggest to name them differently. L185 The authors speak of "subsequent tuning to match a realistic preindustrial equilibrium and present-day climate". This sounds like the model's climate sensitivity was tuned? Or is this just a misunderstanding? L193 I don't find it easy to understand why a change in complexity would have the "potential to modify the sensitivity" beyond the fact that any model change has this potential. I would also like to see an explanation for the statement in the following sentence. Would the assumption be that the addition of an indirect effect would lead overall to a larger aerosol forcing and the attempt to compensate for that by tuning the model to a higher climate sensitivity to obtain a better fit to the historical temperature trend? Code and Data availability: I don't know the exact policy of GMD. But usually

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these days journals require the availability of primary data, which to my understanding is the model code and the scripts and input files needed to run the model, not only for editors and reviewers. Table 2: The "experiment" column should contain more information. E.g. it would be nice to be able to identify quickly which experiment in table 3 belong to which in table 2.

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