

Geosci. Model Dev. Discuss., referee comment RC1  
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## Comment on gmd-2021-11

Anonymous Referee #1

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Referee comment on "Cloud Feedbacks from CanESM2 to CanESM5.0 and their influence on climate sensitivity" by John G. Virgin et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-11-RC1>, 2021

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This paper analyses the changes in radiative feedbacks between CanESM2 and CanESM5.0. The authors show that cloud feedbacks are the main driver for the change in feedbacks. Then, they decompose the cloud feedback into components (fraction, optical depth, altitude) to investigate the main drivers for the changes. Given that CanESM5 is the model with the largest effective climate sensitivity of the CMIP6 ensemble, and that it shows a large change with respect to CanESM2, the topic of this paper is very relevant for the climate community. The results are important because they add to the recent body of literature on the reasons for the increase in EffCS between CMIP5 and CMIP6 models. The paper is logically structured, clearly written, and the conclusions are supported by a clear methodology. I recommend publication after minor revision.

Perhaps my main criticism is the explanation of differences in SW low cloud feedback between amip-p4K and amip-Future (Figure 6, L271-280). I the discussion speculative and not very convincing, as one cannot clearly see how the population of feedback and pattern anomalies is distributed. I suggest changing how this is presented and explained.

### SPECIFIC COMMENTS

Figure A3: given that this figure is referenced before Figure 2, I'd recommend using the full figure caption, not "As in Figure 2".

Figure A2: This figure is referenced after Figure A3, I suggest swapping the order.

Figures: Please increase text size of axes titles and tick labels.

L17: Can the Chaney models be considered ESMs?

L24-25: - "particularly with regards to properties such as cloud optical depth, which reflect shortwave (SW) radiation and cool the planet". This reads weird, clouds reflect radiation, cloud optical depth is a property that changes how much it is reflected.

L43: (CanESM2). (Flynn and Mauritsen, 2020). I'd suggest re-arranging this sentence to avoid model acronym and the citation being together.

L70-71: Strictly speaking, ECS doesn't need the definition of a CFP (time-varying or not). One can run a model to equilibrium (with a practical definition of "equilibrium") and calculate ECS without invoking a feedback parameter.

L165-167: optical thickness and emissivity are not the only properties, cloud fraction and top pressure/temperature can produce radiative feedbacks (as discussed later in the paper).

L169-174: Figure 3 -> Figure 2

L193-194: Perhaps worth noting that, at the same time, the SW feedback (especially for CanESM2) shows differences of similar magnitude in the opposite direction.

L195-198: I think the term 'emissivity' is wrongly used here (perhaps you mean emission). As explained in the second sentence, the altitude feedback is related to the temperature difference between cloud tops and the surface. That mechanism doesn't need a change in cloud emissivity.

L311: The new developments are included in HadGEM3-GC3.1.