

Comments on “Cloud Feedbacks from CanESM2 to CanESM5.0 and their Influence on Climate Sensitivity”

This paper compared the radiative forcing and feedback between CanESM2 and CanESM5 and tried to understand what causes the higher ECS in CanESM5. In the fully coupled experiments (abrupt-4xCO₂), they found the cloud feedback is the dominant factor, especially the shortwave component, which is consistent with previous findings. Further decomposition of cloud feedback using the cloud radiative kernel method showed the reduced shortwave low cloud amount and non-low cloud optical depth are two important factors to produce stronger positive cloud feedback. The cloud feedbacks from amip-p4K and amip-future4K were discussed to understand the impact of spatial sea surface patterns.

The topic is quite important to help understand the high ECS from CMIP5 to CMIP6 given that CanESM5 shows the highest ECS. The motivation and method description are clear and easy-following, however, I think results are not appealing and deep enough to extend and broaden the current understanding about stronger positive cloud feedback because many changes reported in the paper are lacking solid physical explanations from their model perspective. For example, many high ECS models show stronger positive cloud feedback. I think the more appealing question is: why is the positive cloud feedback getting so strong from CanESM2 to CanESM5, not only showing from those cloud feedback decompositions? So I would recommend making substantial revisions on the analysis and explanation to the finding before publishing the paper to GMD.

Major comments:

1. I think it's not enough to just show the cloud feedback difference between CanESM2 and CanESM5. A more physical explanation is expected, instead of only presenting those changes and referring to previous studies. I list some questions/comments below and I think they need to be addressed more. I don't list all of them here and I think explanations to those significant signals are the key point I would like to see.
 1. L177-178: the motivation to show LW components is because although the difference between CanESM2 and CanESM5 is small, there is an important compensation between its individual components. However, in the following discussion, e.g. L198-200, I don't see many discussions about these compensations.
 2. L205-210: Authors refer to previous proposed mechanisms about increased cloud liquid water in mixed-phase clouds or increased cloud liquid water content and the slope of the moist adiabat, which could explain the negative non-low cloud optical depth feedback. Why not further examine these particular state variables to check whether model response is consistent with the previous studies? Furthermore, the negative mid-latitude cloud optical depth feedback is quite popular in climate models, and I think the more important question is: instead of the feedback sign, what controls the feedback magnitude change from CanESM2 to CanESM5?
 3. L236: “For the SW low cloud amount feedback, ...” I notice the strongest SW low cloud amount feedback is in the central to eastern tropical Pacific, rather than

those regions with highest EIS over marine low cloud regions. If you think this low cloud amount change is controlled by the EIS or other factors, it might be better to dig it out and give more physical explanations.

4. Table 1: 1) amip-future4K is closer to the abrupt-4xCO₂ feedback for non-low clouds, but amip-p4K is closer to the coupled for low clouds. Why? 2) For the total cloud feedback, amip-p4K is closer to coupled for CanESM2. amip-future4K is closer to coupled for CanESM5. Why?
 5. Figure 5: 1) non-low cloud: LW and SW cloud amount feedback is largely reduced in CanESM5. Also, SW cloud optical depth feedback is reduced from -0.46 to -0.35 W/m²/K. SW cloud amount feedback is reduced from -0.3 to -0.09 W/m²/K. This change is more significant in amip-p4K and amip-future4K than coupled (Figure 3). Why? I expect the text will show some discussions about this.
2. I would suggest revising some figures or contents to convey clearer ideas.
1. Section 3.3: I don't think this section gives a good explanation of the impact of the spatial pattern of SST change. Except for those changed cloud feedback components, I think more discussion and analysis to understand these changes are more important. Also, comparison with abrupt-4xCO₂ results would be also interesting.
 2. Figure 2: I think this figure is not more informative than just adding the global-mean SW and LW cloud feedbacks in Figure 1 as another two columns. As for the uncertainty brought by different radiative kernels, I think they are not the key point here. So, except for the uncertainty consideration, I think Figure 2 is not necessary to be only used to show the LW and SW cloud feedbacks.
 3. Figure 6: I am not able to get quite clear information from this figure if I don't read the text. First, I suggest that you should report the significance of the correlation. Second, after reading the text, I think your motivation is to show the relationship between SST pattern anomaly and feedback anomaly, but this has been widely investigated in previous studies. I am not sure whether it's necessary to have this figure here to confirm this. Additionally, I think more comparisons of cloud feedbacks from amip4K/amip-future4K and abrupt-4xCO₂ experiments will be better because it can reveal how largely the amip-type feedbacks could reproduce the coupled feedbacks in this model and what contributes to these differences.

Minor comments:

1. In section 2.1 describing the model, it is better to document the major difference between these two models because you are discussing their difference.
2. L74: what does 'in part-' mean?
3. L80: should be 'sstClim and sstClim4xCO₂' in the bracket rather than 'piControl and abrupt4xCO₂'?
4. L99: It might be better to list these three kernels that passed the clear-sky linearity test and the reader doesn't need to find Figure A1 if they are curious what they are.
5. L108: "global uniform proportionality constant" -- why not showing the value here?
6. L144: "strong linear relationship between surface temperature and net TOA flux" → why?

7. L157: suggest changing “due to increases over the Arctic from sea ice loss” to “due to the sea ice loss over the Arctic”
8. Figure 1: why not also showing LW and SW cloud feedbacks in panel (b)? That will be more direct for readers to see the relative contribution of SW and LW.
9. L173: I think it should be “Figure 2” not “Figure 3” in the bracket.
10. L209: “The situation for the non-low ...” -- This sentence is not clear to me. Please consider rephrasing.
11. Table 1 caption: should be “amip-future4K” not “amip-future-4K”