Response to Referee #2

We thank the referee for their review. Below are the original comments in *italics* intermixed with our responses in normal text.

This paper is a technical documentation of the atmospheric model CanAM5 that is part of the CanESM used for its CMIP6 simulations. It documented the modifications made to the previous model version CanAM4, which are for the optical properties of cloud particles and land/ocean/snow surface in the radiative calculations, cloud microphysical scheme, and surface processes. It also contains description of the spin-up of the carbon model and tuning of the CanAM5 and CanESM5. The paper then documented the rudimental performances of climatologies in clouds, radiation, zonally averaged winds and temperature, surface pressure and precipitation against observations and CanAM4. It provided some insight, although rather superficial, into the cause of the model biases. I think the paper is valuable for model developers and potential users of its simulations. I therefore recommend a minor revision. The paper is a straightforward documentation. I only have some minor comments.

1. *For the benefit of the readers, please describe what is the second aerosol indirect aerosol effect that is included in Equation (2). Line 1 on page 5.*

   We have adjusted the text by referencing the second indirect effect and why it is present in CanAM5 but not CanAM4,

   "Along with the new autoconversion parameterization, CanAM5 now accounts for indirect impacts of aerosols on cloud liquid water content and lifetime, i.e., the second aerosol indirect effect (Ghan et al., 2013). This effect was not active in CanAM4 since it used a constant cloud droplet number concentration of 50 cm^{-3} in Eq. 1 (von Salzen et al., 2013).

2. *Line 24 on page 5 missed a period. This is the same in Line 14 on page 7.*

   The periods have been added.

3. *The sentence in line 23 on page 8 is poorly written. Please revise.*

   We have changed the sentence from

   "After finalizing the new and updated physical parameterizations for CanAM5 were finalized, they were held fixed, or frozen, and only a subset of parameters was manually adjusted within a range of physically plausible values to target a stable and reasonable climate in the coupled atmosphere-ocean model CanESM5."

   to

"After finalizing the new and updated physical parameterizations, they were no longer changed, except for a subset of parameters. These parameters were manually adjusted within a range of physically plausible values to obtain an acceptable pre-industrial climate in the coupled atmosphere-ocean configuration of CanESM5 (Swart et al., 2019).".

4. *Line 14 on page 9: add "net downward" after 2.5 W/m2.*

   Thank you for pointing this out. We edited the sentence, so it now reads,

   "Adjustments required to ensure an acceptable preindustrial climate resulted in a net downward fluxes at TOA (~3.1 W m^{-2}) in historical AMIP runs, which is larger than observations."

5. *Line 24 on page 12: "..., there is a shift to more optically thin (< 23) in CanAM5", this is inconsistent with Figure 2 which shows less optically thin clouds with tau less than 6. It is also inconsistent with Figure 3.*

Reflecting on this comment, we suspect the reviewer might have been interpreting the figures as values from the models, not biases relative to ISCCP observations. Below we reproduce Figures 2 and 3 (Figures R1 and R2, respectively), with the model values instead of the bias relative to observations, which shows our text is consistent with the figures.

We have adjusted text on Figures 2 and 3 and the text referring to the figures to make it clearer that the CanAM evaluation plots are biases to make it more explicit for the readers.

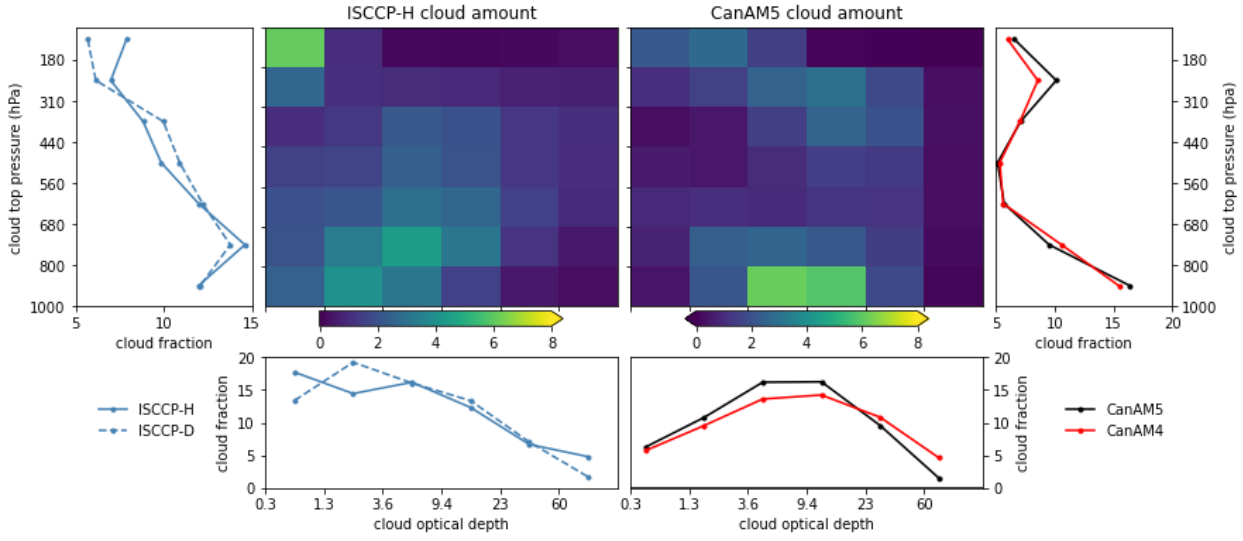

Figure R1. Reproduction of Figure 2 in text but instead of plotting biases for the three right plots, actual values are plotted.

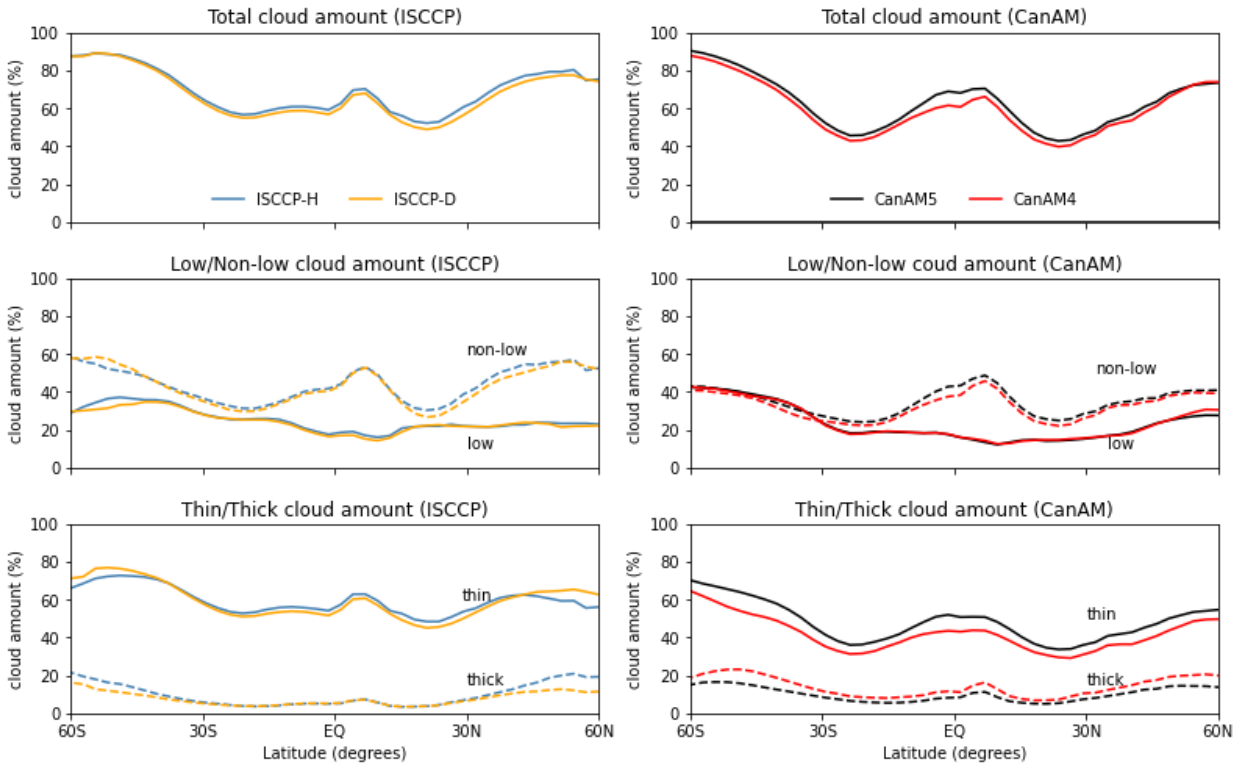

Figure 2. Reproduction of Figure 3 in the text but instead of plotting biases in the right column, the actual values are plotted.

6. First paragraph of Section 6.3 on zonal wind: there seems to be cherry picking. CanAM5 shows larger bias than CanAM4 not just in the Northern Hemisphere. It is also larger in the Southern Hemesphere as indicated in Figure 8. The attribution of orographic gravity wave drag parameterization (Line 6-7 in the paragraph) is thus questionable.

We have attempted to clarify the role of gravity-wave drag and include comment related to SH anomalies as suggested by the reviewer with the change:

"This positive zonal wind bias is associated with changes to adjustable parameter values in the orographic gravity-wave drag parameterization between the two model versions, Sec. 4."

To

"This wintertime positive zonal wind bias is associated with a weakening of the orographic gravity-wave drag due to a change in parameter values between the two model versions (Sec. 4). Similarly, this weakening of the gravity wave drag contributes to a larger positive anomaly of zonal-mean zonal winds in CanAM5 in the Southern Hemisphere wintertime stratosphere."