Response to Reviewer #2

RC2: 'Comment on gmd-2022-283':

This paper leverages the single column modeling framework to compare two physics suites in a unified forecast/climate modeling system and performs various sensitivity experiments. I felt the paper was well written and I do recommend publication after the following issues are addressed.

Response: The authors thank this reviewer for many helpful suggestions.

1. I felt that all (line) plots could benefit from adding a background grid for more ease in interpretation of results (though this is more of a personal preference and leave it up to the authors).

Response: Done. All the line plots are added with tick marks and labels at X-Axis top and Y-Axis right. The legends for the line plots are also modified to help clearly showing the results.

2. It is my viewpoint that SCMs are very useful (even vital) tools for GCMs. However, including a brief discussion on their limitations would be useful for the reader.

Response: Done. We have added the limitation of SCM in the Introduction (Lines 86-89).

"The limitation of SCMs lies in the absence of (3D) physics-dynamics interaction. In the cases such as propagating rainfall episodes or middle-latitude cyclones, the SCM may be viewed only as a way to describe a constrained balance of the model physics to the prescribed large-scale condition (Zhang et al. 2016)."

3. Figure 1: Would it be possible to add profiles of the cloud ice?

Response: Done. The time average cloud ice mixing ratio for convection active and suppressed periods is added in Figures 3e and 3f. PhysW produces larger cloud ice content than PhysC because of the stronger vertical transport by the TB deep convection.

4. For TWP-ICE is it possible to show the profiles of Temperature and Moisture errors with respect to observations?

Response: Done. We add a figure (Figure 2) to show the temperature and water vapor errors for TWP-ICE. The modeled temperature and moisture are not nudged towards the observation during integration. Cool and dry biases increase after day 6 when the large-scale forcing weakens. In the convection suppressed period, PhysW shows slightly smaller negative errors of temperature as compared with PhysC.

5. Some figures use Pressure for the y-coordinate while some use kilometers/meters. Please use the same coordinate for all plots so that they can be directly compared to another.

Response: The y-coordinate (pressure or height) of a plot depends on the reference data (IOP observation or LES). The pressure coordinate is used for the deep convection case (TWP-ICE) while height coordinate is used to evaluate low clouds in the DYCOMS and CGILS cases.

6. Regarding the DYCOMS case, it was not clear to me at all if the authors used the research flight 1 (RF01) or RF02. On page 6 it is stated that DYCOMS focuses on "nonprecipitating marine stratocumulus" which suggests RF01, while on page 9 it is stated that DYCOMS is "… with embedded pockets of drizzling open cellular convection" which suggests RF02. Please explicitly state in the document which flight segment was used and the appropriate reference.

Response: We used the research flight 1 (RF01) of the DYCOMS case (Stevens et al. 2005). The sentence on page 9 is modified as: "The DYCOMS-RF01 is a test case with steady nocturnal non-precipitating stratocumulus-topped mixed layer."

7. Figure 3: Please add the LES mean and spread for variables where available from the LES intercomparison study. Whether it was for RF01 or RF02 this data is publicly available and would add a nice reference point.

Response: Done. We add the LES data for reference of the DYCOMS-RF01 modeling (which is available at http://gcss-dime.giss.nasa.gov). The LES mean and spread for cloud liquid water mixing ratio are added to Figure 5. In addition, the LES data shows that the fraction columns with cloud present is ~0.92, representing a reference of cloud fraction.

8. Regarding the DYCOMS results… 30 layer vertical resolution is quite coarse for this regime. I feel like the paper would be strengthened by adding a vertical resolution sensitivity for the DYCOMS case. Often times parameterizations are tuned to achieve optimal results for stratocumulus to compensate for these very coarse vertical resolutions; which often breaks down when the vertical resolution is increased to something more appropriate for this regime. This would be a nice way to exploit any potential sensitivities to vertical resolution for each physics package and the SCM is the ideal vehicle to do this.

Response: Done. A vertical resolution sensitivity experiment is conducted for the DYCOMS case by increasing vertical resolution from 30 full model layers to 60 layers (section 5.3 on page 14). The increased levels halve the distance between the default model levels.

Figure 15 (in the revised manuscript) compares the temperature and cloud properties for the runs using 60 layers (referred to as "60levs") and 30 layers (referred to as "30levs"). The cloud liquid water content for PhysW decreases by ~50% as the vertical resolution increases. This is accompanied by a lifted inversion and cloud base. The water vapor budget illustrates that the shallow convection for PhysW strengthens with the increasing resolution and transports water vapor to higher levels (Figure 16). It implies that the collaborative effect of shallow convection and PBL turbulence in PhysW to produce stratocumulus clouds is sensitive to vertical resolution. In contrast to PhysW, PhysC has nearly identical cloud properties in the 60levs and 30levs runs, showing a mild sensitivity to vertical resolution.

9. Figure 6, I feel like panels e) and h) should be made into their own figure. There are shared and conflicting color schemes with the other plots in this panel that makes it very confusing (and easily misleading) to interpret.

Response: Done. Panels e) and h) are plotted as Figure 9.

10. Page 11, lines 314-315. The authors state "the nocu runs of PhysC and PhysW produce highly consistent precipitation evolution…". This is really hard to tell from this plot to my eye. I think it would be more illuminating to show the evolution of the difference between the two nocu runs and the two base runs.

Response: Done. The figure is modified to show absolute differences of precipitation evolution between the two "nocu" runs and the two base runs (Figure 8a). The absolute difference of precipitation between the "nocu" runs is smaller than that of the base runs in the convection active period (the first 6 days). The difference in the water vapor budgets between the PhysC and PhysW "nocu" runs is also smaller (comparing Figure 4 and Figure 9).

During the convection suppressed period with weakened large-scale forcing, the difference between the "nocu" runs is larger than that of the base runs from day 7 to day 10. This is mainly attributed to the peak time difference of weak rainfall events.

11. Figure7, is there an observational source available to plot here?

Response: Done. The observed cloud fraction is added in this figure (Figure 10 in the revised manuscript).

12. In the conclusions section it would be nice if the authors could expand on how this work would more broadly benefit modeling centers.

Response: Done. We have now provided some concluding remarks in the last two paragraphs of this paper.