Anonymous Referee #1

This paper documents the precipitation over Asia for CAM5 and two resolution configurations of a quasi-CAM6 version. The authors find that many aspects of the simulated precipitation features (both mean state and variability) are improved with CAM6, though persistent biases remain. Further, higher resolution CAM6 can further improve on the low resolution CAM6 results.

Overall, I found this to be a fairly well written paper that was concise and contained lots of interesting results. My main critique of this paper is not so much with what the authors show but with what the authors DIDN'T show. I recommend publication after the authors have considered addressing my two major points of critique and improve the clarity of the paper by addressing the two minor points.

Response:
We appreciate the constructive comments from the reviewer. We have taken all of the reviewer's comments into consideration and revised the manuscript accordingly. Our detailed responses are as follows.

Major Points

1) The authors present CAM5-1 degree, while presenting CAM6-1 degree and CAM6-0.25 degree. Why not show results from CAM5-0.25 degree? I feel neglecting the inclusion of this configuration leaves a hole in the story the authors are trying to tell.

It would be very interesting to see how two very different versions of CAM respond to increases in resolution and whether the improvements seen in CAM6 high resolution are, in fact, unique to CAM6.

Response:

Thank you for raising this issue. We totally agree with you. We have complemented the CAM5-0.25 degree results into Figure 3, 11, 12, 14, and Table 2. Basically, the response to increase in horizontal resolution depends on CAM version. The statements in below have been added into the manuscript:

"Both CAM versions with higher resolution simulate the climatological precipitation over Northern China better. Increasing model resolution decrease the RMSD and bias of CAM5 over Tibet and Southwestern China while increase those of CAM6 (Figure 3)."

"CAM5-0.25° overestimates the frequency of light precipitation (0.1-10 mm/day) over Southwestern China (purple line in Figure 11b)."

"No significant differences are found between CAM5 and CAM6 over Tibet, Southwestern China, Japan and the Maritime Continent."

"Higher resolutions in CAM6 and CAM5 both decrease the surface latent heat flux and convective precipitation over Southwestern China (Table 2). However, higher resolution leads to an opposite change in surface sensible heat flux between CAM5 and CAM6α (by 12.7 and -7.4 W/m2, respectively)."

"CAM5-0.25˚ simulates similar moisture budget with CAM6-0.25˚, while the corresponding results are different between CAM5-1˚ and CAM6-1˚ over Southwestern China and Northern China (Figure 14a and 14b). "

"With a prognostic treatment of large-scale instability and the convective response, higher horizontal resolution in CAM6 leads to better performance on the frequency distributions of daily precipitation over Southwestern China (close to the edge of Tibet Plateau) and heavy precipitation over Northern China. The improvement, however, is dependent on CAM versions."

"The simulated differences between 1º and 0.25º horizontal resolution are also dependent on CAM model versions."

We also cited two previous studies that compared the results from CAM5 versions with various resolutions with those from CAM6-0.25ºand then compared them with our results in this section:

"*Wehner et al*. [2014] found that the extreme precipitation amounts are larger as the resolution increase in CAM5."

"With a fully coupled Community Climate System Model Version 4 (CCSM4), an earlier version of CAM (CAM4), *Shields et al*. [2016] have shown that higher horizontal resolution tends to decrease convective precipitation and increase large-scale precipitation."

Wehner, M. F., Reed, K. A., Li, F., Bacmeister, J., Chen, C. T., Paciorek, C., ... & Jablonowski, C. (2014). The effect of horizontal resolution on simulation quality in the Community Atmospheric Model, CAM5. 1. *Journal of Advances in Modeling Earth Systems*, *6*(4), 980-997.

Shields, C. A., Kiehl, J. T., & Meehl, G. A. (2016). Future changes in regional precipitation simulated by a half‐degree coupled climate model: Sensitivity to horizontal resolution. *Journal of Advances in Modeling Earth Systems*, *8*(2), 863-884.

2) Page 6, line 2, the authors state "while the poor performance of CAM6, especially over Martime continent will be dealt with in a separate paper". Why? This would be the appropriate paper to discuss this topic and the sudden neglection/omission of this topic gave the paper a rather disjointed feel since I felt like a crucial piece of the story was missing.

Response:
Accepted. We have added the corresponding analysis. The specific changes are the following:

"We will explore the details that might lead to the progressive improvement over Sichuan and Northern China in Section 5, while the poor performance of CAM6, especially over Maritime continent will be dealt with in a separate paper."
==>
"We will explore the details that might lead to the progressive improvement over Southwestern China and Northern China and the poor performance of CAM6-0.25˚ over Maritime continent in Section 5."

Differences due to physical parameterizations and high resolution	Southwestern China		Northern China		Maritime continent	
	Physic P.	High Res. With CAM6α/CAM5	Physic P.	High Res.	Physic P.	High Res. With CAM6α/CAM5
TREFHT (℃)	-0.21	**-0.42**[a]/-0.35	-0.01	**0.48**/0.37	**-0.50**	**-0.42**/**-0.64**
LHFLX (W/m^2)	**2.28**	**-4.03**/**-1.87**	**2.24**	**-1.86**/0.14	**5.81**	**2.01**/**9.17**
SHFLX (W/m^2)	**-3.73**	**-7.37**/**12.71**	0.10	**1.73**/**1.09**	**6.16**	**5.13**/**7.16**
FSDSC (W/m^2)	-0.48	**-3.03**/**-1.14**	**-1.23**	**-3.46**/**-3.17**	-0.55	-0.12/**2.96**
FSDS (W/m^2)	**7.08**	**5.32**/**13.25**	**3.38**	**2.87**/**2.45**	**20.79**	**9.10**/**21.57**
FLDS (W/m^2)	**-5.75**	**-4.00**/**-8.67**	0.08	-0.12/**1.26**	**-9.28**	**-3.24**/**-8.01**
CLDTOT (%)	**-1.46**	0.51/**-3.88**	0.56	-0.68/**-2.75**	**1.70**	**2.80**/**-4.37**
INT_Q (kg/kg)	**-0.12**	-0.01/**-0.13**	-0.13	0.04/-0.04	**-0.23**	-0.06/**-0.39**
PRECT (mm/day)	**-0.44**	**-1.06**/**-1.86**	-0.24	-0.12/**-0.30**	0.35	**1.19**/**0.90**
PRECC (mm/day)	**-0.38**	**-0.81**/**-0.98**	0.01	**-0.31**/**-0.33**	**0.62**	**-1.57**/**-1.74**
PRECL (mm/day)	-0.06	-0.25/**-0.88**	**-0.25**	0.19/0.03	**-0.27**	**2.76**/**2.64**

"Table 2. Simulation differences due to physical parameterizations (CAM6α-1° minus CAM5-1°) and high horizontal resolution (CAM6α-0.25° minus CAM6α-1°), respectively. The values are averages over Sichuan and Northern China during 1980-2004."

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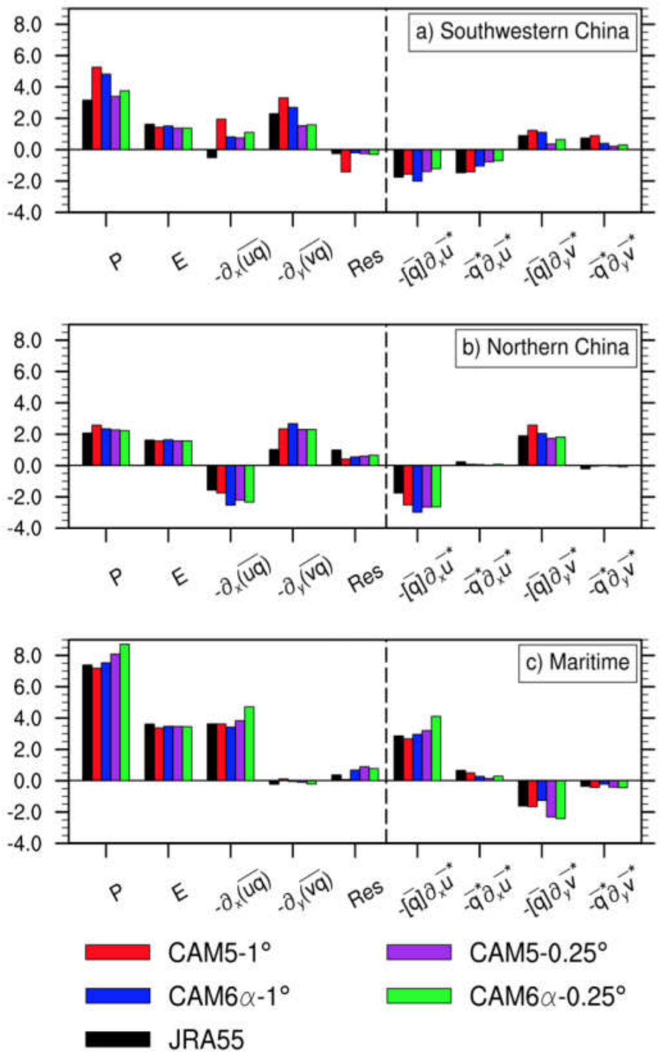
"Table 2. Simulation differences due to physical parameterizations (CAM6α-1° minus CAM5-1°) and high horizontal resolution (CAM6α-0.25° minus CAM6α-1°/CAM5-0.25° minus CAM5-1°), respectively. The values are averages over Southwestern China, Northern China and Maritime continent during 1980-2004."



Added the discussion as below:

“Next we explore the differences in simulated variables due to higher horizontal resolution in CAM6 over the Maritime Continent (Figure 3). As seen in Table 2, the higher horizontal resolution in CAM6 not only increases the vertically-integrated total cloud cover over the Maritime continent, but also leads to more shortwave flux reaching the surface, which tends to release more latent heat. Both CAM5 and 6 versions with 0.25˚ resolution reduce the convective precipitation and increase the large-scale precipitation relative to 1˚ resolution, which leads to overestimation of total precipitation. The two CAM versions with higher resolution simulate a different vertically-integrated total cloud change (Table 2). With a fully coupled Community Climate System Model Version 4 (CCSM4), an earlier version of CAM (CAM4), Shields et al. [2016] have shown that higher horizontal resolution tends to decrease convective precipitation and increase large-scale precipitation. The moisture budget analysis shows that the meridional specific humidity eddy transport is the main factor leading to the bias over Maritime continent (Figure 14c).”

Minor Points

1) The authors need to be more explicit about what they mean when they refer to regions such as “Sichuan” or “southern China”. I know figure 2c has boxes denoting regions, yet these boxes are not labeled anywhere in the figure or caption. Further, these regions are referred to in Figure 1 and it required efforts of my own to try to identify what the authors were referring to in reference to “Sichuan” etc. Explicitly defining these regions EARLY in the paper will go a long way towards improving the clarity of the paper.

Response:

Accepted. We mixed Sichuan province, “Sichuan box” and Southern China. We now adjusted as below. “Sichuan box” marked as “Southwestern China”.

“Because of the large spatial heterogeneity, eight regions are selected to evaluate precipitation. Five domains shown as the purple boxes of Figure 2c are Tibet, Sichuan, Korea, Japan and the Maritime Continent. The other three are India, Northern China and Southern China.”
==>
“Because of the large spatial heterogeneity, eight regions are selected to evaluate precipitation. Five domains shown as the purple boxes of Figure 2c are (1) Tibet: 27°N–37°N, 79°E–99°E; (2) Southwestern China: 28.5°N–35.5°N, 100°E–105°E; (3) Korea: 34°N–40°N, 124.5°E–129.5°E; (4) Japan: 31°N–43°N, 130°E–144°E; (5) the Maritime Continent: 9.75°S–19.75°N, 90°E–150°E. The other three are India, Northern China and Southern China. The "India" average is entirely within mainland India. “Northern China” and “Southern China”, are also defined in Figure 2c, as the where “Northern China” north of the "Qin Mountain and Huai River" at 32.8°N, and “Southern China” south of this. The western boundary of "Northern China" and "Southern China" is a straight line named as "Hu-Huanyong Line" between Heihe (50.2°N, 127.5°E) and Tengchong (24.5°N, 98.0°E)."

2) Table one should include any difference in the time step between the 1 degree and 0.25 degree model. In addition, was the deep convective time scale adjusted in the 0.25 degree simulation versus the 1 degree simulation?

Response:
Accepted. We have added the corresponding information in Table one:

	CAM5-1º	CAM6 α-1º	CAM6α-0.25º	CAM5-0.25º
timestep	1800s	900s	900s	1800s

The deep convective time scale	3600s	3600s	3600s	3600s

Anonymous Referee #2

GENERAL COMMENTS

This is an interesting paper evaluating the performance of the CAM6 prototype in the Asian region at two horizontal resolutions and comparing against CAM5. The paper is reasonably well-written and the figures are clear. I have some concerns regarding the use of reanalyses data as a second benchmark, and it would helpful to clarify how some of the resolution comparisons have been made.
Finally, it would be helpful if the manuscript could be checked carefully by a native English speaker to remove numerous errors.

Response:

Thank you for the time for reviewing and suggesting helpful revisions. We added the CPC data as your suggestion. And the English has been checked by a native English speaker.

SPECIFIC COMMENTS

page 2, line 25: Actually, GA6 is not the latest atmosphere model from the UK Met Office. Williams et al. (2017; https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017MS001115) state that the GC3 coupled configuration, which has GA7 as its basis, will form the basis for their CMIP6 submissions. There are substantial changes between GA6 and GA7. You can still quote the studies relating to GA6, but perhaps reword this paragraph.

Response:

Thanks for the information, we adjusted the statement:
"For example, Global Atmosphere 6.0 (GA6), the latest atmosphere model from the UK Met Office, was used to study the interannual and intraseasonal precipitation variability over China [Stephan et al., 2018a and b]. GA6 includes a new dynamical core and updates various physical parameterizations [Walters et al., 2017]."
==>
"For example, the UK Met Office atmosphere model Global Atmosphere 6.0 (GA6) was used to study the interannual and intraseasonal precipitation variability over China [Stephan et al., 2018a and b; Walters et al., 2017a]."

page 3, line 1: Enhanced model resolution has not always been demonstrated as a means to reduced model biases, especially not in the tropics. For example, Johnson et al (2016; https://link.springer.com/article/10.1007%2Fs00382-015-2614-1) showed that increasing horizontal resolution was not a solution to the South Asian monsoon biases in the Met Office GA3 model and also stated, based on past studies, that "it is difficult to attribute the monsoon improvement to any particular physics or resolution change in the atmosphere or ocean components."

Response:
"Enhanced model resolution has been demonstrated as a means to reduce model biases [Palmer, 2014; Yao et al., 2017; Chen et al., 2018]."
==>
"Generally, enhanced model resolution tends to reduce model biases [Palmer, 2014; Yao et al., 2017; Chen et al., 2018]. Nevertheless, Johnson et al. (2016) indicated that increasing horizontal resolution was not a solution to many South Asian monsoon biases in the Met Office Global Atmosphere 3.0 (GA3) model."

Johnson, S. J., Levine, R. C., Turner, A. G., Martin, G. M., Woolnough, S. J., Schiemann, R., ... & Strachan, J. (2016). The resolution sensitivity of the South Asian monsoon and Indo-Pacific in a global 0.35 AGCM. *Climate Dynamics*, *46*(3-4), 807-831.

page 4, line 2: "time-varying observed sea surface temperatures and sea ice" - what is the time resolution of your forcing dataset? Is it monthly interpolated or actual daily mean values?

Response:
"time-varying observed sea surface temperatures and sea ice"
==>
"observed monthly sea surface temperature and sea ice from 1979 to 2005, which are linearly interpolated to obtain specified daily values"

Section 2.2: I am a little concerned that there is really only one observational rainfall dataset employed here. Rainfall from reanalyses is very dependent on the model physics, and is therefore not really a suitable benchmark. I realise that you may be constrained by the time period and horizontal resolution of your simulations, but it would be good to include more caveats on the APHRODITE data, particularly the potential lack of gauge observations in mountainous areas: how reliable are the values over Tibet, the Himalayas and the Maritime Continent islands? While I would not expect a detailed comparison between observational datasets in your study, some additional discussion on this aspect is warranted, instead of simply says in lines 18-20 of page 4 that you use the reanalyses as a benchmark, thereby implying that this is suitable. Similarly, there are other global datasets for surface air temperature from in situ measurements (such as CPC: https://www.esrl.noaa.gov/psd/data/gridded/data.cpc.globaltemp.html) that could be used as a second benchmark.

Response:
Agreed, APHRODITE might short of surface measurement over mountainous areas, we added CPC daily temperature as your suggestion. Therefore, we get two 'benchmark', while the reanalysis (temperature in JRA55 and daily precipitation from MERRA2) are used as additional 'data products' to evaluate model performance. A key point in our evaluation is that AMIP-style

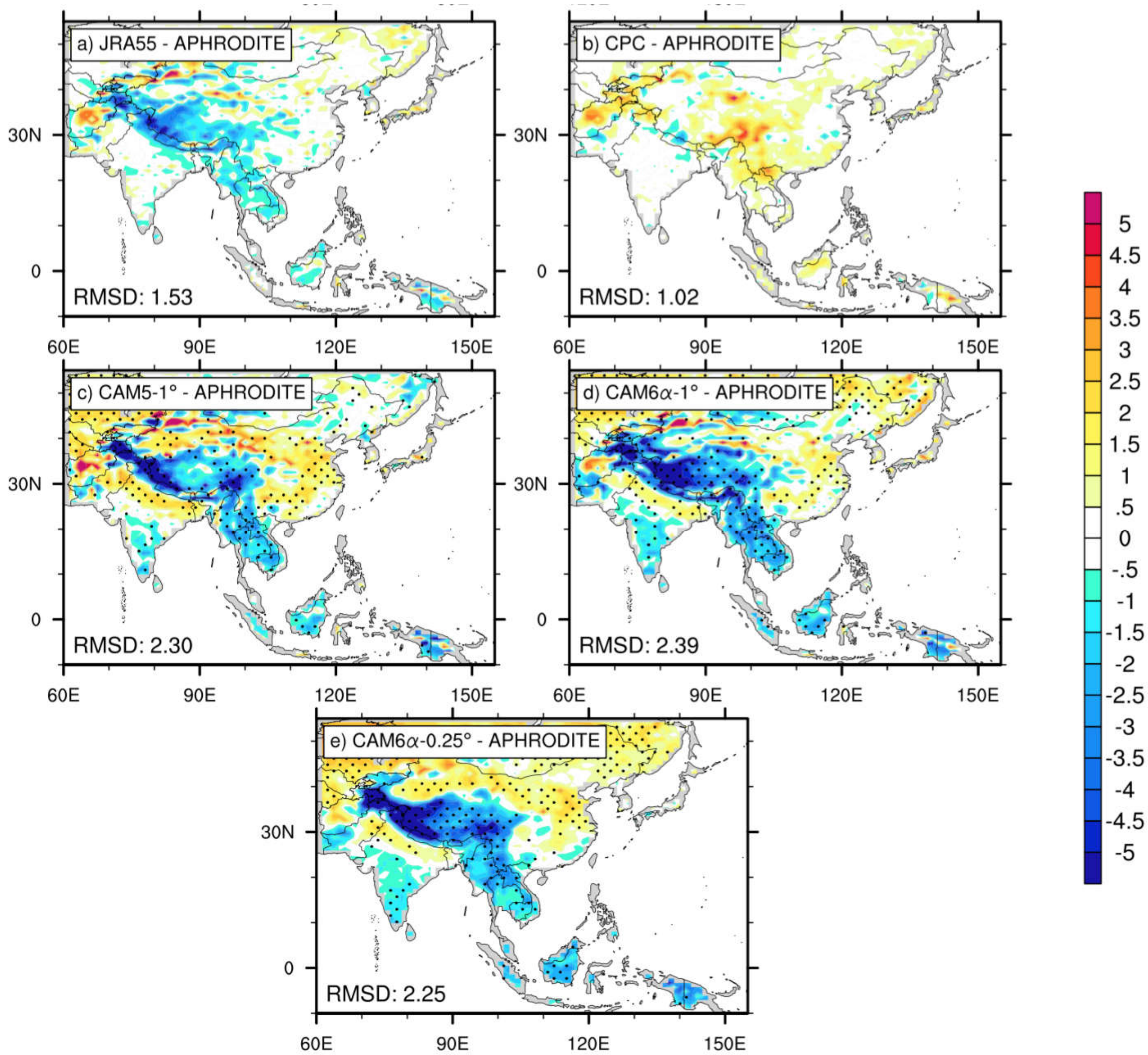
model should not be expected to outperform the reanalysis as the latter is constrained by many other physical quantities.

“We adopted MERRA2 as an additional benchmark specifically for daily precipitation evaluation, because of the well-known large uncertainty among various observational datasets”
==>
“The APHRODITE data might be limited by the potential lack of gauge observations in mountainous areas [Zhao et al., 2015], and therefore we adopted MERRA2 as an additional data source specifically for daily precipitation evaluation. Note, however, that rainfall in the reanalysis products such as JRA55 and MERRA2 is dependent on the reanalysis model physics, and it is well-known that there is large uncertainty among various observational datasets”

We now also adopted the CPC daily temperature as a second benchmark.

The text in below was added in the manuscript:
“2.2.5 Climate Prediction Center (CPC) temperature
CPC global datasets for daily surface air temperature from in situ measurements with 0.5º × 0.5 º resolution is used as a second benchmark [Chen et al., 2008]. CPC data is provided by the NOAA/OAR/ESRL (National Oceanic and Atmospheric Administration/Oceanic and Atmospheric Research/Earth System Research Laboratory) PSD (Physical Sciences Division), Boulder, Colorado, USA.”

Data availability:
“The CPC datasets is from:
https://www.esrl.noaa.gov/psd/data/gridded/data.cpc.globaltemp.html. ”



"First note that although sharing some common surface measurements, the two observational datasets (JRA55 and APHRODITE) have major differences over Tibet and southeast Asia regions (Figure 1a)."

==>

"First note that although sharing some common surface measurements, JRA55 and APHRODITE have major differences over the Tibetan Plateau and Southeast Asia regions (Figure 1a)"

Figures 1 and 2: Please confirm in the caption that you have interpolated the observations/reanalyses to the model's 1 degree grid, and the APHRODITE data to the JRA-55's 0.56 degree resolution, for panels (a) to (c) of these figures?

Response:

Thanks for the concern, we confirmed that and added the text in below to the caption:

“All the data were interpolated to 1° resolution.”

page 5, line 17: "...to fully capture the larger uncertainty of observational datasets" - see previous comment regarding reanalyses. I suggest "...as an estimate of the large uncertainty..." would be more appropriate.

Response:

Thanks for the suggestion, we changed that:

“to fully capture the larger uncertainty of observational datasets”

==》

“as an estimate of the large uncertainty of observational datasets”

page 6, lines 13-14 and 23-24: An increase in horizontal resolution between 1 degree and 0.25 degrees is grossly insufficient to avoid the use of parameterization of clouds and convection by resolving those processes. Even in a prognostic scheme such as CLUBB, the microphysical processes are still parameterized: a prognostic increment to the condensate and rainfall is calculated by making assumptions about (i.e. parameterizing) the relationship between the thermodynamic variables and the microphysical process. Increasing resolution could change the local circulations, the thermodynamic variables and their distribution, and may make them more realistic if the processes driving those are resolved better, but this is not actually resolving the precipitation process itself better. Ultimately, as you note in line 17, the partition between the large-scale and convective rainfall in any model (including reanalyses), and how this changes with resolution, will depend on the parameterization schemes employed.
There are also several statements in this section that imply that convection parameterizations are only there to mop up instability. I do not think that this is true. They should be representing the effects of sub-gridscale convective processes (as opposed to subgridscale stratiform cloud processes, which are handled by the large-scale cloud and precipitation parameterization) on the environment in the gridbox.
Please consider rewording these misleading sentences.

Response:

Thanks for your insightful comments. We had rewritten these sentences:

Page 6, line 13-14:

“One of the reason that the simulated rainfall intensity is expect to improve when the model run at higher resolution is small-scale processes actually simulated as opposed to to parameterizations would produce more rainfall [Kopparla et al., 2013].”

==>

“One of the reasons why the simulated rainfall intensity is expected to improve when the model is run at higher resolution is that the variance of sub-grid scale humidity and thermodynamics drops, and the parameterized sub-grid scale processes (such as sub-grid scale turbulence with CLUBB) are better separated into regimes [Kopparla et al., 2013].”

Page 6, line 22-24:

“Higher horizontal resolution models tend to simulate higher vertical velocities [Gettelman et al., 2018] and a lower ratio of convective to total rainfall, because a larger fraction of precipitation can be resolved as the consequences of large-scale flow, limiting the need of invoking convective schemes.”

==>

“Higher horizontal resolution models tend to simulate higher vertical velocities [Gettelman et al., 2018] and a lower ratio of convective to total rainfall. A larger fraction of precipitation can be resolved as the consequence of large-scale flow, limiting the need to invoke sub-grid convective schemes. Besides, increasing resolution better resolves topographic and surface effects, and separates regimes as sub-grid scale variance is reduced, particularly in the thermodynamic variables.”

The statements on the instability:

“The ratio of convective and large-scale precipitation is a useful diagnostic, because both convective activity and large-scale instability can lead to precipitation in this model. Most atmospheric models use the convective parameterizations to balance large-scale thermal instabilities, and not to derive grid-scale microphysical and precipitation processes.”

==>

“The ratio of convective to large-scale precipitation is a useful diagnostic, because both convective activity and large-scale instability can lead to precipitation in this model. Most atmospheric models use convective parameterizations to represent the effects of sub-grid scale convective processes, with reduced complexity microphysics”

“CAM6 estimate the shallow convective precipitation from explicit prognostic calculation rather than diagnostically estimate from large-scale instabilities.”

==>

“CAM6 estimates shallow convective precipitation from the prognostic calculations in CLUBB (which have memory between timesteps of turbulent motion) rather than diagnostically representing the effects of sub-grid scale convective processes at each location and timestep.”

“In contrast, the convective parameterization with a timescale produces mass flux and precipitation at a defined rate and consumes instability.”

==>

“In contrast, the deep convective parameterization has a timescale that produces mass flux and precipitation at a defined rate. Note that as the timestep gets shorter, the mass flux and precipitation over a timestep will decrease, which is the major reason for the decrease in deep convective precipitation in CAM6.”

page 6, lines 16-21 and Figure 4: Despite your caveat that JRA-55 is providing a partition that is model-dependent, its inclusion in Figure 4 implies that you are considering it as a benchmark for the model comparison. I recommend that you remove this and only consider the comparison between CAM versions.

Instead, you could include in Figure 4 some evidence that the change in timestep affects the partitioning in the way that you assert in lines 26-31 (by showing results from CAM6-1 with a 10 minute timestep, perhaps?).

Response:

Thanks for the good idea. We adjusted the statement and refer a paper to explain the effects of timestep. We just keep it without comparing it with model in the text.

"The reanalysis product JRA55 also provides a decomposition of convective and large scale precipitation. (Figure 4a). Note that the convective and large-scale rainfall in JRA55 is not really observations and the partitioning is highly dependent on the JRA55 model assumptions. The ratio of convective (PRECC) to large-scale (PRECL) precipitation is greater over the ocean than over the land, as expected. CAM6α-1˚ has a larger ratio over the tropics, compared to CAM5-1º and JRA55 (Figure 4c). The CAM6α-0.25˚ simulated ratio is closer to JRA55, due to higher spatial resolution in both datasets (Figure 4d).

...

In addition, the compensation above is a feature of the physical parameterization suite in CAM due to timescale. CLUBB and the prognostic cloud microphysics are run whenever large scale condensation that process removes all liquid supersaturation instantaneously. In contrast, the convective parameterization with a timescale produces mass flux and precipitation at a defined rate and consumes instability. The large scale condensation (including shallow convection and cloud microphysics) does more as the time step changes, while the deep convective parameterization does less. The high-resolution model has a shorter timestep (10 minutes vs. 30 minutes)."

==>

"The reanalysis product JRA55 also provides a decomposition of convective and large-scale precipitation. (Figure 4a). Note that the convective and large-scale rainfall in JRA55 is not from observations and the partitioning is highly dependent on the JRA55 model assumptions. Figure 4 illustrates the ratio of convective (PRECC) to large-scale (PRECL) precipitation. This ratio (PRECC/PRECL) is greater over the ocean than over the land, as expected. CAM6α-1˚ has a larger ratio over the tropics, compared to CAM5-1º. JRA55 (Figure 4c) has a similar ratio, though the thresholds and model differences make a direct quantitative comparison inappropriate. CAM6α-0.25˚ simulated a lower ratio than CAM6α-1˚ (Figure 4d).

...

The compensation above is a feature of the physical parameterization suite in CAM due to timescale. Large-scale liquid condensation by the resolved scale cloud schemes (CLUBB and microphysics), instantaneously condenses all vapor in excess of liquid saturation to cloud liquid. In contrast, the deep convective parameterization has a timescale that produces mass flux and precipitation at a defined rate. Note that as the timestep gets shorter, the mass flux and precipitation over a timestep will decrease, which is the major reason for the decrease in deep convective precipitation in CAM6. The large-scale condensation (including shallow convection and cloud microphysics) does more as the time step changes, while the deep convective parameterization does less [Gettelman et al., 2018]."

page 7, lines 1-13, and Figure 5: Please confirm that you have compared all of these on the same 1 degree grid resolution? This is particularly important for the RX1day and R10 statistics that are measured using threshold values against the intensity distribution, which itself will depend on the resolution of the data (even for the observations).

Response:

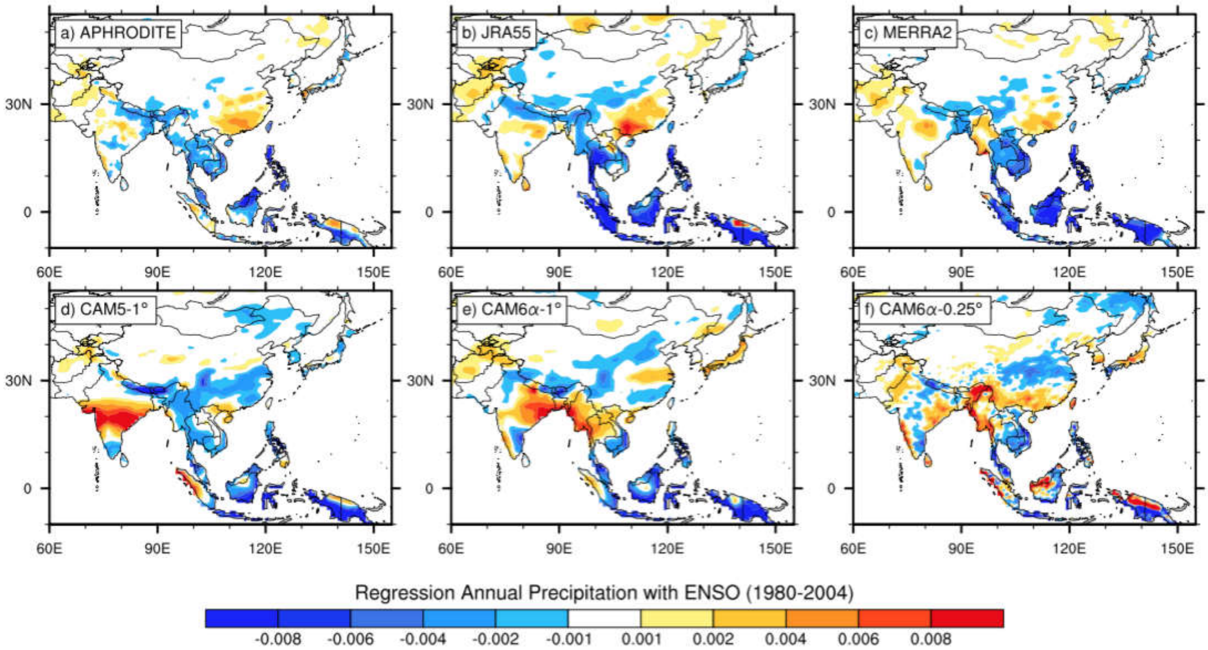
Yes, we double checked. We realised it is unclear to the reader on the resolution. We added the text in below to the caption: “All the data were interpolated to 1° resolution.”

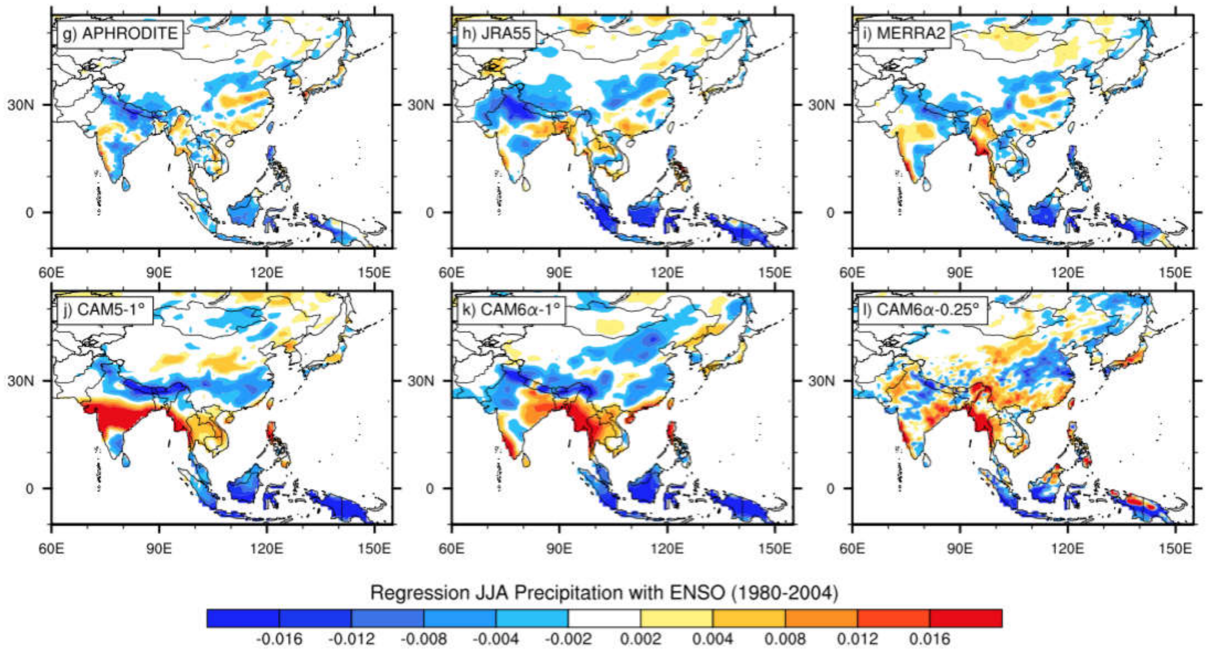
page 8, line 4: "higher frequency fluctuations" - are these really higher frequency fluctuations? It is still an interannual variation, albeit of seasonal mean values.
Also, given the known influences of ENSO on boreal summer monsoon rainfall over Asia, it would be interesting to compare the regression of JJA mean rainfall against ENSO in Figure 7, as well as that of the annual mean rainfall.

Response:

“Next, we examine precipitation variability associated with higher-frequency fluctuations due to”
==>
“Next, we examine seasonal precipitation variability associated with the East Asia Summer Monsoon (EASM).”

It is good idea to compare the regression of JJA mean rainfall against ENSO. We did so.





"**Figure 7. Annual mean precipitation regressed onto the observed ENSO index (mm/day) for 1980-2004**."

==>

"**Figure 7. Regression of annual mean (a-f) / summer (JJA, g-l) precipitation onto the observed ENSO index (mm/day) for 1980-2004.**"

"Figure 7 shows the regression coefficients between annual mean precipitation and ENSO (the cold tongue index used as the ENSO index in this study) [Deser and Wallace, 1987]. Both 1º CAM model (Figure 7d and e) capture the observed wetting anomaly over Pakistan and Afghanistan and drying anomaly over Indonesia. However, we find that the drying tendency over Southern China during El Nino years (the upper row of Figure 7) is completely missing in CAM5 but starts to emerge in CAM6α-1º version and gets better in CAM6α-0.25º version. Our results here thus call into questions of the fidelity of previous ENSO studies on hydroclimate over Southern China using CAM5."

==>

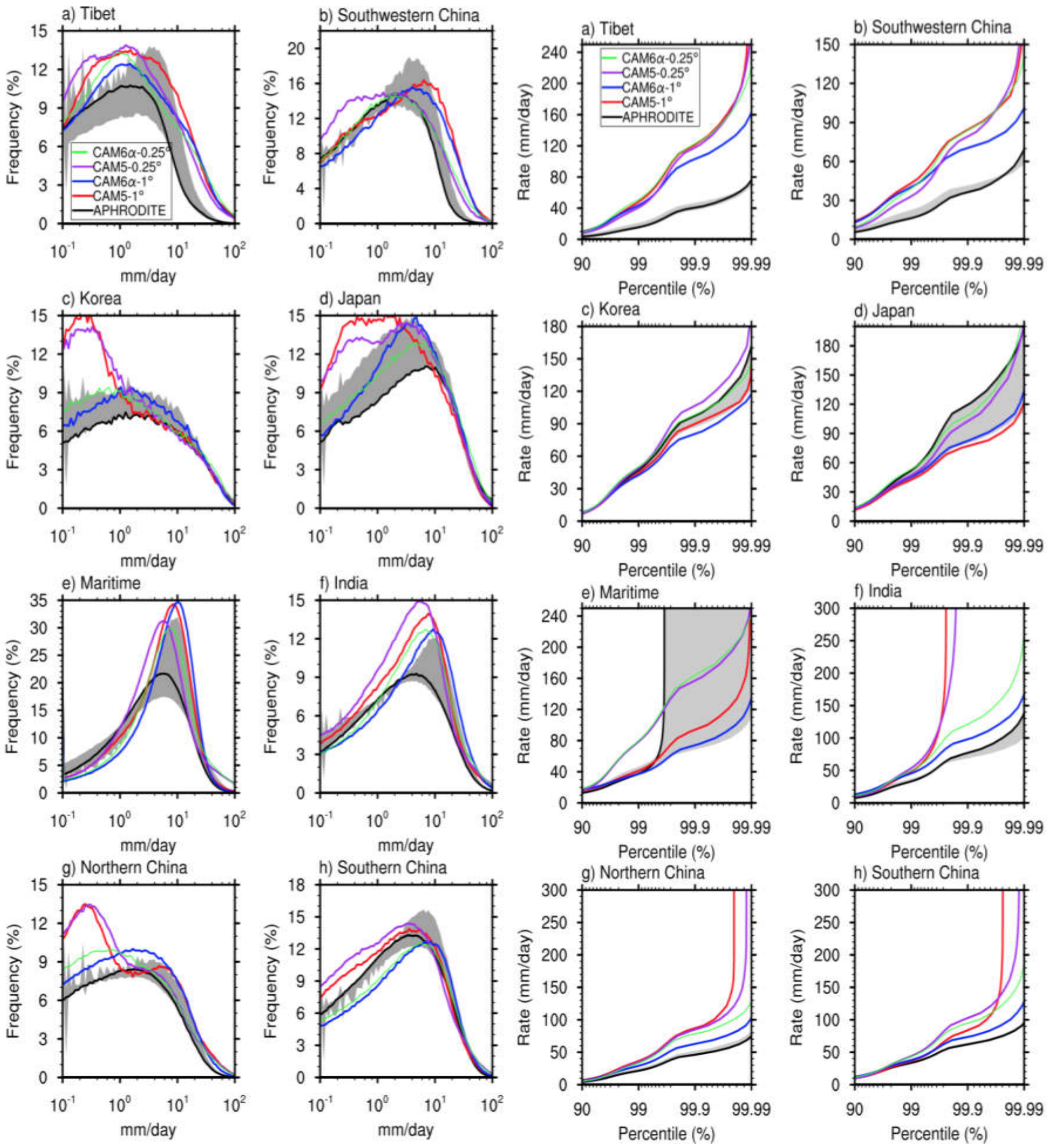
"Figure 7a-f shows the regression coefficients between annual mean precipitation and ENSO. Where the ENSO index is the cold tongue index following Deser and Wallace [1987]. Both 1º CAM5 and CAM6a (Figure 7d and e) capture the observed moist anomaly over Pakistan and Afghanistan and dry anomaly over Indonesia. However, we find that the drying tendency over Southern China during El Nino years (the upper row of Figure 7) is completely missing in CAM5 but starts to emerge in CAM6α-1º version and gets better in CAM6α-0.25º version. Figure 7g-l show similar patterns but with stronger correlation. Our results here thus call into questions of the fidelity of previous ENSO studies on hydroclimate over Southern China using CAM5."

Section 4.3 and Figures 11 and 12: Similar to my previous comment regarding Figure 5, please confirm that everything has been reduced to the same horizontal resolution before doing this analysis.

Response:
Yes, we harmonized the resolution to 1 deg before do the regional average and we added the text in the caption:
"All the data were interpolated to 1º resolution before regional average."

Further, you have suddenly taken the mean of the observations and reanalyses here, in what is perhaps the hardest test for the models. It would be advisable to state or show how these distributions vary between APHRODITE and the two reanalyses - is this really captured with the one standard deviation? There are only three datasets, so why not show the envelope as shading instead (and APHRODITE as the solid line)?

Response:
Yes, we agree with you. The standard deviation can be misleading with only three datasets. We now show the envelope instead shading.



"Figure 11. … Black lines (shading) for the mean (one standard deviation) of APHRODITE, JRA55 and MERRA2. ..."

==>

"Figure 11. … Black lines (shading) for the APHRODITE (the maximum and minimum of APHRODITE, JRA55 and MERRA2). ..."

page 9 line 16: The CAM6-0.25 also looks worse for heavy rainfall (than CAM6-1) for the Sichuan and Tibet regions.

Response:

Yes, that is why we made the following statement:
“Higher horizontal resolution in CAM6 (green) simulates better intensities over the Maritime Continent (Figure 12e), but the results degrade for the heaviest precipitation events over India, Northern and Southern China (Figure 12f-h).”

page 10, lines 3-5: "High-resolution simulations..." - where is your evidence for this statement? Even if it is true (of which I am not sure), there is also horizontal moisture advection which will be different at higher resolution.

Response:

Sorry for misunderstanding, we adjusted the statement and refer the evidence to the Table 2:

“High-resolution simulations tend to decrease the energy used for the convective process (decreased latent heat flux and sensible heat flux), and thus decrease the convective precipitation.”
==>
“Higher resolutions in CAM6 and CAM5 both decrease the surface latent heat flux and convective precipitation over Southwestern China (Table 2).”

page 10, line 6: Presumably the increased downward solar radiation in CAM6 is related to the improved diurnal cycle? Please state this, if it is the case.

Response:

It is possible, but without sub-daily data, we are not able to confirm this. That text is just based on the Table 2:
“New physics parameterizations in CAM6 simulate stronger solar flux reach the surface.”
==>
“Newer physics parameterizations in CAM6α simulate a stronger solar flux reaching the surface in northern China (Table 2). This may be due to improvements in the diurnal cycle of precipitation.”

Section 5: Overall, I do not find this section convincing, nor does it add much to the findings of the study. You make several statements about the impact of the new physics in CAM6 on the balance of processes and the large-scale/convective rainfall partition that are speculative and not supported by evidence. I would suggest that you remove this section and Figure 14 (and the associated bullet point (4) on page 11).

Response:

We agree with you, that part is unclear to the readers. Actually, that section is used to attribute improvements to either new physics module or higher resolution. We contrast climate variables quantitatively in Table 2. Those statements are all based on Table 2 actually. So we added the text in the beginning of Section 5:

"We attempt to attribute changes to either physical parameterizations or resolution. Additionally, we investigate whether the improvement due to resolution is dependent on CAM version. Table 2 illustrates simulation differences due to physical parameterizations (CAM6α-1° minus CAM5-1°) and higher horizontal resolution (CAM6α-0.25° minus CAM6α-1° and CAM5-0.25° minus CAM5-1°, respectively)."

page 11 line 17: "...better performance over Sichuan basin..." - is this true? It looks worse than CAM6 at 1 deg in Figure 12.

Response:
It might not be clear. We are talking about the PDF of daily P (refer to Figure 11), not daily P as a function of percentile (refer to Figure 12).

"higher horizontal resolution leads to better performance over Sichuan basin (close to the edge of Tibet plateau)"
==>
"higher horizontal resolution in CAM6 leads to better performance on the frequency distribution of daily precipitation over Southwestern China (close to the edge of Tibet Plateau)"

TECHNICAL CORRECTIONS
[Note that, in addition to the points raised below, there are numerous wording and grammar issues that require careful editing by a native English speaker]
page 2 line 11: "regarding to" -> relating to

Response:
Thanks, corrected.

page 3, line 27: Please expand CLUBB, or at least mention which part of the model physics this relates to.

Response:
Thanks, we expanded: CLUBB (Cloud Layers Unified By Binormals).

page 6, line 27: "...whenever large scale condensation that process removes all liquid..." - I do not understand this sentence.

Response:
"CLUBB and the prognostic cloud microphysics are run whenever large scale condensation that process removes all liquid supersaturation instantaneously."
==>
"Large-scale liquid condensation by the resolved scale cloud schemes (CLUBB and microphysics), instantaneously condenses all vapor in excess of liquid saturation to cloud liquid."

page 8, line 16: "...edge of the positive correlation is less more northward..." - more, I think.

Response:
"...edge of the positive correlation is less more northward..."
==>
"...edge of the positive correlation more northward..."

Figure 10 caption: This is not just within Southern China.

Response:
“Southern China”
==>
“Part of Asia”

page 9, line 1: "which is missing the persistent in CAM5-1 (the jumping cliff over July to August..." ??

Response:
"which is missing the persistent in CAM5-1˚ (the jumping cliff over July to August, Figure 10d)."
==>
"while CAM5-1º illustrates persistence from June to July only (the area of continuous yellow shading in Figure 10d less than those of CAM6). “

Table 2 - you have not referred to this table anywhere in the manuscript. It may not be needed if you remove section 5.

Response:
We realized that we did not refer it in the text, we referred it now. That table is actually very important to explain the simulation differences due to resolution or new physical module. Please refer to the responses to the last few Minor comments.