Anonymous Referee #2

1 Reviewer's Summary of Manuscript

In "A multi-year short-range hindcast experiment for evaluating climate model moist processes from diurnal to interannual time scales," Ma et al. describe an experimental design for (1) differentiating model errors that arise largely due to errors in parameterized processes (fast processes) versus errors that arise largely due to errors in the model's dynamical state (slow processes); and (2) for aiding in the identification of physical processes that might need focused model development to correct errors in fast processes. The experimental design consists of using a specific atmosphere-only GCM for two sets of simulations:

• 13 years of 3-day hindcast simulations, initialized using state information from ERA-Interim (interpolated to the model grid), and

• 13 years of an Atmospheric Model Intercomparison Project (AMIP) simulation

The authors implement this experimental protocol for the Community Earth System Model (CESM) version 1.0.5, using the CAM5 physics package. They compare simulations from the hindcast and AMIP simulations with a variety of observations, including ARM observations, reanalysis, satellite, and other. The analysis focuses on four aspects of the simulations: the diurnal cycle of convection over the southern Great Plains (SGP) of the United States; diabatic processes in the Madden-Julian Oscillation; dependence of diagnosed errors on El-Nino / Southern Oscillation (ENSO); and cloud radiative effects.

Their analysis of convection over the SGP shows that CESM1.0.5 has too much high cloud cover, which the authors speculate might be due to overly-frequent triggering of convection. They also show that the model has too little mid-level cloud coverage and too much shallow cloud coverage; possible reasons for this are not provided. Their analysis of the MJO shows that the model tends to have too little precipitation in the western half of the MJO core and too much precipitation on the eastern half, even in the hindcast simulations; and they suggest that diabatic processes associated with fast physical processes is likely the cause of these errors.

The authors show that the correlation between short- and long-term errors does not depend on the ENSO state, and they argue that their experimental design is therefore robust with respect to interannual variability. They also give evidence that errors in the large-scale circulation dominate errors in cloud radiative effects diagnosed from the model, relative to errors associated with fast physical processes (e.g., cloud parameterization) alone.

They conclude by arguing that this experimental design–and specifically the CESM 1.0.5 hindcast simulation output are useful for model development.

2 Summary of Review

The authors do a nice job of summarizing several ways in which short-duration hindcast experiments can be used to diagnose the origins of errors in long-term climate simulations.

Overall, the authors make a compelling argument that this type of experimental design is useful for decomposing errors into those associated with fast physical processes and slow (circulation-related) processes.

Despite this, I have several major reservations about the current form of the current manuscript, such that I cannot recommend this manuscript for publication at this time. Most critically, the current manuscript does not make a clear case for how this manuscript presents a new experimental design that is unique relative to what the authors have previously published on. Additionally, the authors do not provide enough information for a reader to replicate their experimental design. Finally, the authors' arguments are undermined by their use of a model version that has not been officially supported or developed for 7 years.

The following sections give a detailed description of these concerns, and the final section points out some specific issues that the authors should address if they submit a revised version of the manuscript.

Response to reviewer:
We thank the reviewer for all the comments. Those certainly helped to improve our manuscript.

Regarding the new uniqueness of the current experiment, this is our first time documenting this suite of multi-years (1997-2012, 16 years) hindcasts and proposing on how one can better utilizing these hindcasts on both mean and variability studies. Our intention is not to promote the hindcast technique itself since climate hindcast experiment approach has become a widely used method in the Transpose AMIP project and other climate model hindcast studies as we mentioned in the introduction. This is why we submitted this manuscript as a "model experiment description paper". In our earlier hindcast studies (e.g., Xie et al. 2012; Ma et al. 2013 J. Climate), we analyzed the mean biases from two years of short-range hindcasts (May 2008 to April 2010) during Years of Tropical Convection (YOTC). In Ma et al. (2015 JAMES) paper, we proposed a refined hindcast approach in improving the initial atmospheric aerosol profiles and initial land conditions. Based on the refined procedure, we proposed a ''Core'' integration (one-year long) with the refined procedure for a simple, easily repeatable test that allows model developers to rapidly compute appropriate metrics for assessing the impacts of various parameterization changes on the fidelity of cloud-associated processes with available observations. In this manuscript, we applied the refined initialization strategy in Ma et al. (2015 JAMES) and performed this "new" suite of multi-year short-range hindcasts. One can now use this suite of hindcasts to conduct more studies (like the examples listed in this manuscript) which cannot be achieved from single or two years of short-range hindcasts. This is a different purpose from what we proposed in Ma et al. (2015 JAMES). We have strengthened this point in the abstract:

"These analyses can only be done through this multi-year hindcast approach to establish robust statistics of the processes under well-controlled large-scale environment because these phenomena are either interannual climate variability or only happen a few times in a given year (e.g. MJO, or cloud regime types)"

and in the introduction over Lines 68-73:

"This experiment provides an new opportunity to address several modeling issues associated with moist processes, which cannot be achieved from previous short Transpose AMIP II hindcasts (Williams et al. 2013), or one or two years of short-range hindcasts that we conducted in the past (Xie et al. 2012, Ma et al, 2013, Ma et al. 2015). This is because these phenomena are either interannual climate variability or only happen a few times in a given year, and thus we need multi-years to robustly quantify the errors associated with these phenomena."

For our initial submission, we did not include detailed information on the initialization procedure since this was already described in Ma et al. (2015 JAMES). We did not want to duplicate the information because the initialization technique is not the main focus of the manuscript. In this revised version of the manuscript, we provided more information on how to conduct the multi-year hindcasts including the initialization information. Recently, we made our scripts and hindcast procedure documentation available to the public on GitHub (https://github.com/PCMDI/CAPT). We also include this information in the revised manuscript over Lines 107-109.

Regarding the concern of using CESM1/CAM5/CLM4 as our base model, we understand this model is not currently supported by NCAR anymore. However, simulations from this version are still used by many people including students in universities because the performance of this model is still very good. For model development and diagnosis purpose, people still compare model performance between the latest version and older version to understand the impacts of parameterization changes to the older version. For example, CAM5 results were still being mentioned in the recent CESM workshop in June 2020. As we are preparing another suite of multi-year short-range hindcasts with DOE E3SM/EAM v1, we will compare our results from E3SM to CESM1. The E3SM EAM v1 was originally branching from CAM5.3, which has very similar model performance to CAM5. Therefore, the comparison between the two suites of hindcasts will provides us information on the impacts of parameterization and other changes on cloud process performance. Also note that E3SM/EAM v1 has a new set of atmospheric physical parameterizations that are very similar to CAM6, the latest CAM.

Finally, this suite of hindcasts was completed back in 2016 and we have been thinking of more ways on how to better utilize these hindcasts other than what we had planned for. Therefore, it took us a while to prepare this manuscript because we want to provide the community more ways on how to use this type of hindcast experiment.

For our responses to other comments, please see our point-by-point responses below in bold.

3 Major Concerns

3.1 Uniqueness of manuscript and relevance for GMD

The manuscript is presented as describing "a multi-year hindcast experiment and its experiment procedure" and giving "examples to demonstrate how one can better utilize simulations from this experiment design." Given that this is the authors' explicitly-stated premise for the paper, it is not immediately clear to me how this manuscript represents a unique contribution to the literature in general, and why it is a good fit for GMD in particular. The authors have written numerous papers about ensembles of short-duration hindcasts for over 15 years, and in that time they have already made a compelling argument that this experimental design is valuable. Why is yet-another-paper demonstrating the utility of this type of experimental design needed in the literature in general? After reading the manuscript several times, it is still not clear how this manuscript is unique relative to existing literature.

Response to reviewer:
Please see our response earlier regarding the concern of uniqueness of manuscript and relevance for GMD.

With respect to GMD in particular, there are three types of manuscript (wrt https://www.geoscientific-model-development.net/about/manuscript_types.html) that this could plausibly fit as:

1. Methods for assessment of models,
2. Model experiment description papers, or 3. Model evaluation papers.

If it is a manuscript of type #1, I believe the main contribution here would be "novel ways of comparing model results with observational data." The authors have written extensively about comparing hindcasts with ARM-SGP data (this was one of the earliest uses of CAPT, as far as I can tell), so the 1st example analyzed doesn't seem sufficiently novel. The authors' composite analysis of MJO in hindcasts does seem unique in the literature, so this could considered a novel way of comparing models and observations. However, I would expect this analysis to be emphasized much more prominently in the paper if it was considered the main, novel contribution of the paper; instead, it is one of three examples that the authors run through, and the authors only devote three paragraphs to the topic. Finally, the analysis of diabatic processes associated with ENSO could be unique, but it wasn't clear to me what the authors were trying to show with this analysis, aside from showing that the correspondence between errors in short- and long-duration simulations is robust with respect to ENSO phase.

Response to reviewer:
This manuscript is not under the methods for assessment of models.

The way the manuscript is written, it seems that the authors are targeting manuscript type #2 "Model experiment description papers", in which case I would expect that the main contribution of the paper is "descriptions of standard experiments for a particular type of model," and "discussion of why particular choices were made in the experiment design and sample model output". The manuscript instead seems to describe a rather vague experimental protocol, consisting of short-duration hindcasts paired with AMIP simulations. The authors also describe their specific implementation of these hindcasts. It also isn't clear how the experimental design presented here differs substantially from other, seemingly similar experimental protocols described in the literature: e.g., Transpose-AMIP II (Williams et al., 2013), and the hindcast approach described by Ma et al. (2015). If it does differ, the authors should explicitly compare and contrast their proposed experimental protocol with those already described in the literature. In particular, Ma et al. (2015)–which this manuscript indicates the hindcast procedure is based on–states that "We also hope to provide guidance for those performing transpose-AMIP/CAPT simulations with their own climate models for model development or error diagnosis purposes." That sounds strikingly similar to a "model experiment description paper," which again raises the unanswered question of how this manuscript represents a unique contribution to the literature. The authors should also follow the GMD guidelines for this particular manuscript type, including giving the experimental protocol a name and version number in the manuscript title.

Response to reviewer:
As we responded earlier, we submitted this manuscript as a "model experiment description paper". We aren't sure if this information was directly provided to the reviewers or not. It is shown on the GMD manuscript page (https://www.geosci-model-dev-discuss.net/gmd-2020-39/#discussion). As we have explained the uniqueness of this suite of multi-year hindcast experiment and why this is different from we have published in earlier studies including Ma et al. (2015 JAMES), please refer to the response above.

From the GMD Manuscript types (https://www.geoscientific-model-development.net/about/manuscript_types.html#item4):

"For model experiment description papers, similar version control criteria apply as to model description papers: the experiment protocol should be given a version number; a data availability paragraph must be included in the manuscript; boundary conditions should be given a version number and uploaded or made otherwise available; a data availability paragraph must be included in the manuscript; and links to the GMD paper should be included on the experiment website. Since the primary purpose of these papers is to make experiments accessible to the community, all input data required to perform the experiments must be made publicly available"

With the description above, it is not clear whether the version number should be on the manuscript title. Nevertheless, we added CESM1 to the manuscript title. The title is now "A multi-year short-range hindcast experiment with CESM1 for evaluating climate model moist processes from diurnal to interannual time scales". We also provided the model version number (CESM1_0_5) and experiment configuration (FC5) in Section 2.1. We added more information regarding how initial conditions were generated in the revised manuscript. The information of boundary conditions and other code information are described in Code and data availability section after the Summary.

In its current form, I don't think this manuscript is appropriate to be considered a paper of type #3. The authors' analysis focuses on an outdated version of CESM that is no longer supported and is decreasingly used. Further, the current manuscript doesn't refer to any of the (extensive) existing literature evaluating CESM1, so there is currently no way to determine how/why this paper is unique relative to other model evaluation papers. (All of that said, I strongly suspect the authors weren't targeting this manuscript type, in which case such a literature review of CESM1 would not be needed.)

Response to reviewer:
This manuscript is not a model evaluation type paper.

Williams, K.D., A. Bodas-Salcedo, M. Déqué, S. Fermepin, B. Medeiros, M. Watanabe, C. Jakob, S.A. Klein, C.A. Senior, and D.L. Williamson, 2013: The Transpose-AMIP II Experiment and Its Application to the Understanding of Southern Ocean Cloud Bi- ases in Climate Models. J. Climate, 26, 3258–3274, https://doi.org/10.1175/JCLI-D- 12-00429.1

Ma, H.-Y., C. C. Chuang, S. A. Klein, M.-H. Lo, Y. Zhang, S. Xie, X. Zheng, P.-L. Ma, Y. Zhang, and T. J. Phillips (2015), An improved hindcast approach for evaluation and diagnosis of physical processes in global climate models, J. Adv. Model. Earth Syst., 7, 1810–1827, doi:10.1002/ 2015MS000490.

3.2 Repeatability of experiment

Assuming that the authors are targeting this manuscript as a "Model experiment description paper", the manuscript does not appear to provide adequate detail for an external group to be able to replicate this experimental protocol a constrained way. More detail would need to be provided for the initial condition generation procedure, the nudging procedure, for the land-surface spinup procedure, and greenhouse gas and solar forcing (do these follow the AMIP protocol?). It also seems like it would be useful to guide other modeling groups on what variables should be saved as output: otherwise, how would experiments be intercompared?

Response to reviewer:
For our initial submission, we did not include detailed information on the initialization procedure since this was already described in Ma et al. (2015 JAMES). We did not want to duplicate the information because the initialization technique is not the main focus of the manuscript and modeling groups who have the capability to conduct hindcast studies already have their own initialization strategy. Nevertheless, in the revised manuscript, we provided more information on how to conduct the multi-year hindcasts including the initialization generation procedure, the nudging procedure, land-surface spin-up procedure. The greenhouse gas and solar forcing is based on the setup of the CESM1 FC5 compset, which corresponds to the year 2000 level for all the simulation period. This is because the CMIP5 forcing data does not go beyond 2005. We also don't want the interannual variations in the solar and greenhouse gas forcing to affect our results so that we can better identify possible causes of model biases associated with model parameterizations. Recently, we made our scripts and hindcast procedure documentation available to the public on GitHub (https://github.com/PCMDI/CAPT). We also include this information in the revised manuscript over Lines 107-109.

Regarding what variables should be saved in the experiment, this really depends on the subjects of the studies. For example, we participated in the MJO diabatic heating process model intercomparison project and we also organized the US summertime warm bias model intercomparison project. There is an overlap of output variables but there are also variables, which are unique to MJO studies, such as the diabatic heating profiles and all the state variable budget terms. While in the warm bias study, we requested more variables associated with clouds and surface processes. Nevertheless, we do have a list of output variable available to others over https://portal.nersc.gov/archive/home/h/hyma/www/CAPT/CAPT_Long/CAPT_Long_output_cesm1_0_5_v5.pdf. This information is under the Code and data availability section.

Specifically, a number of questions come to mind that could impact the results from other modeling groups implementing this experiment:

- What method(s) should be used to horizontally and vertically remap the ERA- Interim data onto the model grid?

  Response to reviewer:
  The goal is to preserve the state variable information from the reanalysis as much as possible after the interpolation. In the present study, we applied the bilinear interpolation with ESMF regridding utility for the horizontal remap for all the state variables. For vertical remap, we follow the procedure used at ECMWF when initializing model with foreign analysis: Quadratic interpolation is used for temperature remap, linear interpolation is used for specific humidity, and a combination of linear and quadratic interpolation is used for zonal and meridional winds. The vertical interpolation scripts were originally constructed following the ECMWF procedure by one of our colleagues who has retired back in 2013. We didn't have the reference listed here because we can't find the link to the reference anymore after an update of ECMWF webpage.

  Note that based on the experience from the past model intercomparison projects that we have organized or participated in, there were generally no guidelines on what method(s) should be used to do horizontal or vertical remap. This is because each model group, especially for operational centers, already have a set of tools to do this.

- Do any adjustments need to be made to the initial conditions to avoid spurious gravity waves associated with differences in topography between ERA-Interim and the given model?

  Response to reviewer:
  We applied a spatial smoothing for the state variables. This is based on Gerrity and McPherson (1970).

  Gerrity, J. P. and R. D. McPherson, 1970: Noise analysis of a limited-area fine-mesh prediction model. ESSA Technical Memoranda, WBTM NMC 46, PB-191-188. 81pp.

  We also adjusted the surface pressure associated with differences in topography between ERA-Interim and CAM5 using hydrostatic approximation.

  Note that the above information is available in the documentation over our GitHub repository (https://github.com/PCMDI/CAPT).

- When running 'nudging' simulations to generate non-state-variable ICs:
  - – What nudging method is used (this is provided in Ma et al. (2015), but it should be included here for completeness)?

    Response to reviewer:

A U, V only nudging was used in the nudging run. We follow the recommendation from Zhang et al. (2014 ACP) and also made a few test runs to reach the same conclusion in Ma et al. (2015 JAMES). This information is included in the revised manuscript over Lines 98-101.

Reference:

Zhang, K., Wan, H., Liu, X., Ghan, S. J., Kooperman., G. J., Ma, P.-L., Rasch, P. J., Neubauer, D., and Lohmann, U.: Technical note: On the use of nudging for aerosol–climate model intercomparison studies, Atmos. Chem. Phys., 14, 8631–8645, 2014.

Ma, H.-Y., C. C. Chuang, S. A. Klein, M.-H. Lo, Y. Zhang, S. Xie, X. Zheng, P.-L. Ma, Y. Zhang, and T. J. Phillips (2015), An improved hindcast approach for evaluation and diagnosis of physical processes in global climate models, J. Adv. Model. Earth Syst., 7, 1810–1827, doi:10.1002/ 2015MS000490.

- – How are the ERA-Interim data interpolated from the ERA-Interim times to the model's current time (nearest-neighbor, linear, spline, other?)

Response to reviewer:
In the nudging simulation, the reanalysis data are linear interpolated between two time steps. Note that the nudging and interpolation codes were created by a NCAR software engineer and we didn't make any more changes.

- – Is the nudging simulation run in an identical configuration to the AMIP run, with the exception of the nudging term?

Response to reviewer:
That is correct. We also added this information in the revised manuscript over Lines 116-117.

- – Why aren't the land-surface conditions from the nudging simulation used for the land-surface initial condition in the hindcasts?

Response to reviewer:
This is because in a nudging simulation, biased precipitation, winds, and surface fluxes are allowed to pass to the land model. This will cause larger biases in the simulated soil moisture and temperature. This was discussed in Ma et al. (2015 JAMES). Therefore, we did not mention this in the present manuscript since the focus is on the multi-year hindcast experiment, not the initialization procedure.

- When running the offline land-surface spinup simulation:
  - – How are surface enthalpy and moisture fluxes calculated? (readers shouldn't have to read through old CESM documentation to figure out what the CESM-community-specific lingo for 'offline' land surface simulation refers to)

    Response to Reviewer:

These are two different questions regarding what is an offline simulation, and how are surface enthalpy and moisture fluxes calculated in CLM.

For an offline land model simulation, we stated in Section 2.1 that it is a land model simulation forced by reanalysis and observations including precipitation, surface winds, and surface radiative fluxes. We added another sentence after the original sentence to make this clear. This is now "Land initial conditions are taken from an offline land model simulation (I2000 compset) forced by reanalysis and observations including precipitation, surface winds, and surface radiative fluxes (N. Viovy 2013, unpublished data) rather than coupled it to an active atmospheric model" over Lines 102-104.

Regarding the calculation of the surface enthalpy and moisture fluxes, this is really not the focus of this manuscript. For us (atmospheric scientists), we also need to read through the CESM documentation to know the exact equations to calculate these fluxes since we are not land model developers. In short, the surface fluxes are based on Monin-Obukhov Similarity Theory. Without copying the entire chapter from the CLM4 documentation to here, we refer the reviewer to see Section 5 Momentum, Sensible Heat, and Latent Heat Fluxes of the CLM4 technical note on how to calculate these fluxes.

http://www.cesm.ucar.edu/models/ccsm4.0/clm/CLM4_Tech_Note.pdf

- – How should chemical fluxes be handled if needed by the land-surface model (e.g., C/N in the case of CLM5 in prognostic Carbon/Nitrogen mode)?

  Response to Reviewer:
  This is an open question since we do not turn on the C/N option in all of our hindcasts. One could perform the same offline land model simulation with C/N turned on although the spin-up time may require much longer time (more cycles).

- – Why is the N. Viovy dataset used for forcing the offline land-surface spinup simulation?

  Response to Reviewer:
  We selected this option (CRUNCEP) in CLM because they offer the most recent years of atmospheric forcing data at that time. Also, the land state from offline simulation is superior than that from a nudging simulation (Ma et al. 2015 JAMES).

- – How are data from these observational datasets interpolated to the model grid (nearest neighbor, linear, conservative remapping, other)?

  Response to Reviewer:

We used the default option in the model setup when running the offline land model simulation. The default method is bilinear interpolation according to CESM1.0 documentation:
http://www.cesm.ucar.edu/models/cesm1.0/clm/models/lnd/clm/doc/UsersGuide/x7895.html

- The authors should provide the code that they use to generate the initial conditions, since there are undoubtedly numerous other questions about implementation of this experiment that would arise when external groups attempt to implement this protocol.

  Response to Reviewer:
  We have now made our scripts and hindcast procedure documentation available to the public on GitHub (https://github.com/PCMDI/CAPT). We also included this information in the revised manuscript over Lines 107-109.

3.3 Old model version

The authors state that "model developers can achieve additional useful understanding of the underlying problems in model physics by conducting a multi-year hindcast experiment." However, this statement is undermined by the author's use of CESM 1.0.5, which stopped being supported and developed by NCAR years ago. The authors state "Although newer version [sic] of the CAM and CLM is now available (CAM6/CLM5), similar systematic errors associated with moist processes remain present in the latest model version," but they state this without any reference to manuscripts that support this statement. Further, CESM2 contains numerous upgrades to key parameterizations associated with moist processes: in particular the adoption of CLUBB, MG2 prognostic microphysics, and a retuning of the convection parameterization to "increase the sensitivity to convection inhibition". Because of all these changes, I don't see how the results from this dataset could be used to inform model development in CESM2, which is the only version of CESM under active development.

If this is indeed intended to be a "Model experiment description paper," then this point is somewhat less relevant. However, the authors should be more forthcoming about these caveats and the utility of the dataset produced as part of this paper. This paper would also be much more impactful if the authors made some specific comments about what (if anything) would need to be done to implement this experimental design for CESM2.

Response to Reviewer:
This manuscript is indeed a "Model experiment description paper". We have provided our response to this concern in the beginning of our responses.

4 Specific, minor issues

pg 1, line 21: "associated parameterized" –> "associated with parameterized"
Response to reviewer:
Revised.

pg 3, line 79: “Section 4 present” –> “Section 4 presents”
Response to reviewer:
Revised.

pg 4, line 104: “output at model timestep” –> “output for every model timestep” (?)
Response to reviewer:
Revised

pg 5, lines 156-158: this is one of several theories for the MJO (e.g., see Yang and Ingersoll, 2011), so these feedback processes may not all be necessary
Response to reviewer:
We revised the sentence to “These feedback processes may contribute to better MJO simulations if they are well represented in the GCMs”, so the sentence does not seem to suggest that these feedback processes are all necessary for realistic MJO simulations.

pg 6, line 165: what is Q1?
Response to reviewer:
We added the following short paragraph for the information of Q1 in the revised manuscript:

“The diabatic heating rate or apparent heating of large-scale motion system (Q1) consists of the heating due to radiation, the release of latent heat by net condensation, and vertical convergence of the vertical eddy transport of sensible heat (Yanai et al. 1973). In CESM1/CAM5, Q1 can be calculated through summing up all the tendency terms with all the diabatic processes.”

Reference:
Yanai, M., Esbensen, S., and Chu, J.–H.: Determination of bulk properties of tropical cloud clusters from large-scale heat and moisture budgets, J. Atmos. Sci., 30, 611–627, 1973.

pg 7, line 220: “the response SST anomalies is much superior” –> “the response to SST anomalies is much superior”
Response to reviewer:
We revised the sentence to “the response of those fields to SST anomalies in Figure 7”.

pg 7, line 221: “the result of poor circulation” –> “the result of errors in circulation” (‘poor circulation’ is usually reserved for describing anatomical difficulties with blood flow)
Response to reviewer:
Revised as suggested.

pg 8, line 253: “the annually cloud error metrics” –> “the annually-averaged cloud error metrics” (?)
Response to reviewer:
Revised as suggested.

pg 9, lines 276-277: “These comparisons identify. . . ” this statement only makes sense to include if the authors repeat the experiments with an actively-developed model version.

Response to reviewer:

Yes, we do plan to perform multi-year hindcasts with an actively-developed model version (E3SM) and compare with the CESM1-CAM5 results. We added “We will also compare the results from E3SM to CESM1 to understand the impact of parameterization and model changes to the performance of moist processes since the atmospheric component of E3SM was originally branching form CAM5.3, which has very similar performance as CAM5 (Xie et al. 2018, Rasch et al. 2019). Note that E3SM version 1 has a new set of atmospheric physical parameterizations that are very similar to CAM6, the latest CAM.” in the revised manuscript over Lines 353-356.

Yang, D. and A.P. Ingersoll, 2011: Testing the Hypothesis that the MJO is a Mixed Rossby–Gravity Wave Packet. J. Atmos. Sci., 68, 226–239, https://doi.org/10.1175/2010JAS3563.1