Comments Reviewer 2

This manuscript evaluates the representation of total column water vapour (TCWV) and total cloud cover (TCC) in seven AMIP6 models and ERA5 against ESA-CCI satellite products over the tropical region. The study applies multi-resolution analysis (MRA) to decompose the signals into multiple temporal bands and assesses model performance across a range of timescales. The topic is relevant, and the timescale-dependent evaluation framework is potentially useful for identifying where model deficiencies become apparent. The manuscript also reports several potentially interesting results, including better agreement at seasonal-to-annual scales than at daily and subseasonal scales in many cases. Overall, the study has merit. However, several methodological and interpretive issues need to be addressed before the manuscript can be considered for publication. I therefore recommend major revision.

We thank the reviewer for the careful assessment of our work. We have addressed all comments and incorporated the recommendations to improve the quality of the manuscript.

Major comments

1. The three datasets (AMIP6, ESA-CCI, and ERA5) have different native spatial resolutions, but the manuscript does not describe clearly how they were made spatially consistent for the comparison. This point is important because the results are presented as tropical land/ocean averages, which may be sensitive to regridding and area weighting. The authors should explicitly state how each dataset was regridded or upscaled.

We thank the reviewer for raising this important point. We acknowledge that all these datasets have different native spatial resolutions. However, the main objective of this work is to assess climate model variability across multiple timescales using multi-resolution analysis, rather than to compare the representation of spatial structures. Accordingly, all datasets were analyzed at their native resolution without applying regridding, thereby avoiding additional uncertainties associated with interpolation methods. To ensure consistency in the comparison, spatial averages were computed using appropriate area-weighting based on grid cell area, and land and ocean contributions were treated separately using consistent masks. This approach minimizes potential biases arising from differences in spatial resolution, particularly those related to land–sea mixing in coarse-resolution datasets. While spatial resolution can influence local variability and extremes, large-scale mean statistics and temporal variability are generally robust across resolutions. To support this point, Figure 1 presents a comparison of tropical ocean TCWV averages derived from ERA5 with and without

regridding. Although some discrepancies are observed for extreme values, the overall temporal evolution remains consistent, indicating that the impact of regridding on large-scale averaged quantities is limited. Therefore, we are confident that the absence of regridding does not affect the robustness of the results presented in this study.

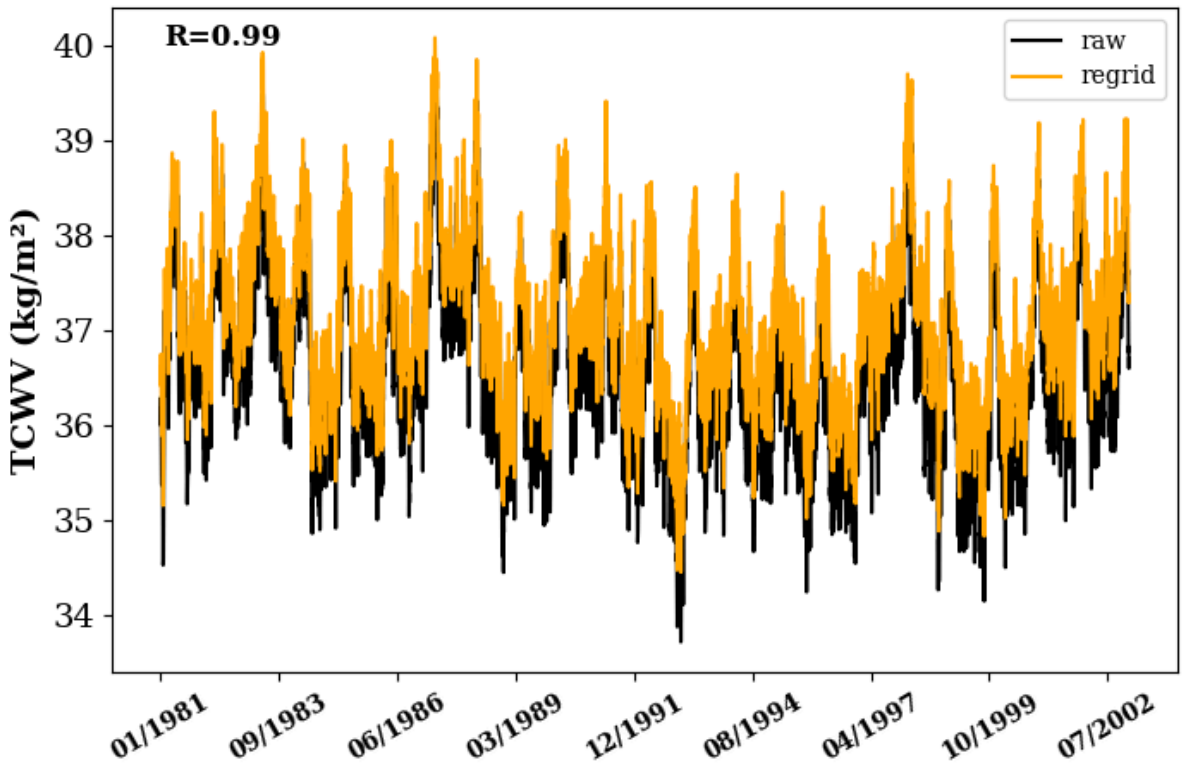

Figure 1: Time series of spatial averages of ERA5 data computed from regridded and native-resolution datasets over the ocean domain using IPSL resolution over the pre-ESA period.

lines 80-85 now read **: "We use daily TCWV and Total Cloud Cover (TCC) from the AMIP6, the ESA-CCI and the fifth generation of the European Centre for Medium-Range Weather Forecasts reanalysis (ERA5), averaged over the tropical region. These three datasets indeed have different native spatial resolutions. However, the main objective of this work is to assess climate model variability across multiple timescales using multi-resolution analysis, rather than to compare the representation of spatial structures. Accordingly, all datasets were analyzed at their native resolution without applying regridding, thereby avoiding additional uncertainties associated with interpolation methods."**

2. The TCC comparison may be affected by a definition mismatch between the observational product and the model-derived diagnostic. In the manuscript, model TCC is diagnosed from vertical cloud profiles using a maximum-overlap-type assumption, whereas the Cloud_cci quantity is retrieved from satellite observations and is not necessarily an equivalent quantity. The manuscript also notes that a full Cloud_cci simulator-based comparison is not feasible with the available model output. Therefore, part of the reported discrepancy may reflect differences in variable definition and observation-to-model comparability, rather than model deficiency alone. This source of uncertainty should be discussed more explicitly.

We thank the reviewer for highlighting this important point. We agree that part of the discrepancies observed in total cloud cover (TCC) may arise from differences in variable definition and observation-to-model comparability, rather than from model deficiencies alone. This source of uncertainty has now been explicitly discussed in the revised manuscript (Section 2.1.1), and the interpretation of TCC results has been clarified accordingly. We added the following information :

lines 131-133 now read : "**These variables could be obtained from climate model outputs using the Cloud_CCI simulator \citep{eliasson2019cloud_cci}, provided that the required atmospheric parameters are available, which is not the case for most AMIP6 models.** "

lines 137-138 now read : "**However, differences in variable definition and retrieval methodology between satellite products and model diagnostics may introduce structural inconsistencies in model observation comparisons.**"

lines 280-297 now read : "**In addition, part of the discrepancies in TCC may arise from differences in variable definition and observation to model comparability. In this study, model derived TCC is diagnosed from vertical cloud fraction profiles using a maximum overlap, whereas the Cloud_cci product is based on satellite retrievals and does not represent a strictly equivalent quantity. As a result, some of the differences between AMIP6 models and Cloud_cci may reflect inconsistencies between datasets rather than model deficiencies alone.**"

3. The MRA framework is not described in enough detail for reproducibility. The manuscript does not sufficiently document key implementation details, including how the 4202-day series is reduced to 4096 points, which wavelet basis is used, and how boundary effects are treated. These choices can affect the decomposition, especially at low frequencies. The authors should provide the exact MRA settings and clarify how sensitive the main results are to these choices.

Thanks to the reviewer for this remark. We clarified this point in the main document by adding the following text :

lines 209-210 now read : "**The MRA decomposition is not sensitive to the extraction of the data within the study period.**"

lines 211-215 now read : "**The MRA was performed using the waveslim package implemented in R with the Least Asymmetric Daubechies wavelet filter with 8 coefficients (LA8, (Rowe and Abbott, 1995)), which provides a good balance between time-frequency localization and reduced phase distortion. To further reduce boundary effects, the time series were extended prior to decomposition using a reflection (mirror) technique, following the boundary handling approach implemented in the package (Whitcher, 2020). This method consists of symmetrically extending the signal at both ends by reflecting the values near the boundaries in reverse order. This ensures continuity at the edges and reduces artificial distortions in the wavelet coefficients.**"

4. The manuscript extends the relationships identified during the ESA-CCI period to the pre-ESA period by using ERA5 as a surrogate reference under a stationarity assumption. However, the manuscript itself shows notable ERA5–ESA-CCI differences, especially over tropical land and in the Niño3.4 interannual analysis. The authors should clarify how these discrepancies affect the interpretation and robustness of the pre-ESA results.

We thank the reviewer for this comment. In this study, ESA-CCI is used as the primary observational reference dataset. However, as ESA-CCI is not available prior to the satellite era, the extension of the analysis to the pre-ESA period relies on the assumption that the statistical relationships identified between ESA-CCI and AMIP6 models during the observational period remain approximately stationary over time. Under this assumption, these relationships are extended to the historical period in order to construct the Best_AMIP6 model. To evaluate its behavior over the pre-ESA period, ERA5 is used as a surrogate reference dataset. The choice of ERA5 is motivated by the fact that its consistency and differences with respect to ESA-CCI are well characterized over the observational period, both over tropical oceans and land regions. We acknowledge that the discrepancies identified between ERA5 and ESA-CCI particularly over tropical land and introduce an additional source of uncertainty in the interpretation of the pre-ESA results. These differences imply that part of the mismatch between the reconstructed Best_AMIP6 and ERA5 during the pre-ESA period may reflect inconsistencies between the reference datasets rather than model deficiencies alone.

This point has been clarified in the revised manuscript, where we emphasize that the robustness of the extension depends on the variable and region considered, with more reliable results over tropical oceans and greater uncertainty over land and for cloud-related variables. We added the following information :

lines 366-369 now read : "**Within this framework, ERA5 is used as a surrogate reference to evaluate the temporal evolution of TCWV and TCC from the Best_AMIP6 model during the pre-ESA period. While this assumption is reasonable for large-scale variability, it introduces an inherent source of uncertainty, particularly in regions and for variables where discrepancies between ERA5 and ESA-CCI are more pronounced.**"

lines 379-381 read: "**Overall, while the extension to the pre-ESA period appears robust for TCWV and large-scale variability over tropical oceans, results for TCC and for tropical land regions should be interpreted with caution, reflecting both dataset-related differences and inherent uncertainties.**"

Minor comments

1. Abstract / Methods / Conclusions: The common observation period is not reported consistently throughout the manuscript. The Abstract states July 2003–December 2014, whereas the Methods and Conclusions refer to July 2003–September 2014. Please use one consistent period throughout the manuscript, figures, and tables.
Thanks to the reviewer, we corrected it in the revised manuscript

2. Section 2.1.1 and Table 1(ii): The description of the Cloud_cci dataset is inconsistent. The main text refers to AVHRR measurements from NOAA platforms, whereas Table 1(ii) lists ATSR-2, AATSR, and SLSTR instruments. Please reconcile these descriptions and specify clearly which Cloud_cci product and version were used in this study.
Thanks to the reviewer for this important remark, we corrected it in the revised manuscript.

	Characteristics						
Instrument	Version	Platform	Operator	LTDN	Spatial resolution	Time span	Reference
AVHRR	3	NOAA-7 to NOAA-19	NOAA	07.30/13.30	~1.1 Km (Nadir)	1982-2016	Stengel et al., 2020

Table 1. Description of the instruments used in the ESA-CCI data retrieval for TCC. LTDN stands for "local time descending node".

3. Lines 180 and 183: The expression “time serie” should be corrected to “time series.” Please check the manuscript carefully for similar grammatical issues.
Thanks to the reviewer , we corrected it in the revised manuscript

4. Throughout the manuscript: The terms “AMIP6” and “CMIP6” are used inconsistently in several places. Please standardize the terminology and use the correct experiment name throughout the text, tables, and figure captions.
Thanks to the reviewer , we corrected it in the revised manuscript

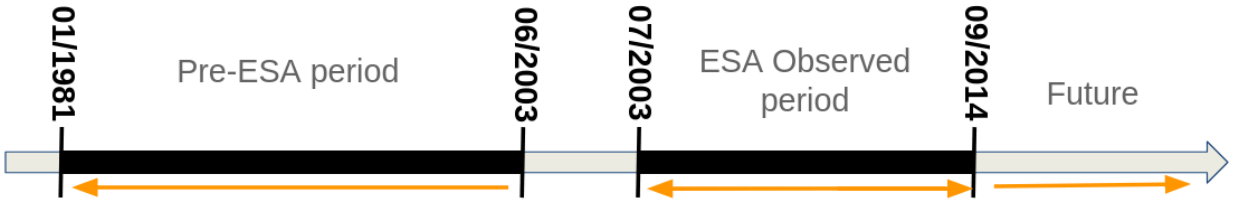

Figure2: Representation of the Pre-ESA and Observational periods

5. Line 285: “Figures 9” should be “Figure 9”.
Thanks to the reviewer , we corrected it in the revised manuscript

6. Throughout the manuscript: Please standardize the citation style for figures, tables, and in-text references. For example, expressions such as “Fig4,” “Fig.5,” [Table 3], and “[Tab.5]” should follow one uniform format.
We thank the reviewer for this remark. We have addressed this point and revised the manuscript accordingly. We changed “Fig4,” to “Fig.4” and [Table 3] to [Tab.3].

7. Section 2.1.3 and Table 2: The ERA5 horizontal resolution is reported inconsistently. Section 2.1.3 states 0.25° × 0.25°, whereas Table 2 lists 0.5° × 0.5°. Please reconcile this discrepancy and clarify the actual spatial grid used in the analysis.
Thanks to the reviewer, we corrected it in the revised document by changing “0.5°x0.5°” to “0.25°x0.25°” in Table 2.

8. Line 163: The reference to 'FIG. 1' in this caption is inconsistent with the actual content of Figure 1. They do not correspond to each other; I suggest that the author carefully check and verify this.
Thanks to the reviewer, we corrected it in the revised document by adding

“Figure 1: Representation of the Pre-ESA and Observational periods”