

**Review of Mean state and day-to-day variability of tropospheric circulation in planetary-scale barotropic Rossby waves during Eurasian heat extremes in CMIP models by Strigunova et al., egusphere-2025-892**

This study investigates how well a subset of CMIP5 climate models represent tropospheric barotropic Rossby waves during Eurasian heatwaves (EHWs), focusing on mean circulation patterns and day-to-day variability compared to ERA5 reanalysis. The authors apply a sophisticated normal-mode decomposition method to isolate planetary-scale waves and analyze differences between historical, AMIP, and RCP4.5 future simulations. The main finding is that while models capture mean circulation anomalies reasonably well, they fail to reproduce the observed changes in day-to-day variability (particularly skewness) during EHWs. Future projections show substantial uncertainty. Overall, the study addresses an important question and the approach is scientifically valuable, but there are several issues that require major attention before the manuscript is suitable for publication.

**Major comments:**

- 1) The manuscript includes qualitative comparisons between models and ERA5 in terms of 500 hPa geopotential height anomalies and wind composites during EHWs (Figs. 2-4), but does not include any quantitative metrics such as spatial correlation coefficients or RMS errors. As a result, the performance statements (e.g., AMIP runs "outperform" HIST runs) are not objectively substantiated.
- 2) The paper uses a subset of four CMIP5 models based on data availability for normal-mode decomposition. While this constraint is understandable, the manuscript does not assess whether these models are representative of broader CMIP5 behavior in terms of heatwave characteristics or large-scale circulation. For example, are these models typical or atypical in terms of blocking frequency or Z500 biases? Do they represent the CMIP5 ensemble well in Eurasian T2m skewness or Z500 amplitude? This is especially important because later conclusions (e.g., lack of skewness, success of AMIP) may depend heavily on model-specific features.
- 3) The paper finds that CMIP5 models do not capture the observed changes in PDF skewness of Rossby wave energy during EHWs, yet offers no discussion of possible physical or dynamical reasons for this failure. Skewness changes indicate nonlinear or intermittent behavior in the planetary wave field during EHWs, likely related to wave-mean flow interactions or blocking onset/stability. Not addressing the dynamical mechanisms weakens the interpretability of the results and their value for model improvement. I suggest the authors to discuss potential reasons why CMIP5 models fail

(e.g., too diffusive numerics, poor blocking representation, unresolved sub-monthly feedbacks) and to frame this failure as a window into dynamical model limitations, not just statistical mismatch.

### **Other comments:**

- Title: I think it is better to clarify "CMIP models" to "CMIP5 models" since only CMIP5 subset is used.
- Line 4: "do not suggest an increase in EWHs" should be EHWs
- Final sentence of abstract: Lacks a conclusion or implication. I would add a final sentence summarizing why this matters (e.g., "This highlights key uncertainties in modelled dynamical variability under warming scenarios.").
- Line 33: Define "NH" (write "Northern Hemisphere") unless you will use it repeatedly later.
- Line 68-69: "do not directly affect" (not "not directly affect").
- Section 2: I suggest the authors to use a clear Data and Methodology section. More details of JRA-55, ERA-Interim, MERRA and ERA5 (e.g., variables) should be given under Reanalysis data subsection.
- The study uses inconsistent time periods: 1980-2005 for historical CMIP5, 2070-2100 for RCP4.5, and 1980-2019 for ERA5. These discrepancies affect the comparability of heatwave metrics and climatologies, especially when using absolute event counts. The manuscript should justify this choice clearly and consider using consistent or normalized periods for fair comparison.
- Line 90-91: I would consider more neutral phrasing: "Our subset reflects the models for which 3D data on model levels were available, without further selection criteria. "
- Methodology: Were reanalysis and model outputs regridded to a common grid before comparison? If so, please say so explicitly.
- Lines 104-105: Better to rephrase as "EHW events are identified by three or more consecutive days of positive anomalies..."

- Line 110: Rephrase as "we extended the set by adding the average duration."
- Line 112: The use of "boxes" to refer to boxplots is slightly informal. Rephrase as "The interquartile ranges shown in the boxplots... "
- AMIP should be spelled out at first use: "Atmosphere-only model simulations (AMIP)... "
- Lines 161-163: Consider rephrasing as "Troposphere-barotropic modes were identified by selecting vertical modes without zero-crossings within the troposphere, following the criteria used in Setal2022. "
- Line 180: Insert comma after "In contrast to CNRM-CM5"
- Line 207: Rephrase for clarity: "for all days in HIST and AMIP runs, respectively. "
- Line 238: Better to rephrase as "The results provide the following answers to the questions posed"
- Line 241: "Rssoby" to "Rossby"
- The issue of model biases impacting Rossby wave dynamics needs stronger discussion. For example, what does this imply for future projection reliability? Currently, it ends too cautiously. I would add a paragraph discussing what improvements would be needed in CMIP models to better capture day-to-day dynamics.