

Author's Response

Final Minor Revision — Hydrology and Earth System Sciences

Manuscript:

*Characterizing Climate-Driven Shifts in Chilean Rainfall Regimes
with a Hybrid Hidden Markov–Copula Framework*

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Dear Dr. Bravo,

We thank you and Referee 1 for the positive evaluation of the revised manuscript and for the remaining editorial suggestions, all of which we have implemented in this final revision. We are grateful for the constructive review process, which has substantially improved the manuscript. Below we respond to each of the five points raised in your decision letter; a tracked-changes file accompanies this response.

Point 1 — Abbreviations

Editor/Referee comment: “Ensure that all abbreviations are defined at their first occurrence and avoid unnecessary abbreviations, especially in the Abstract and the Code and Data Availability sections. Examples noted by the reviewer include GMSST and several other abbreviations that are not explicitly defined.”

Authors' response: We conducted a systematic audit of every abbreviation in the manuscript and revised each first occurrence. In the **Abstract**, all abbreviations are now defined where first used—MJJA (May–August), ENSO (El Niño–Southern Oscillation), SOI (Southern Oscillation Index), ONI (Oceanic Niño Index), and GMSST (Global Mean Sea Surface Temperature)—while abbreviations that appeared only once (CRPS, AUC, HAC) have been replaced by their full names, avoiding unnecessary acronyms as requested. In the **main body**, the following are now defined at first occurrence: PIT (probability integral transform), KS (Kolmogorov–Smirnov), CvM (Cramér–von Mises), HAC (heteroskedasticity- and autocorrelation-consistent), GLMM (Generalized Linear Mixed Model; also spelled out in the Figure 3 caption, which must be self-contained), FDR (False Discovery Rate), MLE (maximum likelihood estimation), AUC (area under the receiver operating characteristic curve), and the interval metrics AW (Average Width), POC (Percentage of Coverage), and AAD (Average Asymmetry Degree), now introduced in prose before their defining equations. The **Code and Data Availability** section was rewritten in plain language without undefined acronyms.

Manuscript change: Abstract rewritten with all abbreviations defined or spelled out; first-occurrence definitions added throughout Sects. 2.3.2, 2.3.3, 2.3.6, 2.4.1–2.4.3, 3.1, 3.3, and 3.5.1; Figure 3 caption updated; Code and Data Availability section rewritten.

Point 2 — Figure 1: anomalies as separate maps

Editor/Referee comment: “Improve the readability of Figure 1 and other multi-panel figures. Some inset anomaly maps and figure annotations are difficult to read. The reviewer suggests presenting the anomaly patterns as a separate, duplicated set of maps rather than as insets.”

Authors' response: Figure 1 has been completely redesigned following the reviewer's suggestion. The anomaly patterns are no longer insets: the figure now consists of two full rows of maps—row (A) shows the conditional mean daily precipitation for each of the five nHMM states (marker size and colour proportional to the conditional mean), and row (B) shows the precipitation anomalies relative to the MJJA climatology as five separate, full-size maps rendered as interpolated contour fields with discrete levels (± 1 , ± 3 , ± 6 , ± 10 , ± 15 , ± 20 mm d⁻¹) for clear quantitative reading. All annotations, axis numbers, and colour-bar labels were enlarged, and coastlines are drawn on top of the anomaly fields so that the geography remains legible.

Manuscript change: Figure 1 replaced by the two-row version (**figures001-002_v4**); caption rewritten to describe the (A)/(B) panel structure.

Point 3 — General figure formatting

Editor/Referee comment: “Improve figure formatting, including color-bar labels, map coordinate annotations, and overall panel organization, where appropriate.”

Authors' response: Both multi-panel map figures were rebuilt with a common, consistent formatting standard: enlarged colour-bar labels (16–17 pt titles, 13.5–14 pt tick labels) with round-number ticks; uniform coordinate annotation conventions across all panels (see Points 2 and 4); identical colour-bar geometry within each figure; state titles shown once at the top of each figure rather than repeated per row; and bold panel identifiers ((A)/(B) in Fig. 1; (A)/(B)/(C) in Fig. 2) consistent across figures.

Manuscript change: Uniform formatting applied to Figures 1 and 2 (**figures001-002_v4**, **figures004-006_v2**).

Point 4 — Figure 2: colour bars and coordinate labels

Editor/Referee comment: “The reviewer also suggests improving the readability of Figure 2. In particular, the color-bar annotations should be enlarged, geographic coordinates should be displayed more consistently across panels, and the overlap between the lower color bar and the bottom-row panels should be removed. The reviewer recommends placing latitude labels only on the outer left and right axes of each row and longitude labels only along the top and bottom boundaries of the figure.”

Authors' response: Figure 2 was recomposed exactly to this specification. Latitude

labels (15°N–60°S) appear only on the outer left axis (State 0 column) and outer right axis (State 4 column) of each row; longitude labels (110°W, 90°W, 70°W) appear only along the top boundary of the figure (above row A) and the bottom boundary (below row C). The three colour bars were rebuilt as vector graphics with enlarged annotations (17 pt variable labels, 13.5 pt tick labels) whose class boundaries reproduce verbatim the values of the original composites, and each colour bar is placed in a dedicated horizontal band between rows, structurally eliminating any overlap with the map panels. The caption was updated accordingly.

Manuscript change: Figure 2 replaced by the recomposed version (**figures004-006_v2**); caption revised (MSLP and Z500 spelled out; description of contour labels).

Point 5 — Citation of the R software environment

Editor/Referee comment: “Provide an appropriate citation for the R software environment used in the analyses rather than simply mentioning the software version.”

Authors' response: The Code and Data Availability section now cites the R environment formally—R Core Team (2023), *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria—together with formal citations for the three contributed packages central to the analysis: **VineCopula** (Schepsmeier et al.), **evd** (Stephenson, 2002, *R News*), and **scoringRules** (Jordan, Krüger, and Lerch, 2019, *Journal of Statistical Software*). The corresponding entries were added to the reference list.

Manuscript change: Code and Data Availability section revised with formal citations; three new entries added to the bibliography (**RCoreTeam2023**, **Stephenson2002evd**, **JordanKruegerLerch2019**).

We believe these changes fully address the remaining editorial points. No modifications were made to the scientific content, methods, or results beyond the presentation improvements described above.

Sincerely,

Mauricio Herrera-Marín (on behalf of all co-authors)