

Editor's Comments

We thank the reviewers for their careful and constructive evaluations of the manuscript. Both reviewers recognize the scientific merit, originality, and potential impact of the proposed framework for characterizing precipitation space–time variability in a highly complex region such as Chile. In particular, the proposed hierarchical modeling approach combines synoptic-regime identification via hidden Markov models, regionalization through clustering, and flexible dependence and extreme-value modeling using copulas and generalized Pareto distributions. This approach is viewed as conceptually sound, well-motivated, and capable of supporting future hydrological and climate-related research. At the same time, the reviews highlight several important issues that must be addressed to improve the clarity and methodological reproducibility of the manuscript.

A primary concern, emphasized particularly by Reviewer 1, relates to the presentation and transparency of results. The manuscript currently contains repeated material across sections, relies heavily on extensive supplementary information (with some figures or tables difficult to interpret), and does not sufficiently clarify how the large number of diagnostic tests and evaluation metrics are used to support inference and model selection. Additional weaknesses include the limited reporting of statistical uncertainty (e.g., confidence intervals or measures of estimation robustness), the absence of explicit discussion of parameter dimensionality relative to sample size, and insufficient examination of the reliability of challenging estimates such as GPD shape parameters. Reviewer 1 also notes that the manuscript reads in parts like a technical project report rather than a fully developed research article and raises concerns about the physical interpretability of the atmospheric drivers, particularly the lack of explicit moisture-related variables that are commonly used in precipitation studies and readily available from reanalysis products.

Reviewer 2, while generally very positive, raises complementary concerns focused on readability and organization, especially in the methodology section. The current structure is a mixture of theoretical content and application in a way that makes the workflow difficult to follow, requiring readers to frequently go back to understand key procedures. Clearer, more sequential presentation of the methodology and explicit justification of important methodological choices—such as the selection of seven precipitation zones—would substantially improve accessibility and coherence. Importantly, Reviewer 2 emphasizes that these issues affect clarity rather than scientific validity and notes that the study offers valuable insights and meaningful results.

In summary, while both reviewers support the scientific value and relevance of the work, they recommend revisions aimed at improving structure, statistical transparency, uncertainty quantification, physical interpretation, and the balance between main text and

supplementary material. Reviewer 1 recommends major revisions to address these substantive concerns, whereas Reviewer 2 suggests that moderate reorganization and clarification would significantly enhance the manuscript's impact and readability. I have attached here both reviewers' comments for completeness of the discussion, and **recommend reconsidering the manuscript subject to major revisions with further reviews by editor and referees.**

Reviewer 1 Comments

This is a puzzling manuscript: on one side it delivers evidence that the chosen approach to study the precipitation space time structure in a highly complex environment (here Chile with its very long extension in latitude together with a complicated and structured orography) is a scientifically fruitful approach. Also the choice to build a hierarchical model with the hidden Markov states to identify synoptic regimes, the clustering to identify regional homogeneous precipitation zones and finally to model the spatial variability within each zone with copulas for the bulk and generalized Pareto distributions for the extremes beyond a fixed quantile is well explained in the introduction. But the presentation of the results is the "black" side of the medal:

(1) in large parts section 2 and section 3 contain repeated texts,

(2) a very large number of actual results is shifted into the supplement text S1 - S10 (the total supplement covers 20 pages!) with the additional caveat that S8 is not readable,

(3) a very large number of evaluation/test variables is introduced often only by name and at no stage it mentioned how this multitude of tests is used for inferences about the results and how the actual decision of choosing the appropriate model is influenced by those test variables,

(4) at no stage of the manuscript the actual number of estimated parameters vs. the actual number of sampling points in space and time used to perform the inference/estimation is mentioned,

(5) very often uncertainty measures such as confidence intervals or p-values in case of test are not given or even mentioned, one example is table S8 in the supplements, here the estimated shape parameter of the Pareto fit of the mediod station is reported (but never mentioned in the main text) for each synoptic regime with one close to zero value and two positive and two negative values which would indicate either clear differences of the tail behavior or very weak properties of the underlying data set to estimate the notorious difficult shape value, this is a clear case to be studied in detail eg by bootstrapping across the stations around the mediod and finally

(6) except for the introduction the remaining manuscript and the supplement reads like a splitted project report about the analysis of Chilean precipitation space-time variability applicable for potential hydrological research, eg physical consistency of mentioned but the selection of atmospheric variables lacks any moisture related variables like specific humidity or vertically integrated moisture transports which is more than the 850 (u,v) data and which can be easily extracted from C3S / ERA5 data sets.

Together with the extensive list of comments (my detailed remarks) in the attached and annotated manuscript I can suggest publication in HESS only after major (major) revisions of the current version of the manuscript.

Reviewer 2 Comments

Overall, I found the methodology section somewhat challenging to follow, likely due to the way it is currently organized. In particular, sections 2.3.2 through 2.4.2 were initially difficult to navigate, and I had to read them multiple times to fully grasp the workflow. My impression is that the clarity could be enhanced by presenting the methodology in a more step-by-step manner. Specifically, rather than interleaving statistical theory and its practical application multiple times, it might be beneficial to either present the statistical framework comprehensively at the beginning and then focus on the application, or to integrate theory and application in a more continuous, guided narrative. This would help the reader to follow the logic without needing to constantly switch between abstract concepts and their implementation. For example, in section 2.3.4, the procedure was not immediately clear and only became understandable after reading subsequent sections. While this does not indicate a methodological flaw, it may affect the readability and flow of the manuscript. Organizing the description of such procedures in a clear, sequential way could make it easier for readers to follow the logic without having to backtrack.

Additionally, regarding the methodology itself, I found it unclear why seven “zones” were selected using the clustering approach. If a specific selection criterion was applied, it would be helpful to state it explicitly, ideally early in the methodology section, perhaps starting in section 2.3.1. This would provide the reader with a clear understanding of the rationale behind the choice and help contextualize subsequent analyses. Providing such context upfront often strengthens the coherence of the methodology and allows the reader to better appreciate the workflow and its outcomes.

Despite these points, I find this paper highly engaging and scientifically valuable. The study presents a good perspective on the topic, and the results are particularly insightful. The approach combines sophisticated statistical modeling with practical application, offering meaningful contributions. The findings not only deepen our understanding but also have the potential to inform future research and practical applications in related areas.

In summary, while the methodology could benefit from a slightly more structured presentation, the study is well-motivated, and provides valuable results. With minor adjustments in clarity and organization, the manuscript would become even more accessible and impactful to readers.