Review of HESS manuscript egusphere-2025-1650

This manuscript analyzes uncertainty partitioning for the Central American midsummer drought (MSD) using multimodel ensembles, two downscaling datasets, and multiple MSD definitions evaluated at specific global warming levels. Its novel contribution is the explicit inclusion of MSD definition as an additional source of uncertainty, and it also demonstrates the value of applying a warming-level framing. This approach has been established in recent climate assessments but is applied here to hydrologic uncertainty partitioning to reduce sensitivity to model selection or emissions scenarios.

The study is a valuable contribution within the scope of HESS, addressing a climatically and socio-economically vulnerable region while applying an uncertainty framework relevant to decision-oriented science. The analysis is scientifically sound and the conclusions are well supported. With improvements to presentation clarity (streamlined writing, clearer figure formatting, consolidated summaries of uncertainty sources) and stronger connection to prior literature, the paper would make a strong contribution to HESS. After addressing the comments below, I would consider the scores across all criteria to be excellent.

1. Scientific Significance

The manuscript addresses a relevant and pressing hydrological issue in a vulnerable region and employs an uncertainty-partitioning framework aligned with HESS's interest in decision-relevant science. Its novel contribution is the explicit inclusion of the definition of the midsummer drought (MSD) as an additional quantified source of uncertainty, assessed alongside climate model spread, internal variability, and downscaling. The conclusion strengthens the broader relevance by noting that this framework can serve as a template for other precipitation-driven cases such as monsoons or rainy season timing (p.14, L285–287).

Suggested enhancement: The introduction notes that *"The uncertainty associated with each step…can become a daunting task for stakeholders"* (p.2, L30–33), but this theme is not revisited later. The discussion would be stronger if the authors explicitly linked their findings to future work aiming to be more decision-ready. In particular, they could emphasize two key contributions of their analysis: (i) that while model spread and internal variability dominate, the role of MSD definition is comparatively small, which highlights the need for future studies to continue testing how event or season definitions influence uncertainty; and (ii) that using specific warming levels rather than fixed time windows revealed how uncertainty evolves with global warming in a way that is less sensitive to model selection or emissions scenarios. Explaining why these findings are relevant for orienting future work toward decision-relevant applications would sharpen the paper's significance.

2. Scientific Quality

The study applies a sound methodological framework and delivers well-supported conclusions. However, certain aspects could benefit from deeper explanation or clarification:

- **Comparison with prior studies:**
  The introduction cites studies where impact definition uncertainty was substantial (e.g., Lemaitre-Basset et al., 2022; Jha et al., 2023; Jeantet et al., 2023). Since this study finds MSD definition is a minor contributor, the discussion or conclusions should briefly contrast this outcome with those earlier findings.
- **References:**
  Some statements require clearer sourcing. For example (L96–98), *"In Nicaragua, distinctly precarious socio-economic and climatic vulnerabilities intersect with a scarcity of observational (station) data, rendering advances in the understanding of the regional hydrologic system particularly pertinent"*. Stewart et al (2021) is cited in the prior sentence, but this is not a primary source for these specific claims. The authors should provide a more appropriate primary citation (e.g., to studies documenting data scarcity or socio-economic vulnerability in Nicaragua).
- **Methods:**
  Restricting the analysis to model runs common to both CIL and NASA-NEX is a sound way to separate downscaling differences from model selection effects. However, the characterization of internal variability may be limited by relying on single realizations per model, and equal model weighting may understate the effect of model dependence or skill. These limitations should be acknowledged.
- **Discussion depth:**
  - The results show downscaling adds ~10–15% uncertainty, but the discussion does not explain why this is relatively small compared to other studies. A short explanation (e.g., method characteristics, regional features) would help.
  - Figures 7–8 could be discussed in more depth, particularly why duration and intensity differ in uncertainty contributions and why MSD definition plays a larger role for duration.
  - Explicitly linking the dominance of model/internal variability back to implications for stakeholders would strengthen conclusions.
  - The introduction's explanation of why precipitation is harder to project than temperature is not revisited. Connecting this physical reasoning to the results would situate findings more broadly.

3. Presentation Quality

The manuscript is structured and purposeful overall, but several presentation enhancements would significantly improve readability and clarity:

- **Clarity of writing**:
  Some sentences are overly long or disrupted by parenthetical clauses, making them hard to follow.
    - For example, the sentence at lines 29–30 could be simplified to: "*This study focuses on future precipitation-driven hydrologic changes, which introduce a cascade of uncertainties into impact projections (Aitken et al., 2023).*"
    - Similarly, the sentence at lines 30–33 could be rephrased as: "*Uncertainty arises at each step of this cascade—including future greenhouse gas concentrations, climate response, downscaling, and hydrologic response—and can be estimated using multimodel ensembles (discussed in more detail below). However, this estimation can be daunting for stakeholders preparing strategies to cope with projected changes in the timing and availability of water.*"
    - Similar improvements can be made to other heavily clause-laden sentences.
- **Summary of uncertainties:**
  The uncertainty sources are described in text but not consolidated. A clear listing or table early in the manuscript would help readers track sources and enhance structural clarity.
- **Linking introduction to conclusions**:
  The conclusion would benefit from explicitly revisiting key themes from the introduction—stakeholders, simplification opportunities, warming-level framing—to improve narrative cohesion.
- **Definition of MSD metrics**:
  MSD intensity should be defined unambiguously, e.g., *"MSD intensity was defined as the mean precipitation of the two seasonal maxima minus the minimum precipitation between them (derived from the smoothed daily series)."* Figure 2 should clarify that red points mark maxima and the blue point marks the minimum used, ideally through a caption note and a simple legend.
- **Notation for warming levels:**
  Warming-level notation throughout the text and figures (Figures 1 and 8) should follow IPCC conventions, using a "+" sign before values (e.g., "+1.5 °C," "+2 °C," "+3 °C").
- **Abstract:**
  The abstract is informative, identifying which uncertainty sources dominate and provides guidance for future studies. To strengthen its impact, the authors could add a clearer statement of relevance for future work wishing to inform water planning/adaptation.
- **Figures**:
    - Ensure consistent font type and size (Arial or Helvetica recommended by HESS) across all figures.
    - **Figure 1:** Add "+" to Y-axis ticks; ensure "2080" is fully visible.

- **Figure 2:** Increase axis font size, add more x-axis ticks/labels, enlarge plotted blue and red points, clarify caption the caption to reference the blue and red data points, include a legend for the blue and red data points, fix cutoff of "0."
- **Figure 3:** Increase font size, and include a legend for CADC boundary, coastlines, and significance marks.
- **Figure 6:** Spell out "Probability," remove underscore in "Ensemble_mean," improve font consistency.
- **Figure 7:** Make color bar clearer with black border/ticks to be consistent with color bars in other figures; replace the legend title of "Percent" with "% of total variance" or "Contribution to total variance (%)."
- **Figure 8:** Remove underscore from "MSD_definition," use a colorblind-friendly palette (e.g., Blue #0072B2, Orange #E69F00, Sky Blue #56B4E9, Vermilion #D55E00).