Response to 'Comment on essd-2026-18', Anonymous Referee #1, 19 May 2026

ESSD-2026-18: Matus, F., Paredes, M., Lagos-Zúñiga, M., Garcés, A., Pinto, D., Aguilar, G., and Montserrat, S.: Extreme Precipitation Events: A Comprehensive Catalog for Northern Chile (17.5° S to 30.0° S), Earth Syst. Sci. Data Discuss. [preprint], https://doi.org/10.5194/essd-2026-18, in review, 2026.

Dear Reviewer,

We sincerely thank you for the time and effort devoted to reviewing our manuscript. We greatly appreciate your insightful and constructive comments and suggestions, which have helped us improve the quality, clarity, and scientific rigor of this work. We have carefully considered all remarks, addressed each comment in detail below, and revised the manuscript accordingly.

In the following sections, we provide a detailed point-by-point response to each of your comments.

Reviewer: *This study presents a catalog of extreme seasonal rainfall events in northern Chile during 1979–2019. Using observation and reanalysis datasets, the authors classify extreme precipitation events across three latitudinal bands. The topic is relevant and potentially useful for understanding extreme precipitation and related hazards in the arid and semi-arid regions of northern Chile. The construction of an event catalog could provide a valuable resource for future storyline analysis, precipitation-pattern identification, and hazard assessment. However, the manuscript still requires substantial clarification and improvement before publication. My specific comments are as follows:*

Authors: We thank the Reviewer for the positive assessment of the relevance of our study and for recognizing the potential utility of the rainfall-event catalog developed in this work. We also appreciate the constructive criticism regarding the need for further clarification and improvement. Following the Reviewer's recommendations, we have thoroughly revised the manuscript and addressed all comments in detail.

Reviewer: ***Lines 25–28:*** *This paragraph would be better placed around Lines 44–51. Please combine these two paragraphs to improve the logical flow of the introduction.*

Authors: We have moved the paragraph (former Lines 25–28) and combined it (former Lines 44–51), improving the logical flow from geomorphological setting to hazard triggering. The modified paragraph is presented as follows:

"*While sediment availability and channel connectivity define the preconditioning of these systems, extreme precipitation events act as the primary trigger for sediment mobilization and debris flows in the studied region. Precipitation in the arid northern region mainly occurs during the austral summer (December to February), mostly related to convective systems (linked to the South American Monsoon System - SAMS), cut-off lows, and the presence of atmospheric rivers (Aceituno et al., 2021; Fuenzalida et al., 2005; Valenzuela and Garreaud, 2019;*

Rondanelli, 2025). The impact of these precipitation mechanisms on natural hazards is strongly modulated by the geomorphological configuration of northern Chile (Aguilar et al., 2020; Cabré et al., 2020)."

Reviewer: *Lines 91–93:* *Please explain the rationale for selecting the three latitudinal bands: 17.5°S–23.5°S, 23.5°S–27°S, and 27°S–30°S. Are these bands based on climatic regimes, topography, hydrological basins, previous literature, or the spatial distribution of extreme events?*

Authors: We have revised the paragraph describing the study area to further explain the rationale behind the selection of the three latitudinal bands, emphasizing the distinct precipitation regimes that characterize each zone.

"To facilitate the isolation of precipitation events from different weather systems, the region is divided into three distinct areas based on the climatological characterization of Chilean precipitation and the synoptic patterns associated with precipitation events, as described in Aceituno et al. (2021). The criteria considered latitude, meteorological station density, the spatial distribution of precipitation, and the frequency and intensity of precipitation events. The latitudinal band 1 (LB1, 17.5°S–23.5°S, see Figure 1) is dominated by austral summer convective precipitation linked to the SAMS, the latitudinal band 2 (LB2, 23.5°S–27°S) represents a transitional zone where both summer convective and winter synoptic systems can produce extreme events, and the latitudinal band 3 (LB3, 27°S–30°S) is increasingly influenced by mid-latitude frontal systems, cut-off lows, and atmospheric rivers."

We have also added this paragraph after Figure 1:

"It is important to note that, since single meteorological events can occur in large spatial extent, some extreme events from the catalog will not be constrained to a single latitudinal band as the same storm date can appear across multiple bands, which can be potentially portrayed as different precipitation categories."

Reviewer: Line 98: *Please clarify the unit used in Figure 1b–d. In the text, the threshold is described as* ***10 mm/day****, whereas the figure appears to use* ***mm*** *as the unit. This inconsistency should be resolved.*

Authors: We have revised Figure 1 to ensure that the units are consistent between the text and the figure. Both now display mm/day as units.

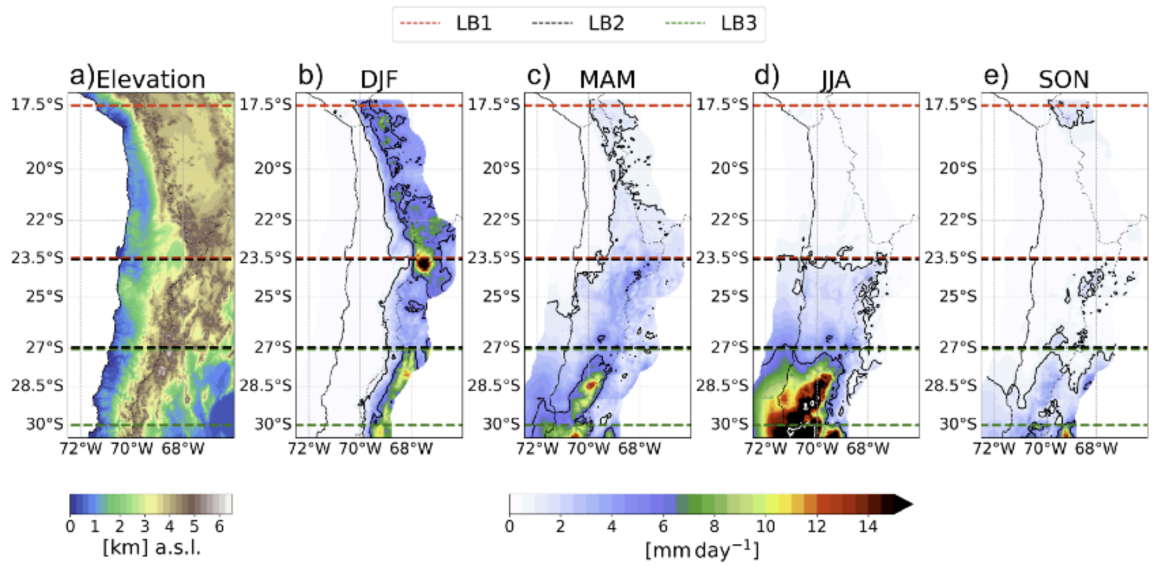

Figure 1. Climate and elevation features in northern Chile. Panel (a) displays the topography (km a.s.l.); panels (b)-(e) show the composite of maximum precipitation events (in mm/day) for each season (DJF: December–February, MAM: March–May, JJA: June–August, SON: September–November). Dashed lines delimit the three latitudinal bands (LB1, LB2, LB3). Black contours indicate the 1 and 5 mm/day thresholds; white contours indicate 20 mm/day.

***Reviewer: Figure 1:** Please label the panels as **a, b, c, d** instead of using the current leftmost and subsequent panel descriptions. In addition, the heights of the colorbars are inconsistent and should be standardized.*

Authors: We have revised Figure 1 to ensure that the caption description and colorbar are consistent. The full revised Figure 1 was attached in the previous comment.

Figure 1. Climate and elevation features in northern Chile. Panel (a) displays the topography (km a.s.l.); panels (b)-(e) show the composite of maximum precipitation events (in mm/day) for each season (DJF: December–February, MAM: March–May, JJA: June–August, SON: September–November). Dashed lines delimit the three latitudinal bands (LB1, LB2, LB3). Black contours indicate the 1 and 5 mm/day thresholds; white contours indicate 20 mm/day.

***Reviewer: Lines 109–110:** I am concerned about the definition of extreme rainfall events. If the maximum rainfall day is identified independently at each grid cell, the maximum day at one grid cell may differ from that at a nearby grid cell. Therefore, the identified “event” may not correspond to a single actual weather system. Under this definition, it is difficult to analyse the spatial and temporal extent of extreme precipitation events. The authors should clarify whether the catalog is based on grid-cell maxima, latitudinal-band maxima, or coherent weather systems.*

Authors: We have rewritten the methodological description in Section 3 to explicitly detail the spatial and temporal criteria used for event identification, as well as the rationale behind these choices. Given that the catalog is intended to serve as a tool for studying hydrometeorological hazards operating at small spatial scales, such as floods, landslides, and debris flows, we chose to study the events that maximized precipitation in a single grid cell:

"To identify extreme precipitation events, we analyzed precipitation at the grid-cell level rather than using spatially averaged values, capturing the localized signals relevant for small-scale hydrometeorological hazards. In a study region characterized by extreme aridity, precipitation events are infrequent and typically short-lived, often of convective origin, making the daily timescale sufficient to capture each storm as a discrete occurrence without risk of merging distinct events. Furthermore, area-based metrics tend to favor large-scale, low-magnitude events that cover extensive areas but are less sensitive to localized high-intensity storms. By selecting the grid cell (~25 km^2) with the highest daily precipitation for each year, season, and latitudinal band, we ensured that these localized extremes were captured. This is particularly relevant for the study area since high-intensity precipitation is a primary trigger for floods and debris flows, whose initiation is governed by rainfall intensity, duration, and antecedent conditions (Berti et al., 2020; Nikolopoulos et al., 2017).

The date of this highest value was then used to extract the full spatial precipitation field for that day, hereafter referred to as the maximum seasonal precipitation event for that band. This approach ensures that each event corresponds to a single coherent day of precipitation while targeting the most intense occurrence in the record. All selected events present in the catalog were also visually inspected to verify that the identified precipitation fields corresponded to coherent storm structures, with affected areas approximately greater than 250 km^2, which is consistent with the spatial scale of convective precipitation (around 100 km in one direction; Houze, 2004).

The analysis was conducted at daily resolution, which is the finest temporal scale available from the CR2METv2.5, with a 0.05° per 0.05° spatial resolution (~25 km^2 per grid cell). Although sub-daily rainfall characteristics are also relevant for debris flow initiation (Berti et al., 2020; Zhang et al., 2020), daily precipitation maxima provide a robust first-order indicator of extreme forcing in arid environments where sediment availability is generally unlimited and transport capacity is primarily controlled by rainfall magnitude and geomorphic connectivity (Aguilar et al., 2020)."

Reviewer: Figure 1 / Figures 3 and 4: *In Figure 1, the authors state that LB3 shows the strongest precipitation events in winter, JJA. However, Figures 3 and 4c–d focus on LB2 during the winter season. Please explain why LB2 was selected for the winter-season analysis instead of LB3.*

Authors: Figures 3 and 4 are not intended to analyze the band with the strongest seasonal events, but rather to provide illustrative examples of each precipitation category identified in the catalog. We have revised the opening of Section 4.1 to state this explicitly and to clarify the rationale behind the selected band and season combinations:

"To illustrate the diversity of spatial precipitation patterns from the catalog, Figure 3 shows representative examples of each precipitation category, with band and season combinations

selected to showcase categories that are unique or best represented in specific contexts. For instance, LB2 winter is shown because it is where both Stratiform and Coast categories coexist (panels c and d), while LB3 summer is presented because it is the only band and season where the Convergence and Westerly IVT subcategories are observed (panels e and f). These events represent the general precipitation categories for each latitudinal band: (1) Andes Mountain, with precipitation over the Andes (panels a, b, e, f); (2) Stratiform, with precipitation spread over most of the latitudinal band (panel c); and (3) Coast, with precipitation concentrated along and near the coastline (panel d)."

Reviewer: Table 1: *The sequence of precipitation categories is not consistent among different latitudinal bands. Please use a consistent category order across all latitudinal bands to make the table easier to compare.*

Authors: We have redesigned Table 1 so that categories are now displayed as columns with a consistent order across all latitudinal bands, and band/season combinations as rows. Hyphens (-) indicate categories not observed for a given band and season, making cross-band comparisons straightforward.

Table 1. Number of events per category, season and latitudinal band of the catalog. Hyphens indicate that the category was not observed for that band and season.

Band	Season	Coast	Stratiform	Andes Mountain				
				North	Along	South	Convergence	Westerly IVT
LB1	DJF	–	–	4	32	5	–	–
	MAM	–	–	5	27	9	–	–
	JJA	–	13	6	10	10	–	–
	SON	–	8	12	19	–	–	–
LB2	DJF	–	–	18	16	7	–	–
	MAM	–	26	–	15	–	–	–
	JJA	4	30	–	4	–	–	–
	SON	–	15	9	12	5	–	–
LB3	DJF	–	–	–	–	–	23	18
	MAM	3	22	–	14	–	–	–
	JJA	4	31	–	4	–	–	–
	SON	8	16	–	8	–	–	–

Reviewer: Figure 5: *I suggest redesigning this figure to make the comparison clearer. The two rows could be combined, and each bar could be divided into components representing the subcategories shown in the second row. For example, for **LB1 DJF**, the bar could be separated into **North Andes**, **Along Andes**, and **South Andes** components.*

Authors: We have redesigned Figure 5 into a single-row stacked bar plot where each bar is divided into its subcategory components, making the relative contribution of each precipitation category immediately visible as follows.

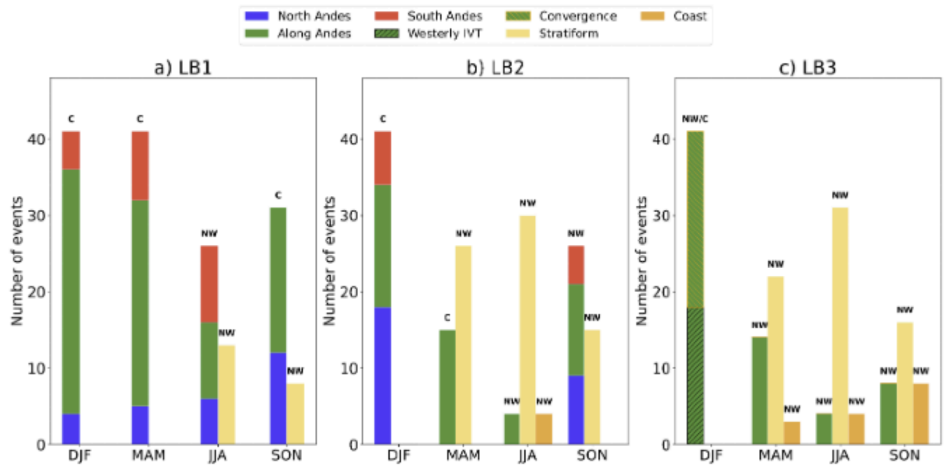

Figure 5. Bar plots for the number of events per category, season, and latitudinal band, observed in Table 1. The upper panel exhibit the distribution of events for the three main categories ($Andes\ Mountain$, $Stratiform$, and $Coast$). The bottom panel depicts the number of events per subdivision of the $Andes\ Mountain$ category. 'NW' and 'C' correspond to $Northwesterly$ and $Convergence$, which are the mean IVT directions observed in the composites of the categories by season over the latitudinal bands.

***Reviewer: Line 279:** Please justify the use of **4000 m³** as the threshold for debris-flow volume.*

***Authors**:* As shown in Figure 10, seven debris-flow deposits with volumes < 4000 m³ were inventoried by Aguilar et al. (2020). Although the agreement between estimated and observed volumes is better for deposits above 4000 m³, this observation does not imply the existence of a singular volume threshold. Given the limited number of inventoried deposits with volumes < 4000 m³ (n = 7), the observed difference in performance should not be interpreted as indicating a physical threshold in debris-flow volume.

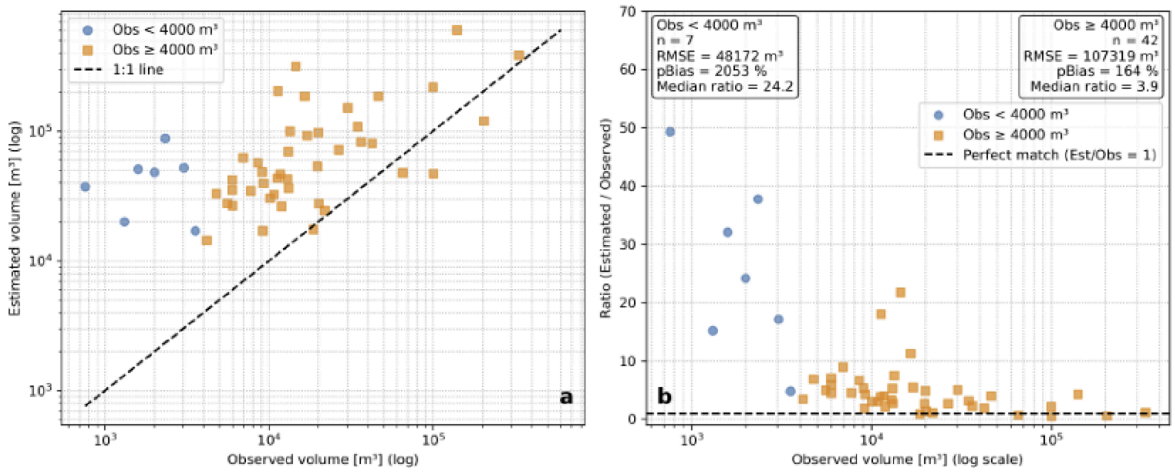

Figure 10. a)Coarse estimation of debris flow volume based on transport capacity for the March 2015 event. Comparison with measured deposited volumes at 49 alluvial fans. b) Ratio of estimated vs observed to quantify the prediction correlation degree

To further clarify this point and avoid potential confusion, we have revised the text as follows:

"Figure 10 indicates that this first-order estimation performs poorly for deposits smaller than 4000 m³ (pBIAS = 2053%). In contrast, the agreement between estimated and observed volumes is substantially higher for the subset of inventoried deposits larger than 4000 m³ (pBIAS = 164%). This difference reflects the performance of the method within the available dataset, and therefore should not be interpreted as evidence of a volumetric threshold in debris-flow deposits."

This statement replaces the previous wording:

"Figure 10 indicates that this first-order estimation performs poorly for deposits smaller than 4000 m³ (pBIAS = 2053%), while the agreement between estimated and observed volumes improves markedly for deposits larger than this threshold (pBIAS = 164%)."

We want to reiterate our gratitude towards your comments and suggestions.