Answers to comments from ESSD reviewers for:

The Southern Andes Daily Snow Depth Dataset (2010–2024): Quality–Controlled Dataset from Chile and Argentina (https://doi.org/10.5194/essd-2026-324).

Replies from authors are written in blue.

RC1:

Caro and co-authors present a new dataset of snow depth observations across the Southern Andes, compiled from several independent sources in Chile and Argentina. The observations are quality-controlled and homogenized through a systematic procedure. The authors demonstrate the scientific value of the dataset by analysing the relationship between snow depth observations and elevation in each of the three best-monitored river basins in the dataset. The article is within the scope of ESSD.

This study is a very welcome contribution, as snow depth data in the Andes are scarce and sometimes very difficult to find and process. The overview of data availability provided by the authors is useful for understanding the current limitations in spatial and temporal coverage. The new dataset will serve as a reference for hydro-meteorological studies in the region.

I am confident that this work can be accepted soon, but I would suggest a major revision at this stage so that the authors have the opportunity to clarify a few methodological issues and refine the presentation. Please see my comments below.

1. Methods

The presentation of the methods is confusing in some parts, and I could not follow all the details, particularly the logic and explanations behind the new PCI index. Please see my specific comments below.

2. Snow depth – elevation gradients

The conclusions about snow depth variations with elevation need to be cautious, as they are not necessarily generalizable from the available stations. Although the results presented here are based on this excellent database, the stations are still restricted to a few accessible locations, and many areas remain unmonitored. I refer especially to the discussion of altitudinal patterns of snow accumulation with breaks at specific elevations, for example in L49–50 and L534–542.

Answer:
In response to the specific comment on Lines 534–542, we have revised this paragraph.

3. Text length

The text is lengthy in some sections. Please check for repetitions and consider shortening some paragraphs. I have left a few suggestions in this direction.

4. Updating the database

And a general question: I didn't understand whether this is a static database, or whether you are planning to have regular updates.

Answer:
Related to the specific comment "239-240: is the dataset going to be regularly updated? See one of my main comments." We have made some alterations to the text for clarity.

Original text

"This step is crucial for ongoing updates to the quality–controlled SD dataset after publication, as revised data releases may differ from earlier versions for the same dates by station."

Edited text

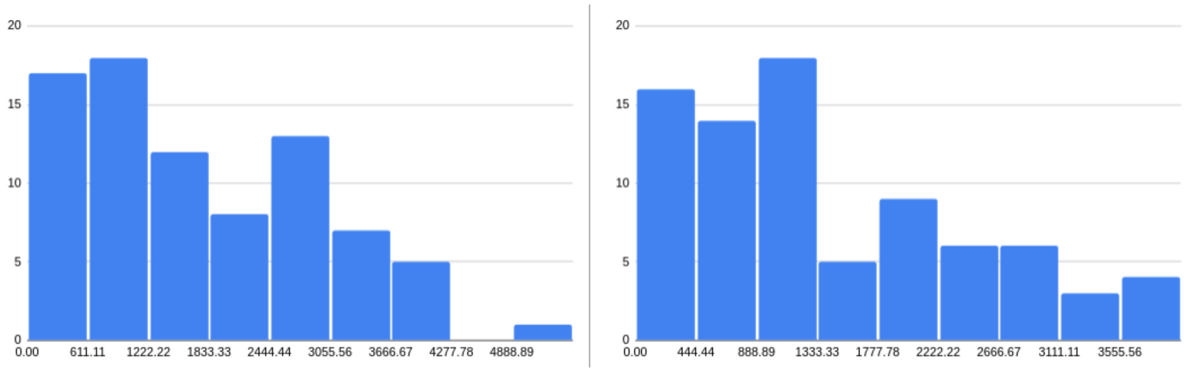
This step is particularly important for any future updates of the quality-controlled SD dataset, as revised data releases from the original data providers may contain different observations for the same station and date than those included in earlier versions.

Specific comments and text suggestions

- 41: I think that the mean is a better indicator here. The median neglects the magnitude of extreme values as it is calculated using only the central values. This comment is valid in several parts of the paper.

Answer:
We appreciate the comment. We report the median because data availability is highly uneven among stations, making it a more robust indicator (than the mean value) of data availability at the typical station. The mean value is more sensitive to stations with exceptionally long records which can skew the statistics, as explained below.

The histograms show the distribution of the number of days with data per station for the raw (left) and cleaned (right) datasets. In both cases, most stations contain fewer than 1,300 days of observations, whereas fewer than five stations exceed 3,500 days. Consequently, the mean (raw = 1738; cleaned = 1436) is disproportionately influenced by these few long-record stations, whereas the median (raw = 1392; cleaned = 1074) provides a more representative measure of the typical station within the network.



Considering that the distribution of this data set (data availability across stations) has a long right tail, the mean statistic would artificially drag the mean value to bigger numbers. We consider that in this case, the median is more representative. Next average statistics used further in this article will be addressed correspondingly.

We have clarified this in the manuscript accordingly as follows.

Original text

“Table 2 summarizes the effective number of days with available SD observations and the relative data availability, defined as the proportion of days with data between the first and last available records, for both raw and quality-controlled datasets across 26 river basins spanning 21° S to 54° S. Details by station are shown in Table A4.”

Edited text

Table 2 summarizes the effective number of days with available SD observations and the relative data availability, defined as the proportion of days with data between the first and last available records, for both raw and quality-controlled datasets across 26 river basins spanning 21° S to 54° S. Details by station are shown in Table A4. Median values are reported throughout this section because the distribution of data availability across stations is strongly skewed by a few stations with exceptionally long records, making the median a more representative measure of the typical station than the mean.

- 56-57: Although this applies only to mid-latitude regions. In fact, you show later that snow accumulation in the northern stations occurs mostly during the austral winter.

Original text

“Seasonal snowpacks are a key component of mountain hydrology, storing winter precipitation and releasing water during the dry season, thereby sustaining downstream water resources (Stewart et al., 2009). However,”

Edited text

Seasonal snowpacks are a key component of mountain hydrology, storing winter precipitation and releasing water during the dry season, thereby sustaining downstream water resources (Stewart et al., 2009). Although snow accumulation generally occurs during the winter, in tropical regions it can also occur during the summer, following the seasonal precipitation regime (Caro et al., 2021). However,

- 58: Can you add a reference for this? Is this meant in general or just for the Southern Andes?

Original text

“ However, quantifying snow storage and its spatial variability remains challenging due to the limited availability and uneven distribution of in situ observations. ”

Edited text

However, quantifying snow storage and its spatial variability remains challenging due to the limited availability and uneven distribution of in situ observations (Masiokas et al., 2020).

- 64: Please specify briefly here the elevation limits of the Mediterranean Andes. Is this above a certain elevation? The rivers of central Chile exhibit an important pluvial component to lower elevations. Or maybe specify that you refer to mountain rivers.

Original text

“In the Mediterranean Andes (31° S–36°S), seasonal and interannual streamflow variability of the main rivers is primarily controlled by snowmelt, with secondary contributions from glacier melt and minimal influence from rainfall.”

and

“In contrast, in the Wet Andes (36° S–55° S), snowmelt accounts for approximately 26 % of the annual runoff (Krogh et al., 2015) and rivers show more complex seasonal patterns influenced by precipitation events throughout the year.”

Edited text

In the Mediterranean Andes (31° S–36°S), seasonal and interannual streamflow variability of the main mountain rivers is primarily controlled by snowmelt, with secondary contributions from glacier melt and minimal influence from rainfall.

and

In contrast, in the Wet Andes (36° S–55° S), snowmelt accounts for approximately 26 % of the annual runoff (Krogh et al., 2015) and mountain rivers show more complex seasonal patterns influenced by precipitation events throughout the year.

- 84: Chile and Argentina?

Original text

"In Chile, these limitations are further exacerbated for SWE, as observations are substantially more restricted than SD data in terms of spatial density and temporal coverage, with large data gaps."

Edited text

In Chile, these limitations are further exacerbated for SWE, as observations are substantially more restricted than SD data in terms of spatial density and temporal coverage, with large data gaps. In Argentina, the number of stations reporting SWE data is also low, with most sites concentrated in the Dry Andes where snowmelt represents a crucial water resource for the adjacent lowlands. Regular daily SWE observations started in the early 21st century, but manual measurements conducted during the winter season at a limited number of snow courses exist since the early 1950s.

- 102-103: percentile ranges of what? Do you mean that 50% of the stations are between 32 and 34 degrees?

Original text

"Across existing regional studies in the Southern Andes (Cornwell et al., 2016; Cortés and Margulis, 2017; Bulovic et al., 2025), the in situ observations are limited to only 12–26 sites and stations, mostly concentrated within a narrow latitudinal range of 32.4° S–34.8° S (25–75th percentile range) and at mid–elevation sites, approximately 2,500–3,600 m a.s.l. (25–75th percentile range). "

Edited text

Across existing regional studies in the Southern Andes (Cornwell et al., 2016; Cortés and Margulis, 2017; Bulovic et al., 2025), *in situ* observations are limited to only 12–26 sites. Considering all stations included in these studies, the interquartile range spans 32.4° S–34.8° S in latitude and approximately 2,500–3,600 m a.s.l. in elevation, indicating a strong concentration of observations in central Chile-Argentina at mid-elevations.

- 103:104: Can you provide examples o these extrapolations? Or do you mean in non-academic work?

Original text

"However, these datasets are used to extrapolate SD and SWE conditions across a much broader region (27° S–37° S), and to higher elevations above 4,000 m a.s.l., as snow accumulation at higher elevations are critical for water supply during the dry season (Masiokas et al., 2020)"

Edited text

However, these datasets are used to extrapolate SD and SWE conditions across a much broader region (29° S–44° S) of the Andes, encompassing climatically contrasting mountain basins and elevations well beyond those represented by the observation network (e.g., Bulovic et al., 2025), including high–elevation areas where seasonal snow accumulation is critical for sustaining downstream water resources during the dry season (Masiokas et al., 2020).

- 104:105: The water supply sentence sounds like a repetition from the first paragraph.

Answer:

We agree. We have edited this sentence in the previous response.

- 107-108: Although Cornwell et al. (2016) did find evidence of a peak in SWE around 5000 m.

Original text

“While some studies in the Southern Andes report positive SD–elevation gradients (Cornwell et al., 2016; Cortés and Margulis, 2017), evidence from other mountain regions suggests more complex, non-linear relationships, with SD increasing up to a peak and decreasing at the highest elevations due to precipitation patterns and snow redistribution processes such as”

Edited text

“While some studies in the Southern Andes report positive SD–elevation gradients from in situ observations (Cornwell et al., 2016; Cortés and Margulis, 2017), evidence from other mountain regions suggests more complex, non-linear relationships, with SD increasing up to a peak and decreasing at the highest elevations due to precipitation patterns and snow redistribution processes such as”

- 131: Check the paper structure. It reads strange that there is only 1.1. I suggest that Study area moves to number 2.

Original text
“1.1 Study area”

Edited text

“2 Study area”, and numbering of all following sections were also updated for continuity.

- 132: commonly -> can be

Original text

“The Southern Andes is commonly divided into the Arid, Mediterranean, and Wet Andes (Saavedra et al., 2017; Caro et al., 2021)”

Edited text

The Southern Andes can be divided into the Arid, Mediterranean, and Wet Andes (Saavedra et al., 2017; Sarricolea et al., 2017; Caro et al., 2021).

- 132-133: Is this classification used in those studies? I thought that Caro et al. (2021) use the Tropical-Dry-Wet classification from Lliboutry, don’t they? Maybe Sarricolea et al. (2017) is a better reference here?

Answer:

We agree and have revised the sentence accordingly. We also added Sarricolea et al. (2017), which classifies low and high elevations, whereas Saavedra et al. (2017) focuses on snow-covered elevations and Caro et al. (2021) extends this classification to even higher elevations.

- 135: delete “northern”

Original text

“However, toward the northernmost sector of the Arid Andes, significant precipitation occur during summer (DJF), associated with the Bolivian Winter.”

Edited text

“However, toward the northern sector of the Arid Andes, significant precipitation occurs during the austral summer (DJF), associated with the Bolivian Winter.”

- 147: “comparatively” to what?

Original text

“Although mean monthly precipitation also peaks in autumn–winter, it remains substantial through spring–summer (SON-DJF), exceeding 150 mm/month (Lago Vargas station, 1977–1991), and is accompanied by comparatively warmer air temperatures (Dussaillant et al., 2012).”

Edited text

Although mean monthly precipitation also peaks in autumn–winter, it remains substantial through spring–summer (SON–DJF), exceeding 150 mm month^{-1} at Lago Vargas station (1977–1991) (Dussaillant et al., 2012).

- 149: can you briefly explain what does “persistent” mean here? Having snow for a minimum number of months during the year?

Original text

“Across Chilean and Argentinean territories, the persistent snow covers 34,370 km² between 29° S and 36° S (Saavedra et al.,2018).”

Edited text

Across Chilean and Argentinean territories, persistent snow cover, referring to areas where seasonal snow remains on the ground for several months each year, extends over 34,370 km² between 29° S and 36° S (Saavedra et al., 2018).

- 150-151: “Chilean ...” can be removed

Original text

“Chilean mountain river basins generally drain westward to the Pacific Ocean, whereas those in Argentina drain eastward to the Atlantic.”

Edited text

Mountain river basins in Chile generally drain westward to the Pacific Ocean, whereas those in Argentina drain eastward to the Atlantic Ocean

- 151-154: Repetition. Can be removed

Original text

“Hydrological regimes vary latitudinally: southern basins are dominated by winter precipitation with secondary contributions from spring snowmelt, producing a pluvio-nival regime; in contrast, northern basins rely mainly on spring and early summer snowmelt and, to a lesser extent in the Chilean basins, winter precipitations, resulting in a mostly nival to nivo- pluvial regimes (Masiokas et al., 2019).”

Answer:

We consider that this paragraph is not redundant. While the previous paragraph describes the general behavior, this paragraph focuses specifically on what has been observed in the Southern Andes.

- 161: At what time resolution are the original data provided?

Original text

“This study compiled data from 118 stations with SD observations distributed across the Southern Andes, between 17° S and 55° S.”

Edited text

This study compiled SD observations from 118 stations distributed across the Southern Andes (17° S–55° S), including both hourly and daily records, although hourly observations were not available at all stations.

- 162-163: Maybe "three" river basins?

Original text

"In addition, precipitation (Pr) and air temperature (AT) data were compiled to assess the physical consistency of the SD records in two river basin"

Edited text

In addition, precipitation (Pr) and air temperature (AT) data were compiled to assess the physical consistency of the SD records at stations located in the Elqui and Maipo river basins (Table 3).

- 163: Delete "including"? These are all the stations used in the article

Original text

"Data were obtained from multiple institutions in Chile, including DGA, CEAZA, UdeChile, CIEP, and IANIGLA from Argentina."

Edited text

Data were obtained from DGA, CEAZA, UdeChile, and CIEP in Chile, and from IANIGLA in Argentina.

- 172: "initial station-level screening" Is this a visual screening based on expert judgment?
- 172: Is this initial screening a type of Step 0?
- 172: "Prior to the data cleaning" Does the "data cleaning" corresponds to steps 2.1 to 2.5?
- 173: Remove "criteria used to evaluate"
- 174-177: I think this would fit better at the end of this sub-section. It is a nice summary of the final dataset.
- 181-182: what is "sufficient temporal coverage"? Did you set a minimum time length?

Original text

"Prior to data cleaning of the "raw" file obtained in Step 1, an initial station-level screening was conducted to remove stations with inadequate data quality. Stations were deemed to have inadequate quality based on criteria used to evaluate data consistency, sensor performance, and record overlap. Following this procedure, 81 out of 118 stations with SD observations were selected, providing coverage across the Andes between 21° S and 54° S. The selected stations span elevations from 30 to 5,804 m a.s.l., and their records cover the period 2010–2024. Table 1 summarizes the main characteristics of the compiled SD dataset aggregated by river basin, while selected metadata for each station are provided in Table A1 in the Appendix.

A total of 37 stations were excluded from the subsequent analyses due to substantial data quality issues. These include unrealistically large day-to-day variations in SD (exceeding 1 m), insufficient record length at monthly and annual scales (in some cases with only a few days of observations per month), and limited temporal representativeness. In addition, several excluded stations correspond to recently available records (late 2025 and 2026) that do not yet provide sufficient temporal coverage for robust analysis. A complete list of excluded stations is provided in Table A2."

Edited text

An initial visual screening was conducted to exclude stations with inadequate data quality based on three criteria: (i) unrealistically large day-to-day variations in SD (exceeding 1 m between consecutive days), (ii) insufficient monthly data availability (less than 50 % of daily observations), and (iii) insufficient annual coverage (fewer than three months with available data during the snow season, from May to October). In addition, several stations were excluded because their records only became available in late 2025 or 2026, providing insufficient temporal coverage for robust analyses.

Following this procedure, 81 of the 118 stations with SD observations were retained, providing coverage across the Andes between 21° and 54° S. The selected stations span elevations from 30 to 5,804 m a.s.l., with records covering the period 2010–2024. Table 1 summarizes the main characteristics of the compiled SD dataset aggregated by river basin, while metadata for the selected and excluded stations are provided in Tables A1 and A2, respectively.

- 184-186: Is this referring to steps 2.1-2.5? Please refer to the corresponding number of each step to be clear about what are you referring to.

Original text

"A series of automated algorithms were implemented using the Pandas library (The pandas development team, 2025) to adjust the ground reference level (corresponding to the soil surface and established after sensor installation or maintenance), to correct anomalous spikes, and to remove implausible or extreme values."

Edited text

A series of automated algorithms were implemented using the Pandas library (The pandas development team, 2025) to perform three quality-control procedures: adjustment of the ground reference level (Step 2.1, Zero-level correction), corresponding to the soil surface established after sensor installation or maintenance; removal of anomalous spikes (Step 2.2, Spike removal); and (iii) identification and removal of implausible or physically unrealistic values (Step 2.3, Physical range check).

- 188: “This step”, what number?
- 184-188: In what temporal resolution are these proceedings applied?

Original text

“This step, based on expert judgment, was used to identify and remove residual localized outliers not captured by the automated procedures, thereby ensuring the overall reliability of the dataset”

Answer:

These lines were deleted

- 194: “a median window length of five days was adopted” But you use different windows for each station, right? Or is there a relation with the macrozone? Please explain better the selection of these windows. How do you select the value for each station?
- 197: Why 5 cm?
- 200: Please introduce the “validated offset” earlier in the text
- 191-207: I suggest the authors to re-structure this paragraph. I think that all the information is there, but the explanations are convoluted.

Original text

“Step 2.1. Zero-level correction: This step realigns the SD ground reference level to account for instrumental drift during snow-free periods. The algorithm identifies abrupt changes by assessing variability in the SD time series using a moving-window range, defined as the difference between the maximum and minimum SD values within each window. Across the three Southern Andean zones, a median window length of five days was adopted, with river basin-specific adjustments ranging from three to five days. A period is classified as stable if the SD moving range falls below the sensor noise threshold for SD measurements (1 cm). To ensure that actual snowpacks are not erroneously corrected, stable windows (as defined by the SD moving range) with median SD values exceeding a predefined snow threshold (5 cm) are preserved. Conversely, if the estimated offset corresponds to a stable window (i.e., SD moving range < 1 cm) and falls within a near-zero tolerance limit (0.5 cm), it is treated as regular SD sensor noise and set exactly to zero. Then, to preserve continuity and avoid constant micro-adjustments, the validated offset (defined as the offset estimated from stable, snow-free windows after applying the tolerance criteria), is subtracted from all subsequent SD observations only if it deviates from the previously established ground reference level by more than a drift tolerance of 0.5 cm. While the SD sensor accuracy is ±1 cm (https://www.campbellsci.com/sr50a), this analysis relies on daily averages derived from high-frequency (hourly) SD observations, further aggregated using a multi-day sliding window. This temporal averaging substantially dampens random noise and reduces the statistical uncertainty of the estimated ground reference level. This reduction in variance justifies the use of a stricter threshold (0.5 cm) for the tolerance limits applied in the correction procedure, enabling the detection of subtle systematic shifts that would otherwise be obscured by the manufacturer’s nominal instrumental error.”

Edited text

Step 2.1. Zero-level correction: This step realigns the ground reference level to account for instrumental drift during snow-free periods. The algorithm detects stable periods using a moving-window range (the difference between maximum and minimum SD) with a 0.5 cm stability threshold. To account for local variability, window lengths were calibrated for each river basin (3 to 5 days, median 5) to capture local variability while remaining sensitive to drift. From these stable windows, we define a 'validated offset' as the calculated displacement from the ground reference level. To protect actual shallow snow records, windows with median values exceeding a 5 cm snow threshold are preserved and not used for correction. This 5 cm value acts as a conservative safety margin to ensure the algorithm does not misinterpret a shallow, stable snowpack as instrumental drift, as it remains well above both the sensor's nominal noise (± 1 cm) and typical surface roughness effects (2 cm). If the validated offset is very small (within 0.3 cm), it is treated as noise and set to zero. Finally, to maintain data continuity, this offset is subtracted from subsequent observations only if the drift exceeds a 0.3 cm tolerance. Although sensor accuracy is ± 1 cm (https://www.campbellsci.com/sr50a), our use of daily averages from high-frequency (hourly) observations over multi-day windows dampens random noise. This reduction in variance justifies the stricter 0.3 cm threshold, enabling the detection of subtle systematic shifts that would otherwise be obscured by instrumental error.

- 202: Is the Campbell sensor accuracy valid for all stations?

Original text

"While the SD sensor accuracy is ±1 cm (https://www.campbellsci.com/sr50a), this analysis relies on daily averages derived from high-frequency (hourly) SD observations, further aggregated using a multi-day sliding window."

Edited text

In addition, the SR50A sensors, which have been widely used across stations in Chile and Argentina, have recently begun to be replaced at some stations by a newer generation of sensors with higher measurement precision. The sensor used at each station is indicated in Table A1.

- 203: Please present the information about the hourly observations earlier in the text

Answer

This information has now been included in response to the comment: 161: At what time resolution are the original data provided?

- 208: Are you using daily or hourly data at this point?
- 210: The use of the median is again not fully informative. See my comment 3 on Table 1.
- 210-211: What criteria did you use to select the window size?

Answer

At this stage of the quality control procedure, we are using daily mean values, as specified in Step 1 (lines 168-170) and Step 2 (lines 202-204). The original observations, which were heterogeneous between sources; sometimes daily mean values, sometimes hourly means, were aggregated into daily median values before applying the spike removal and range filters. To provide more detailed information, we have replaced the single median value with the full range of window sizes used for each macrozone, highlighting the basin-specific nature of the calibration which is consistent with the geographical grouping shown in Table 1. The window size (ω) was selected based on the local SD signal-to-noise ratio and the characteristic duration of snowfall events in each basin. Shorter windows (e.g., 3 days in the Arid Andes) are sufficient to increase sensitivity to isolated anomalies in stable snowpacks where events are infrequent. In contrast, longer windows (up to 15 days in the Mediterranean and Wet Andes) are required to provide a robust baseline in dynamic environments, ensuring the moving median accurately represents the snowpack without being skewed by high-frequency accumulation pulses. Similarly, the scaling factor k was adjusted to balance noise removal with signal preservation: a lower k value provides a stricter filter for removing instrumental noise, while a higher k value is more permissive, ensuring that high-magnitude, extreme physical snowfall events are not erroneously discarded

Original text

"Step 2.2. Spike removal: To identify and remove isolated spikes in SD time series related to each station, the median absolute deviation (MAD, Rousseeuw & Croux, 1993) was applied using a centered moving window (3 to 15 days) tailored to each basin's SD variability. The median window size (ω) was three days in the Arid Andes, nine days in the Mediterranean Andes, and six days in the Wet Andes.

Edited text

Step 2.2. Spike removal: To identify and remove isolated spikes in the daily mean SD time series, the median absolute deviation (MAD, Rousseeuw & Croux, 1993) was applied using a centered moving window. The window size (ω) was adjusted for each basin within a range of 3 to 15 days to match local SD variability, shorter windows increase sensitivity to local anomalies in stable snowpacks, whereas longer windows provide a more robust baseline in dynamic environments. For the Arid Andes, window sizes typically ranged from 3 to 9 days (median: 3), while the Mediterranean and Wet Andes required longer windows (ranging from 6 to 15 days and 9 to 15 days, respectively) to define the moving median accurately considering higher SD variability.

- 216: "k was calibrated", but what is the target in this calibration?
- 217: "the median value" across stations or basins?
- 223-224: How did you select these thresholds? Based on expert judgement?

Answer:

The target of this adjustment was to define a threshold that can effectively separate instrumental noise from expected physical signals. Specifically, k was adjusted to maximize the detection of isolated spikes, ensuring that high magnitude snowfall events that have a short duration were not erroneously removed. The median values (from 4 to 6) refer to the median of the k factors assigned to each basin within the three addressed macrozones.

Original text

A daily observation was flagged as a spike and removed if it met either of two independent criteria. The first criterion evaluated deviations from the window median using a scaling factor, k. Conceptually, k acts as a tolerance threshold that defines the acceptable range of natural variability around the median. Because snow accumulation is inherently irregular, k was calibrated based on the observed behavior at each station within the river basin, with values ranging from 2 to 7. The median value of k was 4 in the Arid and Mediterranean Andes and 6 in the Wet Andes. To avoid inadvertently removing true extreme snowfall events, this criterion required that any suspected spike exhibit clear discontinuities (> k · MAD) relative to both adjacent days. Additionally, the absolute difference between the two adjacent days had to remain small (< k · MAD), confirming that the event represented an isolated anomaly rather than a sustained change in SD. The second criterion acted as an absolute physical filter. Regardless of MAD, an observation was flagged and removed if the absolute difference compared to both adjacent days exceeded a fixed, extreme physical magnitude, depending on SD variability of its respective basin. The median value of this threshold was 75 cm in the Arid, 100 cm in the Mediterranean, and 140 cm in the Wet Andes.

Edited text

A daily observation was flagged as a spike and removed if it met either of two independent criteria. The first criterion evaluated deviations from the window median using a scaling factor, k. Conceptually, k acts as a tolerance threshold that defines the acceptable range of natural variability around the median. Because snow accumulation is inherently irregular, k was adjusted to balance the removal of instrumental errors with the preservation of true snowfall events. This adjustment was based on the observed signal-to-noise ratio and natural SD variability at each station within its basin. In this context, a lower k value provides a stricter filter for noise removal, while a higher k value is more permissive to accommodate natural variability and ensure that extreme physical signals are not erroneously discarded. Across the study area, k values ranged from 4 to 7, with median values calculated across basins being 4 in the Arid and Mediterranean Andes and 6 in the Wet Andes. To avoid inadvertently removing true extreme snowfall events, this criterion required that any suspected spike exhibit clear discontinuities (> k · MAD) relative to both adjacent days. Additionally, the absolute difference between the two adjacent days had to remain small (< k · MAD), confirming that the event represented an isolated anomaly rather than a sustained change in SD. The second criterion acted as an absolute physical filter. Regardless of MAD, an observation was removed if the absolute difference relative to both adjacent days exceeded a basin-specific threshold representing an implausibly large day-to-day change in SD. These thresholds were defined empirically based on visual inspection of station records and inter-station consistency within each basin. Threshold values ranged from 20 to 150 cm (median: 50 cm) in the Arid Andes, 100 to 200 cm (median: 100 cm) in the Mediterranean Andes, and 60 to 350 cm (median: 140 cm) in the Wet Andes.

- 228: “the median physical limits” do the limits depend on each station?

Original text

“The median physical limits were 0–140 cm in the Arid Andes, 2–360 cm in the Mediterranean Andes, and 2–300 cm in the Wet Andes.”

Edited text

The median physical limits for basins, applied to the stations within each basin, were 0–140 cm in the Arid Andes, 0–360 cm in the Mediterranean Andes, and 0–300 cm in the Wet Andes.

- 232: “cleaned SD”, is this the final clean dataset shown in Figure 2? Then the arrow should come from Step 2 and not Step 4?

Original text

“The output of this step is a cleaned SD file that preserves the structure of the original raw SD dataset while containing quality–controlled values for each monitoring station.”

We moved these lines to the end of section 3.3 Step 3 – Harmonization of snow depth observations

- 238: what type of external sources?

Original text

“For example, the DGA dataset for some stations may include multiple versions of the same SD observation, arising either from data updates or from the incorporation of post-processed information obtained from external sources for specific stations”

Edited text

For example, the DGA dataset for some stations may include multiple versions of the same SD observation, arising either from data updates or from the incorporation of post-processed information obtained from external sources for specific stations (e.g., universities or other monitoring agencies).

- 239-240: is the dataset going to be regularly updated? See one of my main comments

We answered extensive this previously in you main comments.

Original text

“This step is crucial for ongoing updates to the quality–controlled SD dataset after publication, as revised data releases may differ from earlier versions for the same dates by station.”

Edited text

This step is particularly important for any future updates of the quality-controlled SD dataset, as revised data releases from the original data providers may contain different observations for the same station and date than those included in earlier versions.

- 245: observations at the same site, right? Maybe specify more explicitly

Original text
“The analysis was restricted to stations located in the Elqui and Maipo River Basins with overlapping daily observations of SD, Pr, and AT during the May–October period,”

Edited text
The analysis was restricted to stations in the Elqui and Maipo River Basins where daily observations of SD, Pr, and AT were simultaneously available at the same station during the May–October period,

- 251: “We developed and implemented a new index of physical consistency” Just to be more explicit

Original text

“The new Physical Consistency Index (PCI) was developed and implemented to classify each day as physically consistent”

Edited text

We developed and implemented a new Physical Consistency Index (PCI) to classify each day as physically consistent

- 252: Here and later, there are several “?” symbols in the equations

We have fixed these formatting issues introduced during the DOC-to-PDF conversion

- 259-260: I don’t understand this part. Why is the temperature threshold defined as the 95th percentile? Wouldn’t be better to use an absolute number between 0 and 2 C? Don’t you obtain values of T well above zero C using the 95th percentile? Or even below zero?

Original text

“Second, to ensure physical consistency with meteorological conditions, only days with measurable precipitation (Pr > 1 mm) were retained, reducing uncertainties associated with gauge undercatch and wind-driven snow redistribution. For these events, an air temperature threshold (ATrain) was defined as the 95th percentile of AT at each station. ”

Edited text

Second, to ensure physical consistency during snow accumulation events, we retained only days with measurable precipitation (Pr > 1 mm), thereby reducing uncertainties associated with gauge undercatch and wind-driven snow redistribution. For these events, an air temperature threshold (AT rain) was defined as the station-specific 95th percentile of AT to account for the large climatic variability across the Andes. A fixed usual threshold (e.g., 0–2 °C) was not adopted because the air temperature associated with snowfall varies substantially with local conditions. Using a station-specific percentile therefore provides a locally adapted threshold that better represents the upper temperature limit at which snowfall is still observed at each station. For example, the median air temperature threshold ranged from −3.2 to 2.2 °C (median: -2.2 °C) in the Elqui River Basin and from −3.8 to 3.8 °C (median: -1.5 °C) in the Maipo River Basin.

- 263-264: So the only difference between the numerator and denominator is the condition of T<Train? Is that the purpose of the PCI index? To detect unplausible events with Delta-S>0 and Pr>1 but with T>Train? Wouldn’t be more logical to use all the SD changes in the denominator (and not only those with Pr>`mm)? Then, the raw, noisy datasets will have low PCIs.

Answer

Yes. The numerator represents accumulation events (SD > t) that occur with precipitation (Pr > 1 mm) and air temperatures below the rain threshold (AT < AT rain), while the denominator (N) includes all accumulation events with Pr > 1 mm, regardless of temperature.

Yes, The purpose of the index is to determine if a detected increase in SD is physically plausible given the recorded meteorological conditions, specifically identifying events that are likely erroneous because they occur at temperatures too high for snowfall.

Regarding the denominator issue, we chose to limit it to days with Pr > 1 mm to specifically evaluate precipitation-driven accumulation, which provides the most robust physical signal. Including all SD > 0 events (including those without precipitation) would introduce noise from wind-driven snow redistribution and instrumental noise, making the index a measure of general noise rather than physical consistency.

Original text

The PCI for each station was calculated as the ratio between the number of physically consistent snow accumulation days (φ_i = 1) and the total number of identified snow accumulation days with Pr > 1 mm (N). This index is defined in Equation 2, where φ_i is a binary consistency indicator for each day i, taking a value of 1 for physically consistent conditions and 0 otherwise.

Edited text

The PCI for each station was calculated as the ratio between the number of physically consistent snow accumulation days ($\varphi i = 1$) and the total number of identified snow accumulation days with Pr > 1 mm (N). This multivariable equation specifically targets the consistency of precipitation driven accumulation. By excluding days without precipitation from the denominator we minimize uncertainties associated with wind driven snow redistribution and instrumental noise, which do not represent true snowfall signals. This index is defined in Equation 2, where φi is a binary consistency indicator for each day i, taking a value of 1 for physically consistent conditions and 0 otherwise.

- 275-276: "The procedure effectively identified and removed…" To what procedure are you referring to? Step 2?

Original text

"Second, the Noise Ratio (NR) is defined in Equation 4 as the proportion of the total number of apparent accumulation events detected in the raw dataset (Nevent ,raw) to the number of events retained after quality–control (N event, QC). Values of NR greater than 1 indicate that the procedure effectively identified and removed spurious positive SD spikes, revealing the presence of noise or measurement artifacts in the raw SD dataset"

Edited text

Second, the Noise Ratio (NR) is defined in Equation 4 as the proportion of the total number of apparent accumulation events detected in the raw dataset (N event, raw) to the number of events retained after quality–control (N event, QC). The interpretation of this metric allows for three scenarios: (1) NR > 1 indicates that the quality-control procedures up to Step 3 effectively identified and removed spurious positive SD spikes, revealing the presence of noise or measurement artifacts in the raw SD dataset; (2) NR = 1 suggests a high-quality raw record where no events were removed or recovered; and (3) NR < 1 indicates signal recovery, where the cleaning algorithm or manual depuration allowed the identification of valid accumulation events that were previously obscured or incorrectly recorded in the raw data. For example, a station with NR = 2.0 has had half of its raw accumulation signals removed as noise, whereas a station with NR = 0.5 has doubled its count of valid events through the correction of systematic errors.

- 282: "we selected precipitation observations" for what? For the classification of years?

Original text

"For the Elqui, Maipo, and Maule–Itata River Basins, we selected precipitation observations from stations at relatively high elevations: La Laguna Embalse station (3,160 m a.s.l.) in the Elqui River Basin; 19 stations in the Maipo River Basin; and the Diguillín (670 m a.s.l.), Río Diguillín en San Lorenzo–Atacalco (727 m a.s.l.), and Las Trancas (1,242 m a.s.l.) stations in the Maule–Itata River Basin. These basins were selected because they contain a sufficient number of SD observations with a well-distributed elevation range"

Edited text

For this classification, precipitation records were obtained from relatively high-elevation stations within each basin to better represent mountain precipitation conditions. Specifically, we used the La Laguna Embalse station (3,160 m a.s.l.) in the Elqui River Basin, 19 stations in the Maipo River Basin, and the Diguillín (670 m a.s.l.), Río Diguillín en San Lorenzo–Atacalco (727 m a.s.l.), and Las Trancas stations (1,242 m a.s.l.) in the Maule–Itata River Basin. These basins were selected because they contain a sufficient number of SD observations spanning a broad elevation range.

- 288-289: "In contrast, mean air temperature…" This sounds trivial, I suggest removing

Original text

"In contrast, mean air temperature is expected to exhibit a negative correlation with elevation, with lower mean temperatures typically observed at higher elevations (Voordendag et al., 2021; Aguayo et al., 2024; Caro et al., 2024)."

Answer

Because air temperature is the primary control on precipitation phase partitioning (g.e. snow fraction), we consider it important to retain this statement together with the cited references. These studies demonstrate that the air temperature lapse rate associated with precipitation phase varies across different climatic conditions, supporting the use of a station-specific threshold in our analysis.

- 290: "competing effects" why are they exactly competing effects? Both positive precipitation gradients and negative temperature gradients affect in the same direction, don't they?

Original text
"To quantify the combined effect of these competing processes,"

Edited text
To quantify the combined influence of these elevation-dependent processes,

- 296: Add the reference of the SRTM dataset

Original text

", and elevation was derived from the 30 m SRTM digital elevation model."

Edited text

, and elevation was derived from the 30 m SRTM digital elevation model (Far et al., 2007).

We have also added the corresponding references to the References section.

Farr, T. G., Rosen, P. A., Caro, E., Crippen, R., Duren, R., Hensley, S., Kobrick, M., Paller, M., Rodriguez, E., Roth, L., Seal, D., Shaffer, S., Shimada, J., Umland, J., Werner, M., Oskin, M., Burbank, D., Alsdorf, D.: The Shuttle Radar Topography Mission. Rev. Geophys. 45, RG2004, doi.org/10.1029/2005RG000183, 2007.

- 297-304: What is the purpose of this procedure using the snow persistence?

Original text

“Additionally, the median snow line elevation in July, as well as its 25th percentile, was estimated for these three river basins using satellite-derived snow persistence for the period 2000–2024. July corresponds to the month with the lowest snow line elevation in the year. ”

Edited text

Additionally, the median July snow line elevation, together with its 25th percentile, was estimated for these three river basins using satellite-derived snow persistence for the period 2000–2024 to provide a reference for evaluating the elevational distribution of the SD observations. July corresponds to the month with the lowest snow line elevation in the year.

- 302: Maybe remove the sentence about SRTM. I would say it is logical that you used the same DEM.

Original text

“Elevation was obtained from the 30 m SRTM digital elevation model”

Edited text

Elevation was extracted from the same digital elevation model described above.

- 303: “elevation contour”

Original text

“The snow line elevation was defined as the contour where snow persistence equals 5%, and its elevation was calculated by intersecting this contour with the DEM and taking the median of the corresponding elevations.”

Edited text

The snow line elevation was defined as the 5 % snow persistence contour. Its elevation was then estimated by intersecting this contour with the DEM and calculating the median elevation of the intersecting pixels.

- 306: As you are analysing the distribution of stations, and not actual observations of snow depth, I suggest changing the title to : “Spatial distribution of snow depth stations” or similar.

Edited text

Spatial and temporal distribution of snow depth observations across the Southern Andes

- 337: delete “effective”

Original text

“This indicates that the **effective** availability of SD observations is likely to continue increasing beyond the period analysed here”

Edited text

This indicates that the availability of SD observations is likely to continue increasing beyond the period analysed here

- 354: “Key places” why are these places key? Maybe change to “selected”

Original text

“Figure 4 presents the daily SD observations in key places along the Southern Andes for the 2010–2024 period.”

Edited text

Figure 4 presents the daily SD observations in selected stations along the Southern Andes for the 2010–2024 period.

- 366: “across the Andes” or just the Mediterranean Andes?

Original text

“A clear west–east gradient is observed across the Andes,”

Edited text

A clear west–east gradient is observed across the Arid and Mediterranean Andes,

- 380: availability -> quality?

Original text

Snow depth data availability: comparison of raw and quality-controlled versions

Edited text

Quality assessment of snow depth observations: comparison of raw and quality–controlled datasets

- 380-434: This section is a bit long providing many details about each corrected station. Can the text be summarized? Specially because the authors comment on several details that can't be seen in any figure.

- 388: Same problem for the median here. Better use the mean?

- 425-426: Here (and in other parts of this subsection) the use of the median can also be misleading. The median of the reductions could have changed little but the median will not capture a station where the reduction was very high.

Answer:

Regarding the use of the median to compare the raw and quality-controlled datasets in terms of days with data, we have provided a detailed explanation of the data distribution in our response to the first specific comment (Line 41).

We appreciate the reviewer's suggestion. While we agree that this section is relatively detailed, we consider that discussing a number of representative stations is important for understanding the characteristics of the quality-controlled dataset, particularly in basins represented by a single station or by stations with long-term records. These examples help explain the main causes of data exclusion and identify the specific periods for which observations were considered unreliable. We also note that the complete quality-controlled snow depth dataset is openly available in Medina and Caro (2026) (https://zenodo.org/records/21577171), as indicated in both the Abstract and the Data availability section. In addition, we developed an interactive snow depth exploration tool (https://javiermedinamen-art.github.io/hidromet), which allows readers to inspect the complete time series and quality-control results for each station. Because these resources provide full access to the underlying observations, we believe that retaining the representative station-specific descriptions in this section adds useful context for interpreting the quality-control procedure and the final dataset.

- 442-444: Please reword these lines

Original text

"These strict data availability requirements resulted in a substantial reduction in the number of analyzed days,dropping from a median value in days with three variables overlap from the quality–controlled data of 714 to 19 analyzed days with PCI in Elqui River Basin and from 1,907 to 79 analyzed days in Maipo River Basin."

Edited text

These strict data availability requirements substantially reduced the number of days available for PCI analysis. In the Elqui River Basin, the median number of days with overlapping quality-controlled SD, precipitation, and air temperature observations decreased from 360 to 19 days after applying all selection criteria. In the Maipo River Basin, the corresponding median decreased from 965 to 79 days.

Answer

For a higher clarity of number of day reduction we added a new table version

Table 3. Assessment of snow depth, precipitation, and air temperature data before and after the quality-control procedure in the Elqui and Maipo river basins for the accumulation period May–October, 2017–2024.

Station name	Basin	Elevation (m a.s.l.)	N° days clean overlapped data				ΔE	NR	Raw PCI (%)	Clean PCI (%)
			With negative and positive Δ SD and Pr > 0 mm	With SD > 1 cm	With Pr > 1 mm	Start–End period				
Cerro Olivares	Elqui	3,566	182	11	10	2024–2024	1	2.1	90.5	90.0
Glaciar Tapado Corrales		4,065	538	29	28	2020–2023	0	1.2	93.9	92.9
Termas Del Plomo	Maipo	3,027	710	77	59	2017–2022	11	1.9	87.3	94.9
Las Melosas		3,317	543	91	79	2022–2024	1	1.0	95.1	94.9
Glaciar Olivares Gamma		3,628	1050	156	107	2019–2024	0	0.6	89.8	94.4
Glaciar Juncal Sur		4,035	1041	113	110	2019–2024	4	1.4	93.4	94.6
Glaciar Olivares Alfa		4,230	965	78	72	2019–2024	2	1.4	93.9	94.4

- 450: why the “spread of values”?

Original text

“In the Elqui River Basin, the PCI in the quality–controlled dataset ranges between 90.0 % and 92.9 %, compared to 90.5 % and 93.9 % in the raw dataset, indicating only minor changes in the spread of values after cleaning"

Edited text

In the Elqui River Basin, the PCI in the quality–controlled dataset ranges between 90.0 % and 92.9 %, compared to 90.5 % and 93.9 % in the raw dataset, indicating only minor changes after cleaning

- 457-459: Isn’t that a consequence of using Pr>1mm in the calculation of N, in the PCI formula? See my previous comment on 263-264.

Answer:

Yes, this is a consequence of the Pr > 1 mm requirement in our denominator. We intentionally implemented this filter to isolate precipitation-driven accumulation events, as they represent the most robust physical signal for cross variable validation. By focusing on these specific events, we can evaluate the relationship between snow accumulation, precipitation and air temperature, which is the primary goal of the PCI. We acknowledge the point that this approach 'pre-filters' much of the instrumental noise occurring during dry periods, but this is why our method treats the PCI as one component of a broader validation; it is complemented by the Noise Ratio (NR) and the Net Inconsistency Reduction (ΔE) to ensure instrumental noise is quantified across the entire time series, regardless of precipitation occurrence.

Original text
"An example of this is observed at the Cerro Olivares station (Elqui River Basin), where despite a high Noise Ratio (NR = 2.1) indicating that more than half of the raw SD days were spurious spikes, the raw PCI (90.5 %) is similar to the clean PCI (90.0 %)."

- 477-478: "but from the effective correction data issues…" in what step is that? Please include it in the next

Answer:

We appreciate the request for clarification here. The recovery of valid signals for the Glaciar Olivares Gamma station resulted from the manual filtering step described in Section 2.2 (Step 2). While our automated algorithms handled the majority of the dataset, this specific station presented complex issues in its raw data, which was attributed to height unit mismanagement, that required manual depuration based on extensive time series observation. Because these issues were very scarce and complex to localize, we decided not to include them in the automated algorithms.

Original text

"The third group exhibits a distinct behavior, represented by the Glaciar Olivares Gamma station, which stands out as a unique case of signal recovery. Unlike the previous groups, its metrics explain this pattern: despite no detected errors (ΔE = 0), the quality–control procedure increased the PCI from 89.8% to 94.4%. This improvement did not result from noise filtering, but from the effective correction of data issues associated with sensor mismanagement, which nearly doubled the total number of valid accumulation events (NR = 0.6)."

Edited text

The third group exhibits a distinct behavior, represented by the Glaciar Olivares Gamma station, which stands out as a unique case of signal recovery. Unlike the previous groups, this pattern is explained by its metrics. Although no errors were detected by the automated filters (ΔE = 0), manual depuration of the record (executed in Step 2) increased the PCI from 89.8% to 94.4%. This improvement did not result from the automated noise filters, but from the correction of specific issues in the raw data associated with height-unit continuity errors caused by sensor mismanagement. These errors could not be corrected automatically and therefore required manual intervention. This process nearly doubled the total number of valid accumulation events (NR = 0.6), diluting the few remaining inconsistencies and increasing the final PCI.

- 483-484: I would delete the first part, start with "We selected…"

Original text

"Considering the availability of SD observations over the 2010–2024 period, which are characterized by heterogeneous spatial coverage and temporal gaps across elevations and basins, we selected three river basins located in the Arid (Elqui), Mediterranean (Maipo) and Wet Andes (Maule–Itata) that provide relatively consistent SD observations distributed along broad elevation gradients"

Edited text

We selected three river basins representing the Arid (Elqui), Mediterranean (Maipo), and Wet Andes (Maule–Itata) because they provide relatively consistent SD observations distributed across broad elevation gradients over the 2010–2024 period, despite the heterogeneous spatial coverage and temporal gaps that characterize the complete dataset.

- 491: Here and throughout this sub-section, what is this median SD? The median across what? years?

Original text

"Figure 5 presents the cumulative distribution function (CDF) of SD observations across three river basins, integrating observations during the accumulation period (1 May and 31 October) for each precipitation-year type. This framework enables a robust characterization of the distribution of SD at each station, while the median SD from CDF 0.5 to 1.0 provides a consistent metric for intercomparison across contrasting precipitation-year type and elevations."

Edited text

Figure 5 presents the cumulative distribution function (CDF) of daily SD observations at each station during the snow accumulation period (1 May–31 October) for the representative dry, normal, and wet years. For each station and precipitation-year type, the median SD (CDF = 0.5) was used as a representative measure of snow accumulation, providing a consistent basis for comparing SD across elevations and climatic conditions.

Additionally, in this section we replaced "median SD values" by median daily SD values, and "SD increases" by median daily SD values increases.

- 518-522: I agree about wind erosion and limited snow deposition, and sublimation. Also, the work of Viale and Nuñez (2011) shows that precipitation has a maximum below the crest of the Andes.

Original text

“The persistence of this mid-elevation maximum suggests the combined influence of wind-driven snow redistribution and enhanced sublimation at higher elevations, where drier atmospheric conditions could limit snow accumulation, thereby preventing the development of a simple positive SD–elevation relationship. Despite the absence of winter-focused studies in this region, Ayala et al. (2017) highlight the significant role of sublimation near 4,500 m a.s.l. on wind-exposed surfaces of the Juncal Norte Glacier. ”

Edited text

The persistence of this mid-elevation maximum suggests the combined influence of several processes. First, mean winter precipitation in the subtropical Andes has been shown to peak on the windward slopes below the crest of the Andes, rather than at the highest elevations, as a result of orographic enhancement and upstream flow blocking (Viale and Nuñez, 2011). Second, wind-driven snow redistribution and enhanced sublimation at higher elevations, where drier atmospheric conditions prevail, may further reduce snow accumulation, thereby preventing the development of a simple positive SD–elevation relationship. Although winter-focused studies addressing these processes remain scarce in this region, Ayala et al. (2017) highlighted the significant role of sublimation on wind-exposed surfaces of the Juncal Norte Glacier near 4,500 m a.s.l.

- 531: “In addition, a more robust…” or something similar to reduce the length of the text.

Original text

“Despite the previous analysis based on CDFs under selected dry, normal, and wet precipitation conditions, a more robust assessment of SD observations is undertaken by examining the SD–elevation relationship in conjunction with the hypsometry of each of the three river basins”

Edited text

In addition, a more robust assessment of SD observations was conducted by examining the SD–elevation relationship together with the hypsometry of the three selected river basins.

- 537-539: Keep in mind that the analysis is made only for a few stations. The text is written as if the pattern was general. See one of my main comments.

Original text

“Figure 6A, shows how SD increases consistently with the rise in total precipitation from the arid to the wet zones of Chile, as expected (Sarricolea et al., 2017). Furthermore, we observed the same SD-elevation pattern analysed through CDF in the three river basins. In the Elqui River Basin (29° S), a positive relationship between SD and elevation is observed for the dry (2021) and normal (2018) precipitation types, although in the wet year (2022) this pattern is interrupted: SD increases up to approximately 3,600 m a.s.l., then declines toward 4,000 m a.s.l., before increasing again up to the highest elevations with available SD observations (4,300 m a.s.l.). These features are reflected in the 25th and 75th percentile SD observations. In the Maipo River Basin (33° S), the SD–elevation relationship remains positive up to approximately 2,800–3,300 m a.s.l. across all climate types. Available data further suggest that above 3,300 m a.s.l., SD begins to decline. In contrast, SD observations in the Maule–Itata River Basin (37° S) exhibit a consistently positive SD–elevation relationship."

Edited text
Figure 6A shows how SD increases consistently with the rise in total precipitation from the arid to the wet zones of Chile, as expected (Sarricolea et al., 2017). Furthermore, similar SD–elevation patterns, analysed through CDFs, were observed in the three river basins. Although the available stations do not fully represent the spatial variability within each basin, they constitute the most comprehensive in situ SD observations currently available and provide evidence of the likely SD–elevation relationships. In the Elqui River Basin (29° S), the available observations indicate a positive relationship between SD and elevation during the dry (2021, based on five stations spanning elevations from 3,209 to 4,306 m a.s.l.) and normal (2018, based on two stations spanning elevations up to 3,500 m a.s.l.) years. However, during the wet year (2022, based on six stations spanning elevations from 3,209 to 4,306 m a.s.l.), this pattern is interrupted: SD increases up to approximately 3,600 m a.s.l., then declines toward 4,000 m a.s.l., before increasing again up to the highest elevation with available SD observations (4,300 m a.s.l.). These features are also reflected in the 25th and 75th percentile SD values. In the Maipo River Basin (33° S), the available observations indicate that the SD–elevation relationship remains positive up to approximately 2,800–3,300 m a.s.l. across all precipitation years, based on at least 10 stations spanning elevations from 2,020 to 4,425 m a.s.l. The available observations further suggest that above 3,300 m a.s.l., SD begins to decline. In contrast, the available SD observations in the Maule–Itata River Basin (37° S), based on at least three stations during the dry year and six stations during the wet year, indicate a consistently positive SD–elevation relationship.

- 554: "that do not provide observations during normal precipitation years" This sounds as the stations would never capture normal years, but I guess the authors refer only to the analysed years.

Original text

"Despite the generally well-distributed elevation range of stations, the Elqui River Basin includes five SD stations that do not provide observations during normal precipitation years,"

Edited text

Despite the generally well-distributed elevation range of stations, the Elqui River Basin includes five SD stations that do not provide observations during the analyzed normal precipitation year,

- 583: "Of the 118…" -> "Of an original total of 118 …" or similar

Original text

“Of the 118 continuous snow depth measurement stations across Chile and Argentina,”

Edited text

Of an original total of 118 continuous snow depth measurement stations across Chile and Argentina,

- 589: “significantly reduced” can you provide the percentage here?

Original text

“These improvements demonstrate the effectiveness of the quality–control procedure, even when the volume of data finally available is significantly reduced.”

Edited text

These improvements demonstrate the effectiveness of the quality–control procedure, despite an average 21% reduction in data availability across the 26 river basins analysed.

- 596: why is it relevant that these basins had a single station?

Original text

“No clear latitudinal pattern is observed in station data quality across the 26 river basins. Instead, data quality limitations are more pronounced in basins located in the Wet Andes, where the proportion of high-quality stations is generally lower and the total number of stations is also limited. This is the case for the Valdivia (two stations), Biobío (five stations), and Baker and Costeras e Islas R. Aisén–R. Baker basins (three stations), which exhibit the largest reductions in data availability (>50 %) after quality control. In contrast, basins with a single station tend to retain most of their observations (>99 %), as observed in the Yelcho, Bueno, and Tunuyán river basins, although their representativeness remains limited. Notably, the Elqui and Maipo river basins, which have the highest station densities (7 and 21 stations, respectively), show only minor reductions after quality control, indicating a higher proportion of high-quality observations and strong potential for robust snow depth analyses.”

Edited text

No clear latitudinal pattern is observed in station data quality across the 26 river basins. Instead, data quality limitations are more pronounced in basins located in the Wet Andes, where the proportion of high-quality stations is generally lower and the total number of stations is also limited. This is the case for the Valdivia (two stations), Biobío (five stations), and Baker and Costeras e Islas R. Aisén–R. Baker basins (three stations), which exhibit the largest reductions in data availability (>50%) after quality control. In contrast, the Elqui and Maipo river basins, which have the highest station densities (7 and 21 stations, respectively), show only minor reductions after quality control. Preserving a large number of high-quality stations is particularly valuable because it improves the spatial representation of snow conditions within each basin and provides a stronger basis for basin-scale snow depth analyses.

- 601: Begin with “Only three river basins…” if you would like to reduce text.
- 601-607: please add some caution to this paragraph stating that the elevation patterns are inferred from a (still) limited set of stations that do not represent the entire catchment. This is valid not only for Maule-Itata but also for Elqui and Maipo.

Original text

“Despite the availability of 81 snow depth stations in our final quality-controlled daily SD dataset, only three river basins provide sufficient elevational coverage to characterize basin-scale snow depth–elevation patterns across the Andean zones. Two of these basins exhibit non–linear relationships, with maximum snow accumulation occurring at approximately 3,300 m a.s.l. in the Maipo River Basin (Mediterranean Andes) and 4,300 m a.s.l. in the Elqui River Basin (Arid Andes). In contrast, a linear SD–elevation relationship is identified in the Maule–Itata River Basin (Wet Andes); however, this result likely reflects limitations in elevational representativeness due to the limited elevation range of the available stations.”

Edited text

Only three river basins provide sufficient elevational coverage to examine basin-scale quality-controlled SD–elevation patterns across the Andean zones, although the available station network, while representing the most comprehensive in situ SD observations currently available, may still be insufficient to fully capture the spatial variability within each basin. The available observations indicate non-linear SD–elevation relationships in two of these basins, with maximum snow accumulation occurring at approximately 3,300 m a.s.l. in the Maipo River Basin (Mediterranean Andes) and 4,300 m a.s.l. in the Elqui River Basin (Arid Andes). In contrast, SD observations in the Maule–Itata River Basin (Wet Andes) indicate a predominantly linear SD–elevation relationship.

Figures

- Fig 1: Mention the 3 highlighted basins in the caption. Why are they highlighted?

Original text

“Figure 1. Spatial distribution of snow depth stations from 81 selected stations across 26 river basins and climate zones (Arid, Mediterranean, Wet) in the Southern Andes. Station locations from the institutional sources used in this study (DGA, IANIGLA, CEAZA, UdeChile, and CIEP) are shown, along with 37 excluded stations. Basemap imagery: Esri World Imagery © Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.”

Edited text

Figure 1. Spatial distribution of the 81 quality-controlled snow depth stations selected for this study across 26 river basins and three Andean climate zones (Arid, Mediterranean, and Wet). Station locations are identified according to the contributing institutional networks (DGA, IANIGLA, CEAZA, UdeChile, and CIEP), together with the 37 stations excluded during the quality-control procedure. The Elqui–Jáchal, Maipo–Mendoza, and Maule–Itata river basins, located in each climate zone, are analyzed in greater detail in subsequent sections. Basemap imagery: Esri World Imagery © Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

- Fig 1: Can you use softer colours for the base maps? Maybe using transparency. As it is, it is difficult to see all the details of the stations.

Answer

We revised the figure by using a lighter basemap to improve the visibility of the stations.

- Fig 2: I think it would be helpful for the reader to show here the 5 sub-steps of Step 2.
- Fig 2: Specify in the figure that five logos above correspond to the data providers

Answer

We revised Figure 2 to provide a clearer and more detailed representation of the quality-control procedure. Specifically, we:

- added the five sub-steps of Step 2
- clarified the sequence of the quality-control procedure by showing Step 1, Step 2 and its five sub-steps, and Step 3
- clarified that Step 4 only validates the dataset and does not modify it.
- specified in the figure that the five logos correspond to the data providers; and

Original text

"Figure 2. Workflow of the data processing and quality–control procedure applied to the 2010–2024 snow"

Edited text

Figure 2. Workflow of the data processing and quality–control procedure applied to the 2010–2024 snow. The logos at the top indicate the institutional networks that contributed the snow depth observations used to develop the final quality–control dataset.

- Fig 3: "Colors indicate" what colours?

Original text

“Figure 3. Availability of quality–controlled daily snow depth observations for 81 stations in Chile and Argentina (21°–54° S) from 2010 to 2024. Stations are sorted latitudinally from north to south. Colors indicate the annual percentage of days with available snow depth observations, based on daily records aggregated over the May–October period.”

Edited text

Figure 3. Availability of quality-controlled daily snow depth observations for the 81 selected stations in Chile and Argentina (21–54° S) from 2010 to 2024. Stations are ordered latitudinally from north to south. Cell colors represent the annual availability of daily observations during the May–October snow season, classified from no data to high data availability. Colored circles beside each station indicate the institutional network from which the observations were obtained.

- Fig 4: Can you use softer colours for the base maps? Maybe using transparency. As it is, it is difficult to see all the details of the stations.

Answer

We revised the figure by using a lighter basemap to improve the visibility of station details.

Tables

- Table 1: Basin area from Table 2 fits better here

Answer:

We believe that including this information in Table 2 is important because it allows readers to relate the number of stations and data availability to the spatial extent of each river basin. For example, the Jáchal River Basin, which covers approximately 32,000 km², is represented by only one station, whereas the Maipo River Basin, with roughly half that area, includes 25 stations.

- Table 1: Given the small number of stations per basin, I think that the mean is a better metric that the median here. If you have, for example, 3 stations in the catchment with elevations E1, E2 and E3, the median elevation will always be E2, and the information about the elevation of the other two stations is lost. Same for latitude.

Answer:

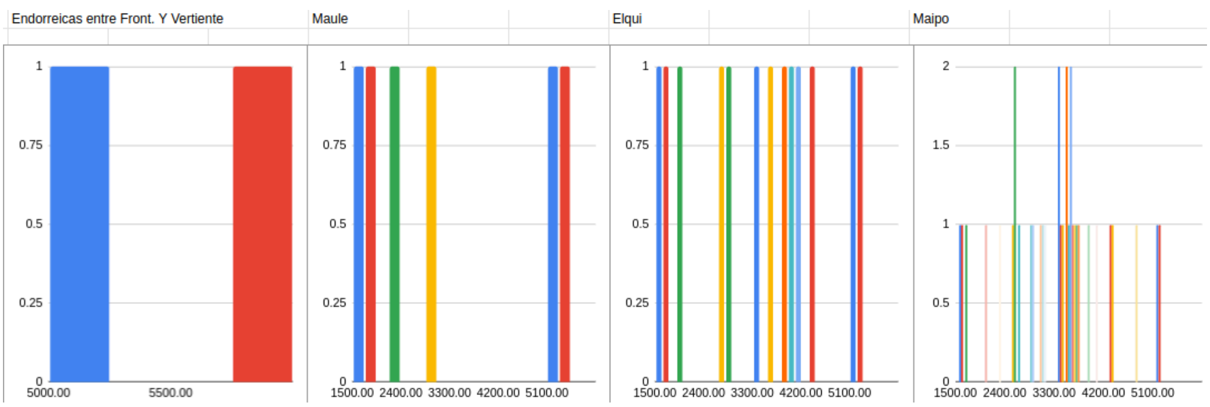
We appreciate the reviewer's comment and the opportunity to clarify our choice of using the median instead of the mean.

Among the 26 analyzed river basins, only 1 basin contains three stations. To assess whether the choice of summary statistic affects the reported values, we calculated both the mean and median station elevations for some basins with 2,4,7 ans 22 stations (Table A1 in the Appendix, which also lists the elevation of every station). We found that the difference between these two statistics becomes larger only in basins with a larger number of stations. The differences between the mean and median elevations are:

- 0 m (*Endorreicas entre Frontera y Vertiente*, 2 stations)
- 108 m (Maule, 4 stations)
- 105 m (Elqui, 7 stations)
- 119 m (Maipo, 21 stations)

The station elevation distributions are presented below

In the Maipo basin, the station elevations are unevenly distributed, and we therefore consider the median elevation (3,340 m a.s.l.) to be slightly more representative than the mean elevation (3,221 m a.s.l.). Nevertheless, the difference between the two statistics is only 119 m and is unlikely to influence the interpretation of the results.



- Table 2: I suggest changing to the mean here too

Answer:

We address this point in our response to the specific comment on line 41 (“41: I think that the mean is a better indicator here.”)

RC2:

General comments

Caro and co-authors present a valuable daily snow depth dataset for the Southern Andes of Chile and Argentina, compiled from several institutional networks and processed through a quality-control and harmonization procedure. The manuscript addresses a relevant observational gap in a region where in situ snow observations are scarce, heterogeneous, and not always straightforward to access or reuse. The dataset has clear potential for hydrological modeling, seasonal streamflow forecasting, satellite and reanalysis evaluation, and broader cryosphere studies in the Andes.

Overall, I consider this contribution well suited to ESSD. The manuscript is timely and useful, and the effort to integrate data from Chile and Argentina is particularly welcome. I also appreciate the authors' attempt to go beyond a simple data compilation by documenting a quality-control workflow and by presenting an initial application related to snow depth–elevation patterns.

At the same time, I think the manuscript would benefit from a major revision before publication. My main concerns are not about the relevance of the dataset, but rather about the level of documentation needed for a data publication. In particular, I encourage the authors to improve the consistency between the manuscript and the dataset metadata, provide a more transparent description of the quality-control procedure, clarify the role of manual filtering, strengthen the discussion of uncertainty, and present the snow depth–elevation analysis more cautiously. These improvements would make the dataset easier to evaluate, reproduce, and reuse by future users. I see the dataset as an important contribution, but several aspects should be clarified to fully meet the expectations of an ESSD data description article. Please see my comments below.

1) The dataset has strong potential for reuse, but the manuscript should provide a clearer description of the files available in the repository. I recommend adding a concise file manifest, either in the main text or as supplementary material. This could include file names, variables, units, station identifiers, temporal coverage, time zone, daily aggregation method, missing-value codes, quality-control flags, and metadata fields. This additional documentation would help users understand and apply the dataset without needing to infer details from the manuscript or contact the authors. It would also strengthen the paper as a data publication rather than only as a description of the processing workflow.

Answer

We added this information in Table A1 and Table A4 and is referenced in the Data availability section.

Edited text

A concise file manifest describing all distributed files and their contents is provided in Table A1 and Table A4. The same information is also available in the Zenodo repository in the file Station metadata for snow depth observations.

2) The quality-control procedure is one of the central contributions of the manuscript. The description is generally informative, but some parts remain difficult to reproduce from the information currently provided. The authors mention a Python-based algorithm and provide a code example, but it is not fully clear whether the complete workflow, parameters, and processing sequence are available. I encourage the authors to provide the full quality-control code, or at least a more complete reproducibility package, including the parameter values used by basin or station, the processing order, and the expected input and output formats. If some raw data cannot be redistributed because of institutional restrictions, the authors could still provide the code, parameter tables, and example files. This would make the workflow more transparent and would increase confidence in the dataset.

Original text

“5 Code availability

A short code to run the quality–control procedure is available via Github at https://github.com/javiermedinamen-art/hidromet/tree/main/sd_cleaning_sample, applied to the Valle Olivares station (33° S).“

Edited text

5. Code availability

The full quality-control workflow comprises four sequential steps described in Section 2: (1) compilation of multi-institutional snow depth records; (2) automated and manual processing, including zero-level correction (Step 2.1), spike removal (Step 2.2), and physical-range filtering (Step 2.3), complemented by station-level expert screening; (3) harmonization of overlapping series; and (4) cross-variable validation using the Physical Consistency Index (PCI).

A reduced, executable sample of Step 2.1 (zero-level / ground-reference correction; function detect_flat_offsets) is available on GitHub at https://github.com/javiermedinamen-art/hidromet/tree/main/sd_cleaning_sample. The sample is applied to the Valle Olivares station (05706003; 33° S) and includes the Python module, a Jupyter notebook, an example input CSV (date and snow depth in centimetres), dependency specifications, and a basin-level parameter table for Steps 2.1–2.3 (QC_parameters_by_river_basin). Default parameters in the sample correspond to the Maipo River Basin settings used for Valle Olivares (window = 5 days; var_thr = 0.5 cm; tol = 0.3 cm; drift_thr = 0.3 cm; snow_thr = 5 cm).

Steps 2.2, 2.3, 3, and 4 are fully specified in Section 2, including the algorithms, decision rules, and thresholds used in the processing workflow. The complete source code implementing these steps is not publicly available but can be obtained from the authors upon request. Expected input and output formats for the automated cleaning stage are daily tabular files with one column per station (raw to quality-controlled snow depth in centimetres). The open dataset provides quality-controlled daily snow depth for 69 stations; institutional restrictions prevent redistribution of the remaining series included in the 81-station analysis.

3) The manuscript indicates that a supplementary manual filtering step was applied based on expert judgment. This is understandable for heterogeneous snow depth records, especially when working with multiple institutions and sensor types. However, the current description does not provide enough detail for users to assess how much of the final dataset depends on automated filtering versus manual decisions. I suggest including a station-level summary of manual interventions. This could indicate the number or percentage of values removed manually, the affected periods, and the main reason for removal, such as sensor drift, unrealistic spikes, summer artifacts, maintenance periods, baseline shifts, or other issues. If possible, the published dataset should retain quality-control flags indicating why a value was removed or modified. This would make the dataset more transparent and allow users to apply alternative criteria if needed.

Answer

This information is described in Tables A1 and A4 in the Appendix, which correspond to the Station metadata for snow depth observations.csv (file included in the Zenodo repository).

4) The reduction in data availability after quality control is an important result and deserves a slightly more detailed discussion. In some basins, especially in the Wet Andes, the percentage of removed data appears relatively high. This may be justified, but the manuscript should provide more evidence that these removed observations correspond to unreliable data rather than to physically plausible but irregular snow conditions. This is particularly relevant in maritime or rain-snow transition environments, where shallow snowpacks, short snow accumulation episodes, rain-on-snow events, and rapid melt can occur. I suggest adding before-and-after examples for a few representative stations, especially those with large reductions in data availability. These examples would help readers understand the effect of the quality-control procedure and would support the interpretation that the final dataset is more reliable.

Answer

We appreciate this comment. We have expanded the description of the quality-control outcomes and the reasons for data exclusion in the manuscript (lines 381–434 of the first version), providing station-specific examples of the main issues identified, including high short-term variability, absence of a consistent ground reference level, lack of a clear seasonal snow accumulation cycle, persistently low snow-depth values, and abrupt changes inconsistent with the expected seasonal behavior.

The requested before-and-after comparison is provided quantitatively for all stations in Table A4, which reports raw and quality-controlled effective days with data and their corresponding availability percentages. These results are summarized at the basin scale in Table 2. Thus, the effect of the quality-control procedure can be evaluated systematically rather than only through selected examples.

Importantly, the relatively large reductions observed in some Wet Andes basins do not represent a generalized or latitudinal loss of data. We find a strong positive correspondence between raw and quality-controlled effective days ($R^2 = 0.8$), while no clear latitudinal dependence is observed in data reduction. Instead, the largest reductions occur at the basin scale and are mainly associated with specific stations exhibiting the data-quality issues described above. This supports the interpretation that the reduction reflects station-specific reliability issues rather than a systematic removal of physically plausible snow conditions across the Wet Andes.

Therefore, we consider that the combination of the detailed station-specific description (lines 381–434), the raw/clean comparison in Table A4, and the basin-scale summary in Table 2 provides the requested evidence supporting the quality and reliability of the final dataset.

5) The Physical Consistency Index (PCI) is a useful idea and provides an interesting way to evaluate whether snow accumulation events are compatible with precipitation and air temperature. However, the current explanation could be clearer. In particular, the index is applied only to selected stations in the Elqui and Maipo basins. I suggest explaining more explicitly why these basins were selected and why the same validation could not be extended to other regions, especially the Wet Andes, where the quality-control procedure seems to remove a relatively large amount of data. It would also be helpful to discuss the limitations of the PCI. As currently defined, the index focuses on positive snow depth changes during days with measurable precipitation. This means that some potentially problematic events, such as positive snow depth changes without recorded precipitation, are not directly included in the denominator. This may be reasonable because of gauge undercatch, wind redistribution, and local variability, but the implications should be clearly stated.

Answer

We added a paragraph at the end of section 3.4 Cross–variable validation of snow depth observations which deals with the choice of these two basins in the PCI analysis

Edited text

The validation was restricted to the Elqui and Maipo River Basins because these basins provide suitable conditions for evaluating the physical consistency of snow accumulation using concurrent SD, Pr, and AT observations. In particular, they contain stations with overlapping observations of the three variables and sufficient altitudinal coverage to evaluate snow accumulation under contrasting meteorological conditions. These characteristics are essential for applying the proposed multivariable validation consistently across stations and for reducing the influence of spatial sampling limitations. The validation could not be extended to other regions, particularly the Wet Andes, because the availability of concurrent

SD, Pr, and AT observations is more limited and unevenly distributed along the elevation gradient. This limitation is particularly evident for SD in the Maule–Itata basins, as shown later in the study.

6) The temperature threshold used in the PCI is defined as a station-specific 95th percentile. I understand the motivation for using a site-specific threshold, but the physical interpretation of this choice is not completely clear. I recommend that the authors report the actual threshold values obtained for each station and discuss whether they are consistent with plausible rain-snow transition temperatures. A simple sensitivity test would also be useful. For example, the authors could compare the PCI results using the current percentile-based threshold and one or more fixed thresholds such as 0 °C, 1 °C, or 2 °C. This would help demonstrate whether the conclusions are robust to the choice of temperature criterion.

Answer

We thank the reviewer for this helpful suggestion and agree that reporting the station-specific thresholds provides useful context. However, the purpose of the 95th-percentile temperature threshold in the PCI is not to estimate the physical rain–snow transition temperature, but to provide a conservative, station-specific criterion for excluding accumulation events occurring under unusually warm conditions and thereby reducing the influence of potential outliers. Although a sensitivity analysis using fixed thresholds (e.g., 0, 1, and 2 °C) could provide additional insight, such an analysis would require a detailed investigation of the physical processes controlling precipitation phase in the Andes and their relationship with near-surface air temperature, which is beyond the scope of this study. In particular, the commonly used 0 °C criterion based on mean air temperature at approximately 2 m does not necessarily represent the rain–snow transition in complex high-elevation Andean environments. We have therefore clarified in the revised manuscript that the 95th-percentile threshold is used as a quality-control criterion for identifying potential outliers rather than as a physically derived rain–snow transition temperature.

Original text

For these events, an air temperature threshold (ATrain) was defined as the 95th percentile of AT at each station. Accumulation days with AT exceeding this threshold were classified as physically inconsistent (i= 0), whereas those with AT below the threshold were considered physically consistent and retained as valid snow accumulation signals (i= 1).

Edited text

For these events, an air temperature threshold (AT_{rain}) was defined as the station–specific 95th percentile of AT to account for the large climatic variability across the Andes. A fixed usual threshold (e.g., 0–2 °C) was not adopted because the air temperature associated with snowfall varies substantially with local conditions. Using a station–specific percentile therefore provides a locally adapted threshold that better represents the upper temperature limit at which snowfall is still observed at each station. For example, the median air temperature threshold ranged from -3.2 to 2.2 °C (median: -2.2 °C) in the Elqui River Basin and from -3.8 to 3.8 °C (median: -1.5 °C) in the Maipo River Basin. Accumulation days with AT exceeding this threshold were classified as physically inconsistent ($\phi i = 0$), whereas those with AT below the threshold were considered physically consistent and retained as valid snow accumulation signals ($\phi i = 1$). The threshold is therefore intended to identify potential outliers in the observed snow accumulation signal rather than to represent a physically derived rain–snow transition temperature.

7) The additional metrics used to complement the PCI are useful, but their interpretation could be improved. The Noise Ratio is described mainly as an indicator of the removal of spurious positive snow depth events when values are greater than 1. However, at least one case appears to show a value below 1, which is interpreted as signal recovery. I suggest clarifying the expected interpretation of NR > 1, NR = 1, and NR < 1. If the metric can indicate both removal of noisy events and recovery of plausible accumulation events after baseline correction, this should be stated more explicitly. A small conceptual example could help readers understand the metric.

Original text

Second, the Noise Ratio (NR) is defined in Equation 4 as the proportion of the total number of apparent accumulation events detected in the raw dataset (Nevent ,raw) to the number of events retained after quality–control (N event, QC). Values of NR greater than 1 indicate that the procedure effectively identified and removed spurious positive SD spikes, revealing the presence of noise or measurement artifacts in the raw SD dataset.

Edited text

Second, the Noise Ratio (NR) is defined in Equation 4 as the proportion of the total number of apparent accumulation events detected in the raw dataset (N event, raw) to the number of events retained after quality–control (N event, QC). The interpretation of this metric allows for three scenarios: (1) NR > 1 indicates that the quality-control procedures up to Step 3 effectively identified and removed spurious positive SD spikes, revealing the presence of noise or measurement artifacts in the raw SD dataset; (2) NR = 1 suggests a high-quality raw record where no events were removed or recovered; and (3) NR < 1 indicates signal recovery, where the cleaning algorithm or manual depuration allowed the identification of valid accumulation events that were previously obscured or incorrectly recorded in the raw data. For example, a station with NR = 2.0 has had half of its raw accumulation signals removed as noise, whereas a station with NR = 0.5 has doubled its count of valid events through the correction of systematic errors.

8) The manuscript refers to the ±1 cm accuracy of the Campbell SR50A sensor when justifying some thresholds. However, the dataset appears to include observations from

different sensor types and possibly different sensor generations or replacements. I recommend clarifying whether all stations used sensors with comparable accuracy. If not, the authors should discuss how sensor-specific uncertainty may affect the quality-control thresholds. This point does not necessarily require a complete redesign of the method, but it would be useful to acknowledge whether common thresholds were applied across different sensors and what implications this may have for shallow snow or near-zero snow depth conditions.

Edited text

If the validated offset is very small (within 0.3 cm), it is treated as noise and set to zero. Finally, to maintain data continuity, this offset is subtracted from subsequent observations only if the drift exceeds a 0.3 cm tolerance. Although sensor accuracy is ± 1 cm (https://www.campbellsci.com/sr50a), our use of daily averages from high-frequency (hourly) observations over multi-day windows dampens random noise. This reduction in variance justifies the stricter 0.3 cm threshold, enabling the detection of subtle systematic shifts that would otherwise be obscured by instrumental error. In addition, the SR50A sensors, which have been widely used across stations in Chile and Argentina, have recently begun to be replaced at some stations by a newer generation of sensors with higher measurement precision. The sensor used at each station is indicated in Table A1.

9) The analysis of snow depth–elevation patterns is a valuable illustration of the dataset's potential. However, I suggest presenting the results more cautiously. The available stations are not uniformly distributed across elevation, latitude, exposure, or accessibility. Therefore, the observed elevation patterns should be described as patterns represented by the available station network rather than as definitive basin-scale gradients. This is particularly important where the manuscript identifies snow depth maxima at specific elevations. These findings are interesting, but they may depend on station location, selected representative years, local topography, wind redistribution, and the uneven distribution of observations. I recommend softening the wording in the abstract, discussion, and conclusions to avoid overgeneralization.

Answer

We will ensure that the interpretation of snow depth–elevation relationships is restricted to the specific spatial and temporal conditions represented by the available data, particularly in the Abstract and Conclusions

10) The workflow includes a fourth step described as cross-variable validation. It would be helpful to clarify whether this step modifies the final dataset or whether it only evaluates the quality-controlled product. If Step 4 is used only for validation, I suggest presenting it as an independent evaluation step rather than as part of the cleaning procedure itself. This

clarification would also improve Figure 2. The figure could show more clearly which steps produce the final clean dataset and which steps are used to evaluate its physical consistency.

Answer:

We thank the reviewer for this suggestion. To clarify, Step 4 (Cross-variable validation) is indeed a diagnostic procedure used to evaluate the effectiveness of the quality-control process and does not modify the values of the final dataset. We agree that presenting it as an independent evaluation step improves the clarity of our workflow. Accordingly, we have corrected the methodology section to distinguish between 'Data Processing and Harmonization' (Steps 1 to 3 and 'Quality Evaluation' in Step 4). We have also updated Figure 2 to reflect this separation, using different visual cues to show that the final 'Clean' dataset is produced at the end of Step 3, while Step 4 serves as an independent consistency check. This distinction ensures the workflow coherency about where the data cleaning ends and the performance assessment begins.

Original Text:

2.1 Step 1 – Compilation of snow depth observations

…

2.2 Step 2 – Preprocessing of snow depth observations

…

Step 2.1. Zero-level correction

…

Step 2.2. Spike removal

…

Step 2.3. Physical range check

…

2.3 Step 3 – Harmonization of snow depth observations

…

2.4 Step 4 – Cross-variable validation of snow depth observations

…

2.5 Snow depth and elevation analysis by river basin

Edited Text:

3.1 Step 1 – Compilation of snow depth observations

…

3.2 Step 2 – Preprocessing of snow depth observations

…

Step 2.1. Zero-level correction

…

Step 2.2. Spike removal

…

Step 2.3. Physical range check

…

3.3 Step 3 – Harmonization of snow depth observations

…

3.4 Cross–variable validation of snow depth observations

…

3.5 Snow depth and elevation analysis by river basin

Specific comments

- Abstract: Please check the consistency of station numbers by Andean zone and ensure that these values match Table 1 and the repository metadata.

Answer

We checked the consistency of the station numbers throughout the manuscript. The values reported in the Abstract, Tables 1 and 2, and Tables A1 and A4 are now fully consistent with each other and with the repository metadata.

- Abstract: The improvement in PCI "from 87% to 95% at some stations" is useful, but it would be clearer to specify the stations or basins involved, or to present the result in more general terms.

Original text

, from 87 % to 95 % at some stations,

Edited text

, from 87 % to 95 % at some stations in the Maipo River Basin,

- Abstract: Please clarify how the 23% reduction in data availability was calculated. Is this based on the median across stations, across basins, or across all daily observations?

Original text

, while reducing the median data availability across all stations by 23 % (from 1,392 to 1,074 observations).

Edited text

, while reducing the median number of effective days with data across stations by 23% (from 1,392 to 1,074 days).

- Lines 160–170: Please specify the original temporal resolution of each data source and explain how daily values were calculated.

Answer

The same question was answered for reviewer 1 as

Edited text

This study compiled SD observations from 118 stations distributed across the Southern Andes (17° S–55° S), including both hourly and daily records, although hourly observations were not available at all stations.

- Lines 172–183: The criteria used to exclude stations should be described more explicitly. For example, was there a minimum number of months or years required?

Answer

The same question was answered for reviewer 1 as

Edited text

An initial visual screening was conducted to exclude stations with inadequate data quality based on three criteria: (i) unrealistically large day-to-day variations in SD (exceeding 1 m between consecutive days), (ii) insufficient monthly data availability (less than 50 % of daily observations), and (iii) insufficient annual coverage (fewer than three months with available data during the snow season, from May to October). In addition, several stations were excluded because their records only became available in late 2025 or 2026, providing insufficient temporal coverage for robust analyses.

Following this procedure, 81 of the 118 stations with SD observations were retained, providing coverage across the Andes between 21° and 54° S. The selected stations span elevations from 30 to 5,804 m a.s.l., with records covering the period 2010–2024. Table 1 summarizes the main characteristics of the compiled SD dataset aggregated by river basin, while metadata for the selected and excluded stations are provided in Tables A1 and A2, respectively.

- Lines 184–188: Please clarify whether the thresholds were selected by basin, by station, or through a combination of both.

Original text

For these procedures, stations were grouped by river basin and processed collectively using shared parameters and thresholds calibrated for each basin, as detailed below. In addition to this basin-level processing, a supplementary manual filtering step was applied on a station-by-station basis.

Edited text

For these automated procedures, parameters and thresholds were calibrated at the river-basin scale to account for regional SD variability and ensure physical consistency across stations sharing similar climatic environments. In addition to this basin-level processing, a supplementary manual filtering step was applied on a station-by-station basis.

- Lines 191–207: The zero-level correction is important but somewhat difficult to follow. I suggest restructuring this paragraph and adding a simple example.

- Lines 202–207: Please clarify whether the Campbell SR50A accuracy applies to all stations or only to part of the network.

Answer

The same question was answered for reviewer 1 as

Edited text

Step 2.1. Zero-level correction: This step realigns the ground reference level to account for instrumental drift during snow-free periods. The algorithm detects stable periods using a moving-window range (the difference between maximum and minimum SD) with a 0.5 cm stability threshold. To account for local variability, window lengths were calibrated for each river basin (3 to 5 days, median 5) to capture local variability while remaining sensitive to drift. From these stable windows, we define a 'validated offset' as the calculated displacement from the ground reference level. To protect actual shallow snow records, windows with median values exceeding a 5 cm snow threshold are preserved and not used for correction. This 5 cm value acts as a conservative safety margin to ensure the algorithm does not misinterpret a shallow, stable snowpack as instrumental drift, as it remains well above both the sensor's nominal noise (± 1 cm) and typical surface roughness effects (2 cm). If the validated offset is very small (within 0.3 cm), it is treated as noise and set to zero. Finally, to maintain data continuity, this offset is subtracted from subsequent observations only if the drift exceeds a 0.3 cm tolerance. Although sensor accuracy is ±1 cm (https://www.campbellsci.com/sr50a) , our use of daily averages from high-frequency (hourly) observations over multi-day windows dampens random noise. This reduction in variance justifies the stricter 0.3 cm threshold, enabling the detection of subtle systematic shifts that would otherwise be obscured by instrumental error.

- Lines 216–224: Please explain how the scaling factor k and the absolute spike thresholds were selected.

Original text

A daily observation was flagged as a spike and removed if it met either of two independent criteria. The first criterion evaluated deviations from the window median using a scaling factor, k. Conceptually, k acts as a tolerance threshold that defines the acceptable range of natural variability around the median. Because snow accumulation is inherently irregular, k was calibrated based on the observed behavior at each station within the river basin, with values ranging from 2 to 7. The median value of k was 4 in the Arid and Mediterranean

Andes and 6 in the Wet Andes. To avoid inadvertently removing true extreme snowfall events, this criterion required that any suspected spike exhibit clear discontinuities (> k · MAD) relative to both adjacent days. Additionally, the absolute difference between the two adjacent days had to remain small (< k · MAD), confirming that the event represented an isolated anomaly rather than a sustained change in SD. The second criterion acted as an absolute physical filter. Regardless of MAD, an observation was flagged and removed if the absolute difference compared to both adjacent days exceeded a fixed, extreme physical magnitude, depending on SD variability of its respective basin. The median value of this threshold was 75 cm in the Arid, 100 cm in the Mediterranean, and 140 cm in the Wet Andes.

The same question was answered for reviewer 1 as

Edited text

A daily observation was flagged as a spike and removed if it met either of two independent criteria. The first criterion evaluated deviations from the window median using a scaling factor, k. Conceptually, k acts as a tolerance threshold that defines the acceptable range of natural variability around the median. Because snow accumulation is inherently irregular, k was adjusted to balance the removal of instrumental errors with the preservation of true snowfall events. This adjustment was based on the observed signal-to-noise ratio and natural SD variability at each station within its basin. In this context, a lower k value provides a stricter filter for noise removal, while a higher k value is more permissive to accommodate natural variability and ensure that extreme physical signals are not erroneously discarded. Across the study area, k values ranged from 4 to 7, with median values calculated across basins being 4 in the Arid and Mediterranean Andes and 6 in the Wet Andes. To avoid inadvertently removing true extreme snowfall events, this criterion required that any suspected spike exhibit clear discontinuities (> k · MAD) relative to both adjacent days. Additionally, the absolute difference between the two adjacent days had to remain small (< k · MAD), confirming that the event represented an isolated anomaly rather than a sustained change in SD. The second criterion acted as an absolute physical filter. Regardless of MAD, an observation was removed if the absolute difference relative to both adjacent days exceeded a basin-specific threshold representing an implausibly large day-to-day change in SD. These thresholds were defined empirically based on visual inspection of station records and inter-station consistency within each basin. Threshold values ranged from 20 to 150 cm (median: 50 cm) in the Arid Andes, 100 to 200 cm (median: 100 cm) in the Mediterranean Andes, and 60 to 350 cm (median: 140 cm) in the Wet Andes.

- Lines 225–231: Please clarify whether near-zero values are set to zero or removed, and whether this operation is flagged in the dataset.

Original text

“Step 2.3. Physical range check: A physical range filter was applied to the SD time series at each station. Lower and upper plausible limits were defined for each river basin based on station elevation, regional climatology, and expert knowledge. Observations below the ground reference level were set to zero, whereas values exceeding the upper physical limit were considered implausible and removed. The median physical limits were 0–140 cm in the Arid Andes, 2–360 cm in the Mediterranean Andes, and 2–300 cm in the Wet Andes. The lower limit in the Mediterranean and Wet Andes was set to 2 cm to account for sensor noise (±1 cm) and local surface roughness (e.g., low vegetation or rocky terrain). Setting these near-zero values to zero prevents instrumental and surface-related noise from being misinterpreted as shallow snow accumulation."

Edited text

Step 2.3. Physical range check: A physical range filter was applied to the SD time series at each station.
Lower and upper plausible thresholds were defined for each river basin based on station elevation, regional climatology, and expert knowledge. Observations below the ground reference level (defined in Step 2.1) were set to zero, whereas values exceeding the upper physical thresholds were considered implausible and removed. The median physical limits for basins were 0–140 cm in the Arid Andes, 0–360 cm in the Mediterranean Andes, and 0–300 cm in the Wet Andes. in some stations, the lower threshold in the Mediterranean and Wet Andes was set to 2 cm to account for sensor noise (±1 cm) and local surface roughness (e.g., low vegetation or rocky terrain). Setting these near-zero values to zero prevents instrumental and surface-related noise from being misinterpreted as shallow snow accumulation.

- Lines 245–266: The PCI method would benefit from a clearer explanation of the denominator and of the events that are excluded from the calculation.

- Lines 259–260: Please report the actual ATrain values and discuss their physical plausibility.

Original text

The new Physical Consistency Index (PCI) was developed and implemented to classify each day as physically consistent (i=1) or inconsistent (i= 0), following a multivariable framework inspired by the Perkins Skill Score (PSS, Perkins et al. 2008) and the Automated Quality assurance of daily surface observations procedures (AQ, Durre et al., 2010). First, to reduce the influence of measurement noise in ΔSD, a station-specific threshold (τ) was defined as the 5th percentile of the positive ΔSD distribution. When τ was lower than 1 cm, corresponding to the sensor accuracy, it was set to this minimum value. A day was classified as a potential snow accumulation event only when ΔSD > τ; all other days (ΔSD ≤ τ and ΔSD = 0) were excluded from further analysis. Second, to ensure physical consistency with meteorological conditions, only days with measurable precipitation (Pr > 1 mm) were retained, reducing uncertainties associated with gauge undercatch and wind-driven snow redistribution. For these events, an air temperature threshold (ATrain) was defined as the 95th percentile of AT at each station. Accumulation days with AT exceeding this threshold were classified as physically inconsistent (i= 0), whereas those with AT below the threshold were considered physically consistent and retained as valid snow accumulation signals (i= 1).

The PCI for each station was calculated as the ratio between the number of physically consistent snow accumulation days (i= 1) and the total number of identified snow accumulation days with Pr > 1 mm (N). This index is defined in Equation 2, where i is a binary consistency indicator for each day i, taking a value of 1 for physically consistent conditions and 0 otherwise.

Edited text

We developed and implemented a new Physical Consistency Index (PCI) to classify each day as physically consistent ($\phi i = 1$) or inconsistent ($\phi i =$ 0), following a multivariable framework inspired by the Perkins Skill Score (PSS, Perkins et al. 2008) and the Automated Quality assurance of daily surface observations procedures (AQ, Durre et al., 2010). This procedure filters the record to identify the robust snowfall signals that collectively constitute the index denominator (N). First, to mitigate measurement noise, a station–specific threshold (τ) was established as the 5th percentile of the positive ΔSD distribution, with a minimum of 1 cm to align with sensor accuracy. A day was retained as a potential snow accumulation event only when ΔSD > τ; consequently, all other observations, including negligible shifts (ΔSD ≤ τ), stable snowpacks (ΔSD = 0), and ablation periods (negative ΔSD), were excluded from the denominator to ensure the index targets active snowfall signals. Second, to ensure physical consistency during snow accumulation events, we retained only days with measurable precipitation (Pr > 1 mm), thereby reducing uncertainties associated with gauge undercatch and wind-driven snow redistribution. For these events, an air temperature threshold (AT rain) was defined as the station-specific 95th percentile of AT to account for the large climatic variability across the Andes. A fixed usual threshold (e.g., 0–2 °C) was not adopted because the air temperature associated with snowfall varies substantially with local conditions. Using a station-specific percentile therefore provides a locally adapted threshold that better represents the upper temperature limit at which snowfall is still observed at each station. For example, the median air temperature threshold ranged from −3.2 to 2.2 °C (median: -2.2 °C) in the Elqui River Basin and from −3.8 to 3.8 °C (median: -1.5°C) in the Maipo River Basin. The threshold is therefore intended to identify potential outliers in the observed snow accumulation signal rather than to represent a physically derived rain–snow transition temperature.

The PCI for each station was calculated as the ratio between the number of physically consistent snow accumulation days (φi = 1) and the total number of identified snow accumulation days with Pr > 1 mm (N). This multivariable equation specifically targets the consistency of precipitation driven accumulation. By excluding days without precipitation from the denominator we minimize uncertainties associated with wind driven snow redistribution and instrumental noise, which do not represent true snowfall signals. This index is defined in Equation 2, where φi is a binary consistency indicator for each day i, taking a value of 1 for physically consistent conditions and 0 otherwise.

- Lines 267–276: Please clarify the interpretation of NR values lower than 1.

Original text

Second, the Noise Ratio (NR) is defined in Equation 4 as the proportion of the total number of apparent accumulation events detected in the raw dataset (Nevent ,raw) to the number of events retained after quality–control (Nevent ,QC). Values of NR greater than 1 indicate that the procedure effectively identified and removed spurious positive SD spikes, revealing the presence of noise or measurement artifacts in the raw SD dataset.

Edited text

Second, the Noise Ratio (NR) is defined in Equation 4 as the proportion of the total number of apparent accumulation events detected in the raw dataset (N event, raw) to the number of events retained after quality–control (N event, QC). The interpretation of this metric allows for three scenarios: (1) NR > 1 indicates that the quality-control procedures up to Step 3 effectively identified and removed spurious positive SD spikes, revealing the presence of noise or measurement artifacts in the raw SD dataset; (2) NR = 1 suggests a high-quality raw record where no events were removed or recovered; and (3) NR < 1 indicates signal recovery, where the cleaning algorithm or manual depuration allowed the identification of valid accumulation events that were previously obscured or incorrectly recorded in the raw data. For example, a station with NR = 2.0 has had half of its raw accumulation signals removed as noise, whereas a station with NR = 0.5 has doubled its count of valid events through the correction of systematic errors.

- Lines 278–286: Please explain why the selected precipitation stations are representative for classifying dry, normal, and wet years.

Original text

“For the Elqui, Maipo, and Maule–Itata River Basins, we selected precipitation observations from stations at relatively high elevations: La Laguna Embalse station (3,160 m a.s.l.) in the Elqui River Basin; 19 stations in the Maipo River Basin; and the Diguillín (670 m a.s.l.), Río Diguillín en San Lorenzo–Atacalco (727 m a.s.l.), and Las Trancas (1,242 m a.s.l.) stations in the Maule–Itata River Basin. These basins were selected because they contain a sufficient number of SD observations with a well-distributed elevation range”

Edited text

For this classification, precipitation records were obtained from relatively high-elevation stations within each basin to better represent mountain precipitation conditions. Specifically, we used the La Laguna Embalse station (3,160 m a.s.l.) in the Elqui River Basin, 19 stations in the Maipo River Basin, and the Diguillín (670 m a.s.l.), Río Diguillín en San Lorenzo–Atacalco (727 m a.s.l.), and Las Trancas stations (1,242 m a.s.l.) in the Maule–Itata River Basin. These basins were selected because they contain a sufficient number of SD observations spanning a broad elevation range.

- Lines 294–296: Please justify the 70% monthly data availability threshold or briefly discuss its sensitivity.

Original text

To analyze the SD–elevation relationship, only stations with at least 70 % of daily SD data availability per month during the accumulation period (1 May to 31 October) were retained,

Edited text

To analyze the SD–elevation relationship, only stations with at least 70 % of daily SD data availability per month during the accumulation period (1 May to 31 October) were retained (Alvial Vásquez et al., 2020; Cordero et al., 2024),

We added these references:

Alvial Vásquez F-J, Abarca-del-Río R and Ávila AI.: High-Resolution Precipitation Gridded Dataset on the South-Central Zone (34° S–41° S) of Chile. Front. Earth Sci. 8:519975. doi: 10.3389/feart.2020.519975, 2020.

Cordero, R.R., Feron, S., Damiani, A. et al.: Rapid decline in extratropical Andean snow cover driven by the poleward migration of the Southern Hemisphere westerlies, Sci Rep **14**, 26365, doi.org/10.1038/s41598-024-78014-0, 2024.

- Lines 297–304: The snow persistence and snowline analysis should be introduced more clearly before the technical description.

The same question was answered for reviewer 1 as

Edited text

Additionally, the median July snow line elevation, together with its 25th percentile, was estimated for these three river basins using satellite-derived snow persistence for the period 2000–2024 to provide a reference for evaluating the elevational distribution of the SD observations. July corresponds to the month with the lowest snow line elevation in the year.

- Lines 385–431: Some detailed station-level explanations could be moved to the appendix to improve readability of the main text.

Answer

We appreciate the reviewer's suggestion. While we agree that this section is relatively detailed, we consider that discussing a number of representative stations is important for understanding the characteristics of the quality-controlled dataset, particularly in basins represented by a single station or by stations with long-term records. These examples help explain the main causes of data exclusion and identify the specific periods for which observations were considered unreliable. We also note that the complete quality-controlled snow depth dataset is openly available in Medina and Caro (2026) (https://zenodo.org/records/21577171), as indicated in both the Abstract and the Data availability section. In addition, we developed an interactive snow depth exploration tool (https://javiermedinamen-art.github.io/hidromet), which allows readers to inspect the complete time series and quality-control results for each station. Because these resources provide full access to the underlying observations, we believe that retaining the representative station-specific descriptions in this section adds useful context for interpreting the quality-control procedure and the final dataset.

- Lines 567–579: The data and code availability section should be expanded to describe the complete processing workflow and repository structure.

Original text

4 Data availability

The dataset is openly available via Zenodo at https://doi.org/ 10.5281/zenodo.20089265 (Medina and Caro, 2026). An interactive snow depth exploration tool is also provided at https://javiermedinamen-art.github.io/hidromet, developed by the Observatorio Satelital de Nieves laboratory.

Input data were obtained from publicly accessible repositories and institutional collaborations, including the DGA, CEAZA (or CEAZAMET), IANIGLA, University of Chile, and CIEP. DGA data are distributed through the Chilean open-data framework, which allows data reuse and redistribution with proper attribution. CEAZA data usage policies explicitly allow their use in scientific publications with acknowledgment of the original source. Datasets from IANIGLA, University of Chile, and CIEP were provided directly by these institutions for scientific research purposes, and co-authors actively affiliated with these institutions facilitated access to the corresponding datasets. The original observations were reprocessed and integrated into the derived dataset distributed in this study while maintaining attribution to the original data providers.

5 Code availability
A short code to run the quality–control procedure is available via Github at https://github.com/javiermedinamen-art/hidromet/tree/main/sd_cleaning_sample, applied to the Valle Olivares station (33° S).

Edited text

5 Data availability

The dataset is openly available via Zenodo at https://zenodo.org/records/21577171 (Medina and Caro, 2026). The repository provides daily snow depth observations from 69 automatic stations across the Southern Andes for 2010–2024, together with station metadata and a dataset overview figure. Additionally, an interactive snow depth exploration tool is also provided at https://javiermedinamen-art.github.io/hidromet, developed by the Observatorio Satelital de Nieves laboratory. A concise file manifest describing all distributed files and their contents is provided in Table A1 and Table A4. The same information is also available in the Zenodo repository in the file Station metadata for snow depth observations.

Input data were obtained from publicly accessible repositories and institutional collaborations, including the DGA, CEAZA (or CEAZAMET), IANIGLA, University of Chile, and CIEP. DGA data are distributed through the Chilean open-data framework, which allows data reuse and redistribution with proper attribution. CEAZA data usage policies explicitly allow their use in scientific publications with acknowledgment of the original source. Datasets from IANIGLA, University of Chile, and CIEP were provided directly by these institutions for scientific research purposes, and co-authors actively affiliated with these institutions facilitated access to the corresponding datasets. The original observations were reprocessed and integrated into the derived dataset distributed in this study while maintaining attribution to the original data providers.

6. Code availability

The full quality-control workflow comprises four sequential steps described in Section 2: (1) compilation of multi-institutional snow depth records; (2) automated and manual processing, including zero-level correction (Step 2.1), spike removal (Step 2.2), and physical-range filtering (Step 2.3), complemented by station-level expert screening; (3) harmonization of overlapping series; and (4) cross-variable validation using the Physical Consistency Index (PCI).

A reduced, executable sample of Step 2.1 (zero-level / ground-reference correction; function detect_flat_offsets) is available on GitHub at https://github.com/javiermedinamen-art/hidromet/tree/main/sd_cleaning_sample. The sample is applied to the Valle Olivares station (05706003; 33° S) and includes the Python module, a Jupyter notebook, an example input CSV (date and snow depth in centimetres), dependency specifications, and a basin-level parameter table for Steps 2.1–2.3 (QC_parameters_by_river_basin). Default parameters in the sample correspond to the Maipo River Basin settings used for Valle Olivares (window = 5 days; var_thr = 0.5 cm; tol = 0.3 cm; drift_thr = 0.3 cm; snow_thr = 5 cm).

Steps 2.2, 2.3, 3, and 4 are fully specified in Section 2, including the algorithms, decision rules, and thresholds used in the processing workflow. The complete source code implementing these steps is not publicly available but can be obtained from the authors upon request. Expected input and output formats for the automated cleaning stage are daily tabular files with one column per station (raw to quality-controlled snow depth in centimetres). The open dataset provides quality-controlled daily snow depth for 69 stations; institutional restrictions prevent redistribution of the remaining series included in the 81-station analysis.

- Figure 1: Consider using a lighter basemap or improving symbol contrast, as some stations are difficult to distinguish.

Answer

We revised the figure by using a lighter basemap to improve the visibility of the stations.

- Figure 2: Please show the substeps of the quality-control procedure and clarify whether Step 4 modifies the dataset or only validates it.

Answer

We revised Figure 2 to provide a clearer and more detailed representation of the quality-control procedure. Specifically, we:

- added the five sub-steps of Step 2
- clarified the sequence of the quality-control procedure by showing Step 1, Step 2 and sub-steps, and Step 3
- clarified that Step 4 only validates the dataset and does not modify it.
- specified in the figure that the five logos correspond to the data providers; and

- Figure 3: The figure contains useful information but is dense. A higher-resolution version or simplified version could improve readability. Or mention if the web version will be available in higher resolution in case any reader requires it.

Answer

We added a higher quality version of Figure 3 on the article

- Figure 6: Please clarify whether D, N, and W refer only to the selected representative years or to broader precipitation-year categories.

Original text

Figure 6. Measured relationships between snow depth and elevation for three precipitation–year types, dry (D), normal (N), and wet (W), across three river basins representing the Arid (Elqui, 29° S), Mediterranean (Maipo, 33° S), and Wet (Maule–Itata, 37° S) Andes in Chile. Only if present SD observations from stations with at least 70 % of daily observations per month during the accumulation period (1 May to 31 October). In each upper panel (A), bars represent the 25th, 50th, and 75th percentile SD values, derived from all available observations for the selected precipitation years. The lower panel (B) compares station elevations with the basin hypsometric curves. The thin line indicates the minimum elevation of July snow persistence over the 2000–2024 period, while the thick line marks the elevation at which snow persistence reaches the 25th percentile (SP25). Circles denote the elevation of SD stations and are labeled according to the lagged precipitation year type (D,

N, or W). Stations without labels correspond to sites with SD observations available under all three precipitation years.

Edited text

Figure 6. Measured relationships between snow depth and elevation for three selected precipitation years, classified as dry (D), normal (N), and wet (W), across three river basins representing the Arid (Elqui, 29° S), Mediterranean (Maipo, 33° S), and Wet (Maule–Itata, 37° S) Andes in Chile. Only SD observations from stations with at least 70% of daily observations per month during the accumulation period (1 May to 31 October) are included. In each upper panel (A), bars represent the 25th, 50th, and 75th percentile SD values, derived from all available observations for the corresponding selected precipitation year. The lower panel (B) compares station elevations with the basin hypsometric curves. The thin line indicates the minimum elevation of July snow persistence over the 2000–2024 period, while the thick line marks the elevation at which snow persistence reaches the 25th percentile (SP25). Circles denote the elevation of SD stations and are labeled according to the selected precipitation year (D, N, or W). Stations without labels correspond to sites with SD observations available for all three selected precipitation years.

- Table 2: Consider including ranges or totals in addition to medians, especially for basins with few stations.

Answer

We appreciate this suggestion.

Table 2 is intended to provide a concise basin-level summary of data availability, and it already contains eight columns. Adding ranges or totals would substantially increase the amount of information presented in the main table and could reduce its readability. To provide the requested station-level detail without overloading Table 2, we have added a note indicating that the specific numbers of days with available data before and after the quality-control procedure for each station are provided in Table A4.

The specific numbers of days with available data before and after the quality-control procedure are provided for each station in Table A4.

- Code availability: A short example script is helpful, but the manuscript would be stronger if the complete processing chain were available.

Answer

We appreciate this suggestion. We have addressed this point by providing a more detailed description of the processing code and the complete processing chain in the corresponding section of the manuscript, as described in our response to the previous comment.