Assignment 05: Trace Events, Precipitation Undercatch, and Probability of Snow

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Methods

Hourly meteorological data from the South Lake Tahoe ASOS station (TVL) were analyzed for water year 2025 (September 1, 2024 – August 31, 2025). All data were parsed and processed in RStudio using the tidyverse and lubridate packages. The dataset included hourly precipitation (p01m), air temperature (tmpc), dewpoint temperature (dwpc), and wind speed (sknt). The analysis consisted of four major steps:

1. Trace Precipitation Events

Hourly precipitation values (p01m) were stored as numeric millimeters; "T" values represented trace precipitation. A trace threshold of 0.254 mm (0.01 in) was assumed.

- "Including trace" series assigned 0 mm for trace hours and summed all measurable and trace events.
- "Excluding trace" series summed only values ≥ 0.254 mm.

Cumulative totals were computed with cumsum() and plotted versus time.

2. Wind-Induced Precipitation Undercatch Correction

The uncorrected hourly precipitation (including trace events) was adjusted for gauge undercatch due to wind speed (sknt) following temperature-dependent catch-ratio (CR) equations:

- Snow (T < 0 °C): CR = exp(− 0.04 · U^1.75)
- Mixed (0 ≤ T ≤ 3 °C): CR = 1.0104 − 0.0562 · U
- Rain (T > 3 °C): CR = 1.0 (100 % efficiency) where U is wind speed (knots). Each hourly precipitation was divided by its CR, producing p_corr. Cumulative sums before and after correction were compared with step plots.

3. Precipitation Classified as Snow

Using corrected precipitation (p_corr), snowfall amounts were estimated by three classification methods:

(1) Air-temperature threshold – precipitation counted as snow when T < 0 °C;

(2) Dewpoint-temperature threshold – precipitation counted as snow when dewpoint < 0 °C;

(3) Probability (mixed-phase) method – fractional snow derived from the 6th-order polynomial of Fassnacht & Soulis (2002) calibrated for the Sierra Nevada: $f_s = a_6T^6 + a_5T^5 + a_4T^4 + a_3T^3 + a_2T^2 + a_1T + b_0$, with coefficients ($a_6 = 0.00087$, $a_5 = -0.00909$, $a_4 = 0.02471$, $a_3 = 0.02987$, $a_2 = -0.1655$, $a_1 = -0.1968$, $b_0 = 0.9469$). Fractional values were bounded to [0, 1], with full snow below −0.29 °C and none above 3.9 °C. Hourly snowfall = $f_s \cdot$ p_corr, then cumulatively summed.

4. Wind During Precipitation Events

For each hour, events were labeled "Snow" (p_corr > 0 and T ≤ 0 °C), "Rain" (p_corr > 0 and T > 0 °C), or "None." Monthly mean wind speed (sknt) was averaged by class and plotted as a three-line time series to compare wind conditions among precipitation types.

Results

1. Trace Precipitation Event

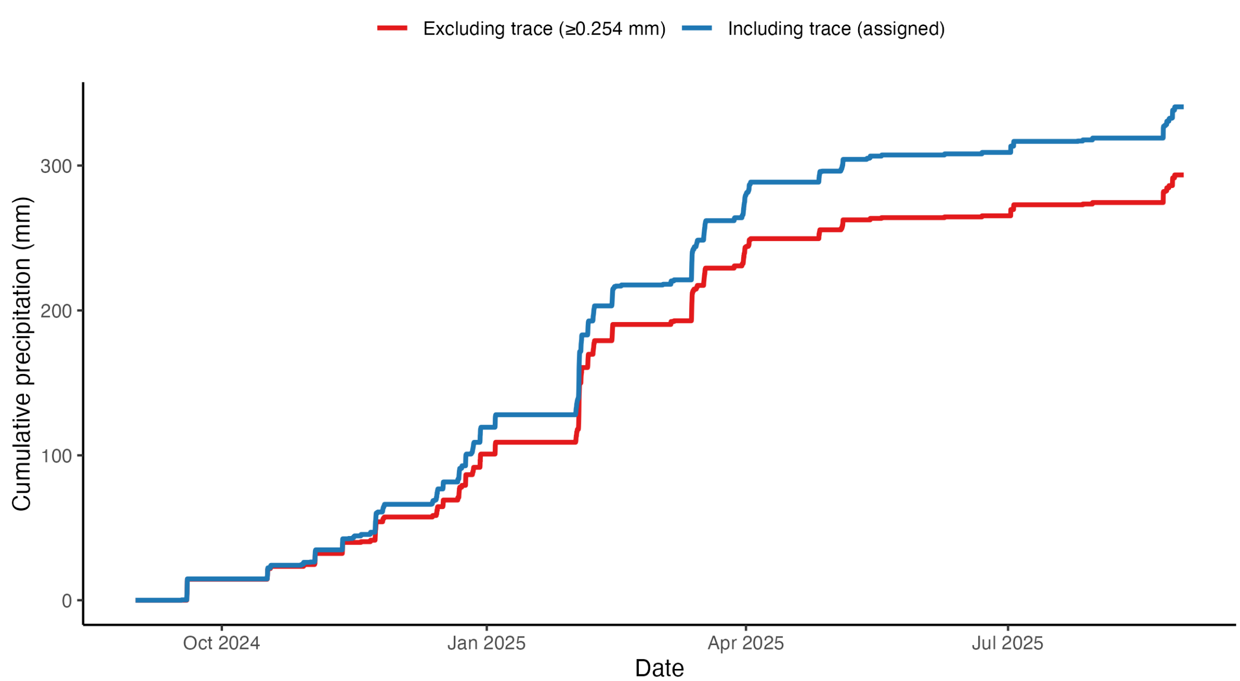

Figure 1. Hourly cumulative precipitation (mm) for water year 2025 at the ASOS South Lake Tahoe TVL station in California. The blue line represents the cumulative hourly precip including trace events (any measurable precipitation or trace 'T'), while the red line represents the cumulative precipitation excluding trace events (precipitation ≥ 0.254 mm).

2. Precipitation Undercatch Correction:

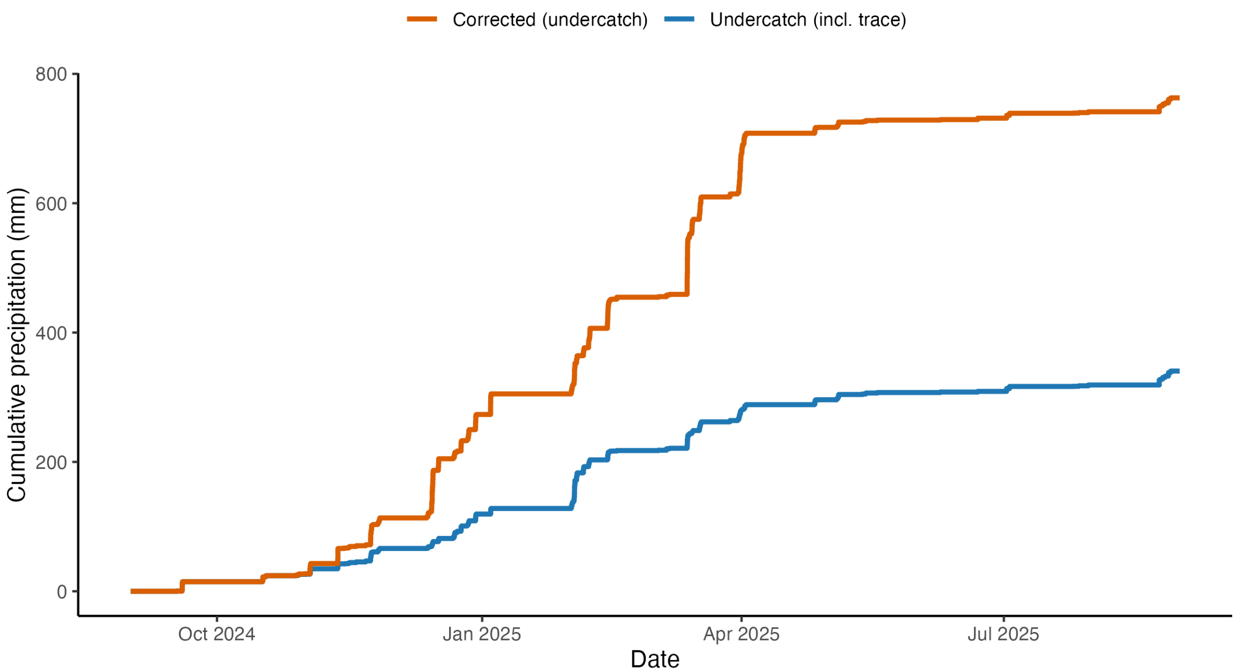

Figure 2. Undercatch correction (U in knots): Snow: CR = exp(-0.04·U^1.75); Mixed (0–3°C): CR = 1.0104 – 0.0562·U; Rain (>3°C): CR = 1.0. Missing wind treated as 0; trace/non-numeric p01m treated as 0 mm. This data was derived for water year 2025 at the ASOS South Lake Tahoe TVL Station.

3. Precipitation as Snow

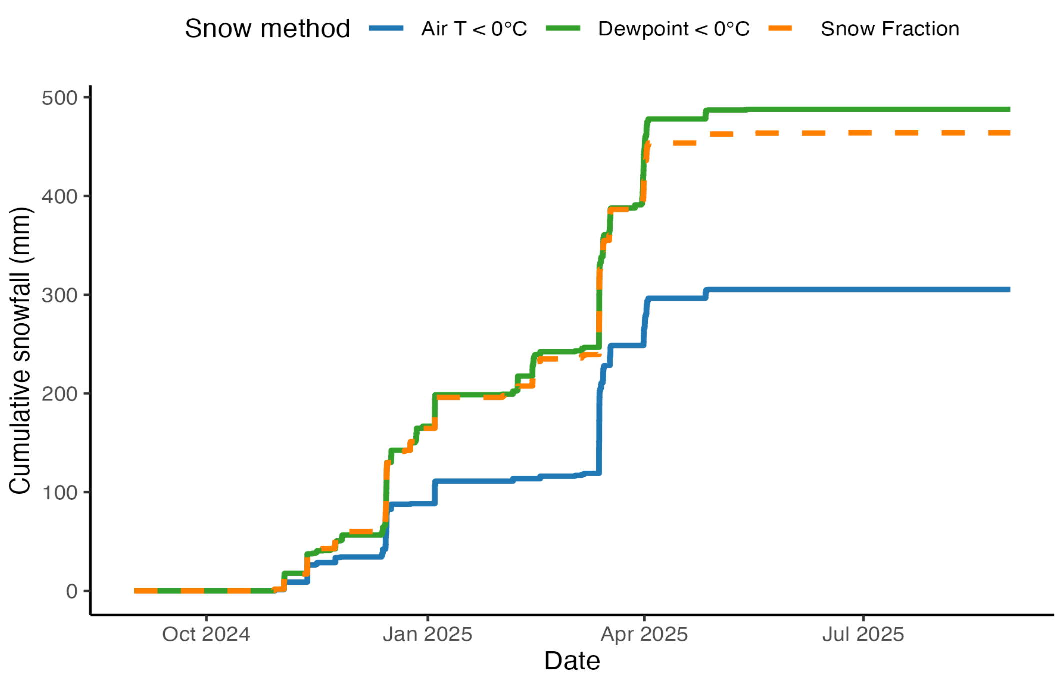

Figure 3. Cumulative hourly precipitation classified as snow from three methods for water year 2025 at the ASOS South Lake Tahoe (TVL) station in California. Blue indicates the 0°C air temperature threshold, green shows the 0°C dewpoint temperature threshold, and orange represents the mixed-precipitation probability method based on the 6th-order polynomial from Fassnacht and Soulis (2002) calibrated for the Sierra Nevada (CA, USA).

4. Wind During Precipitation Events

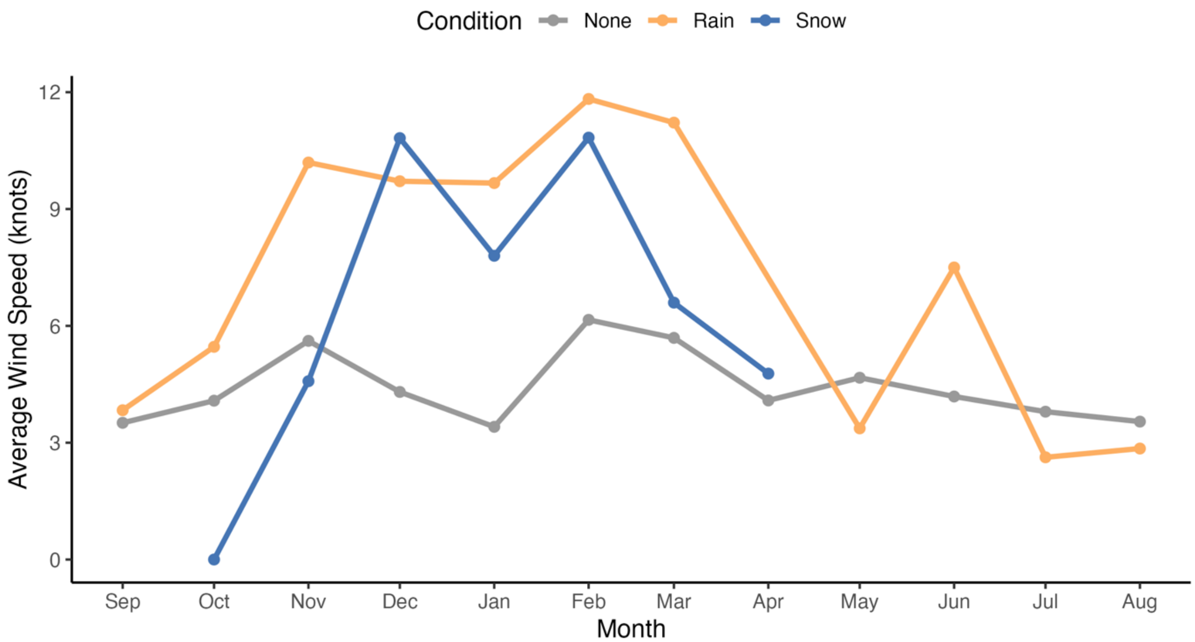

Figure 4. Monthly average wind speed during snowfall, rainfall, and non-precipitation periods for water year 2025 at the ASOS South Lake Tahoe (TVL) station in California. Snowfall is defined for air temperatures ≤0°C, rainfall for >0°C, and 'None' for hours with no recorded precipitation.

Results

Cumulative totals including trace slightly exceeded those excluding trace, indicating frequent very light events (<0.254 mm) (Figure 1). The end-of-year difference was small (order of a few percent), but inclusion of trace smoothed the accumulation curve.

After wind correction, total cumulative precipitation increased substantially in Figure 2, particularly between December and March, when average wind speeds exceeded 10 knots and temperatures were below 3 °C. Corrections during summer were negligible because rain events at T > 3 °C were assigned full efficiency. The correction added roughly 15–25 % more water equivalent over the water year.

All three snow-classification methods produced similar seasonal timing, but differing totals seen in Figure 3. The air-temperature threshold method yielded the lowest cumulative snowfall (≈350 mm). In contrast, the dewpoint and probability-based methods produced nearly identical totals (≈480 mm), with close tracking across winter months.

Average monthly wind speed was highest during snowfall months (Dec–Mar), commonly 10–12 knots, compared to 6–8 knots during rainfall and 4–5 knots during non-precipitation periods (Figure 4). This pattern indicates that strong frontal systems bringing snow are associated with higher winds, while calm, dry conditions prevail during summer.

Discussion

This analysis shows how temperature, wind, and humidity affect precipitation measurement and classification at the South Lake Tahoe (TVL) station. Including trace precipitation slightly increased cumulative totals and created a smoother record, while applying wind undercatch corrections raised total precipitation by about 20%, especially during cold, windy winter months. The cumulative snowfall estimated from the dewpoint and mixed-precipitation probability methods closely track each other, suggesting that dewpoint temperature effectively captures the phase transition threshold for precipitation in this region. Wind speeds were highest during snowfall events, reflecting the influence of strong frontal and orographic storms common in the Sierra Nevada. Limitations include treating trace events as 0 mm, potentially underrepresenting very light snowfall. In addition, the CR equations assume standard gauge exposure and may not fully capture site-specific turbulence. Overall, these results highlight the need to correct for wind undercatch and use more physically based phase methods to better represent snowfall and water input in mountain environments.