Supplementary Information

Insights into the February 2026 Floods in the Tropical Andes of Southern Peru from Satellites and Models.

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Section S1: Evaluation Metrics

The following detection metrics are used to evaluate the performance of the satellite precipitation products.

Probability of Detection (POD): POD measures the proportion of observed precipitation events that are correctly detected by the satellite product. It ranges from 0 to 1, with 1 indicating perfect detection.

$$POD = \frac{CD}{CD+MD} \quad \text{(S1)}$$

where (CD) and (MD) denote the numbers of correct detections and missed detections, respectively.

False Alarm Ratio (FAR): FAR represents the proportion of satellite-detected precipitation events that are not observed by the reference rain gauges. It ranges from 0 to 1, with 0 indicating no false alarms.

$$FAR = \frac{FA}{CD+FA} \quad \text{(S2)}$$

Where FA denotes number of false alarm cases.

Critical Success Index (CSI): CSI measures the overall ability of the satellite product to correctly detect precipitation while accounting for both missed detections and false alarms. It ranges from 0 to 1, with 1 indicating perfect detection performance

$$CSI = \frac{CD}{CD+MD+FA} \quad \text{(S3)}$$

Heidke Skill Score (HSS): HSS measures the accuracy of the satellite precipitation product relative to the accuracy that would be expected from random chance. It accounts for correct detections, missed detections, false alarms, and correct negative cases. The HSS ranges from $-\infty$ to 1, with 1 indicating perfect agreement with the reference observations, 0 indicating no improvement over random

chance, and negative values indicating performance worse than random chance.

$$HSS = \frac{2((CD \times NN) - (MD \times FA))}{[(CD+MD)(MD+NN)] + [(CD+FA)(FA+NN)]} \quad \text{(S4)}$$

The following two estimation metrics are used to assess the quantitative performance of the satellite precipitation products.

Root Mean Square Error (RMSE): RMSE measures the magnitude of the differences between the precipitation estimates from the satellite product and the corresponding rain gauge observations. It is expressed in the same units as precipitation and ranges from 0 to infinity, with 0 indicating perfect agreement.

$$RMSE = \sqrt{\sum_{i=1}^{N} \frac{(RR_{i,rg} - RR_{i,sat})^2}{N}} \quad \text{(S5)}$$

where $RR_{i,rg}$ and $RR_{i,sat}$ denote the rain-rates estimated by raingauge and satellite product at time, i, respectively, and N is the total number of paired observations.

Relative Bias (RB): Relative bias quantifies the tendency of the satellite product to overestimate or underestimate precipitation with respect to the rain gauge observations. A positive value indicates overestimation, whereas a negative value indicates underestimation. A relative bias of 0% indicates no systematic bias.

$$RB = \frac{\sum_{i=1}^{N} (RR_{i,sat} - RR_{i,rg})}{\sum_{i=1}^{N} RR_{i,rg}} \times 100 \quad \text{(S6)}$$

Table S1: List of SENAMHI Rain Gauges within the Arequipa Region, Peru.

Rain Gauge Identifier	Location	Latitude [deg. S]	Longitude [deg. W]	Elevation [m]
R1	Yura	16.302	71.623	2662
R2	La Pampilla	16.413	71.534	2365
R3	Cayma	16.318	71.529	2809
R4	San Francisco	16.385	71.490	2734
R5	Chiguata	16.406	71.409	2885
R6	Tuctumpaya	16.488	71.334	3368
R7	San Jose de Uzuna	16.581	71.328	3669