

Conditional reliability of gridded rainfall datasets in Nigeria

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Abstract

Gridded rainfall datasets support Nigerian research and climate services, but published agreement depends on the rainfall property, release and validation design. This critical narrative review audits 18 Nigerian gauge-reference evaluations and two contextual comparator studies. The core register contains five complete-text, five passage-only and eight abstract-only records. An archived supplementary search maps 93 result appearances to 52 screened records; historical search provider details remain unavailable, limiting reproducibility of retrieval. Domain-based appraisal separates source access from the assessability of product identity, reference support, matching, diagnostics and provenance. No core entry establishes station-and-date independence across the relevant product-input pathways; this unresolved status does not demonstrate actual overlap. Removing abstract-only evidence retains conditional CHIRPS leads and a passage-supported monthly comparison favouring MSWEP v2.2 and IMERG Final v6, while several zonal and local product orderings lose their supporting records. Restrictions on complete texts further narrow the recommendations. Reported annual spatial agreement, monthly climatology and daily correlation test different quantities and cannot form a common accuracy ranking. Six pairs across four national NiMet-based studies share stated reference-year windows, indicating possible dependence that warrants station-level checks. A worked appraisal traces ARC2 gauge inputs and distinguishes zone-average event detection from station-level performance. Practical guidance specifies the statistics, evidence base, and checks required for accumulated rainfall, drought, wet days, extremes, and trends. The principal contribution is a traceable account of which Nigerian recommendations survive source-access restrictions and which remain limited by unresolved methods or observational provenance.

Keywords: Nigeria; gridded precipitation; rainfall validation; evidence appraisal; observational provenance; representativeness error; uncertainty

Highlights

- Eighteen core studies include five full texts, five partial texts and eight abstract-only records.
- Excluding abstracts preserves some accumulated-rainfall leads but removes several specific product orderings.
- Station independence remains unresolved across the core register, and six study pairs share reference-year windows.

- A worked provenance audit and application-specific checks bound practical rainfall-data recommendations.

1 Introduction

Reliable rainfall information supports agricultural planning, water resources management, flood assessment and the interpretation of climate variability in Nigeria. Contrasting coastal, savanna and northern dryland regimes create different observational requirements across the country. Station observations provide direct measurements at individual locations, while their spatial distribution and availability constrain characterisation of rainfall over wider areas. Gridded datasets offer complementary coverage for analyses where station records are sparse or difficult to obtain. Their usefulness depends on how accurately they represent the rainfall property relevant to a particular application (Datti et al., 2024; Ogbu et al., 2020).

The available datasets include interpolated gauge analyses, satellite estimates, atmospheric reanalyses, and products that combine multiple information sources. Station observations may be entered through calibration, bias adjustment, or direct blending. CHIRPS integrates infrared-based estimates with station observations, while TAMSAT uses calibrated relationships between cloud observations and rainfall (Funk et al., 2015; Maidment et al., 2017). Products also differ in how they handle observing-system changes, missing information, rainfall frequency, and temporal disaggregation. Consequently, nominal resolution and spatial completeness are insufficient descriptions of the evidence underlying an estimate.

Nigerian evaluation studies provide important information about product performance under different conditions. Their reference networks, comparison periods, metrics and products vary. Ogbu et al. evaluated three products using 24 gauges, while Nwachukwu et al. compared 16 estimates using 11 gauges for their principal monthly assessment (Nwachukwu et al., 2020; Ogbu et al., 2020). Later studies examine daily rainfall detection, alternative ranking procedures and additional climate products (Datti et al., 2024; Salami et al., 2024; Tanimu et al., 2024). These contributions create an opportunity to assess how their designs support the recommendations that readers may transfer to other locations or purposes.

Reference independence is one determinant of that support. Where evaluation observations also contributed to product construction, agreement gives limited evidence of performance beyond those contributing observations. Mekonnen et al. reported lower performance against independent than incorporated observations in an African assessment (Mekonnen et al., 2023). This motivates tracing

67 the provenance of products and references for Nigeria. Section 5.1 develops a practical audit of that
68 relationship.

69 Validation must also address the rainfall property actually required. Ellis and Samson showed that
70 POWER and CMAP could reproduce broad spatial patterns while exhibiting important limitations in
71 rainfall frequency, interannual covariability and trend representation (Ellis & Samson, 2026).
72 Agreement in a mean rainfall field therefore cannot establish performance for every rainfall statistic.
73 Temporal consistency imposes a further requirement for climate-change applications. A global
74 assessment of 19 precipitation products identified observing-system discontinuities and substantial
75 uncertainty in estimated trends arising from product choice (Zhu et al., 2026). Its findings motivate a
76 regional examination without establishing the magnitude of the error in Nigeria.

77 Global and African reviews already explain precipitation-product construction, geographical
78 variability and application-specific selection (Le Coz & van de Giesen, 2020; Sun et al., 2018). The
79 continental RainCheck Africa synthesis addresses context-dependent performance through systematic
80 review and meta-analysis, although its checked version is a preprint rather than a peer-reviewed
81 article (Mbuva et al., 2026). The present contribution is narrower: it examines how the accessible
82 Nigerian evaluation record supports particular claims after product identity, comparison support and
83 provenance are made explicit. Geographical restriction alone is not the claim of novelty. The added
84 outputs are a study-level domain appraisal, sensitivity to source-access restrictions, a record of
85 possible shared-reference dependence, and a worked-product input audit linked to practical decisions.

86 **Table 1.** Relationship to the closest broader syntheses. The comparison describes their stated emphasis and the
87 distinct outputs of this Nigerian audit.

Synthesis	Established emphasis	Relation to the present audit
Sun et al. (2018)	Global precipitation data sources, estimation and intercomparison.	Provides product context; the present register examines the assessability of individual Nigerian validation claims.
Le Coz and van de Giesen (2020)	African product construction, performance factors and use-specific selection.	Provides the methodological foundation; the present analysis explicitly records Nigerian source access, appraisal limits, and sensitivity.
Mbuva et al. (2026)	Continental systematic synthesis and quantitative patterns; preprint.	Provides a broader comparison of evidence; the present outputs retain local study designs and avoid pooling incompatible Nigerian metrics.

Synthesis	Established emphasis	Relation to the present audit
Present review	18 core publications and two comparators.	Five F, five P and eight A core records; domain appraisal, access sensitivity, six potential temporal-overlap pairs and an operationally specified example.

88

89 The review therefore asks which rainfall properties and settings have usable support, how the
90 inspected methods bound that support, and which recommendations remain after less assessable
91 records are removed. It evaluates evidence for conditional use rather than estimating a national error
92 magnitude or selecting a universal winning product.

93 **2 Review design and evidence appraisal**

94 **2.1 Scope and retrieval record**

95 This critical narrative review combines targeted literature identification with a bounded
96 supplementary retrieval audit. Initial identification and citation tracing took place on 29 October
97 2026. Six fixed English-language queries were run on 30 October with no publication-year, recency
98 or domain filter. The archived log lists two retrieval interfaces as system1 and system2; their
99 providers, underlying engines, and exact execution times were not retained. These labels are
100 preserved as historical interface identifiers, not presented as database names. Coverage of the retained
101 inventory ended on 30 October 2026. Subsequent checks of primary publications and product
102 documentation on 31 October refined interpretation and bibliography without adding query
103 appearances or changing the core inventory.

104 Supplementary Tables S2a-S2c retain exact strings, query-position mappings, work identifiers and
105 screening decisions. The 93 mapped positions are unique and reconcile with the six per-query
106 appearance counts. They correspond to 52 work or source records: 16 core, 10 contextual, 7
107 documentations, 3 awaiting verification, and 16 excluded. The original intermediate count of 64
108 distinct URLs is retained as reported; the published work-level ledger does not preserve a separate
109 URL for every alternate representation, so that intermediate count cannot be independently
110 reconstructed from it alone. The aggregate reduction from 93 appearances to 52 records is 41. Eleven
111 retrieved core publications were previously included, and five were added. Two eligible publications
112 retained from earlier citation tracing were not returned, giving 18 core publications. The earlier
113 exploratory search has no recoverable screening denominator. These are bounded retrieval counts,
114 not estimates of all indexed literature.

115 **2.2 Eligibility and source access**

116 Core evidence required a verifiable journal publication that reports a direct comparison with rain-
117 gauge reference observations in Nigeria and evaluates at least one satellite-based or gauge-adjusted
118 precipitation product. Multicountry studies qualified only when Nigerian methods or findings were
119 separately identifiable. Gauge-only or reanalysis comparisons were retained as contextual
120 comparators. Product-development papers, methodological research and official documentation form
121 a separate interpretive tier. Reviews without identifiable original Nigerian evaluation, applications
122 without gauge-reference validation, non-Nigerian studies and duplicates were excluded from the core
123 inventory. Deposits with unverified journal or peer-review status and records awaiting primary-
124 source verification were logged separately and did not establish empirical recommendations.

125 Supplementary Table S1 contains the 18 core publications and two gauge or reanalysis comparator
126 studies. F denotes an inspected complete primary article, P inspected primary methods or results
127 passages without complete-article retrieval, and A a publisher abstract or preview. The labels
128 describe the material retained for the original study appraisal, separately from publication status or
129 methodological strength. Product-development papers, broader reviews and official documentation
130 support interpretation without expanding the Nigerian core. Unknown releases, reference samples or
131 dates are not inferred from product family names or overall record lengths. Shiru et al. (2025)
132 remains flagged because its publisher genre label and abstract description require reconciliation.

133 **2.3 Domain appraisal and dependence**

134 The extraction unit is the publication. An evaluated comparison is additionally defined by the product
135 and release, the reference sample, matched dates, spatial support, temporal scale, and rainfall
136 statistics. Supplementary Table S3 applies descriptive appraisal to every core and comparator record
137 across product identity and period, reference support and matching, diagnostics, provenance and the
138 resulting scope of a recommendation. A documented feature, an identified reporting limitation and an
139 item not assessable from the inspected material are kept distinct. No numerical quality score is
140 assigned. A full text can contain an unresolved design problem, while an abstract-only record can
141 identify a useful question without supporting a complete methodological judgement.

142 Known and possible dependence are recorded separately. Supplementary Table S4 intersects the
143 stated reference-year windows of four explicitly NiMet-based national evaluations. A temporal
144 intersection and shared agency indicate a possible relationship, not one that matches physical stations
145 or observations. Supplementary Table S5 traces the public construction pathways relevant to the
146 worked example. Verified independence requires positive exclusion or withholding evidence for the

147 actual stations, dates, release and relevant upstream inputs; documented overlap requires an identified
148 contribution; insufficient identities or inventories leave the relationship unresolved. Provenance is
149 assessed separately from a study-specific correction holdout.

150 **2.4 Comparative synthesis and access sensitivity**

151 Findings are organised by rainfall property and source-defined setting. Numerical results retain their
152 metric, dimension, units, product release and comparison interval. Spatial correlations, climatological
153 monthly correlations and interannual or daily correlations are not treated as interchangeable effect
154 estimates. Heterogeneity is handled through structured comparison rather than by pooling ranks or
155 averages. Recommendations distinguish a conditional candidate supported by assessable features, a
156 preliminary lead requiring complete methods and an unsupported transfer to a different target.

157 Two sensitivity restrictions are applied to the recorded core: exclusion of A-tier studies leaves 10 F/P
158 publications, and restriction to F leaves five publications. These restrictions test dependence of
159 specific claims on source accessibility; they are not estimators of publication bias or automatic
160 quality weights. Supplementary Table S6 records which recommendations retain an identifiable
161 source under each restriction. Screening, extraction and domain judgements were not independently
162 duplicated, so transcription and interpretive error remain possible.

163 **3 Rainfall datasets and observational provenance**

164 **3.1 Gauge-based comparators**

165 GPCP, CRU TS and CPC Unified Gauge-Based Analysis provide gauge-informed comparators, with
166 different interpolation methods and temporal support (Becker et al., 2013; Chen et al., 2008; Harris et
167 al., 2020; NOAA Climate Prediction Centre, n.d.; Ziese et al., 2022). GPCP daily and monthly
168 releases are related but distinct. CRU TS is a monthly anomaly-based analysis; it cannot supply an
169 observed daily event sequence. CPC provides daily fields whose interpretation depends on station
170 density and accumulation windows. For all three families, spatial completeness must be distinguished
171 from local station support. Their specific role in an evaluated product set is more relevant here than a
172 catalogue of available releases.

173 **3.2 Satellite estimates and gauge influence**

174 Satellite products infer rainfall from remotely observed properties of clouds and precipitation
175 systems. Gauge information can be entered through historical calibration, current adjustment, or
176 blending. CHIRPS combines infrared-based rainfall estimates with station observations, while
177 TAMSAT uses calibrated cold-cloud-duration relationships and temporal disaggregation (Funk et al.,

178 2015; Maidment et al., 2017). The two approaches require different questions about the timing and
179 role of contributing observations. A calibrated product is not equivalent to an estimate adjusted using
180 the same month's validation observations.

181 ARC2 combines infrared observations with quality-controlled daily Global Telecommunication
182 System gauge reports (Novella & Thiaw, 2013). This is a concrete station-input pathway for the
183 worked example, distinct from demonstrating that any particular NiMet reference record entered it. A
184 provenance check must therefore trace both the documented construction of the product and the
185 identities and dates of the observations evaluated.

186 Release changes can alter both the target and its observational basis. CHIRPS v3 uses ERA5
187 precipitation in its rnl daily variant and IMERG Late V07 in its sat variant to allocate pentadal totals
188 to days (Climate Hazards Centre, n.d.). It also changes climatological and station inputs and applies
189 gauge-undercatch correction (Funk et al., 2026). A comparison with uncorrected gauges can therefore
190 involve both a measurement-target difference and product error. The versioned data repository and
191 corresponding methods should identify the exact release (Climate Hazards Centre, 2025). None of
192 these later details establishes the CHIRPS release used in an earlier paper whose release was not
193 reported.

194 PERSIANN-CDR adjusts monthly totals to align with GPCP (Ashouri et al., 2015). IMERG Final
195 uses monthly GPCC information, while gauge treatment in the lower-latency streams is release-
196 specific (NASA Global Precipitation Measurement Mission, n.d.). Historical calibration,
197 contemporaneous gauge adjustment and daily temporal allocation therefore need separate provenance
198 descriptions. Shared inputs identify constructional links; they do not quantify error correlation or the
199 inflation of a particular validation score.

200 **3.3 Reanalysis and blended products**

201 Reanalyses and blended datasets are retained where they affect an evaluated comparison or its
202 independence. ERA5 precipitation comes from its forecast system (Hersbach et al., 2020); ERA5-
203 Land inherits ERA5 precipitation forcing (Muñoz-Sabater et al., 2021). MSWEP v2 blends gauge,
204 satellite, and reanalysis data (Beck et al., 2019), and GPCP integrates multiple observation types
205 (Huffman et al., 2023). These input relationships help interpret agreement among nominally separate
206 products.

207 NASA POWER is a delivery service whose underlying source depends on the parameter and retrieval
208 specification (NASA POWER Project, n.d.). MERRA-2 corrected precipitation over Africa

incorporates CMAP information, as described by Reichle et al. (2017). Figure 1 shows the selected relationships needed for this appraisal; the actual release and parameter used by each Nigerian study remain the relevant identifiers.

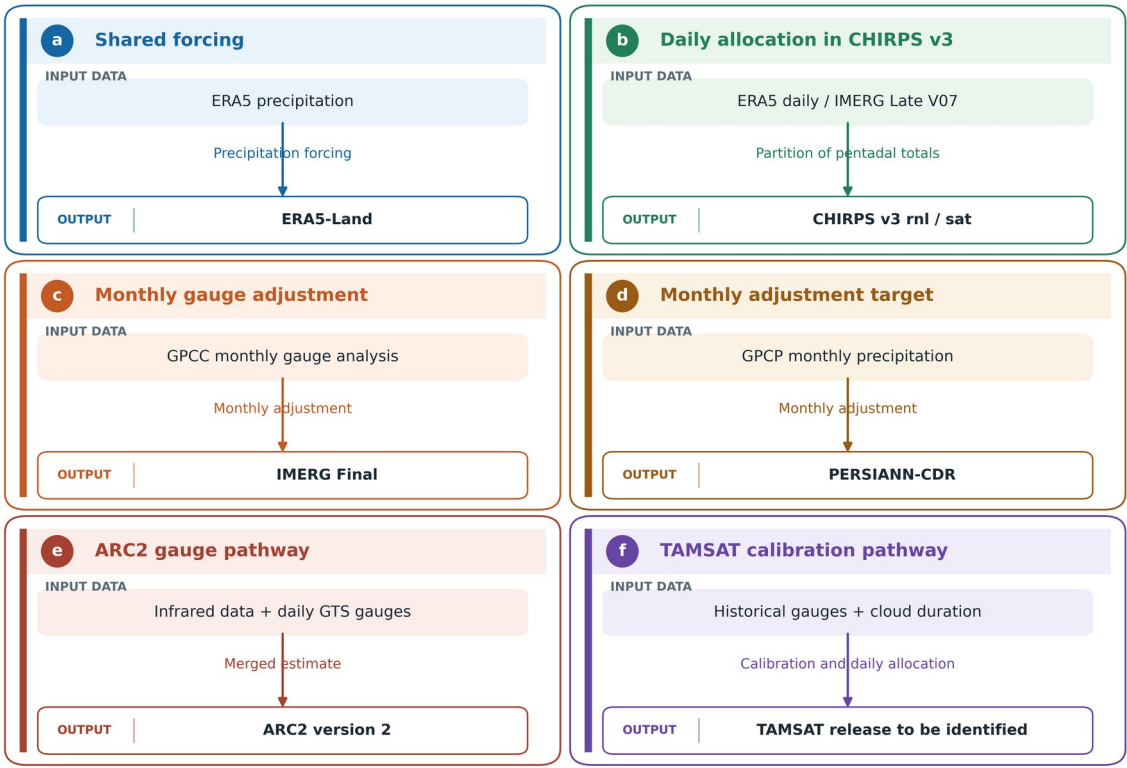


Figure 1. Selected construction pathways relevant to interpretation. ERA5 forcing follows Muñoz-Sabater et al. (2021); CHIRPS v3 daily allocation follows the Climate Hazards Centre (n.d.); monthly adjustments follow NASA Global Precipitation Measurement Mission (n.d.) and Ashouri et al. (2015); ARC2 follows Novella and Thiaw (2013); TAMSAT historical calibration follows Maidment et al. (2017). Paths identify construction links and do not establish overlap with an individual Nigerian reference station.

3.4 Station reference observations

NiMet provides reference records for several Nigerian evaluations, while other studies supplement observations with archives or regional networks. Reference quality depends on completeness, station history, quality control and measurement characteristics. Archive names alone cannot establish independence, since different archives may disseminate reports from the same physical station. Establishing overlap requires station identities, reporting periods, and knowledge of the product's inputs.

Spatial and temporal matching are equally relevant. A gauge samples a small area, while a gridded estimate represents a larger support. A daily station value and a daily product may also cover different accumulation windows. These are comparison uncertainties in addition to retrieval or

228 modelling errors. The consequences are particularly relevant for localised events and threshold-based
229 detection. The distinction between true areal rainfall, point rainfall and a recorded gauge value
230 provides a useful basis for the appraisal framework developed in Section 5 (Tustison et al., 2001).

231 **4 Evidence for rainfall dataset reliability over Nigeria**

232 **4.1 What the available corpus can establish**

233 The 18 core publications comprise five F, five P and eight A records. The two comparator records are
234 A. The five complete-text core sources are Datti et al. (2024), Ellis and Samson (2026), David
235 (2025), Ogidi et al. (2025) and Onah et al. (2026). This distribution means that complete-text
236 appraisal is concentrated in two countrywide station samples and three regional or local comparisons.
237 Northern regional evidence also exists in the P/A records; its lower access tier is an appraisal
238 limitation rather than proof of geographical absence.

239 The domain appraisal identifies different constraints that should not be collapsed into a common
240 quality label. Datti et al. (2024) test zone-average daily occurrence; Ellis and Samson (2026)
241 distinguish the implications of daily observation times and smoothing. David (2025) reports different
242 preferences for amount-error and detection metrics, with release and product-period overlap
243 unresolved. Ogidi et al. (2025) give conflicting station-table and results periods, so a defensible
244 ordering is withheld. Onah et al. (2026) use a common monthly performance interval ending in 2019,
245 although the gauge archive extends to July 2025, and some comparisons involve min-max
246 normalisation. Normalised agreement must be separated from rainfall-amount error in physical units.
247 All 18 core entries remain unresolved for station-and-date reference independence. That status limits
248 certification of performance beyond incorporated observations; it does not establish actual overlap or
249 invalidate every reported comparison.

250 **4.2 Accumulated rainfall and the dimension of agreement**

251 Ogbu et al. (2020) compared CHIRPS, PERSIANN-CDR and TAMSAT with 24 NiMet stations over
252 1983-2013, using nearest-grid values and temporal aggregation. The products generally captured the
253 annual cycle and broad rainfall gradient, with CHIRPS favourable in many locations. However,
254 interannual and seasonal agreement varied, including weak correlations at some stations.
255 Reproducing the familiar climatic structure, therefore, did not establish equal reliability for local
256 anomalies.

257 Nwachukwu et al. (2020) compared 16 estimates with 11 NiMet stations, principally at monthly scale
258 during 2000-2012. Inspected primary methods describe resampling to 0.1° and a modified Kling-

259 Gupta efficiency using the coefficient-of-variation ratio. MSWEP v2.2 and IMERG Final v6 were
260 favourable, with local product orderings varying. This supports monthly candidates within that
261 reference sample and product set. It does not establish daily event performance or an independent
262 national ordering.

263 The full-text evaluation by Datti et al. (2024) compared ARC2, CHIRPS, and TAMSAT using data
264 from 42 NiMet stations during 2002-2022. Its continuous and detection diagnostics show seasonal
265 and regional differences, with CHIRPS generally favourable. Section 6.2 applies the six checks to
266 this study and makes the constraints on that conclusion explicit.

267 Akinyemi et al. (2020) compared TRMM, CHIRPS and RFE2.0 with NiMet observations in
268 southwestern Nigeria over 1998-2016, reporting strong associations for TRMM and CHIRPS. The
269 accessible publisher abstract establishes regional correspondence, but does not justify extending the
270 reported correlations to daily extremes or treating their magnitude as a direct measure of unbiased
271 rainfall amounts.

272 Ogunjo et al. evaluated GPCC, NOAA precipitation reconstruction, and UDEL at 21 locations in
273 Nigeria over 1960-2010. Their monthly assessment found stronger wet-season performance and
274 limitations at northern stations during the dry season, with GPCC generally favourable within that
275 comparison. This extends the evidence beyond primarily satellite-based estimates, while keeping the
276 result specific to the three gauge-based products and monthly observations examined (Ogunjo et al.,
277 2022).

278 The numerical contrasts in Table 2 show why the metric dimension matters. High agreement in a
279 mean annual spatial field tests the rainfall gradient, while a mean-monthly comparison can be
280 dominated by the seasonal cycle. Neither establishes year-to-year anomaly skill. The daily-to-
281 monthly difference reported for a local comparison tests a different dimension again and is not a
282 cross-study estimate of aggregation benefit. The values are retained as source-specific examples, not
283 pooled or used to manufacture a national ranking.

Table 2. Source-specific numerical comparisons. F and A are access tiers, not quality scores. Values are reproduced with their reported comparison setting; the rows are not commensurate effect estimates.

Study and tier	Reference support	Compared quantity	Reported result	Bounded interpretation
Datti et al. (2024); F	42 NiMet gauges; 2002-2022.	CHIRPS mean annual spatial rainfall pattern.	$r = 0.92$; bias ratio = 0.97; RMSE = 61 mm per year.	Spatial climatological agreement; not daily event or trend validation.
Datti et al. (2024); F	Same study; mean-monthly comparison.	Mean monthly rainfall characteristics.	All products $r > 0.94$; CHIRPS RMSE 4.02 and TAMSAT 8.86 mm per month.	Mean-monthly performance must be separated from interannual anomalies.
Ganiyu et al. (2025); A	Five gauges; 2013-2022.	PERSIANN-CDR daily versus monthly comparisons.	Median $r = 0.33$ daily and 0.86 monthly.	A preliminary local lead; modest daily correlation and unassessed bias/event adequacy remain.

286

4.3 Regional choices and composite rankings

Shiru et al. (2025) compared CHIRPS, CMORPH, MSWEP, PERSIANN-CDR and TAMSAT using several statistical measures combined through compromise programming. The publisher's abstract reports different annual leaders across the Sahel and Sudan, Guinea, and rainforest and mangrove settings: CHIRPS, TAMSAT, and MSWEP, respectively. TAMSAT frequently ranked first in individual comparisons, whereas MSWEP led after metric aggregation. The accessible record therefore illustrates both geographic sensitivity and sensitivity to the method used to combine performance measures.

The broader multi-scale evaluation by Salami (2026) used 48 stations across six eco-climatic zones within an overall 1981-2019 study frame. Its publisher-indexed methods describe GSOD supplementation of missing daily reference observations and inverse-distance weighting for monthly gaps. Product rankings varied with temporal scale and climatic setting, and annual correlations were weaker than those for some monthly and seasonal comparisons. The overall date span should not be automatically assigned to every product; products with shorter records necessarily require their own evaluation intervals. This distinction is important when comparing performance across product families and interpreting apparently long validation records.

303 Evidence from Yobe further illustrates application-specific selection. Dawa et al. (2024) compared
304 CHIRPS, CRU, GPCC, NASA POWER and TerraClimate within a 1981-2021 study frame. GPCC
305 was favourable for monthly and annual rainfall and SPI-6, whereas POWER was less suitable for the
306 evaluated drought assessment. This is a regional result for accumulated rainfall and a specified
307 drought index, rather than a national endorsement of GPCC or a verified test of short-duration rainfall
308 extremes.

309 Ganiyu et al. (2025) evaluated IMERG v7, CHIRPS v2, CPC-CMORPH and PERSIANN-CDR
310 against five gauges in the Niger Central Hydrological Area during 2013-2022. Their publisher
311 abstract identifies PERSIANN-CDR as comparatively favourable, with median correlations of 0.33
312 for daily and 0.86 for monthly comparisons. This local preference differs from several national
313 summaries, but the difference cannot be attributed to geography alone, as versions, reference
314 samples, periods, and candidate products also differ. The modest daily correlation remains relevant
315 even when that product leads its particular comparison.

316 Tanimu et al. compared CRU, TerraClimate, CPC, ERA5 and CHELSA using time-series similarity
317 measures and conventional criteria at 26 Nigerian locations. Their study considered rainfall and
318 temperature and identified CRU as favourable among the evaluated sets. A recommendation derived
319 from that design must retain the variable and metric to which it applies; a combined climate-data
320 evaluation does not establish equivalent performance across all rainfall properties (Tanimu et al.,
321 2024). Salami et al. also evaluated eleven gridded products using compromise programming across
322 daily to annual scales, providing another example of recommendations conditional on the aggregation
323 procedure and the criteria combined (Salami et al., 2025).

324 Taken together, these records show at least two sources of changing preferences: the candidates and
325 diagnostics being compared, and the setting and temporal support of the reference sample. They do
326 not isolate a causal geographical effect because these design features change together. A composite
327 score is a decision rule whose outcome depends on the choice of metrics, normalisation, and weights.
328 Inspectable component results are required before a composite leader is transferred to another
329 application. The published climatic labels are retained, with no assumption that zones with identical
330 names have identical boundaries.

331 **4.4 Daily occurrence and upper tail evidence**

332 Ellis and Samson (2026) compared POWER and CMAP with 20 NiMet stations for 1982-2011. Both
333 products represented mean spatial rainfall patterns, yet overestimated rainfall frequency and exhibited
334 weak interannual correspondence and trends that opposed the reference record. This provides a

335 concrete example of climatological resemblance coexisting with deficiencies in rainfall properties
336 needed for monitoring.

337 Salami and Fenta (2022) evaluated 11 precipitation products using point-to-pixel comparisons and
338 several continuous metrics. Their published abstract reports an overestimation of low daily rainfall
339 amounts, an underestimation of higher amounts, and improved cumulative estimates at longer
340 integration intervals. These findings support scale-specific interpretation, with the exact product-zone
341 comparisons requiring the corresponding station and period information.

342 Salami et al. (2024) assessed nine estimates against 48 gauges using seven daily thresholds and
343 categorical measures combined through compromise programming. The publisher's abstract reports
344 overestimation in the 1-5 mm per day range and underestimation in the 10-20 mm per day range. It
345 also identifies comparatively favourable performance by GPCC, TAMSAT/TARCAT, and CHIRPS
346 across the evaluated settings. These findings indicate intensity-dependent behaviour and support
347 retaining threshold-specific results alongside combined rankings.

348 Datti et al. (2024) report occurrence and upper-quantile detection statistics using daily rainfall
349 averaged across the stations within each agro-climatic zone. Those scores address zone-average
350 rainfall and do not establish event detection at each individual station. The worked example retains
351 this distinction.

352 The probability of detection, false-alarm ratio, and critical success index answer different questions.
353 High event detection can be achieved by predicting rain too often, while high overall accuracy can
354 result from correctly identifying many dry days. Neither outcome by itself establishes adequate
355 heavy-rainfall performance. Threshold-specific contingency tables are therefore more informative
356 than a single percentage of correct classifications. Comparisons should also retain whether thresholds
357 are fixed in physical units or defined relative to a local percentile, since these approaches test
358 different rainfall properties and have different event frequencies.

359 Reliability for daily extremes requires evidence beyond agreement in seasonal or annual totals.
360 Interpolation, spatial averaging and retrieval limitations can alter the upper tail without greatly
361 changing accumulated rainfall. At the same time, a station measures a smaller spatial footprint than a
362 grid cell. A lower grid-cell maximum may therefore reflect both estimation error and a difference in
363 spatial support. Evaluation should specify whether the target is local point intensity, area-mean
364 rainfall or a catchment aggregate before this discrepancy is interpreted.

Reference screening also matters. Ogbu et al. (2020) report that daily values above 200 mm are replaced with missing-value codes. A fixed cutoff cannot alone distinguish an erroneous observation from an unusual but plausible event. This does not establish that valid extremes were removed; it requires event-specific verification before transferring that screening rule to upper-tail analysis.

4.5 Variability trends and additional local studies

Usman et al. (2018) linked product evaluation with rainfall-change analysis in northern Nigeria. They compared ARC, CHIRPS, TAMSAT, and TRMM across several accumulation scales; the daily comparison used 10 stations, while the broader analysis used additional station records. CHIRPS was particularly favourable for dekadal, monthly and seasonal rainfall, and the subsequent 1981-2015 analysis examined growing-season characteristics and dry spells. This provides an example of using validation to justify a specific analytical application. It does not establish that every inferred trend is insensitive to the selected product or to changes in observational inputs.

Nwachukwu et al. (2020) examined long-record products before and after 2000 as well as in their main intercomparison period. The reported change in performance between subperiods emphasises that a product can retain a consistent name while its effective observational support changes. Trend assessment therefore requires attention to temporal stability in addition to average agreement.

A West African comparison of 23 gridded products likewise found spatial and temporal variation in reliability (Satgé et al., 2020). An African observational ensemble analysis identified substantial differences in daily precipitation characteristics relevant to model evaluation (Dosio et al., 2021). These regional findings provide methodological context; Nigerian conclusions still require identifiable local observations.

The supplementary search added five eligible publications. David's full-text Jos comparison reports metric-dependent performance, with product-specific record overlap requiring clarification (David, 2025). Ogidi et al. compare three products at five southwestern stations, but their station table and results span different periods, limiting defensible ranking (Ogidi et al., 2025). The Borno publisher's abstract reports a favourable correlation and RMSE for PERSIANN-CDR within its three-product set, without establishing superiority across all metrics or daily-event validity (Wulet et al., 2026). Salami and Togo's publisher abstract identifies CHIRPS v2.0 and GPCC v2018 as favourable under different regional and temporal conditions (Salami & Togo, 2026). Onah et al. compare monthly products at six southeastern stations using a common 2000-2019 performance interval, although the gauge archive extends through July 2025 (Onah et al., 2026). These additions extend local evidence while preserving its source-specific limits. Table S1 records the design and access constraints of each.

Potential mechanisms help explain why the setting should be retained, but require appropriate evidence. Coastal precipitation processes, terrain, gauge density and dry-season event rarity are plausible influences discussed in the wider product literature (Le Coz & van de Giesen, 2020; Novella & Thiaw, 2013). Within this Nigerian corpus, they are often confounded with releases, reference samples and diagnostics. The review therefore treats such mechanisms as explanations to investigate, rather than estimating their independent effect from differences between published rankings.

4.6 Sensitivity of the recommendations to source access

Removing eight A-tier core records leaves 10 F/P studies. CHIRPS remains a conditional candidate for accumulated rainfall, as reported by Ogbu et al. (2020), Datti et al. (2024), and Usman et al. (2018). The specific MSWEP v2.2 and IMERG Final v6 monthly lead remains because Nwachukwu et al. (2020) is P, and the Yobe GPCC lead remains through Dawa et al. (2024). By contrast, the zonal annual orderings in Shiru et al. (2025) and the particular local PERSIANN-CDR comparisons in Ganiyu et al. (2025) and Wulet et al. (2026) lose their supporting records under this restriction. The result is a change in which specific recommendations can be carried forward, not evidence that an excluded product performs poorly.

Restriction to the five F records further narrows support. Datti remains a countrywide sample example for CHIRPS in its reported diagnostics, while Ellis and Samson retain caution about transferring mean-pattern agreement to temporal monitoring. The specific 11-gauge MSWEP/IMERG comparison is no longer retained under F-only restriction. The three other F sources supply local, metric-specific or reporting-constrained results. Neither restriction produces verified station independence or nationally transferable station-level rare-extreme evidence. Supplementary Table S6 preserves this claim-by-claim sensitivity, while the A-tier records remain visible as preliminary leads in S1.

5 Interpreting the strength and transferability of agreement

5.1 Claims and reference independence

The appraisal proposed here distinguishes five kinds of claims: agreement in climatology, reproduction of temporal variability, detection of rainfall events, transferability to other conditions, and credibility for trend analysis. These claims describe different properties of a dataset. They should be evaluated separately and accompanied by information on reference independence, station coverage and comparison scale. Agreement in an annual cycle supports a climatological claim; evidence for interannual anomalies requires a comparison that retains year-to-year departures. Event-based claims

429 require observed and estimated events to be matched using stated accumulation windows and
430 thresholds. Transferability requires observations outside the setting used to establish performance,
431 while a trend claim additionally requires evidence about temporal consistency. This taxonomy is an
432 interpretive framework for the review, with no numerical product ranking.

433 Reference independence concerns whether evaluation observations were incorporated into product
434 construction. Calibration independence concerns reuse of observations to fit and test a study-specific
435 correction. A temporal holdout during analysis cannot remove observations that have already been
436 incorporated into the original product. The following proposed audit makes that distinction
437 operational. Its classes describe observational provenance, not statistical independence of random
438 errors.

439 A practical independence record has four linked components. The reference manifest gives station
440 identifiers and aliases, coordinates and history, evaluated dates, reporting archives, quality control,
441 reconstructed values and observation windows. The product manifest provides the release and stream,
442 and all relevant uses of gauges in calibration, climatology, merging, adjustment, reprocessing, and
443 upstream components. A dated crosswalk reconciles physical stations and contribution periods across
444 archives. The decision record retains the evidence that supports a verified exclusion, a documented
445 contribution, or an unresolved status. Archive names alone, proximity alone, and station-density
446 counts alone do not establish observation identity or exclusion. Provider confirmation or a product
447 input inventory must refer to the relevant stations and dates.

448 A study-specific correction should be fitted and evaluated on appropriately separated observations,
449 but its holdout record remains distinct from the original product-input provenance. An unresolved
450 product-reference relationship should be reported as unresolved, without recoding it as confirmed
451 overlap or independence. Where actual independent and incorporated subsets are identifiable, their
452 comparisons should be kept separate. With restricted observations, an auditable nonidentifying
453 manifest can document the procedure without redistributing the gauge data.

454 **5.2 Product error and comparison mismatch**

455 A station measures rainfall over a small sampling area, while a gridded estimate characterises a larger
456 spatial support. A direct point-to-grid difference, therefore, reflects more than just retrieval or model
457 error. Tustison et al. (2001) demonstrated that the scale transformation used in precipitation
458 verification creates representativeness error even for an otherwise perfect estimate. Gervais et al.
459 (2014) further showed that station density and gridding procedures affect the distribution and
460 extremes of gridded rainfall. Their quantitative results concern the United States; the methodological

461 implication for Nigeria is that spatial matching must be assessed before attributing the full observed
462 discrepancy to a rainfall product.

463 For a common accumulation interval, let $P(A,t)$ be an estimated grid-cell mean, $R(A,t)$ the unknown
464 true areal rainfall, $R(s,t)$ the true rainfall at a gauge location, and $O(s,t)$ its recorded value. The
465 comparison difference can be expressed exactly as

$$466 \quad P(A,t) - O(s,t) = [P(A,t) - R(A,t)] + [R(A,t) - R(s,t)] + [R(s,t) - O(s,t)] \quad (1)$$

467 The three terms represent product error relative to areal rainfall, spatial representativeness difference
468 and gauge measurement error. A single station comparison generally cannot identify them separately.
469 The variance of their sum equals the sum of their variances plus twice each pairwise covariance, and
470 reduces to a simple variance sum only when those covariances vanish. The identity therefore
471 separates interpretation without assuming an additive error budget. Daily comparisons also require
472 matched 24-hour accumulation windows; smoothing changes the target rainfall statistic.

473 **5.3 Diagnostic interpretation and reporting accuracy**

474 Performance measures should answer the stated application question. Correlation describes
475 covariation without establishing agreement in rainfall amounts, and a shared seasonal cycle can
476 strongly contribute to correlation in a raw monthly series. Climatological correlations, raw time-
477 series correlations and correlations of anomalies therefore require separate interpretation. Error
478 magnitudes must retain their accumulation interval and units; an RMSE expressed for daily totals is
479 not directly comparable with one for monthly totals.

480 Gupta et al. (2009) showed the value of decomposing mean-square-error-based evaluation into
481 interpretable components. The original Kling-Gupta efficiency combines correlation, a mean ratio
482 and a standard-deviation ratio; the modification used by Kling et al. (2012) replaces the variability
483 component with a coefficient-of-variation ratio. Consequently, an extracted KGE value requires its
484 defining formulation. Knoben et al. (2019) also demonstrated that NSE and KGE do not share the
485 same benchmark interpretation. This supports the examination of metric components and explicit
486 benchmarks before assigning qualitative labels such as satisfactory or reliable. Rainfall detection also
487 requires considering hits, misses, and false alarms together, while retaining the wet-day threshold and
488 event prevalence. A high detection probability alone does not indicate a low false-alarm rate or an
489 accurate event intensity.

490 Reporting consistency is also an appraisal domain. In the published Datti et al. (2024) methods, the
491 mean error is defined as the signed average difference, and its printed range is nonnegative. The

492 definition permits negative values, so the stated range is a reporting inconsistency requiring
493 correction or clarification. This observation does not establish that the calculations or plotted results
494 are wrong. It illustrates why they worked: appraisal checks, metric definitions and units, and the
495 presence of familiar metric names.

496 **5.4 Temporal consistency and dependence between studies**

497 Trend interpretation requires a stable relationship between the estimate and the rainfall process over
498 time. Satellite transitions, changes in station contributions, and algorithm revisions can alter this
499 relationship. Zhu et al. (2026) identified observing-system discontinuities and substantial product-
500 related trend uncertainty in a global analysis. Those findings provide a reason to test temporal
501 consistency; they do not determine the magnitude or direction of trend uncertainty in Nigeria.
502 Regional conclusions require matched periods, examination of available station-support diagnostics
503 and sensitivity to product revisions and changes in the observing network.

504 The reference-window comparison in Supplementary Table S4 records six possible dependence pairs
505 among Ogbu et al. (2020), Nwachukwu et al. (2020), Datti et al. (2024) and Ellis and Samson (2026).
506 Each pair names NiMet and shares years in its stated reference frame: 2000-2012 for
507 Ogbu/Nwachukwu, 2002-2013 for Ogbu/Datti, 1983-2011 for Ogbu/Ellis-Samson, 2002-2012 for
508 Datti/Nwachukwu, 2002-2011 for Datti/Ellis-Samson and 2000-2011 for Nwachukwu/Ellis-Samson.
509 These intersections do not prove that the same stations or matched product dates were used. They
510 make the unresolved relationship visible and prevent publication counts from being treated as
511 independent replication counts. Station identifiers and contribution dates would be required to
512 quantify actual overlap.

513 Shared construction inputs form another relationship. Agreement between ERA5 and ERA5-Land or
514 between an adjusted product and its upstream information is not equivalent to corroboration from
515 unrelated observations. Figure 1 records selected links relevant to that judgement. The review assigns
516 no numerical error-correlation or effective-sample-size correction because the required observations
517 and matched metadata are unavailable.

518 **6 Practical selection and reporting recommendations**



519
520 **Figure 2.** Six checks linking a recommendation to the target application, product identity, reference provenance,
521 comparison design, diagnostics and scope of inference. The study appraisals and source-access restrictions apply
522 these checks to the retained evidence; the worked example illustrates their use rather than establishing the
523 framework's empirical validity.

524 **6.1 Decisions and application-specific checks**

525 A recommendation should name a product release, rainfall target, evaluated support and evidence
526 basis. Table 3 translates the appraisal into decisions that remain assessable from this corpus.
527 Evidence confidence here is a descriptive statement about the claim and inspected methods, not a
528 validated numerical scale. Application-specific tolerances must be set by the intended decision and its
529 consequences. The review does not impose an arbitrary national threshold for acceptable error. A
530 product can be a reasonable candidate for accumulated rainfall, while station-level wet-day, rare-
531 extreme, or trend applications still require the relevant comparison.

532 **Table 3.** Conditional guidance by application. F, P and A describe source access; they do not certify methodological quality. The named checks are required before
533 transferring a recommendation beyond its evaluated target.

Application and target	Lead or relevant evidence	Assessable basis	Decision and required checks
Monthly and seasonal accumulated rainfall	CHIRPS in sampled comparisons; MSWEP v2.2 and IMERG Final v6 in the 11-gauge monthly comparison (Datti et al., 2024; Nwachukwu et al., 2020; Ogbu et al., 2020; Usman et al., 2018).	Conditional F/P leads; reference independence unresolved.	Match release, season, accumulation interval and spatial support. Check amounts, signed bias, variability and relevant uncertainty in physical units. No fixed tolerance is supplied by this review.
Wet days and dry spells at individual stations	Datti supplies zone-average occurrence evidence for ARC2, CHIRPS and TAMSAT (Datti et al., 2024).	F evidence for an averaged target; station-level transfer unestablished.	Align daily observation windows and missing days; test the intended wet-day threshold, false alarms, misses and spell lengths at the target support.
Accumulated-rainfall drought indicators	GPCC is a lead for the evaluation of the monthly/annual and SPI-6 applications in Yobe (Dawa et al., 2024).	P evidence; regional scope and reference provenance remain bounded.	Verify station support, GPCC release, matched years and the SPI calibration/reference period. Examine drought classification and sensitivity to reference reconstruction.
Rare daily extremes	No nationally transferable ordering is established. Upper-quantile and screening evidence provide limited context (Datti et al., 2024; Ogbu et al., 2020).	Insufficient evidence for station-level rare-extreme certification.	Define point intensity, areal rainfall or catchment target; verify unusual gauge events and test the required tail statistic, event timing and accumulation window.
Interannual anomalies and trends	POWER/CMAP limitations and evidence from northern accumulated rainfall motivate direct testing (Ellis & Samson, 2026; Usman et al., 2018).	F/P evidence identifies concerns; no product is certified for all Nigerian trends.	Separate seasonal-cycle agreement from anomalies; inspect homogeneity, input changes, matched periods and sensitivity across releases and products.

534

535 6.2 Worked application to the Datti evaluation

536 Table 4 applies the six checks to Datti et al. (2024). The study provides a complete-text comparison
 537 of three product families over 2002-2022, while its reported metadata leave some releases and
 538 reference relationships unresolved. The appraisal therefore changes the recommendation from a
 539 general product preference to a conditional candidate for the sampled settings and statistics. It
 540 identifies both missing evaluation metadata and construction information that can be recovered from
 541 product documentation. No rainfall fields are reanalysed.

542 **Table 4.** Worked six-check appraisal. Supplementary Table S5 provides the product-specific manifest and
 543 documentary basis. Q90 retains the source’s upper-quantile label; an unverified reference population is not inferred.

Check	Documented evidence and limitation	Resulting interpretation
1 Application	42 NiMet stations; 2002-2022; amount metrics and zone-average daily occurrence.	Retain the sampled interval, climatic settings and the actual comparison support.
2 Product identity	ARC2 version 2 is identified; CHIRPS/TAMSAT releases are not specified in the dataset descriptions.	Transfer requires exact releases; an access date does not identify a release.
3 Provenance	ARC2’s GTS gauge pathway is documented (Novella & Thiaw, 2013); CHIRPS station blending and TAMSAT historical calibration are distinct (Funk et al., 2015; Maidment et al., 2017). No station-and-date crosswalk is established.	Classify reference independence as unresolved for each evaluated product-reference-period combination.
4 Matching	Point-to-pixel extraction is reported; a common daily accumulation window is not established.	Retain spatial representativeness and daily timing uncertainty.
5 Diagnostics	POD, FAR and CSI concern daily zone averages; ≥ 1 mm per day and Q90 are reported. The printed signed-ME range is inconsistent.	Do not infer individual-station event detection; resolve the reporting issue without assuming computational failure.
6 Transfer	CHIRPS is generally favourable within the comparison; seasonal and regional differences remain.	Treat it as a conditional candidate, without certification for a different release, station event, rare extreme or trend target.

544

545 6.3 What the operational provenance audit resolves

546 The public documentary chain used for the example includes the evaluation itself, the ARC2
 547 development paper, the CHIRPS construction paper and TAMSAT documentation (Datti et al., 2024;
 548 Funk et al., 2015; Maidment et al., 2017; Novella & Thiaw, 2013). It establishes a GTS gauge-input

549 pathway for ARC2, station blending for CHIRPS and historical gauge calibration for TAMSAT. It
550 does not establish which of the 42 reference station records contributed during 2002-2022. No dated,
551 release-matched contribution inventory, station crosswalk or positive withholding evidence was
552 established from the inspected resources. Supplementary Table S5 explicitly records this outcome.
553 Later CHIRPS v3 metadata are not used to identify or certify an unspecified earlier release.

554 The audit, therefore, resolves the investigative pathway but leaves the station-level status unresolved.
555 Completion would require the relevant NiMet station manifest, archive aliases and product-input or
556 provider records for the actual dates. A current station-density raster can describe support without
557 proving that a named historical station was included or excluded. Confirmed contribution would
558 change the status to documented overlap; positive withholding across the relevant pathways would
559 support verified independence. These outcomes must remain product-, station- and period-specific.

560 **7 Limits of inference and priorities**

561 This review provides an auditable analysis of a bounded corpus rather than exhaustive coverage of
562 the database. The historical search providers and alternate-URL mapping are incompletely preserved,
563 the exploratory search denominator is unavailable, and selection and appraisal were not
564 independently replicated. The supplementary ledger makes retained decisions inspectable but cannot
565 recreate the original ranking environment. Eight core findings remain abstract-supported, five depend
566 on partial articles, and several complete texts retain unresolved design or reporting issues. Access
567 restriction is therefore examined directly rather than hidden within a common confidence label.

568 The reference-window mapping identifies possible dependence, not measured station overlap.
569 Product-input inventories and gauge observations were not available to establish or quantify station-
570 level independence, error correlation or a corrected effective sample size. Spatially and temporally
571 incompatible statistics prevent a defensible pooled performance magnitude. The worked framework
572 has not been tested for inter-reviewer reproducibility or predictive decision value. Priorities are
573 release-specific manifests, transparent station matching, reference-day alignment, identifiable
574 treatment of reconstructed values and evaluation of the target statistic. Future framework testing
575 should examine reproducibility of the domain judgements before assigning a numerical score.

576 **8 Conclusions**

577 The retained Nigerian evidence supports conditional choices for rainfall data, with important
578 differences in what can be inspected and transferred. Of 18 core publications, five are available as
579 complete texts, five as inspected passages and eight as abstracts or previews. None establishes

580 verified station-and-date independence across the relevant construction pathways. The finding is an
581 unresolved provenance status, not proof of overlap or universal product inadequacy.

582 Excluding abstract-only evidence retains CHIRPS accumulated-rainfall leads and the passage-
583 supported MSWEP v2.2/IMERG Final v6 monthly comparison, while several zonal and local
584 orderings lose their supporting sources. Complete-text restriction narrows the claims further.
585 Numerical comparisons demonstrate that annual spatial agreement, mean-monthly climatology and
586 daily association cannot be combined into a national accuracy ranking. Six temporal-overlap pairs
587 among four NiMet-based evaluations also limit unqualified interpretation of publication counts as
588 independent replication.

589 The contribution is a traceable connection between those evidence limits and practical choices: study-
590 level appraisal, explicit access sensitivity, documented potential dependence and a product-specific
591 worked provenance audit. Monthly amounts, drought indices, wet days, extremes and trends require
592 different diagnostics. A useful recommendation names the release, target, reference support and
593 unresolved conditions, allowing readers to retain a local finding while recognising the further
594 evidence needed for transfer.

595

596

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608 **Authors' Contributions**

609 Segun Ezekiel Akorede: conceptualisation, methodology, formal analysis, visualisation, writing -
610 original draft, and writing - review and editing. Chioma Suzan Dibani: validation and writing -
611 review and editing.

612 **Data availability**

613 No new rain-gauge observations or precipitation fields were generated. The accompanying
614 Supplementary Evidence and Search Audit contains S1, the included-study register; S2a-S2c, the
615 archived queries, retrieval accounting and record-level decisions; S3, domain appraisals for all 20
616 included and comparator publications; S4, the six reference-window intersections; S5, the product
617 manifests for the worked example; and S6, recommendation sensitivity to access restrictions. These
618 materials document the evidence and do not redistribute restricted station observations.

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Supplementary Evidence and Search Audit

Conditional reliability of gridded rainfall datasets in Nigeria

S1 Included Nigerian evaluations

Table S1 records 18 core publications and two contextual comparators. A core publication directly compares at least one satellite-based or gauge-adjusted rainfall estimate with Nigerian gauge observations. The register retains five F, five P, and eight A core records. F means complete primary text inspected, P inspected primary passages without complete-article retrieval and A a publisher abstract or preview. These access labels describe the retained material for the original appraisal, not publication status or methodological quality. Domain judgements are in S3; no numerical quality score is assigned.

The stated study frame is not automatically a verified product-specific overlap. Unknown stations, dates and releases remain explicit. Reference independence is unresolved for every entry on the inspected evidence, without implying actual overlap. Author-date citations correspond to the APA reference list; DOI identifiers remain stable. The scope caveat for the Shiru publication is retained because the publisher labels its genre differently from the direct evaluation described in the abstract.

Table S1. Included publications and material available for appraisal.

Study and role	Reference support and stated period	Products and verified releases	Comparison and diagnostics	Tier	Bounded finding and remaining limit
Ogbu et al. (2020) Core	Nigeria; Sahel, Savannah and Guinea coast. 24 NiMet gauges; stated frame 1983-2013.	CHIRPS, PERSIANN-CDR and TAMSAT; releases require source-specific checking.	Nearest-grid extraction; correlation, RMSE and PBIAS; climatology, anomalies and trends.	P	CHIRPS favourable at many locations; local and interannual agreement varied. Methods screen daily values above 200 mm; valid-event exclusion is not established. https://doi.org/10.3390/cli8100103 Independence: unresolved for the relevant station, product and period.
Datti et al. (2024) Core	Nigeria; three agro-climatic zones. 42 NiMet gauges; daily 2002-2022.	ARC2, CHIRPS and TAMSAT; CHIRPS/TAMSAT release identity unresolved.	Point-to-pixel amount comparisons; zone-average daily POD, FAR and CSI at ≥ 1 mm per day and Q90.	F	CHIRPS generally favourable; season and intensity matter. Evaluated thresholds do not establish rare-extreme accuracy or independent validation across all settings. https://doi.org/10.3390/rs16101755 Independence: unresolved for the relevant station, product and period.

Study and role	Reference support and stated period	Products and verified releases	Comparison and diagnostics	Tier	Bounded finding and remaining limit
Nwachukwu et al. (2020) Core	Nigeria; sampled locations spanning contrasting rainfall regimes. 11 NiMet gauges; principal monthly comparison 2000-2012; long-record split 1985-1999 versus 2000-2012.	16 estimates; favourable MSWEP v2.2 and IMERG Final v6.	Monthly Kling-Gupta efficiency and component diagnostics; indexed primary methods/results inspected.	P	Rankings depend on region and period. Complete article not retrieved; an internal reference to 12 locations is not adopted. https://doi.org/10.3390/rs12233964 Independence: unresolved for the relevant station, product and period.
Salami et al. (2024) Core	Nigeria; nationwide threshold assessment. 48 gauges; precise dates not verified from accessible preview.	Nine estimates; full release inventory not verified.	Seven daily rainfall thresholds; categorical measures combined through compromise programming.	A	Preview reports overestimation at 1-5 mm per day and underestimation at 10-20 mm per day. Aggregate classification accuracy is not a heavy-rainfall validation. https://doi.org/10.1080/02626667.2024.2395462 Independence: unresolved for the relevant station, product and period.
Tanimu et al. (2024) Comparator	Nigeria; 26 locations. In situ rainfall and temperature; precise reference period not verified from preview.	CRU, TerraClimate, CPC, ERA5 and CHELSA; complete releases unverified.	Short time-series distance, cross-correlation distance, Perkins skill score and compromise programming.	A	CRU favourable within the evaluated set. Combined climate-variable rankings and time-series similarity do not establish daily event or extremes skill. https://doi.org/10.1007/s11356-024-32128-0 Independence: unresolved for the relevant station, product and period.
Ellis and Samson (2026) Core	Nigeria; 20 station locations. 20 NiMet gauges; 1982-2011.	POWER daily precipitation and CMAP pentads; lineage follows evaluated parameters.	Climatology, rainfall frequency, interannual covariability and trends; POWER also smoothed to three days.	F	Broad mean spatial patterns reproduced; frequency overestimated, interannual correspondence weak and trends opposed the reference. Unknown station observation times motivated smoothing, which changes the comparison statistic. https://doi.org/10.1007/s00704-026-06121-1 Independence: unresolved for the relevant station, product and period.

Study and role	Reference support and stated period	Products and verified releases	Comparison and diagnostics	Tier	Bounded finding and remaining limit
Akinyemi et al. (2020) Core	Southwestern Nigeria. Selected NiMet stations; 1998-2016; station count unverified in preview.	TRMM, CHIRPS and RFE2.0; exact releases unverified.	Reported association with ground records; aggregation and metric dimension require full methods.	A	TRMM and CHIRPS showed strong correspondence. Correlation alone does not establish unbiased estimates of rainfall amounts or daily-extreme reliability; transferability beyond the sampled region remains untested here. https://doi.org/10.1007/s41976-019-00029-3 Independence: unresolved for the relevant station, product and period.
Ogunjo et al. (2022) Comparator	Nigeria; 21 locations. NiMet observations; monthly 1960-2010.	GPCC, NOAA precipitation reconstruction over land and UDEL.	Monthly comparison; correlation and seasonal performance reported in publisher abstract.	A	GPCC favourable within three products; stronger wet-season agreement and northern dry-season limitations. Monthly gauge-based comparisons do not establish daily chronology; station overlap requires separate checking. https://doi.org/10.1007/s41976-022-00069-2 Independence: unresolved for the relevant station, product and period.
Shiru et al. (2025) Core	Sahel-Sudan, Guinea and rainforest-mangrove settings. Observed precipitation; station count and period unverified in preview.	CHIRPS, CMORPH, MSWEP, PERSIANN-CDR and TAMSAT.	Annual/seasonal metrics aggregated by compromise programming.	A	The annual leaders were CHIRPS, TAMSAT, and MSWEP in their respective settings. Metric aggregation changed the leader. Publisher labels Review Article; the abstract describes direct analysis, so detailed genre/method confirmation remains pending. https://doi.org/10.1007/s41748-024-00563-1 Independence: unresolved for the relevant station, product and period.
Salami (2026) Core	Nigeria; six eco-climatic zones. 48 NiMet stations; overall 1981-2019 frame; GSOD daily and IDW monthly gap filling.	11 estimates; includes CHIRPS v2, TAMSAT v3, IMERG v06 and gauge-based comparators.	Daily to annual assessment; multiple seasons and metrics; indexed methods/results inspected.	P	Performance varies with scale and climate. Overall study dates cannot be assigned to every product. Reconstructed reference values warrant separate sensitivity analysis. https://doi.org/10.1080/02626667.2025.2581859 Independence: unresolved for the relevant station, product and period.

Study and role	Reference support and stated period	Products and verified releases	Comparison and diagnostics	Tier	Bounded finding and remaining limit
Dawa et al. (2024) Core	Yobe, northeastern Nigeria. Overall 1981-2021 study frame; exact station support and product-specific intervals require checking.	CHIRPS, CRU TS4.06, GPCC, NASA POWER and TerraClimate.	Monthly/annual rainfall metrics and SPI-6; indexed primary methods and conclusions inspected.	P	GPCC favourable for the evaluated accumulation and drought measures. This local result does not validate daily extremes or justify a national ranking. https://doi.org/10.2166/ws.2024.113 Independence: unresolved for the relevant station, product and period.
Ganiyu et al. (2025) Core	Niger Central Hydrological Area. Five gauges; 2013-2022.	IMERG Final v7, CHIRPS v2, CPC-CMORPH and PERSIANN-CDR.	Daily/monthly continuous metrics; categorical statistics and four-component error decomposition.	A	PERSIANN-CDR favourable, with median daily/monthly correlations 0.33/0.86. The basin sample is small; correlation and local rank do not establish the adequacy of daily events. Full methods inaccessible in the inspected preview. https://doi.org/10.1007/s00704-025-05388-0 Independence: unresolved for the relevant station, product and period.
Salami et al. (2025) Core	Nigeria: location- and zone-specific support requires full methods. Rain-gauge reference; station count and exact dates not verified in preview.	11 gridded rainfall estimates; complete releases unverified.	Compromise programming across multiple metrics and daily to annual scales.	A	Reported rankings illustrate dependence on scale and metric aggregation. Detailed methods are needed before interpreting station independence, product-specific periods, or transfer beyond the sampled settings. https://doi.org/10.1007/s41748-025-00601-6 Independence: unresolved for the relevant station, product and period.
Salami and Fenta (2022) Core	Nigeria; point-to-pixel evaluation. NiMet acknowledged; station count and exact dates unverified in preview.	11 precipitation products; full release list unverified.	Correlation, mean error, multiplicative bias, RMSE and NSE; several accumulation scales.	A	Low daily amounts were overestimated, and higher amounts were underestimated; accumulated estimates improved with longer integration. Detailed product-zone conclusions require accessible station, period and version information. https://doi.org/10.1007/s12517-022-11071-9 Independence: unresolved for the relevant station, product and period.
Usman et al. (2018) Core	Sudano-Sahelian Nigeria. 10 gauges for daily comparison; 18 wider records; intercomparison 1998-2014 and trend frame 1981-2015.	ARC, CHIRPS, TAMSAT and TRMM.	Multiscale validation followed by growing-season and dry-spell analysis; indexed primary passages inspected.	P	CHIRPS favourable for dekadal, monthly and seasonal rainfall. Long-record dates do not apply to every product; validated accumulation does not establish homogeneity of the observing system. https://doi.org/10.1016/j.agrformet.2018.06.016 Independence: unresolved for the relevant station, product and period.

Study and role	Reference support and stated period	Products and verified releases	Comparison and diagnostics	Tier	Bounded finding and remaining limit
David (2025) Core	Jos Plateau NiMet and University of Jos stations; stated 1998-2021 objective; product-specific overlap unresolved.	PERSIANN-CDR, SM2RAIN-ASCAT, TAMSAT and POWER/MERRA-2; releases unresolved.	Annual/monthly summaries and detection; correlation, bias, RMSE, POD, FAR and CSI.	F	The report favours TAMSAT for amount-error measures and SM2RAIN-ASCAT for detection measures. The local, metric-dependent finding is limited by unresolved matching, release and product-period details. https://doi.org/10.35248/2332-2594.25.13(1)001-005 Independence: unresolved for the relevant station, product and period.
Ogidi et al. (2025) Core	Abeokuta, Osogbo, Ibadan, Ikeja and Akure Five NiMet stations: the station table covers 2001-2020, while the results use 2002-2012.	POWER, PERSIANN and TRMM; exact releases unresolved.	Annual results; correlation, MAE, RMSE and mean bias.	F	Conflicting reference periods and product descriptors constrain interpretation. Local differences are reported, but a robust product ordering cannot be extracted without clarification. https://doi.org/10.4314/fuoyej.v10i3.23 Independence: unresolved for the relevant station, product and period.
Wulet et al. (2026) Core	Borno State NiMet observations during 1993-2021; station count unavailable in the retrieved abstract.	PERSIANN-CDR, CHIRPS and CRU TS; releases unresolved.	Correlation, MAE, RMSE and Bland-Altman analysis; aggregation not established in the abstract.	A	The abstract favours PERSIANN-CDR for correlation and RMSE, while CHIRPS has a slightly lower MAE. Missing aggregation and matching details prevent inference about daily thresholds or an all-metric leader. https://doi.org/10.4314/just.v44i3.1 Independence: unresolved for the relevant station, product and period.
Salami and Togo (2026) Core	Six Nigerian eco-climatic regions Ground observations; station count and comparison period unavailable in the retrieved abstract.	Eleven products; CHIRPS v2.0 and GPCC v2018 explicitly identified.	Annual, monthly and seasonal comparisons; continuous metrics and compromise programming.	A	The abstract favours CHIRPS v2.0 for annual rainfall in Sudan/Sahel and GPCC v2018 for monthly/seasonal rainfall in Sahel/Montane settings. Full design and sample relationships with other studies remain unverified. https://doi.org/10.1007/s41976-025-00259-8 Independence: unresolved for the relevant station, product and period.

Study and role	Reference support and stated period	Products and verified releases	Comparison and diagnostics	Tier	Bounded finding and remaining limit
Onah et al. (2026) Core	Six stations in southeastern Nigeria Monthly NiMet records January 2000-July 2025; common product performance interval 2000-2019.	IMERG, CHIRPS, CMORPH, TRMM, CHRS/PERSIANN, ERA5, ERA5-Land, AgERA5, MERRA-2, GPCC and CRU; releases unresolved.	Nearest-neighbour matching; monthly and wet-season summaries, continuous metrics, SPI and trends.	F	Several products show favourable monthly agreement. Some comparisons use min-max normalisation, which must be distinguished from physical rainfall-amount accuracy. The design does not establish daily-event performance. https://doi.org/10.7780/kjrs.2026.42.1.8 Independence: unresolved for the relevant station, product and period.

S2 Archived supplementary retrieval and screening

Six fixed queries were run without a publication year, recency, or domain filter. The log labels Q1-Q4 as system2 and Q5-Q6 as system1. These are historical interface identifiers; the provider, underlying engine and exact clock times were not retained. The audit below describes retained outputs and work-level decisions, not search-engine total-hit estimates or exhaustive literature coverage. No registered protocol, independent duplicate screening or PRISMA compliance is claimed.

Table S2a. Exact query strings and retained appearance counts. Strings and historical interface labels are preserved verbatim.

Query	Interface	Exact search string	Count
Q1	system2	Nigeria gridded rainfall satellite precipitation evaluation rain gauges CHIRPS TAMSAT	21
Q2	system2	Nigeria precipitation products daily heavy rainfall validation Datti Salami	17
Q3	system2	Nigeria rainfall gridded satellite validation monthly IMERG MSWEP Nwachukwu	19
Q4	system2	Nigeria precipitation satellite validation Yobe southwestern Niger basin	22
Q5	system1	Nigeria gridded rainfall validation ERA5 CRU GPCC rain gauge	6
Q6	system1	Nigeria satellite precipitation evaluation 2025 2026 NiMet	8

Deduplication first matched returned URLs, then DOI or title equivalence between representations of the same work. The ledger maps all 93 query positions exactly once to 52 work or source records. It contains one or more identifying source links per work, rather than a complete list of alternate URLs for every appearance. Accordingly, 64 distinct URLs remain an originally reported intermediate count; it cannot be independently reconstructed from the work-level ledger alone. The verified aggregate difference is 93 minus 52, or 41 appearances consolidated. Adaptive primary-source checks did not add query appearances.

Table S2b. Retrieval accounting and dispositions. The five work-level dispositions sum to 52.

Retrieval or disposition	Count or status
Returned result appearances	93
Distinct returned URLs originally reported	64; alternate-URL mapping incompletely retained

Retrieval or disposition	Count or status
Work or source records after DOI and title equivalence	52
Aggregate appearances consolidated to work records	41
Core publications among the 52 records	16
Contextual records	10
Documentation records	7
Awaiting primary or publication verification	3
Excluded records	16
Previously included core publications returned	11
New eligible core publications added	5
Earlier citation-traced core publications not returned	2
Final core inventory after retaining the earlier sources	18
Additional comparator publications in Table S1	2

The 16 retrieved core publications comprise 11 previously included and five added studies. Ganiyu et al. (2025) and Usman et al. (2018) were retained through earlier citation tracing, giving 18 core publications. Two comparator publications are reported separately in S1.

Table S2c. Every retained work or source record and its original screening decision. Query positions preserve all 93 mapped appearances.

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R01 Q1, Q2, Q4, Q6	Evaluation of Satellite-Based Rainfall Estimates against Rain Gauge Observations across Agro-Climatic Zones of Nigeria, West Africa	Core. Direct Nigerian gauge-reference satellite evaluation. Peer-reviewed full text; publisher and institutional PDF.	Source: Datti et al. (2024) DOI: 10.3390/rs16101755 https://www.mdpi.com/2072-4292/16/10/1755 Returned positions: Q1:1; Q2:8; Q4:11; Q6:2; Q1:10; Q2:14; Q4:17
R02 Q1, Q2, Q4	Performance assessment of satellite rainfall estimates in rain detection capabilities at different thresholds over Nigeria: Hydrological Sciences Journal: Vol 69, No 14 - Get Access	Core. Direct Nigerian gauge-reference occurrence-threshold evaluation. Peer-reviewed publisher abstract only for extracted claims.	Source: Salami et al. (2024) DOI: 10.1080/02626667.2024.2395462 https://www.tandfonline.com/doi/full/10.1080/02626667.2024.2395462 Returned positions: Q1:2; Q2:7; Q4:3
R03 Q1, Q4	Performance Evaluation of Satellite-Based Rainfall Products over Nigeria MDPI	Core. Direct Nigerian gauge-reference satellite evaluation. Primary methods/results passages inspected (P); complete-article retrieval not claimed for this appraisal.	Source: Ogbu et al. (2020) DOI: 10.3390/cli8100103 https://www.mdpi.com/2225-1154/8/10/103 Returned positions: Q1:3; Q4:7; Q1:11; Q1:15
R04 Q1	Evaluation of 23 gridded precipitation datasets across West Africa - ScienceDirect	Context. West African comparison; used as regional context, not Nigerian standalone performance proof. Publisher abstract; existing contextual citation.	Source: Satgé et al. (2020) DOI: 10.1016/j.jhydrol.2019.124412 https://www.sciencedirect.com/science/article/pii/S0022169419311473 Returned positions: Q1:4

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R05 Q1, Q2, Q3, Q4, Q6	Full article: Enhancing rainfall monitoring in Nigeria: a multi-scale performance evaluation of satellite-based precipitation estimates across eco-climatic zones (1981-2019)	Core. Direct Nigerian multi-scale precipitation evaluation. Peer-reviewed primary abstract and indexed article passages; not complete full text.	Source: Salami (2026) DOI: 10.1080/02626667.2025.2581859 https://www.tandfonline.com/doi/full/10.1080/02626667.2025.2581859 Returned positions: Q1:5; Q2:10; Q4:13; Q6:1; Q1:9; Q3:10; Q1:12; Q2:2; Q3:14
R06 Q1	Multiscale Evaluation of Gridded Precipitation Datasets in Jos, Plateau State, Nigeria	Core. Direct satellite/gauge-reference comparison at Jos. Published full PDF inspected. The stated objective spans 1998-2021; matched product-specific periods remain unresolved.	DOI: 10.35248/2332-2594.25.13(1)001-005 https://www.iomcworld.com/open-access/multiscale-evaluation-of-gridded-precipitation-datasets-in-jos--plateau-state-nigeria.pdf Returned positions: Q1:6
R07 Q1, Q2, Q4, Q5	Evaluation of five gridded precipitation products for estimating precipitation and drought over Yobe, Nigeria Water Supply IWA Publishing	Core. Direct Nigerian gauge-reference comparison involving CHIRPS and gauge analyses. Primary methods/results passages inspected (P); complete-article retrieval not claimed for this appraisal.	Source: Dawa et al. (2024) DOI: 10.2166/ws.2024.113 https://doi.org/10.2166%2Fws.2024.113 Returned positions: Q1:7; Q2:12; Q4:4; Q5:3
R08 Q1, Q6	Evaluation of Remote Sensing Precipitation Estimates: A Case Study of Jalingo, Taraba State, Northeast Nigeria Zenodo	Awaiting verification. Relevant Jalingo monthly evaluation, but repository journal-article designation alone does not independently establish peer-review status. Zenodo primary deposit metadata/abstract verified; PDF retrieval decoding failed. Await publication/peer-review verification.	DOI: 10.5281/zenodo.20021026 https://zenodo.org/records/20021026 Returned positions: Q1:8; Q6:3
R09 Q1, Q2, Q3, Q4	From TRMM to GPM: How Reliable Are Satellite-Based Precipitation Data across Nigeria?	Core. Direct Nigerian gauge-referenced multi-product comparison. Primary methods/results passages inspected (P); complete-article retrieval not claimed for this appraisal.	Source: Nwachukwu et al. (2020) DOI: 10.3390/rs12233964 https://www.mdpi.com/2072-4292/12/23/3964 Returned positions: Q1:13; Q2:6; Q3:1; Q4:1; Q3:2; Q4:8; Q3:3; Q4:14; Q3:8
R10 Q1	Performance Assessment of Satellite Precipitation Products over Nigeria: A Compromise Programming Approach - Seoul National University of Science & Technology	Core. Direct Nigerian product-performance comparison, retained with publisher publication-type caveat. Primary publication checked previously; indexed abstract/institutional record. Publisher labels Review Article despite comparative abstract.	Source: Shiru et al. (2025) DOI: 10.1007/s41748-024-00563-1 https://pure.seoultech.ac.kr/en/publications/performance-assessment-of-satellite-precipitation-products-over-n/ Returned positions: Q1:14
R11 Q1, Q3	Evaluation of High-Resolution Gridded Precipitation Datasets Against a Dense Rain Gauge Network During the Indian Summer Monsoon	Excluded. India; no Nigerian gauge-reference results. Title/abstract sufficient to exclude.	https://arxiv.org/abs/2509.20778 Returned positions: Q1:16; Q3:19

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R12 Q1, Q2, Q4	Validation of Satellite and Reanalysis Rainfall Products in Ghana and Zambia	Excluded. Ghana and Zambia; no Nigerian results. Title/abstract sufficient to exclude.	https://arxiv.org/abs/2501.14829 Returned positions: Q1:17; Q2:17; Q4:22
R13 Q1	A Benchmark Dataset for Satellite-Based Estimation and Detection of Rain	Excluded. Benchmark development, no identifiable direct Nigerian gauge-reference evaluation. Title/abstract screened.	https://arxiv.org/abs/2509.08816 Returned positions: Q1:18
R14 Q1	Evaluation of Selected Numerical Weather Prediction Models for a Case of Widespread Rainfall over Central and Southern Nigeria	Excluded. Forecast-model case study posted on Reddit; not a direct gridded-observation evaluation. Title/snippet screened; no empirical claim extracted.	https://www.reddit.com/r/u_merissadennis/comments/cj8kbx Returned positions: Q1:19
R15 Q1	Merging satellite and gauge-measured precipitation using LightGBM with an emphasis on extreme quantiles	Excluded. Merging-method development outside Nigerian evaluation scope. Title/abstract screened.	https://arxiv.org/abs/2302.03606 Returned positions: Q1:20
R16 Q1	Precipitation	Excluded. General encyclopaedia entry, not a primary evaluation. Source type screened.	https://en.wikipedia.org/wiki/Precipitation Returned positions: Q1:21
R17 Q2	Spatio-temporal evaluation of open access precipitation products with rain gauge observations in Nigeria Request PDF	Core. Direct Nigerian multi-product evaluation. Primary publisher abstract checked in original evidence audit; returned ResearchGate mirror not used as sole evidence.	Source: Salami and Fenta (2022) DOI: 10.1007/s12517-022-11071-9 https://www.researchgate.net/publication/366357789_Spatio-temporal_evaluation_of_open_access_precipitation_products_with_rain_gauge_observations_in_Nigeria Returned positions: Q2:1
R18 Q2	(PDF) Multi-Criteria Assessment of Gridded Rainfall Data Accuracy in Nigeria Using Compromise Programming	Core. Direct Nigerian multi-criteria comparison. Primary publisher abstract checked in original evidence audit; returned ResearchGate mirror not used as sole evidence.	Source: Salami et al. (2025) DOI: 10.1007/s41748-025-00601-6 https://www.researchgate.net/publication/389000815_Multi-Criteria_Assessment_of_Gridded_Rainfall_Data_Accuracy_in_Nigeria_Using_Compromise_Programming Returned positions: Q2:3
R19 Q2	Integrating Multi-Sensor Data for Ecologically Sensitive Rainfall Assessment Across Nigeria	Core. Direct eleven-product evaluation across six Nigerian zones. Publisher abstract inspected; complete text inaccessible. CHIRPS v2.0 and GPCC v2018 are identified. First online in 2025; issue year 2026.	DOI: 10.1007/s41976-025-00259-8 https://link.springer.com/article/10.1007/s41976-025-00259-8 Returned positions: Q2:4

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R20 Q2	Comparative assessment of POWER and CMAP satellite-derived rainfall products for hydroclimate monitoring in Nigeria Theoretical and Applied Climatology Springer Nature Link	Core. Direct Nigerian-gauge reference comparison between gauge-adjusted CMAP and POWER. Peer-reviewed publisher full text verified in original audit.	Source: Ellis and Samson (2026) DOI: 10.1007/s00704-026-06121-1 https://link.springer.com/article/10.1007/s00704-026-06121-1 Returned positions: Q2:5
R21 Q2	Microsoft Word - 4th IPWG Program - 10Mar09-VL-2	Excluded. Proceedings compilation rather than an eligible, identifiable Nigerian empirical article. Source type/title screened.	https://www.eorc.jaxa.jp/IPWG/meetings/beijing-2008/4th-IPWG-Proceedings-web-March-2009.pdf Returned positions: Q2:9
R22 Q2	Optimising Rainfall Prediction in Nigeria: Integrating Ground-Based, Satellite, and Climate Model Data	Context. Predictive regression/ARIMA/CMIP5 study; model-fitting performance is contextual, not untreated product-validation accuracy. Primary Springer publisher abstract verified; full text inaccessible.	DOI: 10.1007/s41748-025-00901-x https://link.springer.com/article/10.1007/s41748-025-00901-x Returned positions: Q2:11
R23 Q2	Which rainfall product were: Precipitation Intercomparison	Context. Practical intercomparison guidance, not primary Nigerian evaluation. Guidance webpage.	https://ocha-dap.github.io/ds-precip-intercomparison/which-product/ Returned positions: Q2:13
R24 Q2	Validation and Intercomparison of Satellite-Based Rainfall Products over Africa with TAHMO In Situ Rainfall Observations in: Journal of Hydrometeorology Volume 23 Issue 7 (2022)	Context. Continental TAHMO comparison retained as regional methodological context; no Nigerian-specific inference extracted. Primary journal article search record.	DOI: 10.1175/JHM-D-21-0161.1 https://journals.ametsoc.org/view/journals/hydr/23/7/JHM-D-21-0161.1.xml Returned positions: Q2:15
R25 Q2	Nigerian Journal of Technological Research Federal University of Technology, Minna, Niger State, Nigeria.	Awaiting verification. Repository PDF title is a generic journal header, and access timed out; eligibility cannot be established. Retrieved title/snippet insufficient; no findings extracted.	https://api-uilspace.unilorin.edu.ng/server/api/core/bitstreams/22c88ac6-45a5-447a-9230-e2253833ba97/content Returned positions: Q2:16
R26 Q3, Q4, Q5	Multi-Metric Evaluation of Satellite and Reanalysis Rainfall Products over Southeastern Nigeria: Implications for Hydroclimatic Variability and Agricultural Decision Making	Core. Direct eleven-product comparison against six Nigerian gauge stations; primary publisher PDF retrieved and inspected. Published full PDF inspected. Common monthly performance interval 2000-2019; gauge availability January 2000-July 2025. Release identifiers and station-input overlap remain unresolved.	DOI: 10.7780/kjrs.2026.42.1.8 https://pdf.medrang.co.kr/KJRS/2026/042/KJRS042-01-103.pdf Returned positions: Q3:4; Q4:6; Q5:2
R27 Q3	IMERG: Integrated Multi-satellitE Retrievals for GPM NASA Global Precipitation Measurement Mission	Documentation. Official IMERG landing documentation, not empirical evidence. NASA official source.	https://gpm.nasa.gov/data/imerg Returned positions: Q3:5

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R28 Q3	Precipitation Data Directory NASA Global Precipitation Measurement Mission	Documentation. Official precipitation directory, not empirical evidence. NASA official source.	https://gpm.nasa.gov/data/directory Returned positions: Q3:6
R29 Q3	Global high-resolution precipitation: MSWEP Climate Data Guide	Documentation. MSWEP overview, not an independent Nigerian validation. UCAR Climate Data Guide.	https://climatedataguide.ucar.edu/climate-data/global-high-resolution-precipitation-mswep Returned positions: Q3:7
R30 Q3, Q4	Frontiers Validation of high-resolution satellite precipitation products over West Africa for rainfall monitoring and early warning	Context. West African validation retained as regional context; do not infer a Nigerian result without disaggregation. Peer-reviewed publisher source and institutional mirror.	DOI: 10.3389/fclim.2023.1185754 https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2023.1185754/full Returned positions: Q3:9; Q4:16
R31 Q3	Integrated Multi-Satellite Retrievals for GPM (IMERG V5.2 and V6)	Documentation. IMERG description page, not a direct Nigerian evaluation. University-hosted dataset description.	https://nordata.physics.utoronto.ca/en/annexes-datasets-descriptions/72-precipitation/integrated-multi-satellite-retrievals-for-gpm-imerg-v52-and-v6/ Returned positions: Q3:11
R32 Q3	IMERG Final Run NASA Global Precipitation Measurement Mission	Documentation. IMERG Final documentation/category page, not empirical evaluation. NASA official source.	https://gpm.nasa.gov/taxonomy/term/1417 Returned positions: Q3:12
R33 Q3	IMERG V07 Technical Documentation NASA Global Precipitation Measurement Mission	Documentation. IMERG V07 technical documentation, not empirical evaluation. NASA official source.	https://gpm.nasa.gov/resources/documents/imerg-v07-technical-documentation Returned positions: Q3:13
R34 Q3	Evaluation of gridded rainfall products in three West African basins	Excluded. Senegal, Gambia and Casamance basins, outside Nigeria. Full institutional PDF confirms geographical exclusion.	DOI: 10.3390/hydrology11060075 https://horizon.documentation.ird.fr/exl-doc/pleins_textes/2024-08/010091041.pdf Returned positions: Q3:15
R35 Q3	Statistical Downscaling of Daily Precipitation from ERA5 Atmospheric Fields to IMERG over West Africa	Excluded. Downscaling method using IMERG target, not direct Nigerian gauge-reference validation. Preprint abstract screened.	https://arxiv.org/abs/2610.16816 Returned positions: Q3:16
R36 Q3	MSWEP V3: Machine Learning-Powered Global Precipitation Estimates at 0.1° Hourly Resolution (1979-Present)	Documentation. MSWEP v3 product-development preprint; contextual documentation only, no Nigerian performance inference. Preprint explicitly distinguished from peer-reviewed evidence.	https://arxiv.org/abs/2602.01436 Returned positions: Q3:17

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R37 Q3, Q4	Verification of Operational Numerical Weather Prediction Model Forecasts of Precipitation Using Satellite Rainfall Estimates over Africa	Excluded. Numerical weather prediction forecasts evaluated against satellite estimates, not gridded rainfall estimates against Nigerian gauges. Title/abstract screened.	https://arxiv.org/abs/2201.02296 Returned positions: Q3:18; Q4:19
R38 Q4	Comparative Evaluation of Satellite Measured Data with Ground Measured Data for Five Selected Rainfall Stations in Southwestern Nigeria UNIABUJA Journal of Engineering and Technology (UJET)	Context. POWER-only Nigerian comparison retained as reanalysis/delivery-service comparator context. Primary publisher abstract inspected: 2025, volume 2, issue 2, pages 108-113; comparison period 2002-2012.	https://ujet.uniabuja.edu.ng/index.php/ujet/article/view/72?articlesBySimilarityPage=12 Returned positions: Q4:2; Q4:12
R39 Q4	Comparative Performance Evaluation of Satellite-Based Rainfall Products over South-West Nigeria FUOYE Journal of Engineering and Technology	Core. Direct three-product satellite/reference comparison in southwestern Nigeria. Publisher full PDF verified. Period and product-metadata contradictions limit interpretation; retain without a new definitive ranking.	DOI: 10.4314/fuoyejet.v10i3.23 https://journal.engineering.fuoye.edu.ng/index.php/engineer/article/view/1380 Returned positions: Q4:5
R40 Q4	A Comparison of the Accuracy of Multi-satellite Precipitation Estimation and Ground Meteorological Records Over Southwestern Nigeria - University of Vienna	Core. Direct southwestern Nigerian satellite/reference comparison. Primary publisher abstract checked originally; institutional records are mirrors.	Source: Akinyemi et al. (2020) DOI: 10.1007/s41976-019-00029-3 https://ucrisportal.univie.ac.at/en/publications/a-comparison-of-the-accuracy-of-multi-satellite-precipitation-est/ Returned positions: Q4:9; Q4:10
R41 Q4	Spatio-Temporal Precipitation Trend and Homogeneity Analysis in Komadugu-Yobe Basin, Lake Chad Region	Context. Trend/homogeneity study; does not establish untreated satellite-product accuracy. Title/snippet screened; full repository access timed out.	https://bec.uac.bj/uploads/publication/13c0e0cc2d4a75b1124224dce36380cd.pdf Returned positions: Q4:15
R42 Q4	International Journal of Water Resources and Arid Environments 10(1): 46-55, 2021	Awaiting verification. Generic journal-heading result, no retrievable article text or verified Nigerian comparison. Access blocked by verification page; no findings extracted.	https://www.psipw.org/attachments/article/2977/1.pdf Returned positions: Q4:18
R43 Q4	Quality Assessment of the 20m SPOT DEM in Nigeria	Excluded. Digital elevation model, not rainfall evaluation. Title sufficient to exclude.	https://arxiv.org/abs/2205.02946 Returned positions: Q4:20
R44 Q4	PERSIANN	Excluded. Encyclopaedia product entry, not primary empirical evidence. Source type screened.	https://en.wikipedia.org/wiki/PERSIANN Returned positions: Q4:21

Record and queries	Returned work or source	Decision and reason	Persistent or primary source and occurrence mapping
R45 Q5	Selecting the optimal gridded climate dataset for Nigeria using advanced time series similarity algorithms.	Context. Gauge/reanalysis-only comparison outside satellite-focused core. Primary abstract checked in original audit; PubMed surfaced mirror.	Source: Tanimu et al. (2024) DOI: 10.1007/s11356-024-32128-0 https://pubmed.ncbi.nlm.nih.gov/38308777/ Returned positions: Q5:1
R46 Q5	Evaluation of ground-based, daily, gridded precipitation products for Upper Benue River basin, Nigeria Engineering and Applied Science Research	Context. Gauge-only comparison, outside satellite-focused core. Primary publisher abstract inspected: 2021, volume 48, issue 4, pages 397-405; eight stations during 1982-2006.	https://ph01.tci-thaijo.org/index.php/easr/article/view/242405 Returned positions: Q5:4; Q5:5
R47 Q5	Evaluation of Two Global Rainfall Models for Water Resources Planning and Management in Nigeria FUOYE Journal of Engineering and Technology	Context. Gauge-only CRU/UNIDEL comparison, outside satellite-focused core. Primary publisher abstract inspected; 24 stations during 1980-1999.	DOI: 10.46792/fuoyejet.v5i2.558 https://www.journal.engineering.fuoye.edu.ng/index.php/engineer/article/view/558 Returned positions: Q5:6
R48 Q6	Evaluation Of Satellite Rainfall Products for Water-Related Studies Across Borno State, Nigeria: Abstract Journal of Science and Technology	Core. Direct Borno satellite/reference comparison. Abstract-supported extraction; publisher PDF subsequently checked for bibliography. Journal of Science and Technology 44(3), 1-15 (2026). DOI corrected from the published PDF.	DOI: 10.4314/just.v44i3.1 https://journal.knust.edu.gh/index.php/just/article/download/1946/1463 Returned positions: Q6:4
R49 Q6	NiMet	Excluded. Seasonal forecast service, not gridded-product gauge validation. Official service page.	https://nimet.gov.ng/scp Returned positions: Q6:5
R50 Q6	NiMet	Excluded. Agency homepage, not a direct evaluation record. Official service page.	https://nimet.gov.ng/ Returned positions: Q6:6
R51 Q6	NiMet SCP	Excluded. Seasonal forecast presentations, not a direct evaluation record. Official service page.	https://scp.nimet.gov.ng/ Returned positions: Q6:7
R52 Q6	NiMet	Excluded. State-of-the-climate report, not direct validation of gridded products. Official report page.	https://nimet.gov.ng/SoCN Returned positions: Q6:8

S3 Domain appraisal of the retained studies

The appraisals below concern the material represented by the F/P/A register. Documented information, an identified limitation and an item not assessable from the inspected material are distinguished in the wording. The release/period, reference/matching and diagnostic judgements determine the scope of the final claim. Studies with incomplete access remain visible rather than being treated as complete methodological evaluations.

Table S3. Domain judgements and resulting scope of inference for all 18 core and two comparator publications.

Study role and access	Product identity and period	Reference support and matching	Diagnostic appraisal	Resulting claim
Ogbu et al. (2020) Core; P	Partial: releases unresolved; stated 1983-2013 frame.	24 NiMet gauges; nearest-grid extraction; high-value screening needs event verification.	Amounts, anomalies and trends distinguished; upper-tail screening limits transfer.	Accumulated-rainfall lead; no rare-extreme certification.
Datti et al. (2024) Core; F	ARC2 version 2 identified; CHIRPS/TAMSAT releases unresolved; 2002-2022.	42 gauges; point-to-pixel extraction; reference-day alignment unresolved.	Annual spatial and mean-monthly diagnostics differ from zone-average daily events; signed-ME range is inconsistently printed.	CHIRPS candidate within sampled amount and zone-average comparisons.
Nwachukwu et al. (2020) Core; P	MSWEP v2.2/IMERG Final v6 named; main monthly interval 2000-2012.	11 NiMet gauges; inspected passages describe resampling to 0.1°.	Modified KGE and components; monthly performance and subperiod changes.	Version-specific monthly leads; complete-method appraisal remains partial.
Salami et al. (2024) Core; A	Nine products; release and exact matched dates not assessable from abstract.	48 gauges reported; matching and quality control not assessable.	Threshold-specific categorical results are reported; metric aggregation must be retained.	Preliminary intensity-dependent finding, not a verified heavy-event recommendation.
Tanimu et al. (2024) Comparator; A	Five climate datasets; complete releases and matched dates unresolved.	26 locations; rainfall and temperature combined in the evaluated scope.	Time-series distance and composite criteria; variable-specific interpretation required.	Contextual comparator; no daily-rainfall recommendation.
Ellis and Samson (2026) Core; F	POWER parameter and CMAP pentads identified; 1982-2011.	20 NiMet gauges; observation times unknown; raw and smoothed comparisons distinguished.	Frequency, anomalies and trends explicitly tested; smoothing changes the target statistic.	Strong reason to withhold transfer of broad mean agreement to monitoring skill.
Akinyemi et al. (2020) Core; A	TRMM, CHIRPS and RFE2.0 named; 1998-2016 frame.	Southwestern stations; exact count and matching not assessable from preview.	Reported association; correlation dimension and event definition require full methods.	Preliminary regional correspondence only.
Ogunjo et al. (2022) Comparator; A	Three gauge-based comparators; 1960-2010 monthly frame.	21 locations; station contributions and matching unresolved.	Monthly/seasonal correlation; northern dry-season limits reported.	Comparator context; no evidence for daily timing.
Shiru et al. (2025) Core; A	Five products named; versions, station count and period unresolved.	Source-defined zones; detailed reference design not assessable.	Composite ranking changes the leader; publisher genre label needs clarification.	Abstract-supported zonal leads; exclude from stronger recommendations.
Salami (2026) Core; P	Several releases are named; 1981-2019 is an overall frame; not all products overlap.	48 gauges; GSOD daily and IDW monthly gap-filling identified.	Multiple scales/seasons; reconstructed references need separate treatment.	Scale-dependent evidence with reference-reconstruction limits.
Dawa et al. (2024) Core; P	CRU TS4.06 identified; other releases/intervals need checking; 1981-2021 frame.	Yobe reference support requires complete-method confirmation.	Monthly/annual metrics and SPI-6; not a direct daily-event test.	GPCC lead for the evaluated Yobe accumulated rainfall and drought setting.

Study role and access	Product identity and period	Reference support and matching	Diagnostic appraisal	Resulting claim
Ganiyu et al. (2025) Core; A	IMERG Final v7/CHIRPS v2 named; 2013-2022.	Five gauges; full matching and reference procedures unavailable in preview.	Daily/monthly median r values reported; correlation does not establish bias or event adequacy.	Preliminary local PERSIANN-CDR lead, with modest daily correlation.
Salami et al. (2025) Core; A	Eleven estimates; complete releases and product-specific periods unresolved.	Reference count and comparison details not assessable from abstract.	Composite metrics over several accumulation scales; weights affect ranks.	Preliminary scale- and criterion-dependent ordering.
Salami and Fenta (2022) Core; A	Eleven products; releases and exact evaluated periods unresolved.	NiMet acknowledged; point-to-pixel comparison reported; detailed support unavailable.	Amount and continuous metrics at several scales; intensity-dependent errors reported.	Preliminary error-pattern evidence, not a general product selection.
Usman et al. (2018) Core; P	ARC/CHIRPS/TAMSAT/TRMM; intercomparison 1998-2014, trend frame 1981-2015.	10 daily gauges; 18 wider records; product intervals differ.	Multiscale comparisons followed by growing-season/dry-spell analysis; homogeneity not certified.	CHIRPS accumulated-rainfall lead; trend credibility requires additional checks.
David (2025) Core; F	Four families; releases and product-specific overlap unresolved.	Jos references from NiMet and University of Jos; stated 1998-2021 objective.	Amount-error and detection metrics favour different candidates.	Local, metric-dependent finding; no unique all-purpose leader.
Ogidi et al. (2025) Core; F	POWER/PERSIANN/TRMM releases unresolved; conflicting period statements.	Five named southwestern stations; table 2001-2020 versus results 2002-2012.	Annual continuous metrics cannot resolve the period contradiction.	Withhold a robust product ordering until source ambiguity is clarified.
Wulet et al. (2026) Core; A	Three products; releases and aggregation unresolved; 1993-2021 frame.	Borno NiMet records; station count and matching unavailable in abstract.	Correlation/RMSE and MAE favour different products.	Abstract-supported local evidence; no all-metric or daily-event leader.
Salami and Togo (2026) Core; A	CHIRPS v2.0/GPCC v2018 named; complete dates and releases unresolved.	Six eco-climatic regions; station support not assessable from abstract.	Continuous/composite annual, monthly and seasonal criteria.	Preliminary release-, region- and scale-specific leads.
Onah et al. (2026) Core; F	Eleven families; releases unresolved; common performance interval 2000-2019.	Six southeastern gauges; archive extends to July 2025; nearest-neighbour extraction.	Monthly/seasonal statistics; min-max-normalised comparisons must be separated from rainfall units.	Bound conclusions to the specific monthly diagnostic and interval.

S4 Potential dependence between reference samples

Four national evaluations explicitly use NiMet reference observations. The six pairwise intersections below are calculated from their stated reference-year frames, not from verified station-day or product-specific matches. A shared agency and overlapping dates make dependence possible. They do not establish identical stations, actual reuse or the magnitude of error dependence. Unknown identity is retained as unknown.

Table S4. Reference-window intersections. Every pair name is NiMet; actual station identity and contribution dates remain unresolved.

Study pair	Intersection of stated year frames	Station identity match	Interpretation
Ogbu et al. (2020) / Datti et al. (2024)	2002-2013	Not established from the retained manifests.	Possible shared observations; do not count publications as independent station-sample replications.
Ogbu et al. (2020) / Nwachukwu et al. (2020)	2000-2012	Not established from the retained manifests.	Possible shared observations; do not count publications as independent station-sample replications.
Ogbu et al. (2020) / Ellis and Samson (2026)	1983-2011	Not established from the retained manifests.	Possible shared observations; do not count publications as independent station-sample replications.
Datti et al. (2024) / Nwachukwu et al. (2020)	2002-2012	Not established from the retained manifests.	Possible shared observations; do not count publications as independent station-sample replications.
Datti et al. (2024) / Ellis and Samson (2026)	2002-2011	Not established from the retained manifests.	Possible shared observations; do not count publications as independent station-sample replications.
Nwachukwu et al. (2020) / Ellis and Samson (2026)	2000-2011	Not established from the retained manifests.	Possible shared observations; do not count publications as independent station-sample replications.

S5 Product manifests for the worked example

The example concerns the 42-station 2002-2022 evaluation by Datti et al. (2024). The inspected documentary chain includes the evaluation and development papers for CHIRPS, TAMSAT and ARC2 (Funk et al., 2015; Maidment et al., 2017; Novella & Thiaw, 2013). It identifies construction pathways but does not provide a dated contribution or withholding record for the evaluation stations themselves. Later CHIRPS v3 information is retained as release-change context and is not used to assign an unspecified older release.

Table S5. Product-specific documentary records and independence decisions. A known gauge pathway is distinct from a proven contribution of particular NiMet records.

Evaluated family	Release identity	Documented construction pathway	Missing station and date evidence	Decision
ARC2	Version 2 is named in the evaluation.	Infrared observations and daily GTS gauges are documented construction inputs (Novella & Thiaw, 2013).	A station-and-date crosswalk between the 42 NiMet references and relevant GTS inputs was not established.	Unresolved: a known gauge-input pathway warrants investigation; specific overlap is not demonstrated.

Evaluated family	Release identity	Documented construction pathway	Missing station and date evidence	Decision
CHIRPS	The evaluation does not identify the release; a later release must not be assigned retrospectively.	Infrared estimates, climatological information and station blending are documented at product-family level (Funk et al., 2015). Later v3 changes are separate (Climate Hazards Centre, n.d.; Funk et al., 2026).	No release-matched station contribution/exclusion record was established for the evaluation dates.	Unresolved: current station-density diagnostics alone cannot certify historical station independence.
TAMSAT	The evaluation does not identify the release.	Cold-cloud-duration relationships use historical gauge calibration; daily allocation and the calibration pathway require release-specific description (Maidment et al., 2017).	No dated crosswalk or withholding statement linking the NiMet evaluation records to calibration inputs was established.	Unresolved: distinguish historical calibration from contemporaneous gauge blending.

Verified independence would require positive, dated evidence of exclusion or withholding for the evaluated station records and for every identified relevant construction pathway. Documented overlap requires an identified station-and-date contribution and its pathway. Incomplete inventories, unidentified releases or unresolved archive aliases leave the decision unresolved. The current assessment does not claim a provider response or station-inventory match that was not obtained. A study-specific calibration holdout is reported separately and cannot be used to remove observations already incorporated into the original product.

Diagnostic reporting also matters. In the Datti methods, signed mean error is accompanied by a nonnegative printed range (Datti et al., 2024). Its definition allows negative differences, so that range needs clarification. This is a reporting inconsistency rather than evidence of a computational error. The occurrence diagnostics refer to zone-average rainfall and do not directly establish event detection at individual stations.

S6 Sensitivity to source access restrictions

The full core comprises 18 records. Removing the eight A-tier records leaves 10 F/P records; retaining only F leaves five. These are transparent restrictions on assessable source material, not numerical quality weights or publication-bias tests. A claim is retained only when its named supporting comparison remains in the restricted corpus. Loss of an abstract-supported claim does not establish poor performance of the product it discussed.

Table S6. Claim-level sensitivity. Supporting publications remain identifiable through S1 and the APA references.

Claim or application	All 18 core records	After removal of A records	F records only
CHIRPS for specified accumulated-rainfall settings	Supported as a conditional candidate in several comparisons (Datti et al., 2024; Ogbu et al., 2020; Usman et al., 2018).	Retained after removing eight A-tier core studies; relevant F/P sources remain.	Datti remains as a full-text example; interpretation stays within its settings and diagnostics.

Claim or application	All 18 core records	After removal of A records	F records only
MSWEP v2.2 and IMERG Final v6 in the named monthly comparison	A release-specific lead from inspected passages (Nwachukwu et al., 2020).	Retained because Nwachukwu is P, not A.	The specific 11-gauge comparison is not retained under F-only restriction; this does not prove poor product performance.
Zonal annual leaders and local PERSIANN-CDR preferences	Several leads rely on abstracts (Ganiyu et al., 2025; Salami & Togo, 2026; Shiru et al., 2025; Wulet et al., 2026).	These particular ordering claims are removed; they remain questions for full-method verification.	The F-only corpus does not restore these specific comparisons.
Independent validation and station-level rare extremes	No entry has verified station independence; zone-average Q90 is not a station-level rare-extreme test.	The absence of certification is unchanged.	The absence of certification remains unchanged; it is an evidentiary limitation, not proof that every product is unsuitable.

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