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A Near-Real-Time Precipitation Product Intercomparison and Validation System for Operational and Research Applications

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SYSTEM AT A GLANCE

~30	60+	0.25°	6	NRT
precipitation products	**automated comparisons**	**common regular grid**	**cascading modules**	**updates**
satellite · rain gauge · radar	same method for every pair	pixel-by-pixel comparison	day → month → season → full period → multi-pairs	operational since July 2024

01 CONTEXT & MOTIVATION

Satellite, reanalysis and ground-based precipitation products have multiplied in recent years, but each embeds different observing sources and retrieval schemes leading to non-negligible differences in accuracy, systematic bias and event-detection skill.

Building on the methodological heritage of EUMETSAT H SAF, CNR-ISAC and DPC developed SPC (Satellite Precipitation Comparison): a near-real-time validation and intercomparison system spanning single-event to climatological assessment, supporting both operational monitoring and research.

02 KEY FEATURES & NOVELTY

Systematic N×M cross-comparison: identical methodology for every pair

0.25° common grid: rain gauges, radar mosaics and satellite products enter as pixel-based comparisons

Two-level hierarchical matching: balances computational efficiency and accuracy, robust on orbital products

Fully automated & traceable: every output (scores, results, images, binaries, jsons, …) reconstructible from source files

Native L2 + L3 support: orbital products (DPR, GMI) and gridded products handled with the same pipeline

Easy addition of new products: adding new products only requires a product configuration card

03 SYSTEM ARCHITECTURE — from ~30 raw products to over 60 comparisons into a live web platform

INPUT: 5 product families

- **GEO** — H SAF (H60B, H61B, …) · NWC SAF (CRR)
- **LEO / L2** — GMI · DPR (native orbital)
- **L3 gridded** — IMERG · GSMaP · SM2RAIN · CMORPH
- **Radar** — Italian mosaic · European OPERA
- **Gauges** — EGD · CPC · GPCC

unified reader → one in-memory structure:
rain · quality (0–100 %) · time · lat/lon

CORE ENGINE

Comparison code with arguments : product, reference, domain and grid

1 · **Temporal matching (two-level)**
L0 metadata pre-filter (no file read) · L1 refined Δt pairing

2 · **Spatial matching (two-level)**
L0 bounding-box test · L1 bidirectional pixel masks

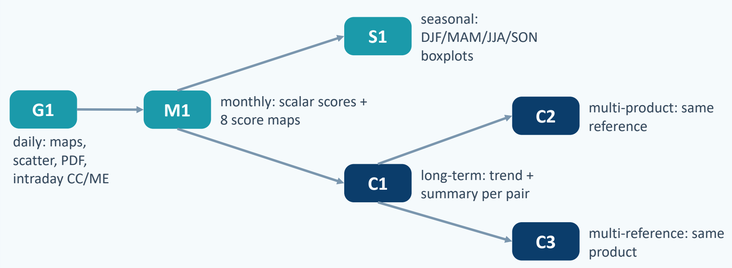
3 · **Quality filtering**
physical limits + per-product quality thresholds

4 · **Regridding to common 0.25° grid**
natural-neighbor · convex-hull mask · cached Delaunay

5 · **Metrics (see Section 04)**
continuous · categorical · volumetric · field similarity

6 · **Comparison outputs**
Binaries, images, scalar and spatial scores, json files

HIERARCHICAL STATISTICS PIPELINE: 6 cascading modules (See Sect. 06)



each module reads only the previous level — full traceability from any PNG back to its source daily file

WEB FRONT-END

spc.artov.isac.cnr.it

- every pair & module browsable in NRT
- operational monitoring for users/developers/DPC
- updated in near real time

→ *scan the QR*

FULLY AUTOMATED BACK-END — cron-driven on two servers (EWC · Sirio) · incremental NRT updates: only new or changed data is reprocessed · idempotent runs

04 DIAGNOSTIC TOOLKIT — all statistical scores and relative thresholds used to compare products

Continuous (thresholds 0 / 0.25 / 1 / 10 mm)
ME · MAE · MB · STD · CC · RMSE · KGE · FSE · NSE

Volumetric
VHI · VFAR · VMI · VCSI (events weighted by rain volume)

Categorical (thresholds 0.25 / 1 / 10 mm)
POD · FAR · MIS · CSI · ETS · HSS

Field similarity
Cosine similarity · Jaccard index · L1 / L2 distance

05 APPLICATIONS & FUTURE WORK

Applications

- ✓ Product calibration & algorithm refinement
- ✓ Benchmarking new sensors — e.g. ongoing MSG → MTG comparison (H60B vs H40B)
- ✓ Operational support to DPC for hydrometeorological risk management
- ✓ Performance matrices for future multi-product combination / blending strategies

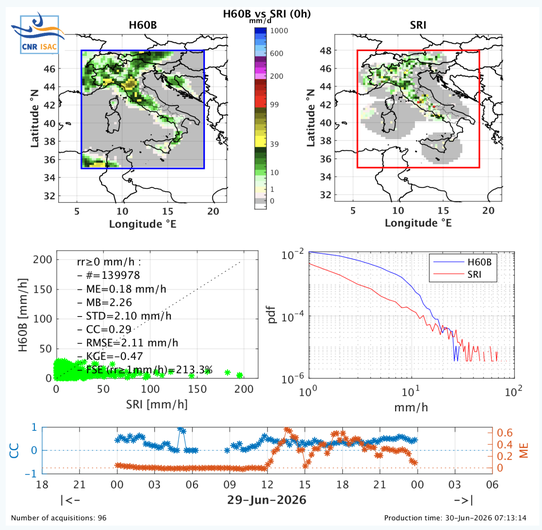
Future developments

- ➢ Configurable Areas of Interest (AOI) and interactive web front-end
- ➢ Migration to a relational database with user-configurable queries
- ➢ Statistical significance testing for multi-product/reference comparisons; multi-year climatological score maps
- ➢ Expanding the portfolio of integrated products

06 RESULTS SHOWCASE — example of results browsable on the live platform

EVENT / DAILY SCALE — MODULE G1 · Italy, H SAF vs ground radar · 29 June 2026 convective system

G1 — H60B vs SRI — 15-min instantaneous



G1 · daily output — accumulation maps on the common grid, scatter density, rain-rate PDF and intraday CC/ME evolution for one product–reference pair (96 × 15-min acquisitions).

H60B vs SRI — instantaneous, 15-min native resolution, 96 acquisitions/day

N = 139,978 pixel pairs
ME = +0.18 mm/h MB = 2.26
CC = 0.29 RMSE = 2.11 mm/h
KGE = −0.47 FSE (≥1 mm/h) = 213%

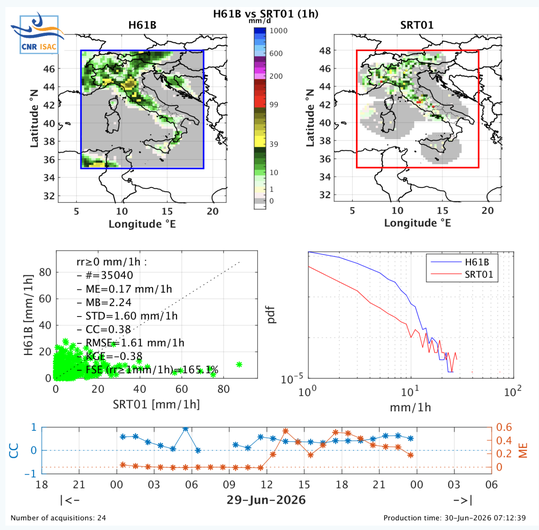
Same event, coarser accumulation:
H61B vs SRT01 (1h accumulated, 24 acq./day)

CC = 0.38 (vs 0.29 instantaneous)
RMSE = 1.61 mm/h (vs 2.11 mm/h)
KGE = −0.38 (vs -0.47)

Temporal aggregation scale visibly affects apparent skill.
The same reason daily (G1) and monthly (M1) statistics are not directly comparable.

Both products correctly capture the convective cell along Italian peninsula. The maps agree on location and shape, while the scalar scores expose exactly how much the intensity estimate still diverges pixel-by-pixel.

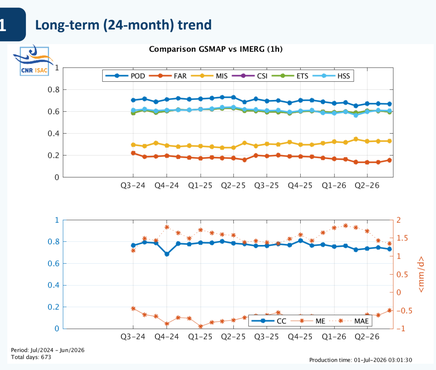
G1 — H61B vs SRT01 — 1-h accumulated



Same event through the 1-h accumulated chain (24 acquisitions): identical layout, coarser time base — the aggregation effect quantified in the centre panel.

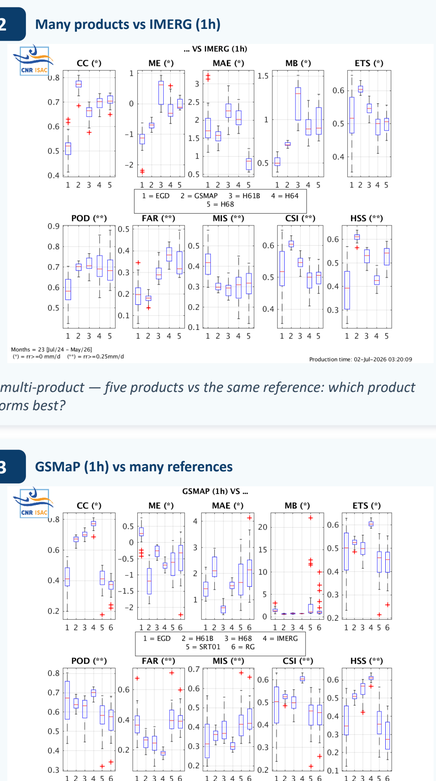
LONG-TERM SYNTHESIS — C1 · C2 · C3

C1 — Long-term (24-month) trend



C1 · full-period synthesis, one pair — monthly scores over 24 months / 673 days: CC stable at 0.70–0.80.

C2 — Many products vs IMERG (1h)



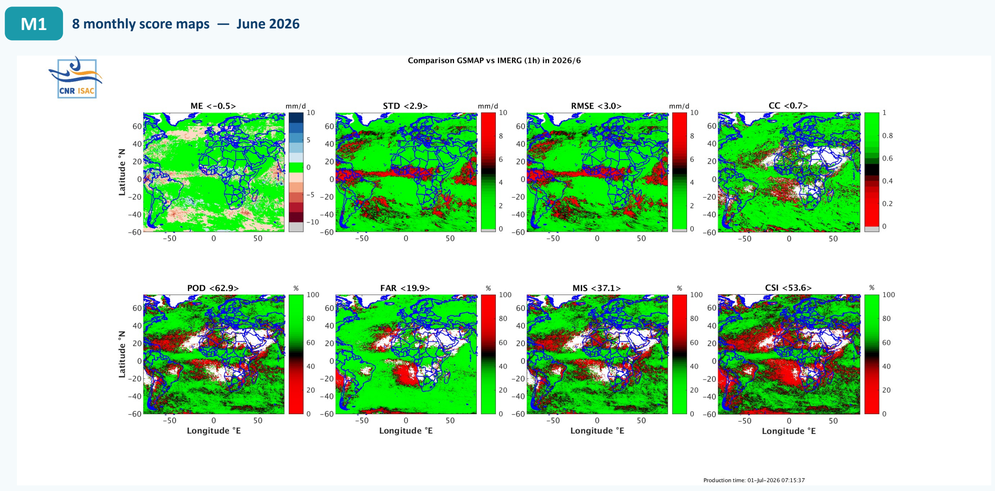
C2 · multi-product — five products vs the same reference: which product performs best?

C3 — GSMaP (1h) vs many references

C3 · multi-reference — one product vs six references (gauges, radar, satellite): how robust across ground truths?

MONTHLY & SEASONAL SCALE — MODULES M1 · S1 · GSMaP vs IMERG (1h), full disk · Jul 2024 – Jun 2026

M1 — 8 monthly score maps — June 2026



M1 · monthly output — maps of eight mean-daily scores (ME, STD, RMSE, CC / POD, FAR, MIS, CSI) on the 0.25° grid: low CC over Sahara/Middle East (few rain days), high POD/CSI along the ITCZ — the spatial counterpart of the (Section 04) scalar scores.

S1 — Seasonal boxplots + data availability

S1 · seasonal output — DJF/MAM/JJA/SON distributions of the monthly scores (11 metrics) with the day-availability record, Jul 2024 – Jun 2026.

ONE pipeline, MAIN products, INFINITE combinations: from a single convective event to a multi-year global analysis, same metrics end-to-end

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Live platform - Precipitation products, comparisons and results updated in near real time

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Funded by Civil Protection Department · Built on EUMETSAT H SAF methodology · Data: EUMETSAT (H SAF/EGD/NWC SAF), NASA/JAXA (IMERG, DPR, GSMaP), EUMETNET (OPERA), NOAA/CPC, DWD/GPCC, DPC/SRI