

THE EVOLUTION OF COMPOSITING IN
BALTRAD – AN EVALUATION

SMHI

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1 RADAR COMPOSITING

Two-dimensional weather radar composites of reflectivity or precipitation are widely used by forecasters and in downstream applications. Traditional distance-based methods, such as “closest radar” and “minimum distance to the Earth”, select radar cells in overlapping areas. Quality-based methods instead use quality indicators and acceptance criteria.

The open-source BALTRAD software [1] provides a compositing factory implementing these methods. Following a successful proof of concept presented at ERAD 2024, Adaptive Compositing of Quality Volume data (ACQVA) [2] is undergoing pre-operational evaluation. Its processing chain includes clutter and blockage handling, path-integrated attenuation correction, and optional gauge–radar bias adjustment.

Table 1: Radar composite products evaluated, with a brief description of the methods and input data.

Product	Compositing method	Input
HCOMP	Legacy height-based compositing using each radar's PCAPPI at a height of 500 m	• Full volume • Beam height above mean sea level
QCOMP	Quality-based compositing using each radar's PCAPPI at a height of 500 m	• Full volume • Quality indicators: "bropo", intensity, ground proximity
ACQVA	Lowest valid data from any sweep. Validity determined by categorisation.	• Full volume • Categorisation: "beamb", clutter map

2 RADAR DATA AND PRODUCTS

Data were collected through SMHI's operational radar data exchange with Denmark, Estonia, Finland, Germany, Lithuania, and Norway. Quality control (QC) was performed using the BALTRAD Toolbox.

For HCOMP and QCOMP, QC was applied during compositing. For ACQVA, QC was applied to the volumes before compositing, including anomaly removal with “bropo”, beam-blockage correction with “beamb”, and path-integrated attenuation correction.

The evaluation considers the three products listed in Tab. 1, all without gauge–radar bias adjustment.

3 REFERENCE DATA AND EVALUATION

The evaluation used an SMHI verification tool developed to assess precipitation products against the national hydrological dataset PTHBV [3] and rain gauge observations. The tool was extended to include daily precipitation from CERRA-Land [4].

Based on the availability of radar products and reference datasets, the evaluation covered October 2023 to April 2025 and included only January, April, July, and October as representative months for the four seasons.

The selected statistical measures assess different aspects of product performance, including precipitation bias and precipitation frequency, relative to the reference datasets (Tab. 2).

Table 2: Selected statistical measures, including the definition and constituents of “comp score”. The “Direction” column indicates whether higher or lower values are preferred, together with the value representing perfect agreement between the product and reference.

Measure	Description	Direction
comp score	The composite score comprises five transformed measures: ACCSUM, MCC 0.1, MCC 1, NSE, and MAE	Lower Perfect: 0
KGE	Kling–Gupta efficiency combines correlation, the variance ratio, and the mean ratio between the product and the reference	Higher Perfect: 1
NSE	Nash–Sutcliffe efficiency, measuring the relative magnitude of the product error compared with the variability of the reference	Higher Perfect: 1
ACCSUM	Relative accumulated precipitation difference between the product and the reference over the evaluation period, expressed as a percentage	N/A Perfect: 0
MCC T	Matthews correlation coefficient for categorical wet/dry agreement at threshold T	Higher Perfect: 1
MAE	Mean absolute error: mean absolute difference between the product and the reference, expressed in mm per timestep	Lower Perfect: 0

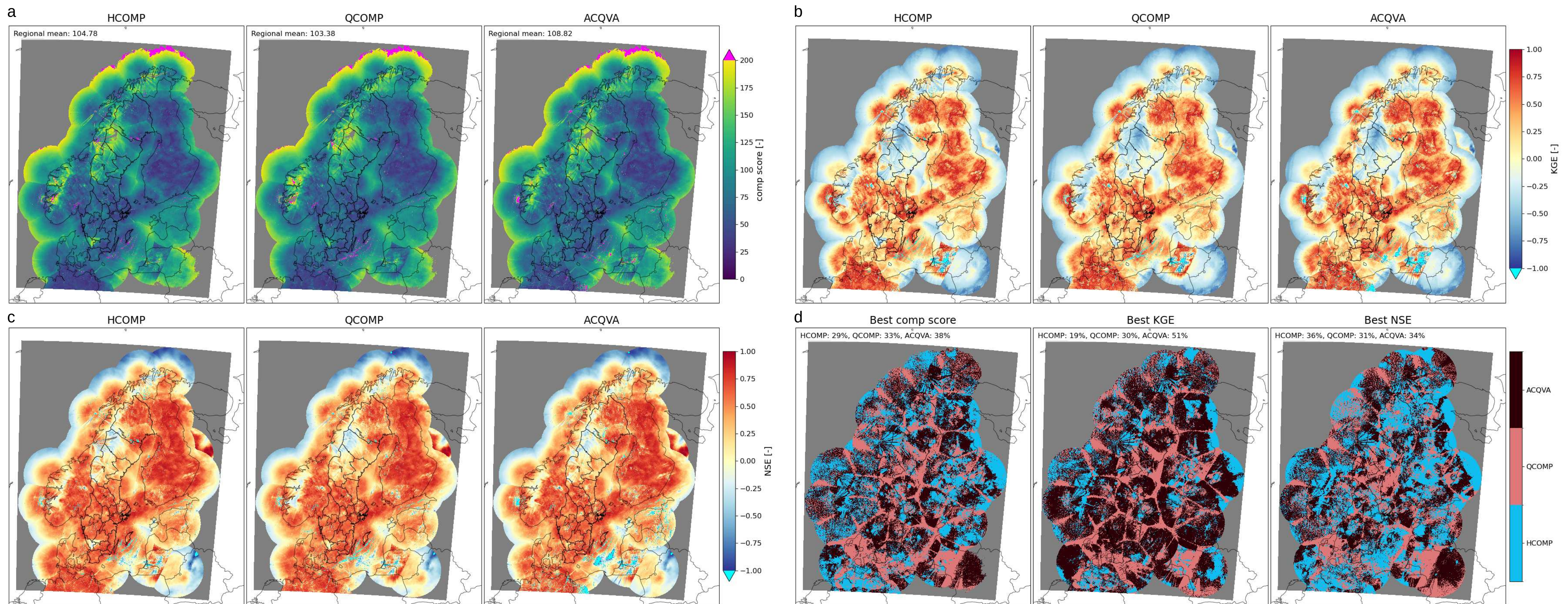


Figure 1: Evaluation results for each product and statistical measure (2023-2025). Invalid pixels are shown in grey. (a) Composite score, including the mean across valid pixels. (b) Kling–Gupta efficiency. (c) Nash–Sutcliffe efficiency. (d) Best-performing product at each location for each statistical measure. Fractional area coverage is also shown. Note that the Finnish radar Nurmes was introduced into SMHI's products during this period. This inconsistency is clearly visible in (b) and (c), but is excluded from (a) and (d) to ensure fair comparisons of mean values and fractional area coverage.

4 RESULTS

Figure 1 shows that the statistical measures provide both consistent and contrasting results. For example, the mean composite score indicates that QCOMP performs best (Fig. 1a), whereas ACQVA achieves the largest fractional area coverage (Fig. 1d).

The quality of the CERRA-Land dataset is expected to be highest over land and within the underlying inner NWP model domain. However, this spatial variation in quality has not been taken into account in the present study.

5 OUTLOOK

For a complete and consistent evaluation, we aim to reproduce all products using identical input radar data, preferably the data provided to EUMETNET OPERA.

As the OPERA NIMBUS production chain uses BALTRAD as its processing engine, ACQVA could potentially improve the NIMBUS products. Figure 2 shows preliminary results from a comparison of the NIMBUS rain-rate product with the other products included in the evaluation.

Further development of ACQVA will focus particularly on clutter rejection.

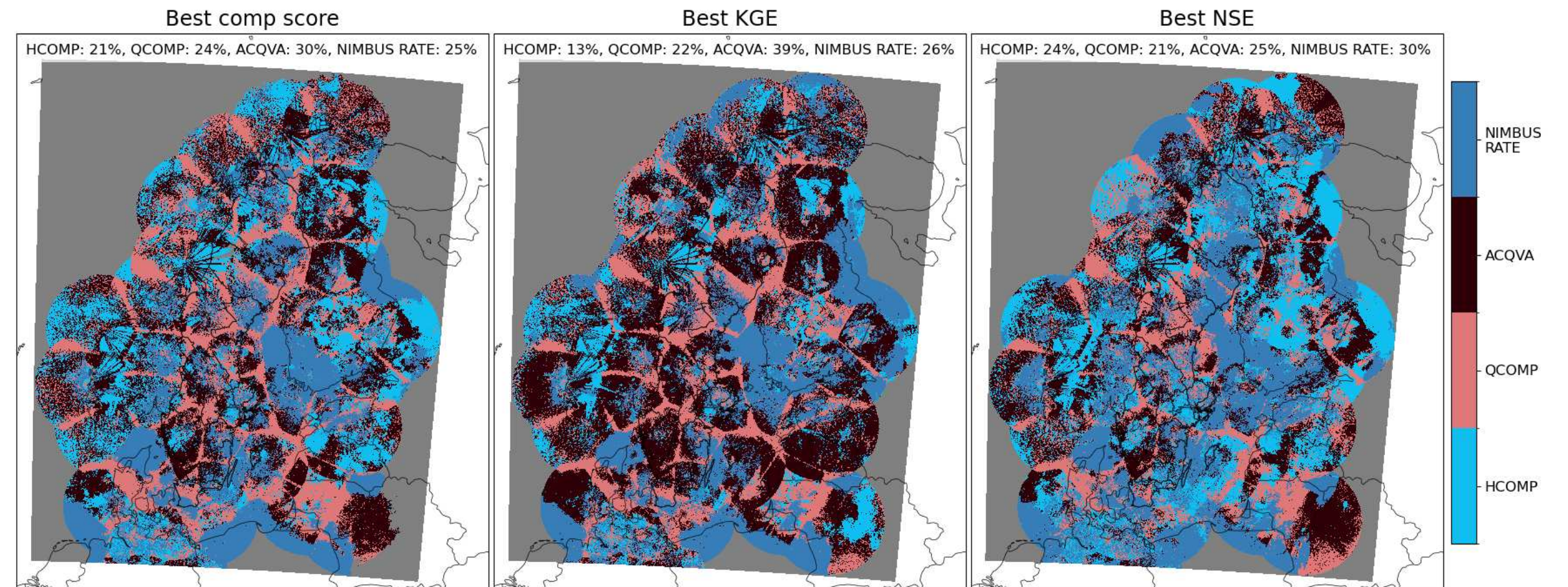


Figure 2: The OPERA NIMBUS rain-rate composite product included in the evaluation. The comparison assesses which product performs best for each statistical measure at each location. Note that the NIMBUS product includes data from additional radars, particularly in the southern part of the domain.

REFERENCES

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