IMPROVER Tools for Physically Consistent Realizations: Extra information

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This document offers supporting material for the poster *IMPROVER Tools for Physically Consistent Realizations*, presented at EMS2026. Specifically, below is a repeat of the poster contents, alongside links to relevant documentation from the IMPROVER repository.

Contents

Poster

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IMPROVER Tools for Physically Consistent Realizations

Open-source Python functionality for transforming calibrated probabilistic forecasts into coherent weather scenarios

IMPROVER is a weather post-processing toolbox, providing calibrated, multi-model blended probabilistic forecasts that improve forecast skill and reliability.
The physically consistent realisations toolbox converts these calibrated probabilistic forecasts into coherent weather scenarios, enabling downstream applications that require forecasts to be consistent across space and time.

1 Realization clustering

The challenge
Create a small set of realistic weather trajectories that represent the range of possible weather scenarios.

IMPROVER capability
- Use **K-Medoids clustering** to reduce large ensembles into representative scenarios.
- Select trajectory templates from raw ensemble members.
- Match forecasts from multiple forecast systems to trajectories.
- Track forecast-source provenance.

Example
51 ECMWF members → 24 representative trajectories → matched nowcast, UKV and ensemble guidance.

2 Probability sampling

The challenge
Replace raw model values with calibrated forecast values whilst preserving realistic weather structure.

IMPROVER capabilities
- Apply **Ensemble Copula Coupling (ECC)** to combine calibrated values with trajectory templates *(see Schefzik et al., 2013)*. Supports ECC-Q and ECC-T.
- Preserve spatial and temporal rank structure.
- Generate calibrated realisations from probabilities and percentiles.

Example
The wettest trajectory remains the wettest member after calibration but now contains calibrated precipitation values.

3 Trajectory blending

The challenge
Create seamless forecast evolution across forecast systems, lead times and temporal resolutions.

IMPROVER capabilities
- Blend multiple forecast sources into a continuous trajectory.
- Fill temporal gaps between forecasts.
- Smooth forecast-source transitions.
- Generate intermediate forecast fields using standard interpolation methods or Google FILM.

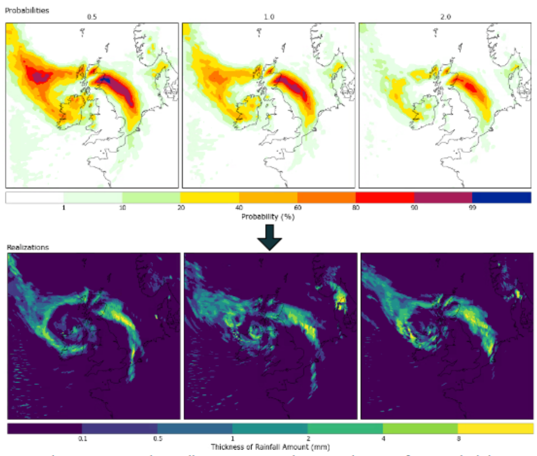
Example
Nowcast → UKV → Ensemble guidance combined into one continuous weather evolution.

4 Improve realism

The challenge
Large areas of identical values (e.g. zero precipitation) make ensemble ranking ambiguous.

IMPROVER capabilities
- Generate spatially correlated stochastic noise using a Short-Space Fourier Transform approach (see *Nerini et al., 2017*).
- Resolve tied ensemble members.
- Increase ensemble diversity.
- Avoid unrealistic pixel-scale artefacts.

Example
Multiple dry ensemble members can be uniquely ranked before ECC is applied.



Example: Generating physically consistent realizations (bottom) from probabilistic forecasts (top).

5 Recover fine-scale structure

The challenge
Calibration improves reliability but can smooth local extremes and small-scale weather features.

IMPROVER capabilities
- Compare ECC-generated realizations against the original template realizations.
- Apply quantile mapping to recover some of the local-scale variability present in the raw forecasts.
- Restore sharper spatial features.
- Reintroduce realistic local extremes whilst retaining calibration.

Example
A smoothed rainfall field is adjusted to recover realistic precipitation maxima and sharper spatial features.

References

Nerini, D. *et al.* (2017) "A non-stationary stochastic ensemble generator for radar rainfall fields based on the short-space Fourier transform," *Hydrology and Earth System Sciences*, 21(6), pp. 2777–2797. Available at: https://doi.org/10.5194/hess-21-2777-2017.

Schefzik, R., Thorarinsdottir, T.L. and Gneiting, T. (2013) "Uncertainty quantification in complex simulation models using ensemble copula coupling," *Statistical Science: A Review Journal of the Institute of Mathematical Statistics*, 28(4), pp. 616–640. Available at: https://doi.org/10.1214/13-sts443.

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Links to tools within the IMPROVER toolbox

Poster section	Task name	Tool name (hyperlinked)
1	Realization clustering	RealizationClusterAndMatch
2	Probability sampling	ConvertProbabilitiesToPercentiles CalculatePercentilesFromIntensityDistribution EnsembleReordering
3	Trajectory blending	RealizationClusterAndMatch ForecastTrajectoryGapFiller TemporalInterpolation GoogleFilmInterpolation
4	Improve realism	StochasticNoise
5	Recover fine-scale structure	QuantileMapping

References

Nerini, D. *et al.* (2017) "A non-stationary stochastic ensemble generator for radar rainfall fields based on the short-space Fourier transform," *Hydrology and Earth System Sciences*, 21(6), pp. 2777–2797. Available at: https://doi.org/10.5194/hess-21-2777-2017.

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