The Bureau of Meteorology

Convective-scale models in Improver

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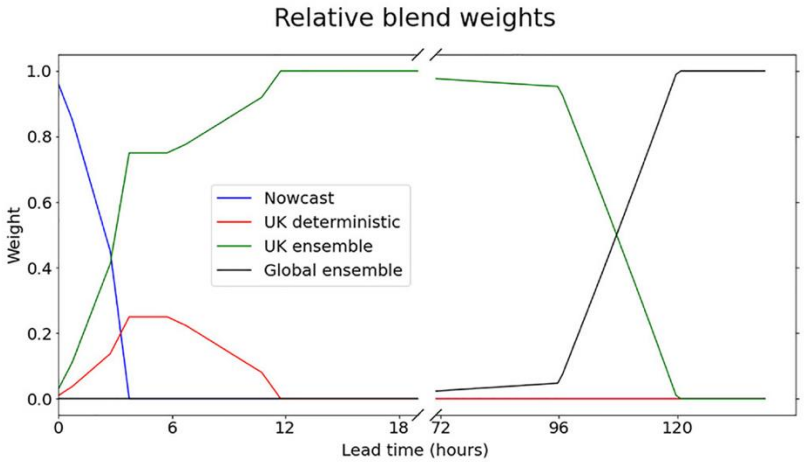
Improver: preparing for convective-scale

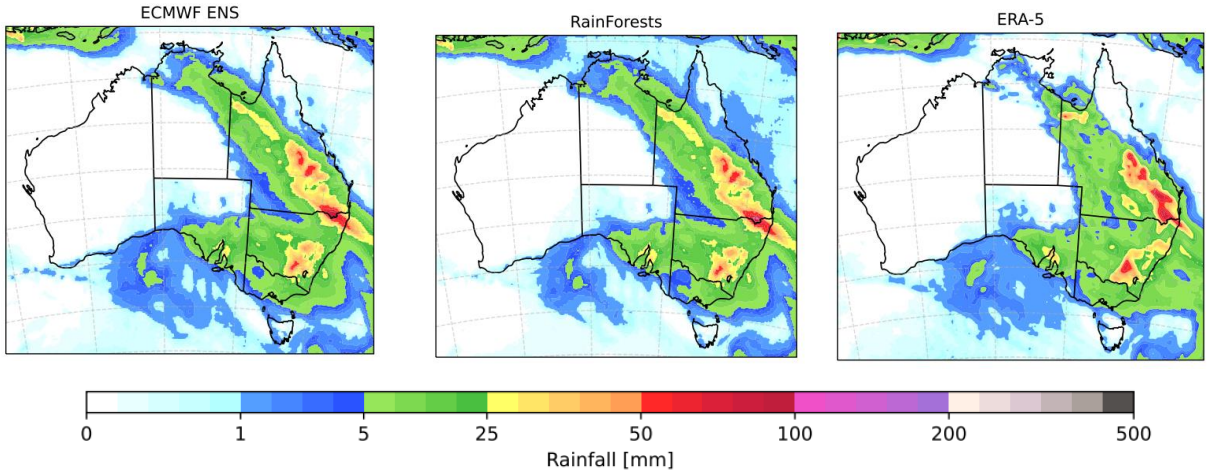
- Improver currently uses 4 models: ECMWF-ens, ECMWF-HRES, ACCESS-GE, ACCESS-G.
- Plans to add convective scale ACCESS-CE and ACCESS-C in future. Significant work needed because they have restricted spatial domain and forecast period.
- Met Office implementation includes convective deterministic and ensemble models.
- Improver makes integrating convective-scale models easy:
  - Time-varying blending weights.
  - Aggregation in space and time to better estimate uncertainty.
  - Reliability calibration to ensure models have similar distributions.



Model weights at Met Office (Roberts et. al., 2023)

Rainforests: ML post-processing for rainfall

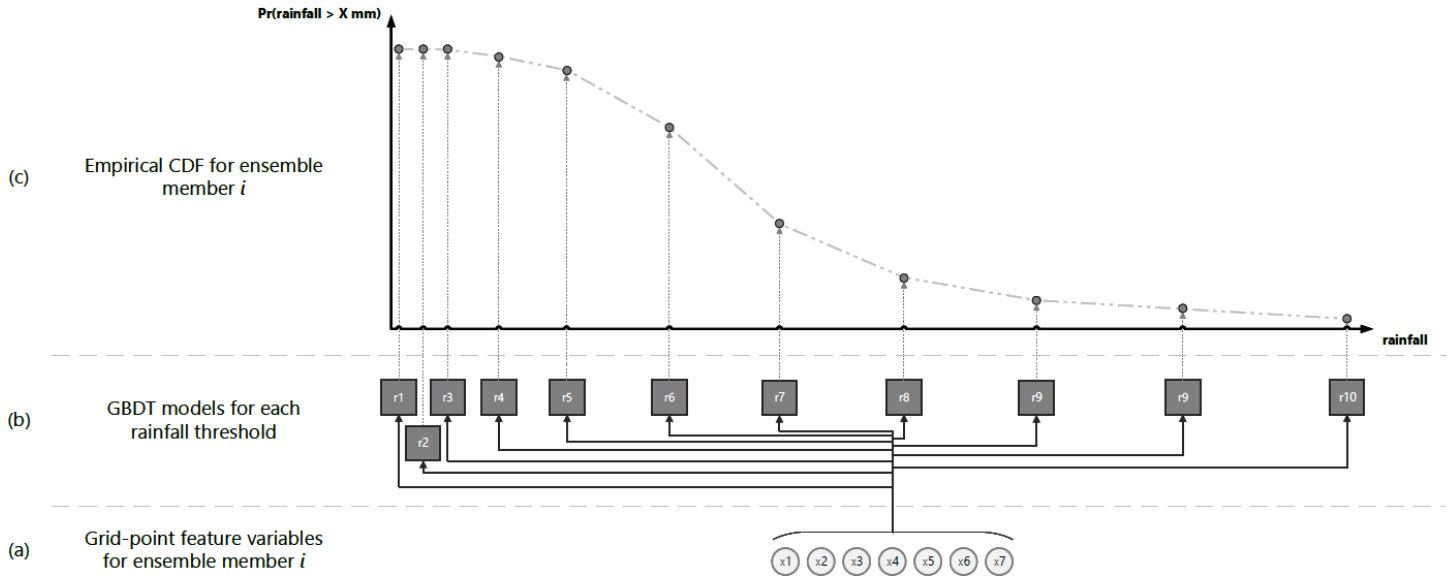
- Calibrates output from NWP models ECMWF-ens, ECMWF-HRES, ACCESS-GE, and ACCESS-G. More models are planned in future, including convective-scale ACCESS-C.
- Learns to downscale from grid-cell to point scale, correcting for errors caused by parametrised convection.
- Uses NWP forecasts of total and convective precipitation, windspeed, convective and potential energy to better estimate uncertainty in NWP.
- Based on ecPoint (developed by ECMWF), but more automated, fully-ML approach using gradient-boosted decision trees.
- Outperforms benchmark parametric and non-parametric non-ML approaches.



Expected value forecasts for valid time 2021-11-12 UTC 0

Rainforests: model structure

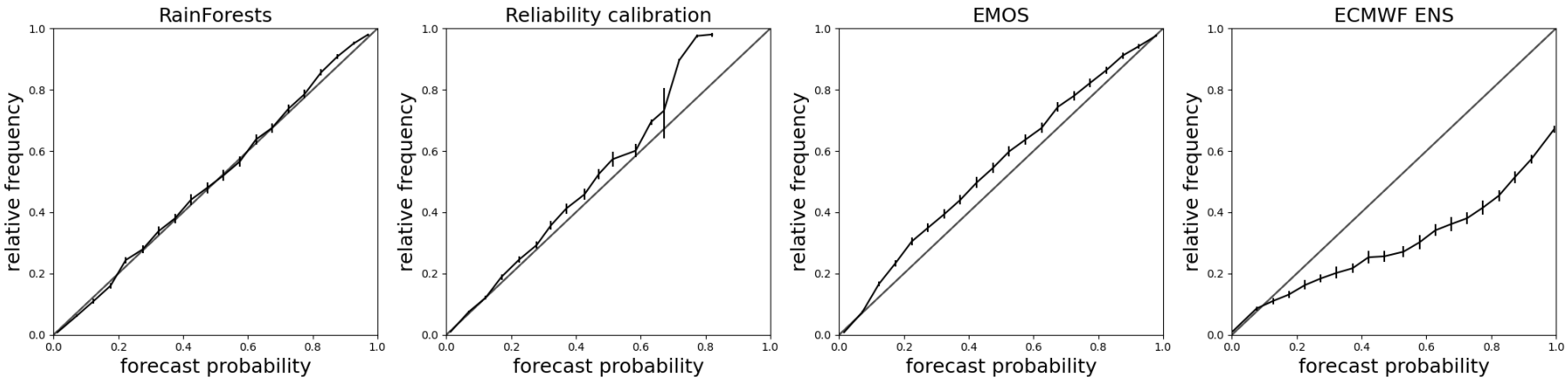
- Individual gradient-boosted decision tree (GBDT) model for each threshold predicts probability of exceedance.
- Ensemble members processed separately, then predicted distributions averaged.



(a) Construction of the per-member CDF. At each grid point, the feature variables from the ensemble member (a) form the inputs to the GBDT models, with a separate model for each threshold (b). These models predict the probability of exceedence for the given threshold; collectively these probabilities form the CDF for the ensemble member at the given grid point (c).

Results: reliability

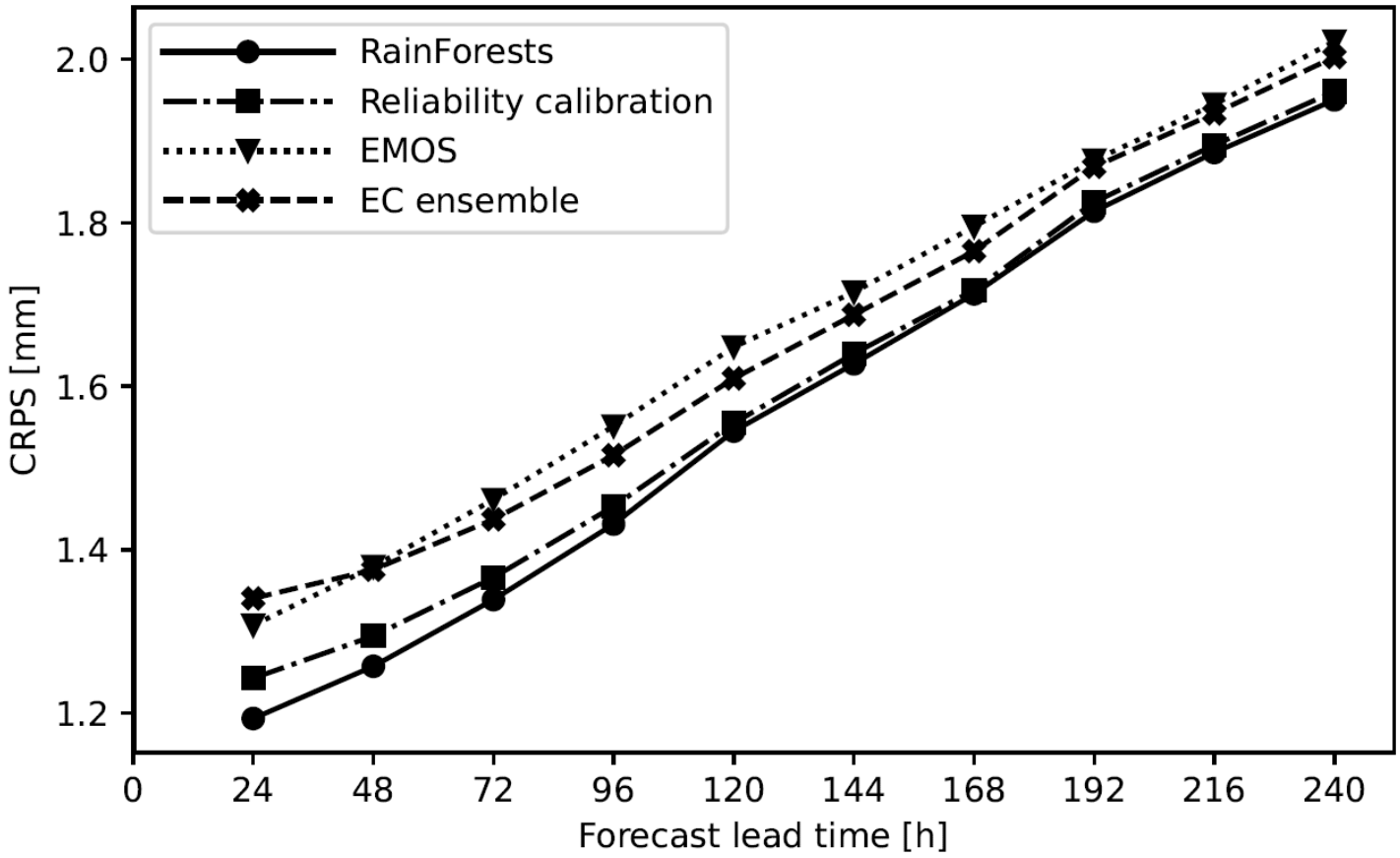
Rainforests has excellent calibration compared to the raw ensemble and benchmark methods. The raw ensemble tends to be over-confident, while the benchmark methods are somewhat under-confident.



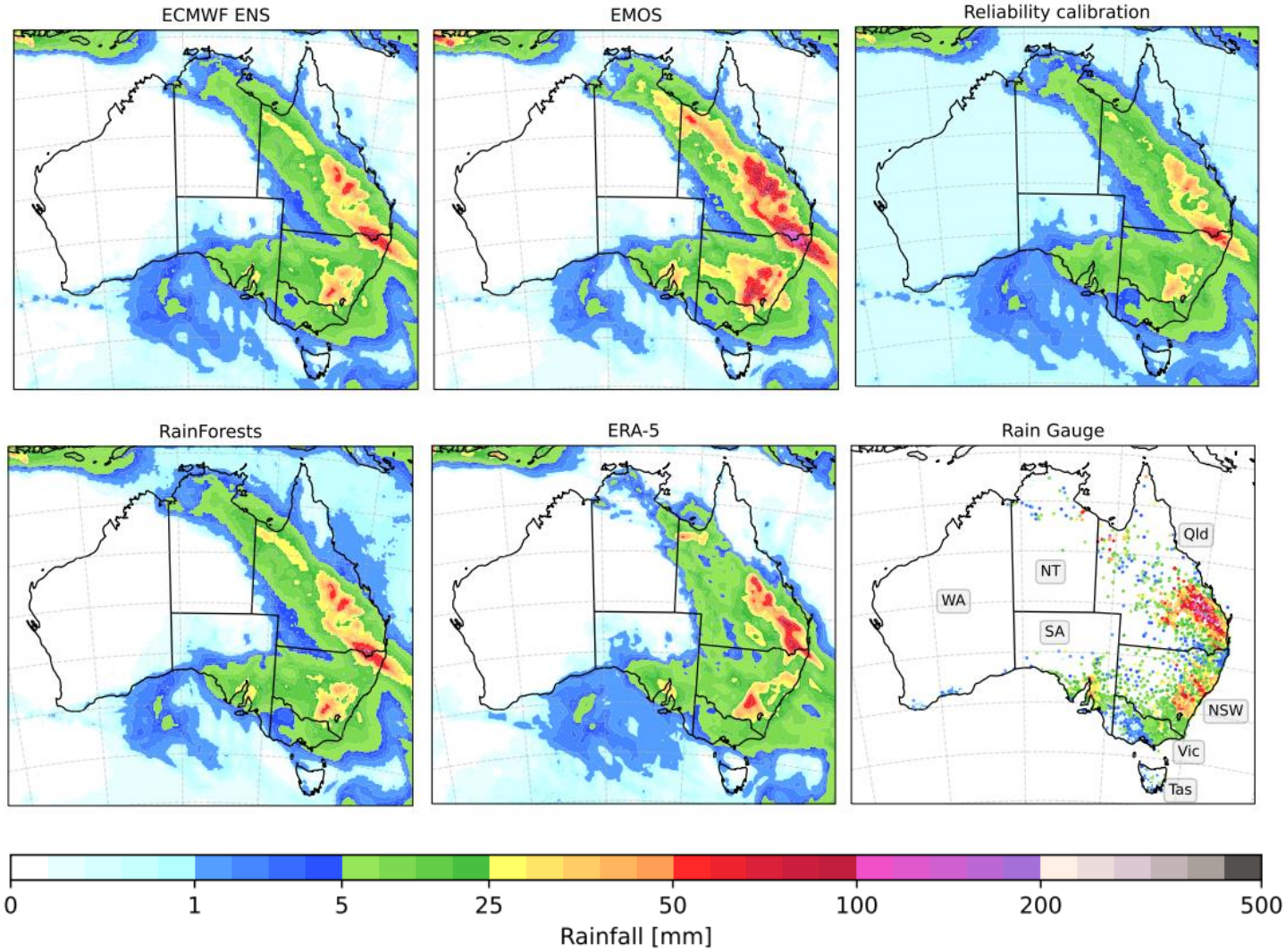
Reliability calibration curves at 1 mm threshold.

Results: CRPS

Rainforests has better CRPS than raw ensemble and benchmark method, with the largest gains at the short lead times.



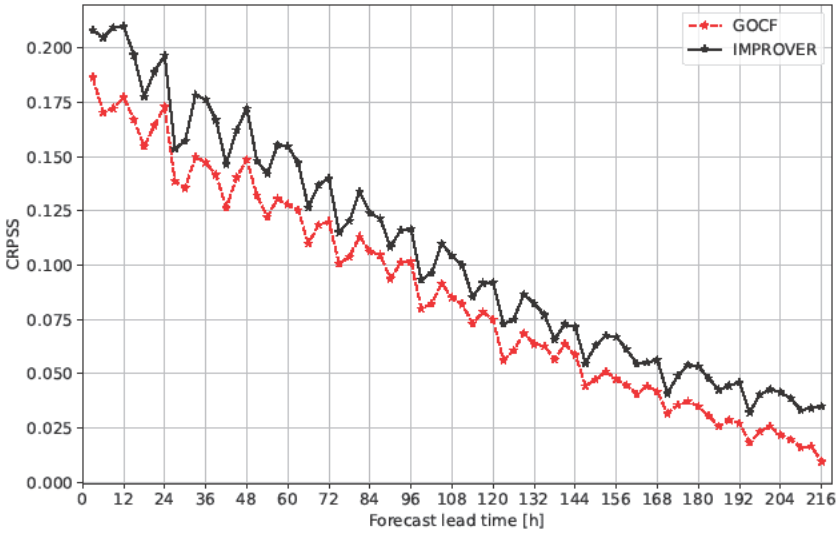
Results: gridded forecasts



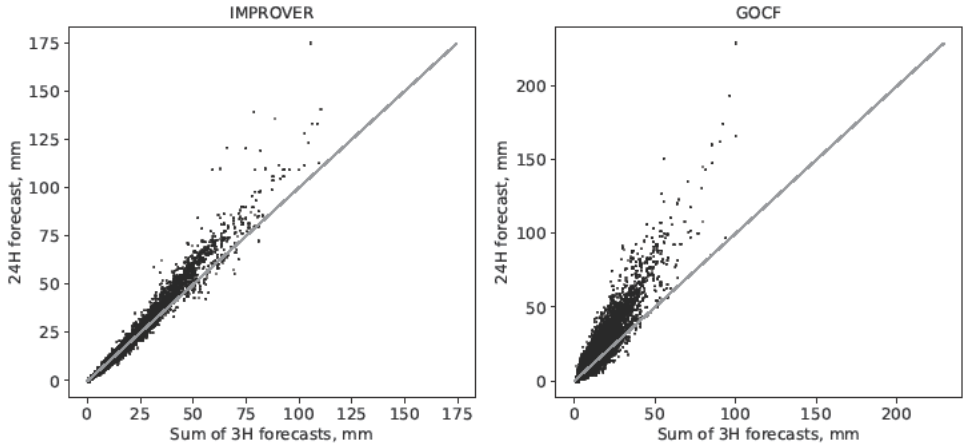
Expected value forecasts for valid time 2021-11-12 UTC 0

Results vs GOCF

CRPS of 3-hour forecast



Consistency of 3H and 24H forecast



Rainforests key achievements

- Significant improvements in skill and consistency.
- Reduced manual intervention effort for operational forecasters.
- Bureau's first machine learning model in public-facing guidance.

References

N. Roberts et. al., IMPROVER: The New Probabilistic Postprocessing System at the Met Office. Bulletin of the American Meteorological Society 104(3), 2023. doi:https://doi.org/10.1175/BAMS-D-21-0273.1

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