Ensemble Model Output Statistics

Non-homogeneous regression (EMOS; Gneiting et al., 2005) allows to calibrate parametric forecast distributions.

IMPROVER (Roberts et al., 2023), developed by the MetOffice, includes a module for EMOS with various distributions, using either the ensemble's mean and standard deviation or its individual realizations.

In this study, individual realizations is tested due to the multi-model ensemble's non-equal probability members. Then, the normal distribution is defined as follows:

$$\mathcal{N}(\mu, \sigma) \rightarrow \mathcal{N}(a + b_1 X_1 + ... + b_m X_m, \sqrt{c + dS^2})$$

where the location parameter is the weighted mean of the ensemble forecasts. Parameters are determined using the training data and by minimising the Continuous Ranked Probability Score (CRPS).

The methodology employs a rolling training period of 45 days, meaning today's forecast is based on the past 45 days of data.

Distributional Regression Networks

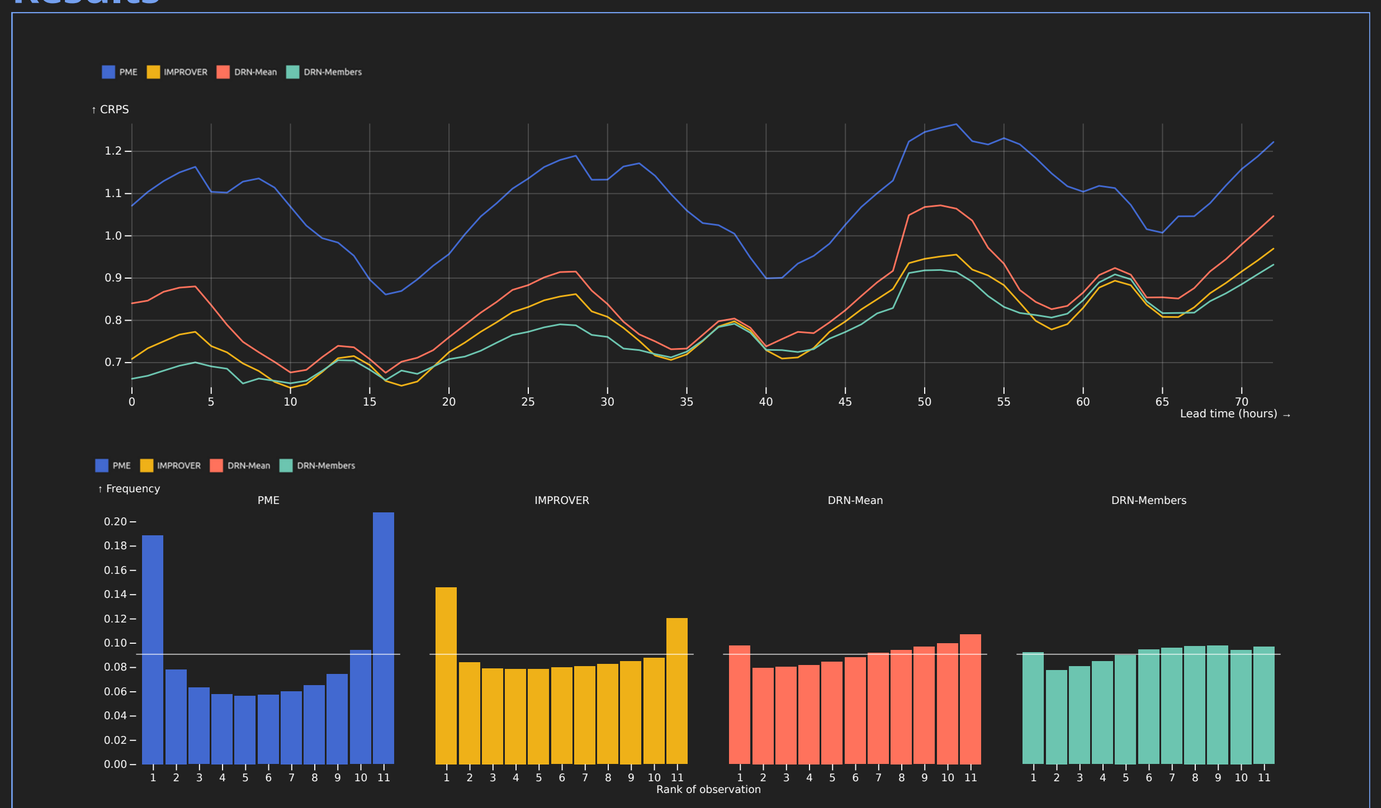
The estimation of the calibrated distribution parameters can also be performed using neural networks (DRN). Rasp and Lerch (2018) proposed using neural networks for distributional regression tasks.

The DRN techniques implemented in this study use station embeddings to allow the network to learn station-specific information, different numbers of hidden layers, and a dropout rate. The loss function used is the CRPS, as in Rasp and Lerch (2018), with all methods implemented using TensorFlow (Abadi et al., 2016).

The use of a multi-model ensemble (PME) involves different models, then it may benefit from considering individual members as input features of the network. Therefore, two approaches were followed:

- DRN-Mean: The mean and standard deviation of the ensemble are used as input features.
- DRN-Members: The ensemble members are used as input features.

Results



Postprocessing multi-model ensemble temperature forecasts using Distributional Regression Networks

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Take home messages

- Using any postprocessing methodology improves the multi-model ensemble (PME) raw forecast.
- DRN-Members, which uses PME members as input features, achieves the lowest mean CRPS and the flattest rank histogram for 0-48 hour lead times, with a slight positive bias for 49-72 hours.
- IMPROVER performs better in terms of CRPS compared to DRN-Mean, but DRN-Mean has better rank histogram performance, showing a slight positive bias while IMPROVER shows some underdispersion.

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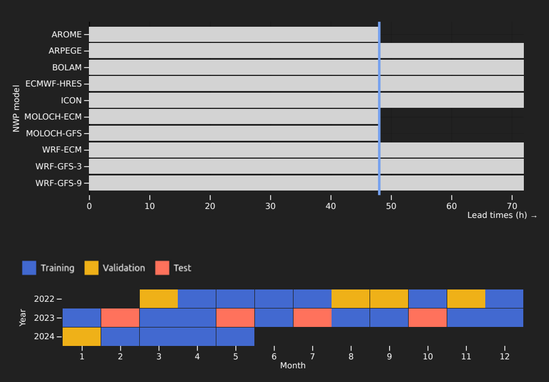
Data



27 months of air temperature data

10 member multi-model ensemble (PME)

185 automatic weather stations as ground truth

Study site

Catalonia, in northeastern Iberia, spans 32,000 km² with a Mediterranean climate, bordered by the Pyrenees, the Mediterranean Sea, and the Ebre Valley.

Catalonia's varied terrain results in significant temperature and precipitation contrasts, with mean annual temperatures ranging from 2.1°C to 18°C and mean precipitation from 320 mm to 1,560 mm (Barnolas et al., 2024).

The Meteorological Service of Catalonia operates 185 automatic weather stations (AWS) meeting WMO standards. Data is collected every 30 minutes.