Motivation
• Ensembles are not perfect, they are subject to deterministic and probabilistic biases
• Statistical post-processing can correct many of these errors
• Optimize sharpness subject to calibration

Conclusions
• After post-processing with EMOS and BMA, forecasts are calibrated (see histograms)
• CRPS improved by ~16% for temperature and ~11% for wind speed (site-specific)
• EMOS + ECC provides calibrated and physically realistic forecast fields

Methods

Ensemble Model Output Statistics (EMOS)
Step 1: Model observation conditional on the ensemble mean and variance using a standard probability distribution
\[ Y | X_1, \ldots, X_M \sim N(a + \beta X, \gamma^2 + \delta^2 \cdot S^2) \]
\[ Y | X_1, \ldots, X_M \sim N(t_\nu(a + \beta X, \gamma^2 + \delta^2 \cdot S^2)) \]
Step 2: Estimate coefficients by minimizing the CRPS over a rolling training period (~25-40 days)
Step 3: Apply coefficients to most recent ensemble forecast

Bayesian Model Averaging (BMA)
Step 1: Model observation conditional on the ensemble forecasts using standard probability distributions
\[ Y | X_1, \ldots, X_M \sim \sum_{m=1}^{M} \omega_m \cdot N(\alpha_m \cdot b_m \cdot X_m, \sigma^2) \]
Step 2: Estimate weights, coefficients and variance by applying linear regression and maximum likelihood (EM algorithm) over a rolling training period (~25-40 days)
Step 3: Apply to most recent ensemble forecast

Ensemble Copula Coupling (ECC)
Preserves physical consistency from the ensemble, between sites, weather parameters, time steps, ...
Step 1: Apply univariate calibration method, e.g. EMOS, BMA
Step 2: Draw a sample from the post-processed predictive distribution
Step 3: Rearrange the sample according to the rank order structure of the raw ensemble

Site-specific forecasts

CRPS: the lower the better!
Histograms: the flatter the better!

Gridded forecasts

Data (surface temperature):
MOGREPS-G restricted to the UK area
00 UTC run, 24 hours ahead
07/2013 - 05/2014

References
Gneiting et al. (2005), Mon. Weather Rev., 133, 1098-1118
Raftery et al. (2005), Mon. Weather Rev., 133, 1155-1174
Sloughter et al. (2010), JASA, 105, 25-35
Schefzik et al. (2013), Statist. Sci., 28, 616-640

NWP Models

MOGREPS-Uk
- 2.2km 70 Levels
- 36 hour forecast 4 times/day
- 12 members
- Here: forecasts at 152 observation sites
- Compared to station obs

MOGREPS-G
- 33km 70 Levels
- 7 day forecast 4 times/day
- 12 members
- 24 member lagged products
- Here: restricted to UK area
- Compared to ECMWF analysis