Better de-icing with probability forecasts

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Conclusions

- We propose a procedure for creating and calibrating wing temperature probability forecasts.
- This procedure (BMA) adds skill and calibrates probabilities for near-future forecasts.

Introduction

Airplanes need to be free of ice before take-off. This puts a scheduling challenge on airports when the weather is uncertain. A calibrated and skillful wing temperature probability forecast is essential for planning de-icing capacity. While current ensemble probability forecasts are skillful, they are often underdispersed for short-range forecasts. We propose an approach for skillful, sharp and calibrated wing temperature probability forecasts.

Calibrated means that predicted probabilities match the observed frequency.

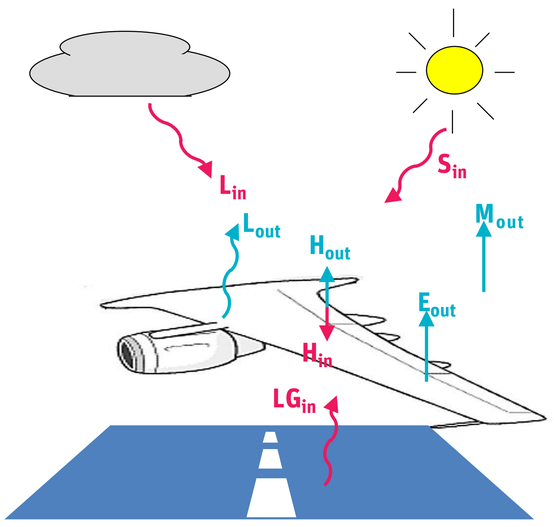
Sharpness refers to how dispersed the model probabilities are. Probabilities of 0% or 100% are very sharp.

Skill refers to how good a model is on predicting a specific outcome, such as temperatures below 0°C.

A de-icing event

Wing Temperatures

To calculate wing temperatures we use an **energy balance model** configured for wings. We installed sensors on a measurement wing at Schiphol airport for validation.



Energy fluxes in the model

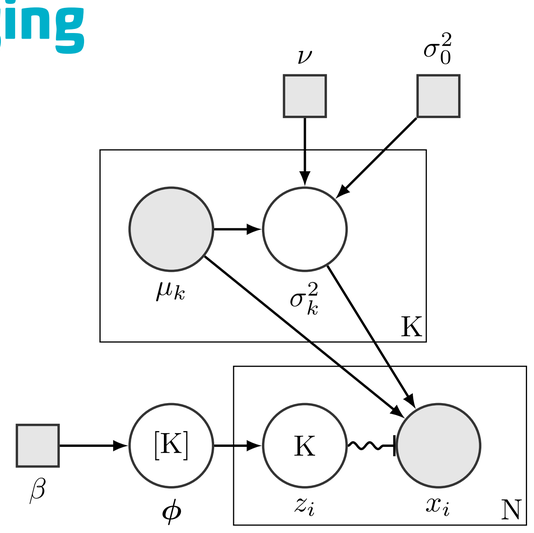
The measurement wing

The wing model is initialized with forecasts from bilinear interpolated weather prediction forecasts up to +48h over the period *Dec-2014 – Apr 2015*. Forecasts are de-biased with a **moving window correction**.

Bayesian Model Averaging

We create an ensemble by using many different weather predictions. Probabilities then become relative frequencies. With a small amount of members, these probabilities are *uncalibrated*.

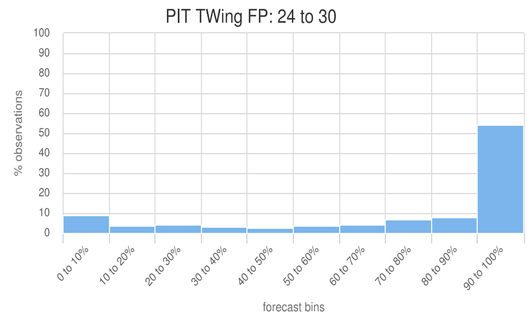
Instead, **BMA** [1] fits each member with a probability density function – Normal for temperature – and jointly fits the ensemble parameters and the weighting. We use Expectation-Maximization to fit these parameters.



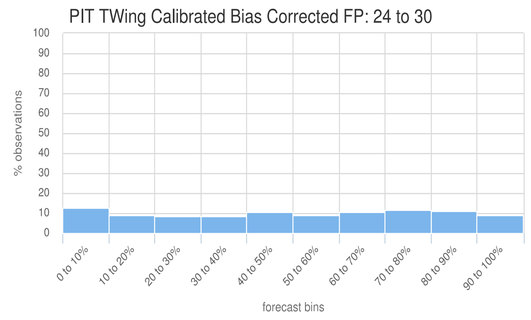
Graphical model of the wing BMA model.

Results

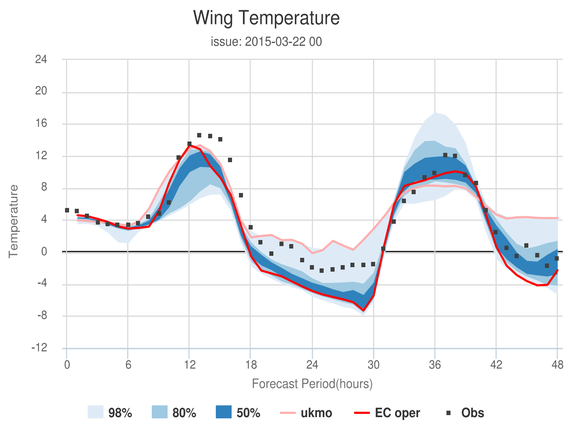
Uncalibrated

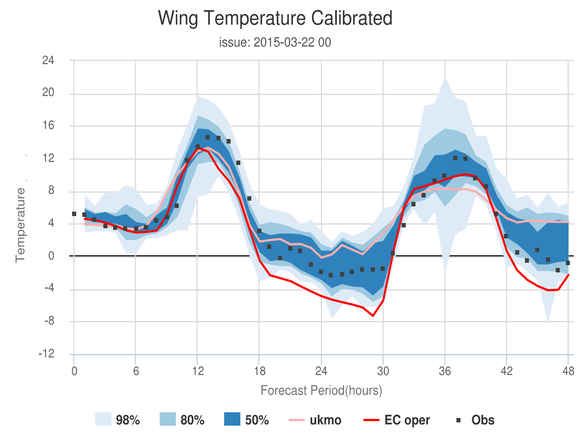


Calibrated

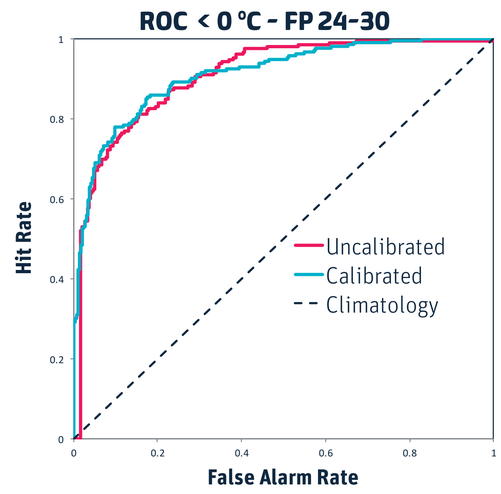


The Probability Integral Transform (PIT) histograms show how predicted probabilities correspond with observed frequencies. Uniform is better.





Metric	Uncalibrated	Calibrated + Bias corrected
AUC (< 0 °C) higher is better	0.908	**0.911**
RMSE Ensemble Mean lower is better	1.84	**1.64**
CRPS lower is better	0.0171	**0.0148**



Ensemble setup:

- 51 Member ECMWF ENS
- ECMWF HRES
- UK MetOffice EURO4

Discussion

- Calibration does not come at the cost of skill
- Dataset is limited due to special measurements
- No joint modelling of forecast hours yet
- How to calibrate forecasts when no measurement wing is available?

References

[1] Using Bayesian Model Averaging to Calibrate Forecast Ensembles, Raftery et. al. (2005), University of Washington, Monthly Weather Review, vol 133, no. 5

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