Experimenting a calibration method on Canadian meteorological ensemble forecasts for uncertainty assessment of Hydro-Quebec streamflow predictions

Evora, N.D. (1), Perreault, L. (1), Favre, A.-C. (2), Fortin, V. (3), Massé, H. (2)

(1) Institut de recherche d'Hydro-Québec (2) Institut National de la Recherche Scientifique - Eau, Terre, Environnement (3) Service météorologique du Canada

Why should we calibrate ensemble weather forecasts?

Ensemble weather forecasts are often biased and underdispersed. We propose herein a method that corrects the bias and calibrates the forecasts.

Bias correction and calibration method

The model

The bias correction model is a simple linear regression model applied to each member k of the ensemble

$$y_t \mid f_{kt} \backsim N\left(a_k + b_k\, f_{kt}\,,\, \sigma_k^2\right)$$

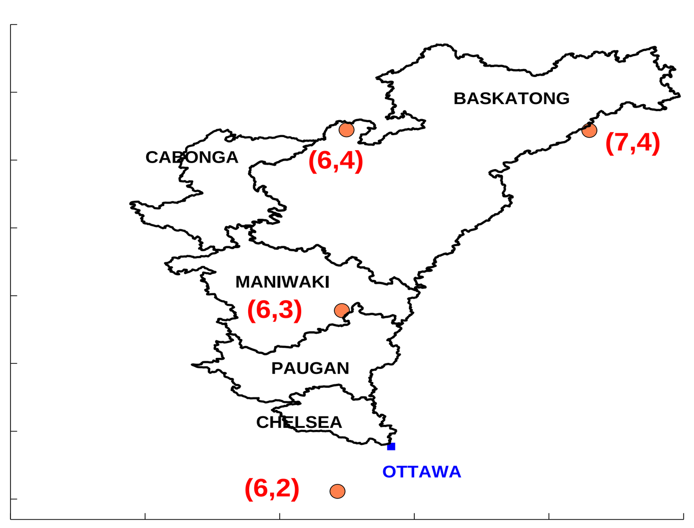
As far as temperature forecasts are concerned, a normal distribution for y_t is a reasonable assumption. y_t is the weather element that should be forecasted at time t, f_{kt} is a forecast of y_t provided by the kth member of the ensemble, a_k, b_k and σ_k^2 are the parameters of the linear regression model. a_k and b_k represent respectively the additive and multiplicative components of the bias.

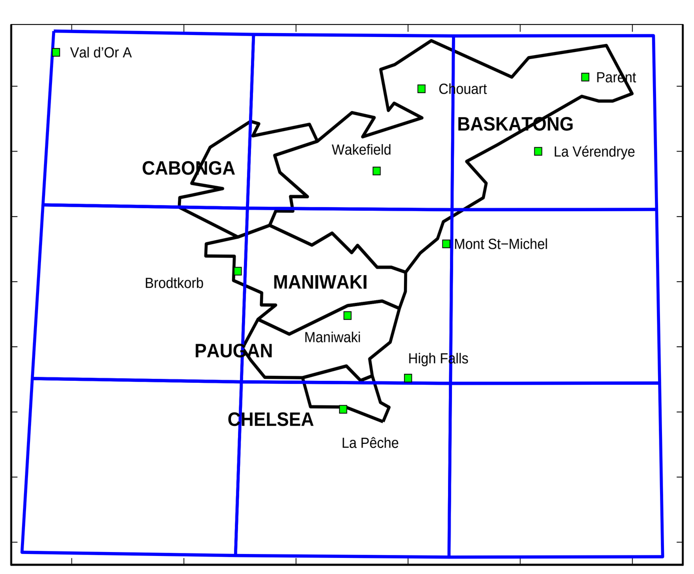
Parameter estimation

a_k, b_k and σ_k^2 are estimated by maximum likelihood method.

Study area, ensemble weather forecasts and verification data

The Gatineau River, located in western Quebec, rises in lakes north of the Baskatong Reservoir and flows south to join the Ottawa River at the city of Gatineau, Quebec. The river is 386 km long and drains an area of 23,700 km^2.

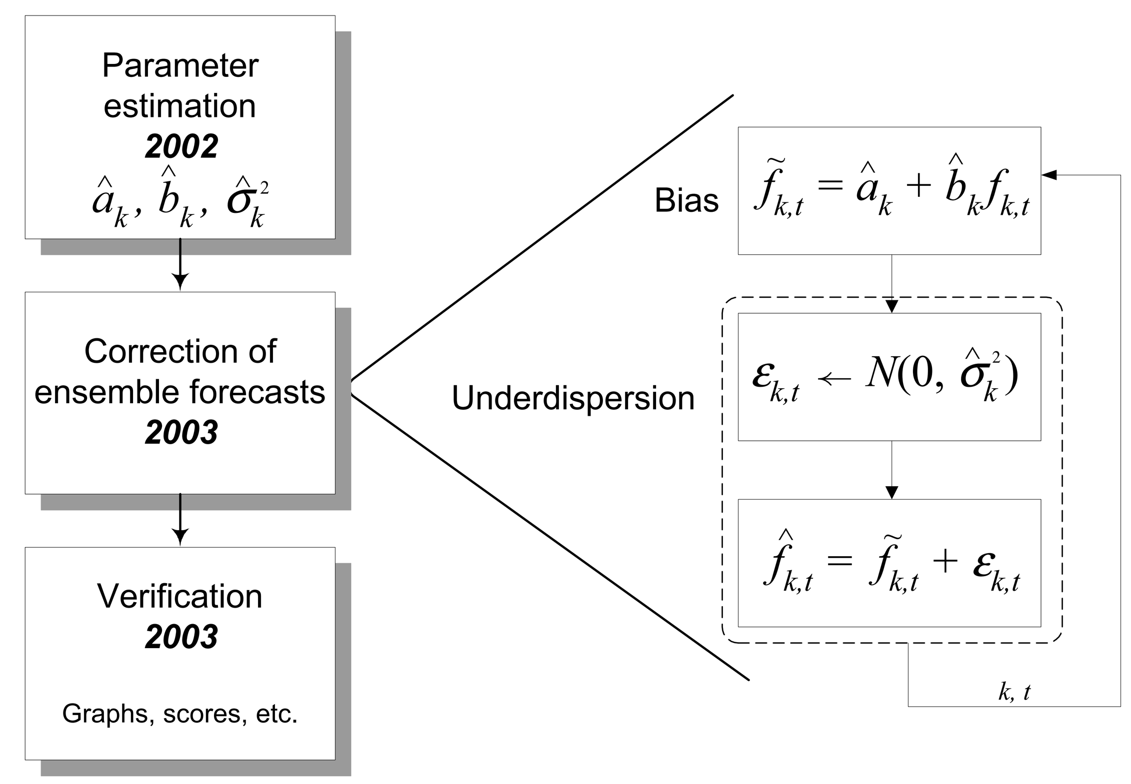




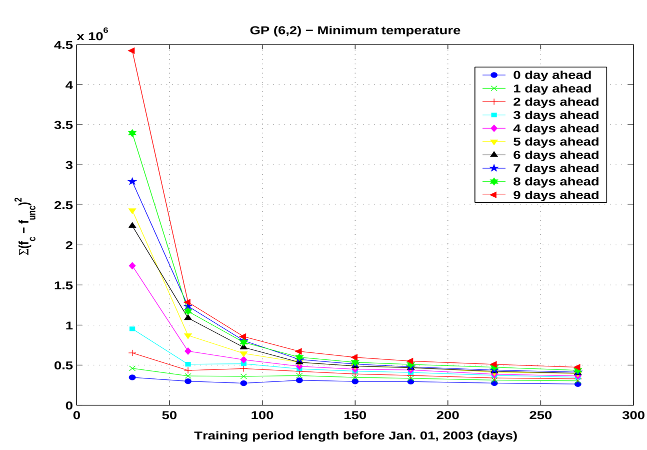
- Environment Canada SEF and GEM models
- $1.2^\circ \times 1.2^\circ$ grid resolution
- 16 members and a control run
- Forecast range : k = 1 to 10 days
- Data from March 1, 2002 to December 31, 2003

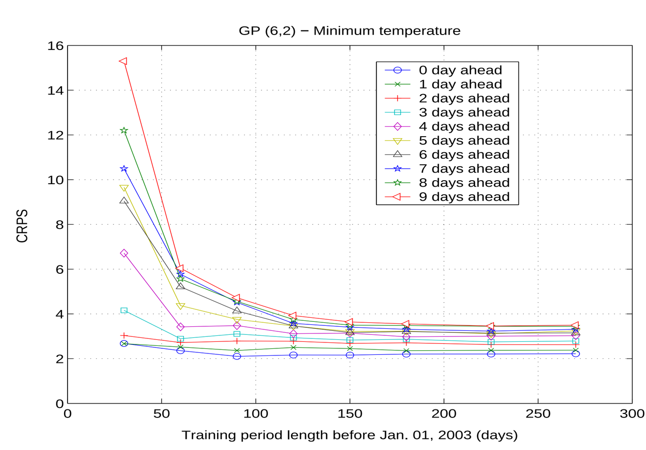
Interpolation at higher resolution of observed data at 10 ground weather stations on a surface representative of the grid point

The experiment

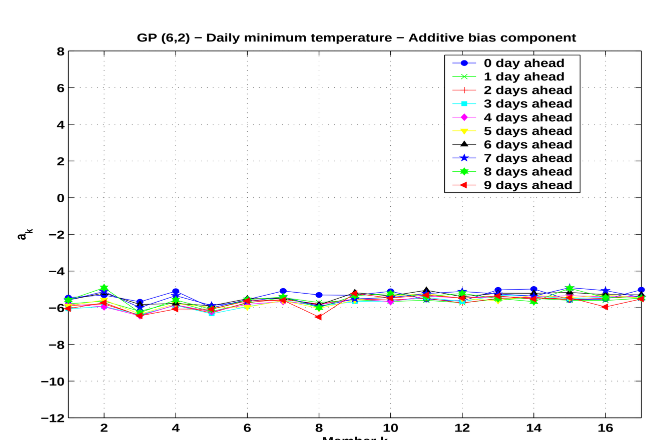


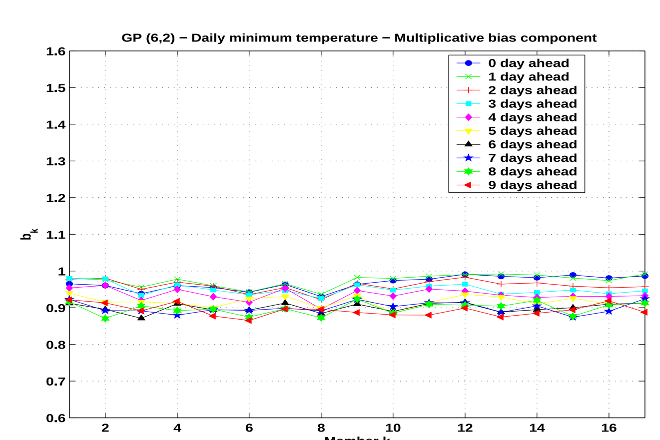
Selecting a training period length (2002)

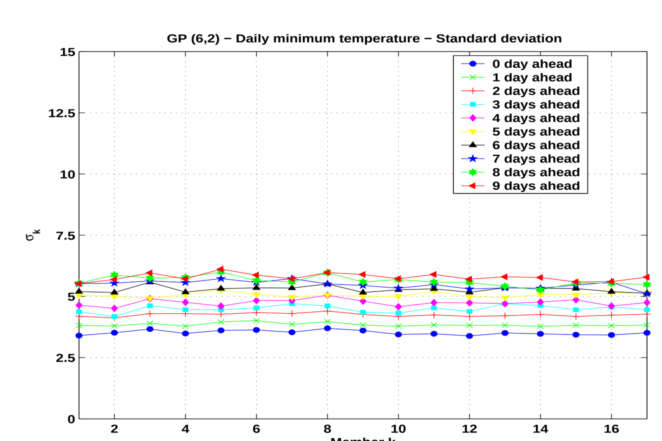




Parameter estimates



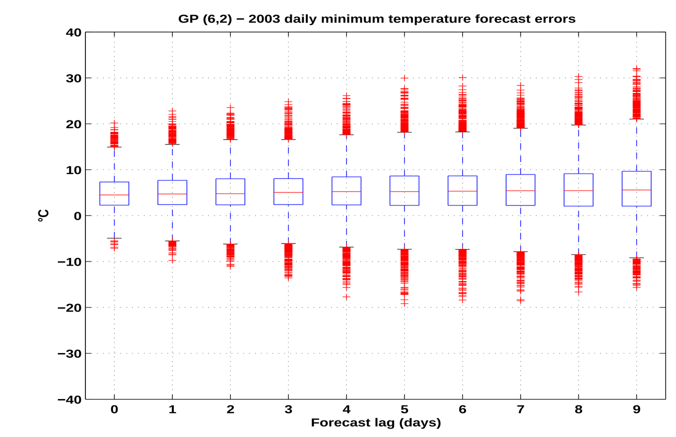


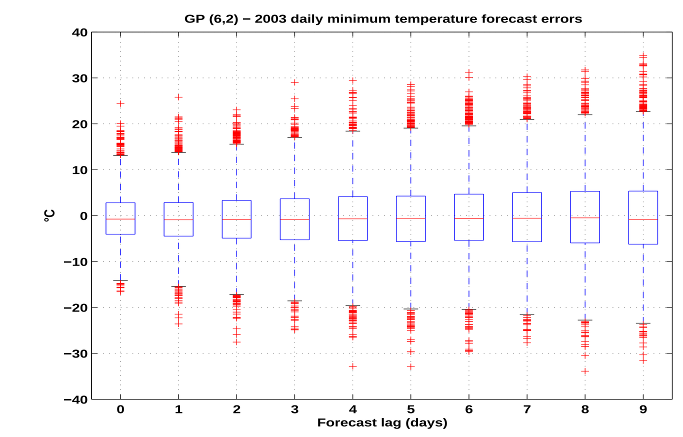


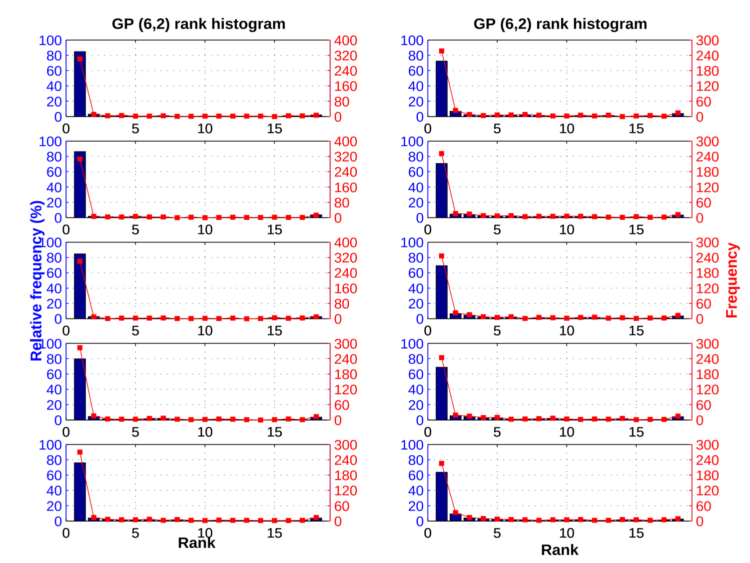
Verifying corrected forecasts (2003)

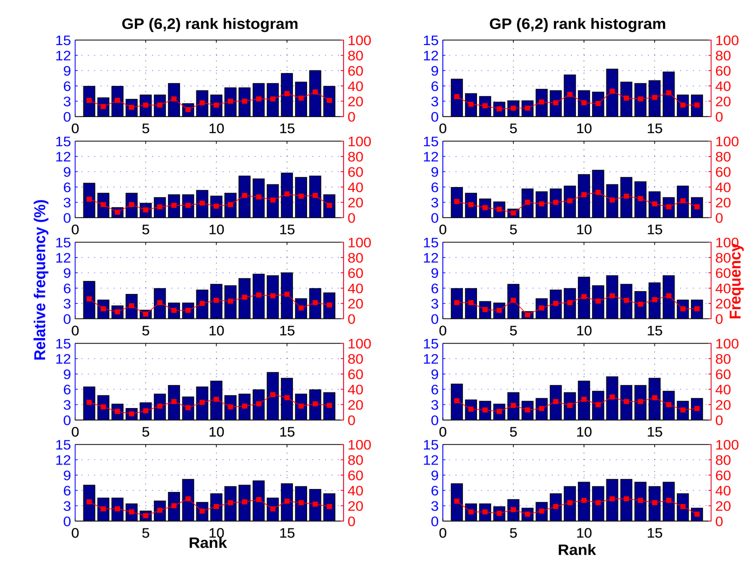
2003 uncorrected forecasts

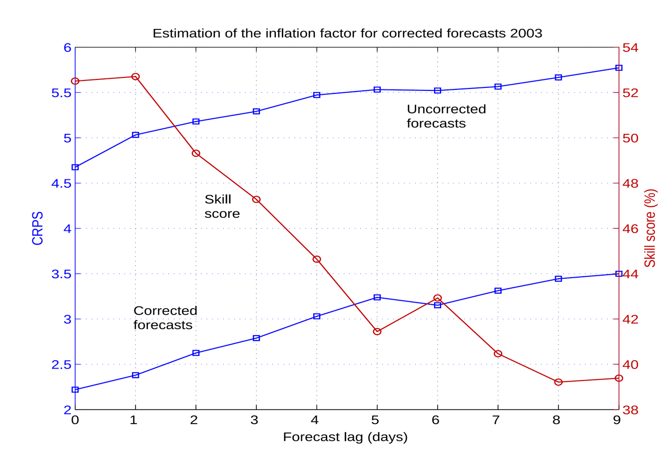
2003 corrected forecasts (270 days of training)

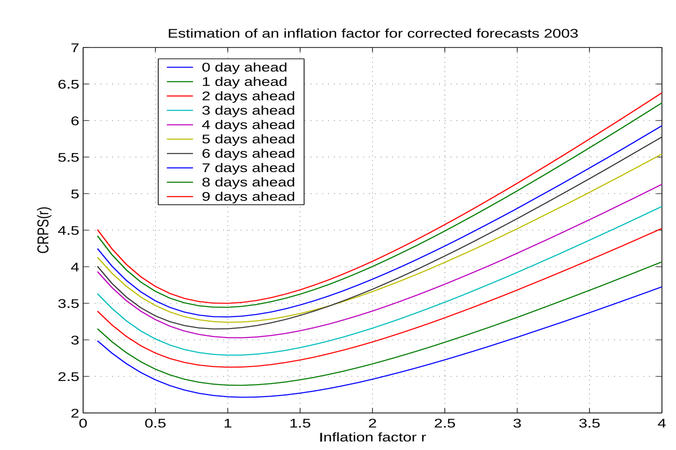












$$CRPS(F,x) = \int_{-\infty}^{+\infty} \left[F(y) - I(y \geq x)\right]^2 dy$$

$$CRPS(r) = \frac{1}{355}\sum_{t=1}^{355} CRPS(F_t, x_t),\ \text{where } F_t = N(\mu_t, r\sigma_t)$$

Conclusions and further work

- We have developed a simple model to calibrate daily minimum temperature ensemble forecasts provided by Environment Canada. The parameters have been estimated with a 2002 training sample, and validation of the method has been performed for 2003 forecasts.
- The 2003 corrected ensemble forecasts seem well calibrated.
- This method can be easily implemented in an operational mode.
- Should be investigated:
  - the ability of this model to correct the bias and underdispersion of daily maximum temperature ensemble forecasts;
  - the effect of seasonality;
  - a simpler model such as $b_k = 1$ or use different training lengths depending on the forecast lags;
  - the assignment of weights to each member which, for instance, could depend on the goodness-of-fit of the linear models;
  - the assumption that the parameters may be independent of the member's index k;
  - impact on streamflow predictions.