Using Verification Data to Improve Forecasts

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1 Introduction

Conventional ensemble techniques seek to take into account the extent of uncertainty in the forecast for a particular locality of interest at a particular situation. They achieve this by statistically analysing the array of Numerical Weather Prediction (NWP) model output. The array is derived from output generated by imposing a random set of perturbations on the initial analysis.

To illustrate this concept, suppose we take the case of 5 runs of the NWP model, with 5 slightly different initial states. Suppose further that the particular system of forecast guidance that is applied to the NWP model output to yield a prediction of maximum temperature suggests the 5 outcomes:

16,
21,
23,
21,
& 22

for the 5 runs of the NWP model. In this situation, the ensemble of NWP output is suggesting a maximum temperature of 20.6 deg C (the average of the 5 suggested maximum temperatures).

A parallel approach may be to run several different NWP models, and to average the outcomes suggested by the outputs of the different models.

Stern (2004) described a different approach to taking into account uncertainty in the NWP models and associated statistically based forecast guidance.

- Firstly, a database of observed weather, and forecast weather using the PERFECT PROG approach (that is, under the assumption that the NWP model output is perfect), is established.
- Secondly, the forecast weather component of the database is expressed in terms of "departure from normal". To illustrate, a forecast maximum temperature of 40 deg C, at a time of year when the climatological normal is 26 deg C is expressed as +14 deg C.
- Thirdly, these data are statistically analysed utilising regression techniques in order to determine the optimal proportion of "departure from normal" to be applied. This yields a more accurate measure of uncertainty than what would be achieved utilising conventional ensemble forecasting techniques, as the measure is derived directly from an array of actual forecasts.

2 Illustrative Example

Stern (2004) illustrated the concept with an example relating to the estimation of the Probability of Precipitation (PoP). Estimates of PoP were generated during a 100-day trial of a knowledge based (statistical) forecasting system. These estimates were produced by the system via a statistical algorithm that interpreted the output of the Bureau of Meteorology's (BoM) global NWP model. Regression analysis was then applied to a data-base comprising actual observations, and estimates produced by the algorithm. This was done in order to determine how one might modify these estimates in order to maximise the performance of the statistical algorithm. In effect, what was established was that proportion of the estimates' suggested departure from normal that, if used by the knowledge based system, would maximise the performance of the estimates of PoP.

In the event, it was found that, for Day 1 PoPs, the estimates' departure from the seasonal normal PoP should be reduced to 68.8% of that departure, in order to maximise the performance. To illustrate, suppose that the seasonal normal PoP is 50%, and the PoP derived using the PERFECT PROG approach is 80%. In this situation, in order to maximise performance, the PoP should therefore be modified to:

50% + (80%-50%)x0.688 = 71% for Day 1.

Similarly, it was found that, for Day 7 PoPs, the departure from the seasonal normal PoP should be reduced to 28.1% of that departure. For the aforementioned example, the PoP should therefore be modified to:

50% + (80%-50%)x0.281 = 58% for Day 7.

Conventional ensemble forecasting suffers from the disadvantage of the level of uncertainty in the initial analysis being unknown, whereas the uncertainty associated with a database of actual forecasts is known precisely.

3 Applying the Verification Data

The approach was then applied to an extensive 5+ years (April 1998 to December 2003) database of officially issued Melbourne maximum temperature forecasts. It was found that the proportion of the official forecasts' suggested departure from normal that, if used, would maximise the performance of the forecasts as measured by the RMS Error, and illustrated at Figure 1, are:

- 0.947 for Day 1,
- 0.887 for Day 2,
- 0.831 for Day 3,
- 0.790 for Day 4,
- 0.717 for Day 5,
- 0.613 for Day 6,
- & 0.511 for Day 7.

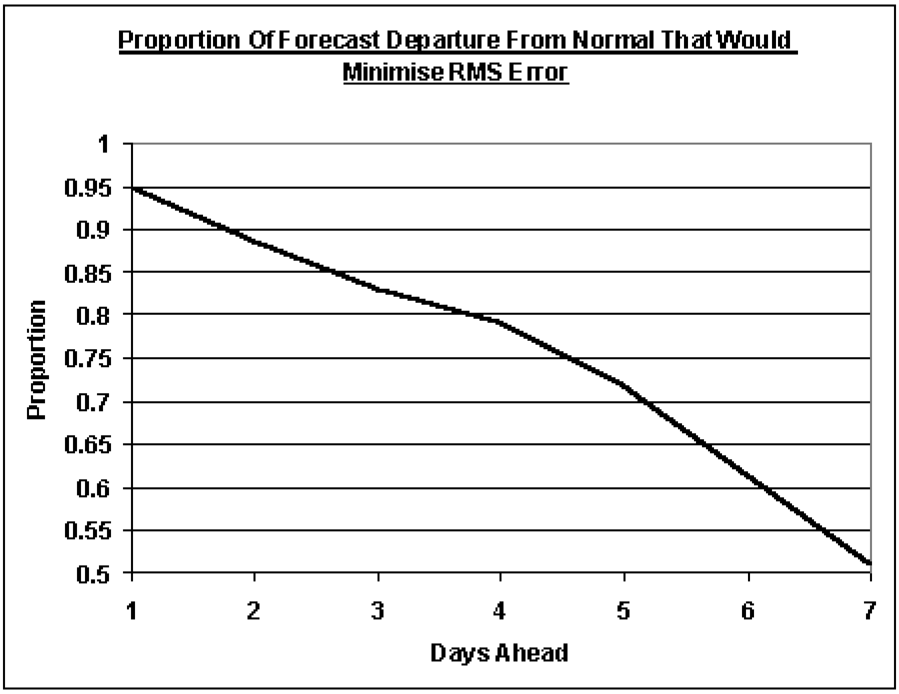

Figure 1 Proportion of the official forecasts' suggested departure from normal that, if used, would maximise the performance of the forecasts as measured by the RMS Error.

Suppose that it is valid to assume that, over the period of analysis, the official forecasts were usually made largely accepting the best available objective guidance. A strategy for improving the accuracy of forecasts, as measured by the RMS Error, then emerges. To illustrate, it will now be assumed that on January 8, the best available objective guidance for Day 7, January 15, when the climatological normal is 26 deg C, suggests a maximum temperature of 40 deg C. In this situation, the guidance is modified to yield a prediction of 26 + (40-26) x 0.511 = 33 deg C.

Utilising the suggested proportions of the official forecasts' departures from normal as proxies for the suggested proportions of the objective guidance's suggested departures from normal is supported by evidence.

Figure 2 compares the relationship derived between *Days Ahead* and *Proportion* for the knowledge based system with the corresponding relationship for the official forecasts, that was presented in Figure 1. The two relationships prove to be quite similar. This is notwithstanding the relationship for the knowledge based system using forecasts produced by that system during a **very short** (100-day) trial between September 2002 and January 2003 and that as a consequence, all the system's forecast data were combined, to result in a linear relationship.

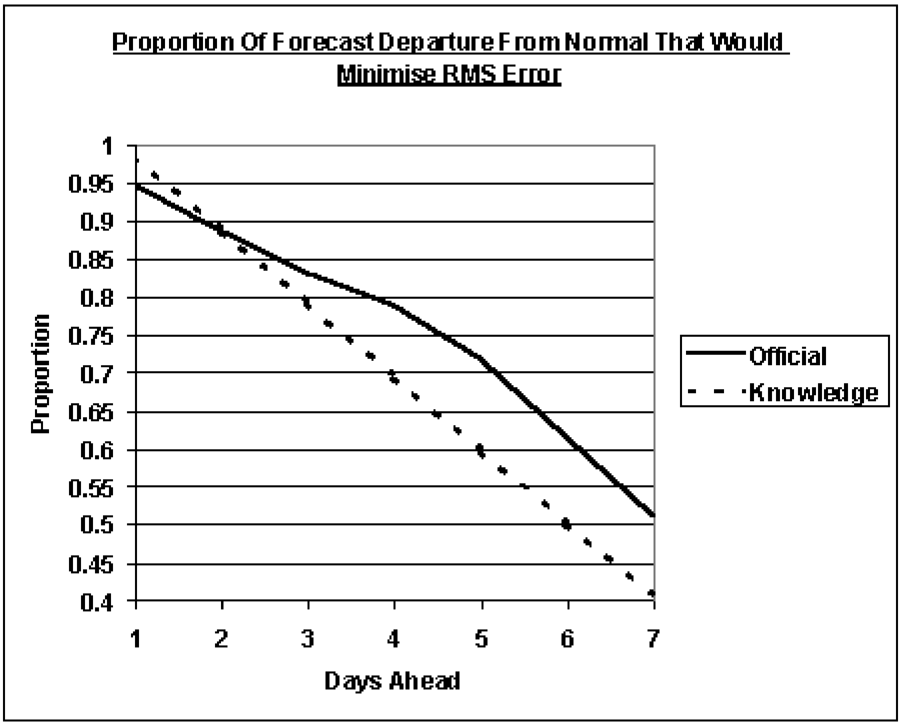

Figure 2 A comparison of the proportion suggested for the knowledge based system with that suggested for the official forecasts.

It will now further be assumed that, as January 15 approaches, the best available objective guidance maintains its initial forecast of 40 deg C. Under this scenario, the modified guidance, after initially suggesting a somewhat conservative estimate of 33 deg C seven days ahead, will gradually approach the more extreme value of 40 deg C by suggesting:

- 35 deg C 6 days ahead,
- 36 deg C 5 days ahead,
- 37 deg C 4 days ahead,
- 38 deg C 3 days ahead,
- 38 deg C 2 days ahead,
- & 39 deg C 1 day ahead.

If one should use this approach, based on data from the April 1998 to Dec 2003 period of record, the potential exists for a substantial decrease in the RMS Error for Day-7 forecasts to 3.65 deg C, from 4.01 deg C, for the Day-7 forecasts. Figure 3 shows similar decreases, albeit smaller, may also be achieved for shorter-range Melbourne maximum temperature forecasts.

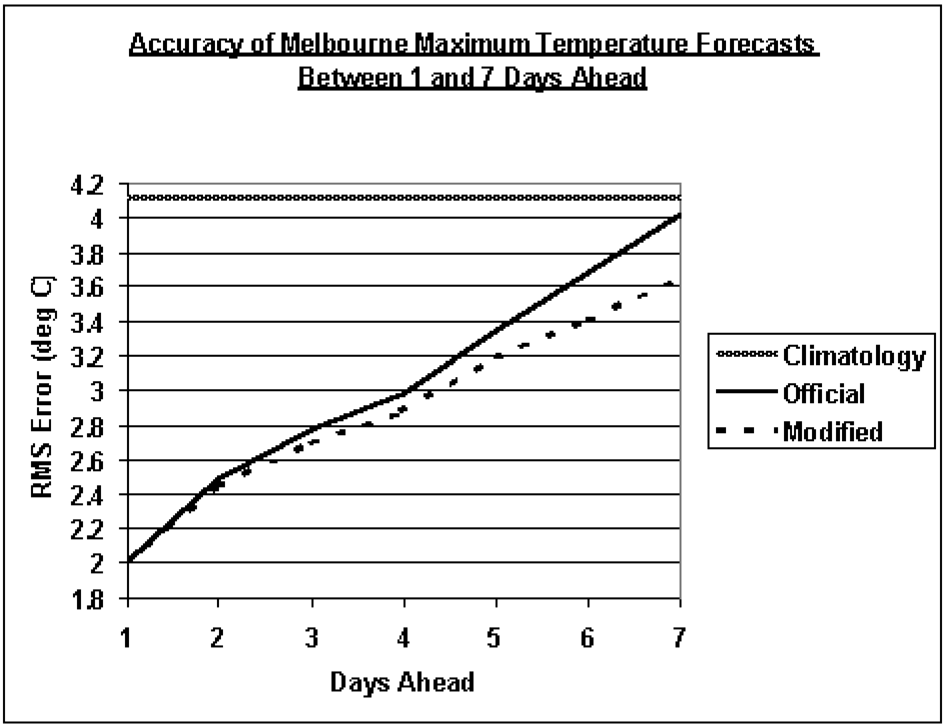

Figure 3 The accuracy of Melbourne maximum temperature forecasts - based on the assumption of Climatology (always predicting the monthly normal), the official forecasts, and forecasts modified in accordance with the approach outlined.

4 Reference

Stern H (2004) Incorporating an ensemble forecasting proxy into a knowledge based system. *20th Conference on Interactive Information and Processing Systems, Seattle, Washington, USA 11-15 Jan., 2004.*