

Harvey Stern*

Victorian Regional Office, Bureau of Meteorology, Australia

1. INTRODUCTION

1.1 *The knowledge-based system*

A "pilot" knowledge-based system for the automated generation of internet weather forecasts is described. The system has been developed for the small (227,000 sq km) southeast Australian State of Victoria. Forecasts generated include those for public, aviation, marine, and media interests.

1.2 *Background*

Most work that has been carried out in Australia towards providing automated forecast guidance has focussed upon weather elements contained in public forecasts (Stern, 1980; Dahni *et al.*, 1984; Dahni, 1988; Dahni and Stern, 1995; Stern, 1996). Little such work has been carried out in Australia towards providing guidance for aviation forecasting, although Stern and Parkyn (2001) have developed a web-based forecasting technique for Melbourne Airport, and work progresses towards automated generation of terminal aerodrome forecasts (Godau *et al.*, 2001).

There is also a web-based product that generates time series of expected weather directly from the latest NWP model output, but this product doesn't statistically correct for systematic model biases.

1.3 *The Perfect Prog Approach*

Brunet *et al.* (1988) found that Perfect Prog (PP) forecasts perform better than MOS forecasts for short-term predictions and note that PP forecasts possess the overwhelming advantage of portability of the system when the driving model changes. For these reasons the PP approach is used in the development of the system described herein.

2. DESCRIPTION

2.1 *The JavaScript Algorithm*

At the core of the system is an algorithm, written in *JavaScript*. The algorithm combines a statistical

*Corresponding author address: Harvey Stern, Victorian Regional Office, Bureau of Meteorology, Box 1636M, Melbourne, 3001, Australia; e-mail: H.Stern@bom.gov.au

interpretation of NWP model data in terms of local weather, with other knowledge. The output generated is HTML code, which is then up-loaded to a web site.

2.2 *Statistical Interpretation*

The statistical interpretation component of the system is (presently) fairly simplistic. It identifies the synoptic pattern type suggested by the NWP output, suites of forecasts having been derived for each of the different synoptic patterns. Knowledge about the weather associated with each synoptic type is utilised in developing these suites of forecasts. The current day's maximum temperature is used as a predictor in the generation of temperature predictions.

2.3 *Standard Forecasting Terminology*

Nearly three decades ago, Dobryshman (1972) discussed the importance of a standard forecasting terminology. A standard terminology, relatively straightforward to implement in the context of an automated system, ensures unambiguous interpretation of the forecasts, and also allows the forecasts to be objectively verified. To this end, the system employs Stern's (1980) terminology.

3. SYNOPTIC TYPING

The synoptic typing procedure used by the system is that for southeast Australia first referred to by Treloar and Stern (1993), and defined in detail by Stern and Parkyn (1999). The synoptic types are described in terms of the direction, strength and curvature of the isobaric (surface) flow. These characteristics are determined from a grid of pressure values as follows:

- The direction of the flow is divided into 8 key categories, corresponding to each of the eight octants (*NNW, WNW, ... , NNE*).
- The strength of the flow is divided into 3 key categories (*weak, moderate* and *strong*).
- The curvature of the flow is divided into 2 key categories (*cyclonic* and *anticyclonic*).
- Combining these features yields 48 (8x3x2) types.
- Two additional types, *light and variable cyclonic*, and *light and variable anticyclonic*, bring the total number of synoptic types to 50.

4. BENEFITS

4.1 An Extensive "Bank" of Forecaster Experience

A major benefit of the knowledge-based system is that it incorporates an extensive "bank" of forecaster experience. Ramage (1993) has proposed an "iterative" approach to "locking in" improvements in forecasting methodology, and this approach was recently illustrated by the present author (Stern, 1996).

This is the approach adopted by the forecasting system described herein. The system's skill increases as new knowledge is incorporated into its operation. Hence, progress is gradually made towards the realisation of Ramage's dream.

4.2 Forecasts for Numerous Localities

The other major benefit of the knowledge-based system is the elimination of typing on the part of forecasters. This allows the production of forecasts for numerous localities. Indeed, the system generates forecasts in words, forecasts depicted by an icon graphic, forecasts of maximum and minimum temperature, and estimates of precipitation probability and amount, all out to *day seven* for 210 places.

At present, worded forecasts, and forecasts of maximum and minimum temperature, are provided officially only out to *day four*, and only for 24 places.

5. PERFORMANCE

5.1 Evaluation Measures

The performance of the system is evaluated utilising the same five skill scores used by Stern (1998). These skill scores, which assume a *positive* value if the forecast performance is *superior* to that of climatology, are derived from:

- root mean square error (*rmse*) of the minimum temperature predictions (MIN);
- *rmse* of the maximum temperature predictions (MAX);
- *rmse* of the quantitative precipitation forecasts (QPF);
- % of correct indications of the occurrence of precipitation or no precipitation (PNP); and,
- Brier score of the probability of precipitation estimates (BRIER).

5.2 Preliminary Verification Statistics

A preliminary test of the "pilot" system was conducted in April 2001. The "pilot" system was only developed for one calendar month, the transition month of April being selected because of the fairly

representative balance of winter and summer synoptic types. Previously, the analogue statistics model, which has now been operational in the Victorian office for over 15 years, was also initially developed for only one calendar month (Stern, 1980).

Although the associated verification statistics (Table 1) are limited to one month's forecasts, and are also limited to forecasts for *day one*, and for only one location (Melbourne), the results are encouraging. They show that, on each of the five measures, the system's performance is superior to forecasts based purely on climatology or persistence (PER).

However, the system, on account of its (presently) fairly simplistic statistical interpretation component, is shown to be inferior to the independently produced official (OFF) forecasts. This situation would be expected to change as the statistical component becomes more sophisticated.

TABLE 1 Preliminary verification statistics.

	SYSTEM	PER	OFF
MIN	+13	-24	+78
MAX	+84	+10	+128
QPF	+5	-8	+34
PNP	+16	+3	+19
BRIER	+14	-21	+31

6. COMPARISON WITH IFPS

6.1 Similarities

The system's approach has some similarities to that of the US Interactive Forecast Preparation System (IFPS) - in both cases, the forecaster works with the system in an interactive manner in the course of generating forecasts.

6.2 Differences

However, the extent of interaction associated with the Australian system is far less than that with IFPS. It is intended that the Australian system's forecasts are (mostly) automatically generated and transmitted, the real-time forecaster-role being largely confined to decisions about which NWP model data to input.

In fact, the Australian system's main human-interaction is in utilising forecast verification analyses (after the event) to iteratively incorporate new additional forecaster knowledge into its algorithm.

Another difference from IFPS lies in the Australian system's provision of forecasts for specific localities. IFPS generates forecasts for an array of grid points for subsequent interpretation by private providers.

However, provision of forecasts for specific localities might be the preferred route for the weather

services of a country such as Australia, where there are only a small number of private meteorologists.

7. MULTI-LINGUAL FEATURE

Gillies (2001) notes that "55% of the web is in languages other than English", and it is becoming increasingly important to cater for these other languages.

Chinese is the world's most widely spoken language, and Whittaker (2001) contemplates the possibility of it becoming "the common language of the Web". As a first step towards providing a multi-lingual product, the system, in addition to providing predictions in English, also generates a forecast summary in Chinese.

8. VIEWING THE OUTPUT

For an update on the work's progress, and to view a complete sample of the system's output, go to:

<http://www.weather-climate.com/fc.html>

Features of the output to note, in addition to the 7-day forecasts for 210 places, include:

- a broad description of the expected weather pattern, in both English and Chinese;
- a marine forecast for Port Phillip;
- a set of terminal aerodrome forecasts; and,
- a set of graphics, for use by the print media.

9. FUTURE PLANS

It is planned to extend the "pilot" system to all twelve calendar months, and to carry out an extensive verification of its predictions, that verification embracing all current observing sites. This will be done with a view to then incorporating additional knowledge about the weather associated with each of the synoptic types. As a consequence, the suites of forecasts will be further developed. It is also planned to enhance the sophistication of the statistical analysis component, and to extend the multi-lingual feature to include Australian indigenous languages.

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