P3.5 TAFTOOLS: DEVELOPMENT OF OBJECTIVE TAF GUIDANCE FOR CANADA
PART 2 - DEVELOPMENT OF THE SHORT-RANGE FORECAST MODULE AND RESULTS

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1. INTRODUCTION

The Meteorological Service of Canada (MSC) is developing TAFTools, a software package to produce objective aerodrome forecasts (TAFs). TAFTools is composed of a very short-range forecast (VSRF) module (Bourgouin et al., 2002), a short-range forecast (SRF) module and a third module that blends both forecasts into one (Fig. 1).

We expect the VSRF system to provide the best possible forecast at very-short range using the most recent observations available. However, the skill of such a technique degrades rapidly in time. For that reason, a technique based on numerical weather prediction (NWP) model output should prove to be superior for short range forecasts beyond about 6-12 hours depending on the site, the forecast hour and the period of year. It was decided to develop a perfect-prog system for the SRF module to forecast the various weather elements required to write a TAF (Fig. 2).

2. THE DATABASE

Each aviation weather elements required to write a TAF can be forecast with TAFTools: wind, visibility, weather and obstruction to vision and cloud. These are the predictands and are available from the TAFTools database of observations described in Bougouin et al. (2002). The atmospheric re-analyses from the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) were used to derive site-specific predictors such as temperature, vorticity, moisture advection, stability indices, solar angle and declination, etc. Polynomial and spline interpolation were used to interpolate data from a 2.5 degree grid and 6-hourly resolution to specific airports with an hourly time resolution. That database was split into a development database (1958-1996) and a validation database (1997-1999).

Furthermore, a verification database is currently under construction. NWP model output for the period 1997-1999 are available from the CMC archive system and will serve to compute probability forecasts necessary for a verification and a comparison with the VSRF probability forecasts.

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Equations were developed using a Multiple Discriminant Analysis (MDA) technique. MDA has recently been shown to give superior forecasts to a Classification And Regression Trees (CART) technique for cloud amount (Burrows and Wilson, 2000). The MDA software was built by Recherche en prévision numérique (RPN) to enhance the capabilities of the operational updateable MOS (UMOS) software in use at CMC as well as provide an analysis tool for various research projects.

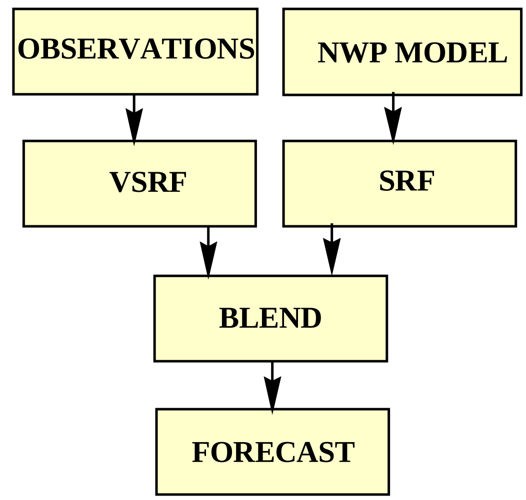

Figure 1. Schematic flow diagram showing the three main components of TAFTools: VSRF, SRF and BLEND.

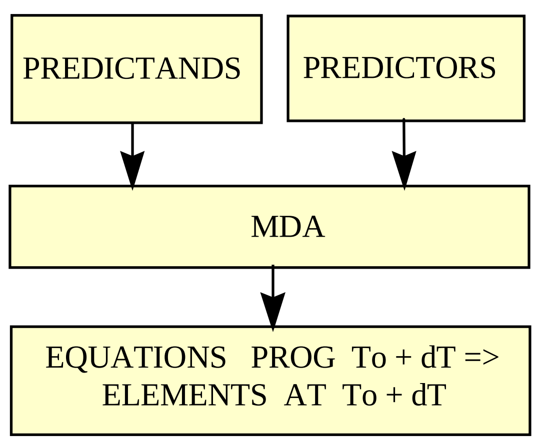

Figure 2. Schematic diagram showing the data flow for development of the SRF component of TAFTools.

3. METHODOLOGY

The test bed included 8 sites representing various climatological regimes occurring in Canada: Saint-John's, Halifax, Montreal, Toronto, Winnipeg, Calgary, Vancouver and Yellowknife. Ceiling and visibility observations were split into categories representative of operational requirements at the 8 airports. The MDA was applied using those categorizations with various forms of seasonal stratification (including no stratification). Ideally, stratification should be specific for each site but, in order to accelerate development, the seasonal stratification that maximises the overall ranked probability score (RPS - Epstein, 1969) was preferred.

The occurrence of precipitation is a little trickier to predict objectively because of the large number of possibilities obtained when combining the different types, intensity and convective nature. For that reason, we decided to consider 3 separate elements for precipitation : occurrence (yes/no), convection (none, light, moderate, strong), and a reduced set of precipitation types, formed by aggregating some of the observed types into single categories: snow, rain, drizzle, freezing rain and ice pellets, freezing drizzle, rain and snow, thunderstorm. The MDA analysis was applied on the categorized data.

Currently, a classification by thresholding (Miller, 1981) is under development for the categorical selection. Decision-making will be done by means of thresholds chosen to maximise or minimise one or more verification statistics (for example, probability of detection, false alarm ratio, threat score, Heidke skill score).

The categorical selection will be done on both VSRF and SRF, as well as those forecasts issued from the fusion of probability forecasts from both modules. Many strategies are possible to perform the fusion but all will be based on the relative performances of each system.

The final step will be the construction of a rule-based system to build the TAFs so coveted. The result will be three different series of TAFs: VSRF, SRF and a blend of both.

4. BLENDING

The blended TAFs will result from a fusion of the probability forecasts from both VSRF and SRF system. The verification database will be used for the latter system to determine its performance and compare it to the VSRF system (Bourgouin et al., 2002).

5. RESULTS

Analysis for ceilings and visibilities have been produced using different seasonal stratifications. Probability forecasts were then produced using predictors from the validation database. Figure 3 shows that results improve with the number of seasons (from one to four). On the other hand, as the number of seasons increase, the MDA software merges categories with fewer cases to

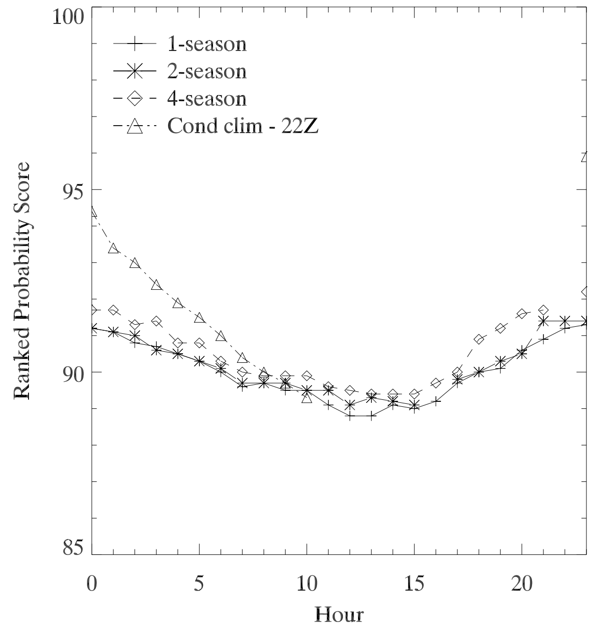

Figure 3. RPS for the 8 sites using no season, 2- and 4-season stratifications (8760 cases for each hour). Results using conditional climatology are also included for reference (Bourgouin et al., 2002).

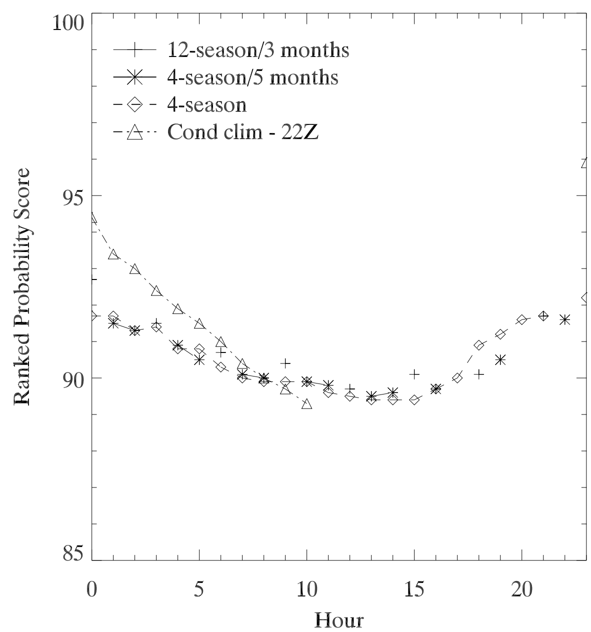

Figure 4. RPS for the 8 sites using 4-season stratification of 3 and 5 months and 12-season stratification of 3 months (8760 cases for each hour). Results using conditional climatology are also included for reference (Bourgouin et al., 2002).

compensate for the loss of cases due to the stratification process. This problem is corrected by adding cases to each season from the contiguous seasons. A first attempt with a 4-season stratification of 5 month per season showed this approach to yield performance very similar to a regular 4-season stratification but a 12-season stratification of 3 months per season resulted in performance slightly better overall than any of the other stratifications (Figure 4).

The selection of predictors by the MDA-software is typical of the type of meteorological variables normally considered by forecasters to evaluate the potential for a specific weather element (Fig. 5, Table 1). For example, precipitable water, relative humidity at various levels, the laplacian of surface pressure and the tendency of surface pressure are the most frequently selected. The latter is often considered to be too noisy a field but the MDA analysis shows there is a strong signal exploitable for predictive purposes. In second place come the laplacian of the surface pressure tendency, advection of temperature in the lower troposphere, the lifted index and relative humidity at 1000 hPa. This last predictor is selected less often than relative humidity at other levels possibly because this is a diagnostic level.

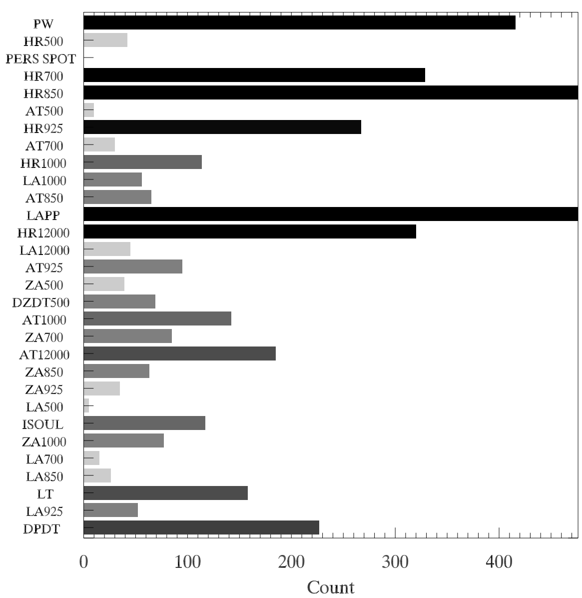

Figure 5. Count of predictors selected for the 8 sites using a 12-season stratification of 3 months. Acronyms are defined in Table 1.

Table 1. Selection of predictors for the MDA analysis.

Predictor	Definition
PW	Precipitable Water
DPDT	Pressure Tendency
LAPP	Laplacian of surface pressure
LT	Laplacian of surface press. Tendency
HR	Relative humidity
AT	Advection of temperature
PERS SPOT	Persistance
LA	Laplacian of advection of temperature
ZA	Advection of vorticity
DZDT	Height tendency
ISOUL	Lifted Index

6. CONCLUSION

In an effort to improve production efficiency of terminal aviation forecasts in Canada, a project was designed to produce objective TAFs. The project relies on statistical methods to produce two separate forecasts, one aimed at the very short-range from observations only and the other for the short-range from NWP model output. The two forecasts will be blended to produce a third forecast. The 40-year database of hourly observations and predictors as well as the statistical technique are completed. Equations are currently produced and tested separately for each modules. Preliminary results indicate that the predictors selection is physically sound. The system automatically selects predictors such as pressure tendencies and its laplacian or precipitable water. Performances are as expected with the SRF showing superior RPS after 9 hours in the overall validation procedure. Finally, a verification procedure using NWP model output archived at CMC and a classification by thresholding are under development. Testing of the blended forecasts will begin in late fall for the selected Canadian sites.

7. REFERENCES

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