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APPLICATION OF BAYESIAN NETWORKS FOR FOG FORECASTING FOR AVIATION IN AUSTRALIA

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INTRODUCTION

The occurrence of fog at airports has a significant impact on aircraft operations in terms of safety and economics. An unforecast fog event at any major airport in Australia can cause major disruption with aircraft diversions, delays and cancelled flights. The flow-on disruption can extend around the country and last many hours with resultant costs that can be very significant.

For some years there has been development work in Australia directed at improving the forecasting of fog. The work includes the provision of fog forecasting guidance and the development of an improved fog forecast process.

The occurrence of fog is dependent on synoptic scale factors and also on local mesoscale factors that are often not well observed or understood. This introduces uncertainties in the forecasting of fog that can be very difficult to quantify. Various forms of forecast guidance are available based on NWP model output, statistical techniques and pattern matching techniques but these often have limitations. Despite these uncertainties the forecaster must make a categorical judgment of the likelihood of fog based on scientific knowledge and experience, available observations and available guidance. Although the forecaster aims to capture all fog events and at the same time minimise the false alarms, the uncertainties do lead to unforecast fog events, false alarms and some inconsistency. In recent years there has been work to develop a more structured fog forecasting process that aims to use available guidance more effectively, provides a more consistent forecast outcome and which can be more readily adapted to different locations.

FORECAST DECISION SUPPORT SYSTEM

In order to support a more structured and unified forecast process a Forecast Decision Support System (FDSS) has been developed. This presents relevant observational and forecast data for the period of interest, relevant fog forecasting guidance and the final forecast outcome. The decision support system allows users to modify forecast data and the guidance and generates an outcome of fog likelihood in accordance with predetermined rules. The system has been developed so that it can be configured for different locations. Relevant data and parameters are written to a forecast database which facilitates post analysis aimed at improving the methodology and generation of performance metrics.

APPLICATION OF BAYESIAN NETWORKS

Until recently the forecast outcome from the FDSS has been based on predetermined and simplistic rules and work has been underway on the development of a more sophisticated decision process based on Bayesian Network (BN) technology and integration of this into the FDSS.

With the aim of improving forecast performance Bayesian Networks have been developed for Melbourne, Sydney and Perth in conjunction with a study of relevant meteorology to assess available guidance and identify new predictors (Weymouth etal 2007, Newham etal 2007). The identified guidance and predictors were discretised where appropriate and then combined into a BN structure with a conditional probability table (CPT) associated with each node. This was an iterative process to ensure the nodes are scientifically reasonable and the possible states associated

with the CPT for each node do not have too many entries.
Experience has shown that Bayesian networks provide a graphical and sound method for combining predictors or guidance, dealing with uncertainty and providing objective probabilities for different scenarios. The advantages include robustness to missing data, the ability of forecasters to interpret and add value to their outputs, and adaptability in cases where a forecaster recognizes that a predictor is unrepresentative and should be modified.
The forecast skill of the BN was evaluated using relative operating characteristic (ROC) curves which show the trade-off between detection efficiency and the false alarm ratio. The system has been used operationally in the Melbourne Regional Office for the past two years and has led to improved operational forecasts.

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