

Application of Bayesian Networks for fog forecasting for aviation in Australia



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A partnership between CSIRO and the Bureau of Meteorology



Application of Bayesian Networks for fog forecasting for aviation in Australia

- Bureau of Meteorology – aviation weather service
- Fog and fog forecasting
- Development of Bayesian Networks
- Integration into forecast process
- Conclusions



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Fog forecasting for aviation

- Terminal Aerodrome Forecast (TAF) – issued 6 hourly, valid 24-30 hr
- Code Grey – warning of lower probability of fog – issued during afternoon
- Trend Type Forecasts (TTF) – issued ½ hourly, valid for 3 hr



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Fog cause delays

From ABC
March 3, 2008



Foggy morning causes delays at Melbourne Airport. Photo: Craig Abrahams

Operations are returning to normal at Melbourne Airport as the heavy morning fog begins to thin out, but some flights will still be delayed this afternoon.

A total of ten international flights have been diverted to Adelaide and Sydney airports to avoid the heavy fog but have now begun returning to Melbourne.

A further 12 domestic flights were cancelled and many others delayed.

Why fog causes airport chaos

By Nigel Pankhurst
BBC News

Dense fog has brought misery to thousands of travellers after causing major disruption to flights in the run-up to Christmas.
But why do such weather conditions result in chaos at airports such as Heathrow?

The Advertiser: Sunday Mail

June 01, 2008 04:50pm

MELBOURNE Airport is warning that further fog tonight and tomorrow morning could disrupt more flights.



All five... jets took up at Adelaide Airport after eastern states fog diverted some planes here and grounded flights to Melbourne.
Photo: Brad Pitt

Sydney Airport reopens after fog delays



Fog takes the national airport by storm.
Photo: ABC

After a long delay...
Every morning fog has hit and flights as well as...
International flights were diverted to Brisbane and...
Melbourne this morning because of the heavy fog.

Fog forecasting for aviation

- Challenging forecast problem
 - Development of fog dependent on synoptic scale factors + mesoscale factors – mesoscale factors not well observed or understood
 - Relatively uncommon at most airports
 - Required forecast specificity is high – min vis, onset, clearance
 - Potential consequences of an unforecast fog are high
- Subjective judgement based on:
 - Scientific understanding of physical processes
 - Good knowledge of climatology
 - Synoptic situation, observations – T, Td, Wd, Ws, cld, precip
 - Available guidance – statistical, rule based, NWP based
 - Experience
- Do get false alarms / unforecast fogs / inconsistencies
- Structured forecast process



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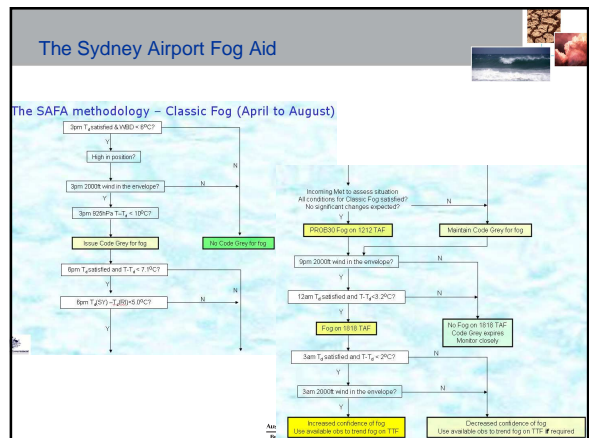
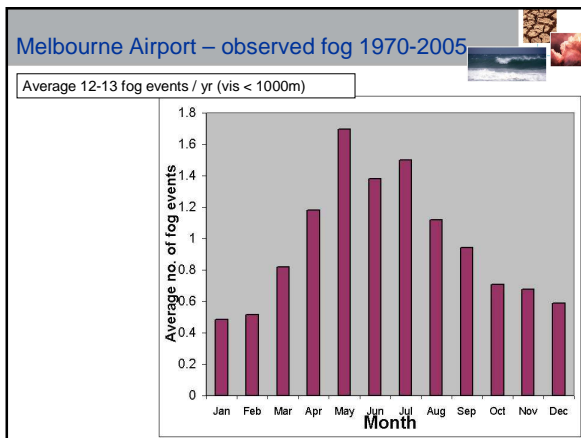
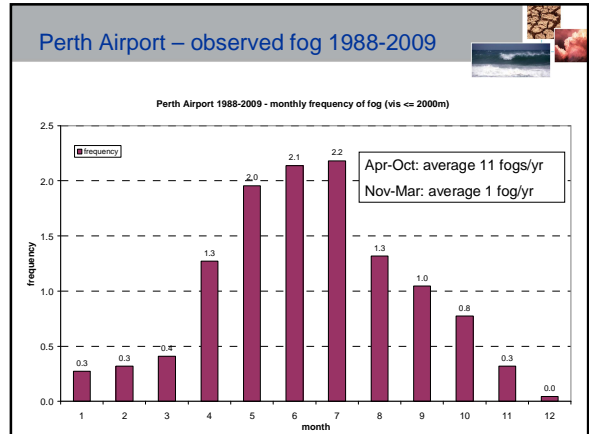
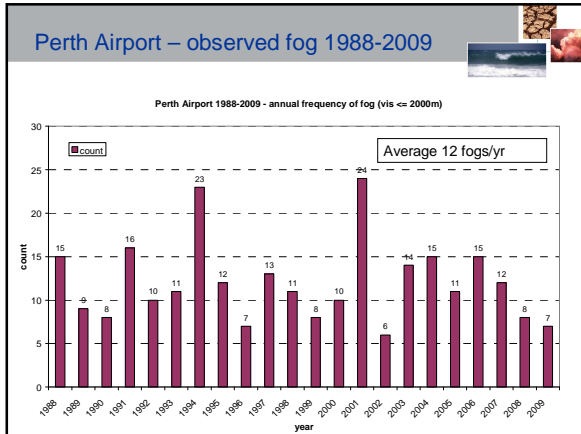
Fog forecasting for aviation ... cont

- Operations
 - Planning stage – long lead time, flight sectors of 15-18 hours
 - Tactical stage – 0-6 hr, onset and clearance
- Airlines using more sophisticated risk management strategies
 - Mgt of fuel policy, alternate airports, crew support
 - Demand for better information on probability of fog including the temporal variation
- BN's offer good potential!



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Forecast Decision Support System (FDSS)

Consensus has proved to be more reliable

Development of Bayesian Network

- Identify relevant indicators / predictors / guidance
- Classify indicators as background factors, predictors, guidance or expert opinion
- Discretise indicators
- Develop BN structure including decision node
- Revise BN
- Incorporate expert opinion into prior probabilities
- Train network
- Evaluate network – cross validation

Australian Government
The Centre for Australian Weather and Climate Research
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CSIRO

Fog indicators / predictors / guidance

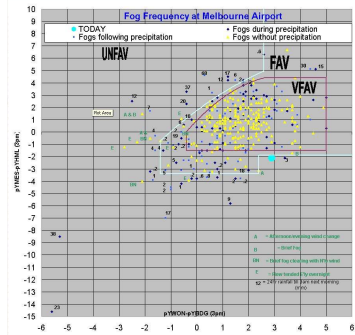
- Season
- Rainfall – additional moisture
- Pressure gradient – flow direction / speed
- Temperature / dew point – moisture availability
- Stability – temperature lapse rate
- Cloud cover – radiational cooling
- Regano
- GASM
- Stern / Parkyn - Melbourne
- Fuzzy model – Perth Airport



Melbourne Airport - pressure gradient

- Observed 3pm Pressure gradient (Wonthaggi-Bendigo & East Sale-Hamilton MSLP)
- Defined as Very FAVourable, FAVourable or UNFAVourable.

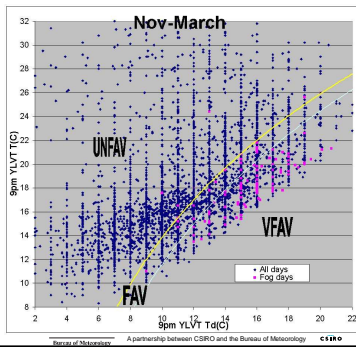
	Fog days	All days	% Fog
VFAV	276	3477	7.9
FAV	55	2154	2.6
UNFAV	37	5548	0.7
TOTAL	368	11179	3.3



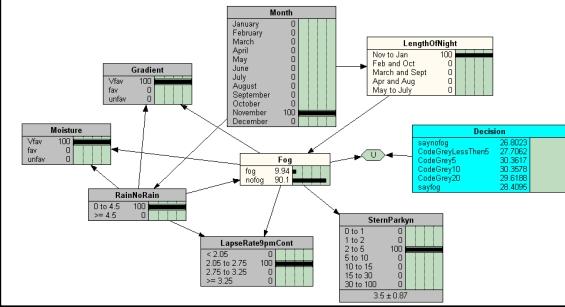
Melbourne Airport – moisture

- YLVT T/Td a good indicator of available moisture for YMML overnight
- 6pm or 9pm observation depending on time of year.
- Defined as VFAV, FAV or UNFAV.

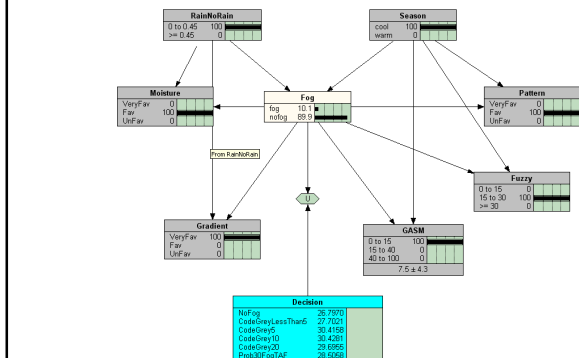
	Fogs	All days	% Fog
VFAV	84	1127	7.5
FAV	17	968	1.8
UNFAV	5	3080	0.2
TOTAL	106	5175	2.0



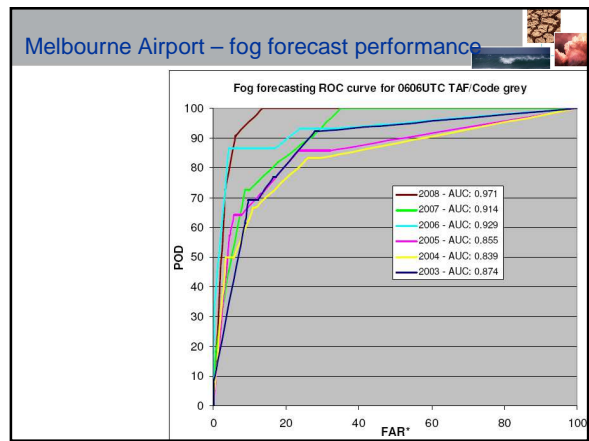
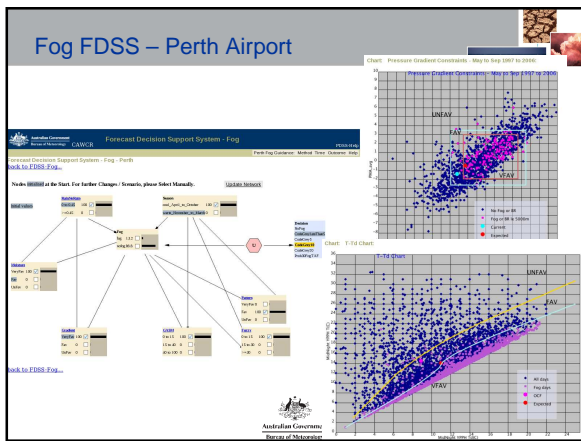
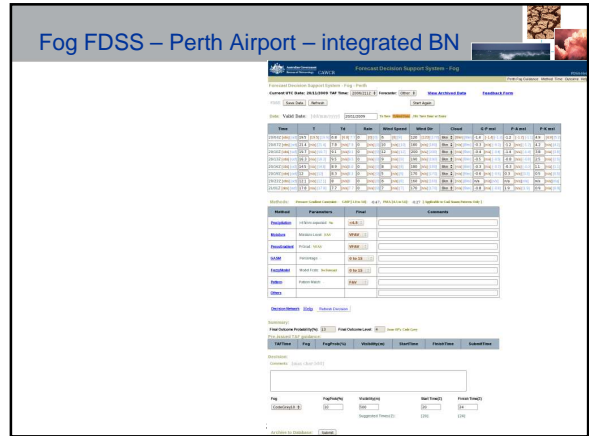
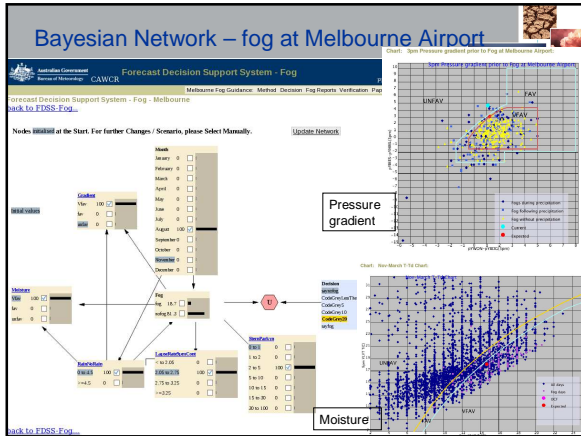
Melbourne Airport – BN



Perth Airport – BN



FDSS – Melbourne Airport – integration of BN



- ### Conclusions
- Described issues associated with fog forecasting for aviation
 - Experience has shown consensus forecast with structured forecast process is more reliable
 - Integration of Bayesian Networks into fog forecast process
 - Based on probability theory – solid mathematical foundation
 - Enables the integration of range of data types
 - Can handle missing data
 - Enables assessment of different scenarios
 - Decision based on well founded decision theory

Thank you