A dynamic Bayesian network template for fog forecasting

ARC Linkage Research Project
Monash University

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Fog Forecasting for Airlines

- Terminal Aerodrome Forecast (TAF) issued every 6 hours; valid for 30h

3pm ----------→| ~ 9am (Perth) /11am (Melbourne)

9pm ----------→| ~ 9am

3am ----------→| ~ 9am

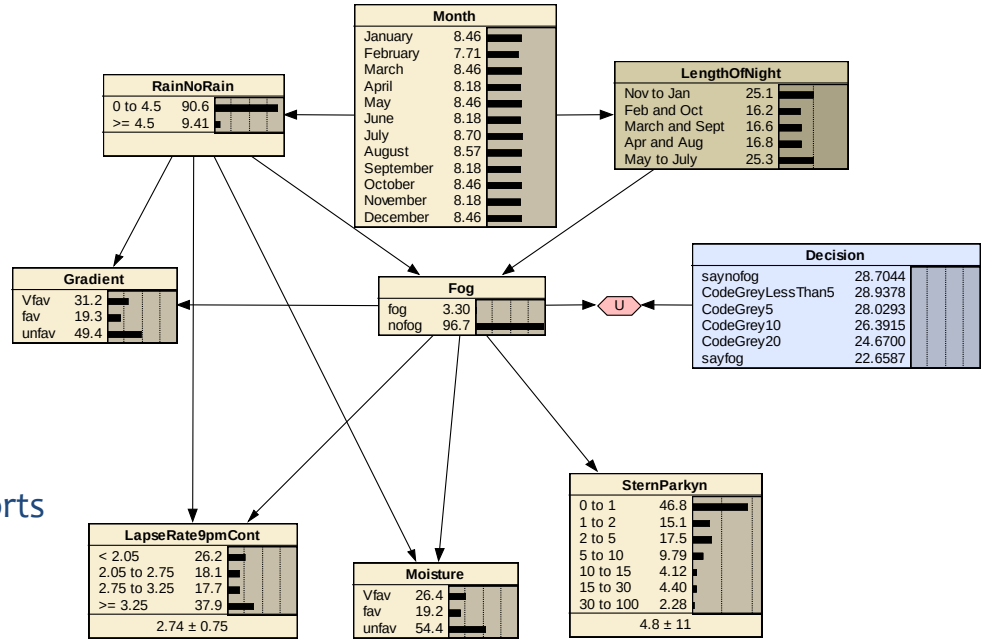
  - when fog probability ≥ 30% -> included in the TAF
  - If fog forecasted, aircrafts must carry enough fuel to
    - reach an alternative airport
    - maintain a holding pattern above the airport

- When chance of fog >5% but <30% -> Code Grey

Current (static) BNs

Four priority airports were chosen for fog forecast improvement:

- **Melbourne** (~ 12-13 fogs)
  - **Networks for 3pm, 6/9pm, midnight**
- **Sydney** (~ of 4 to 5 fogs per year),
  - with the largest traffic volumes
  - **Networks for midnight, 2am and 3am**
- **Canberra** (~ 42 fogs)
  - **Networks for 6pm, midnight and 3am**
- **Perth** (~ 12 fogs per year),
  - large distances to the nearest alternate airports
  - **A network for 3pm**



Fog Y/N

No prediction of onset and clearance

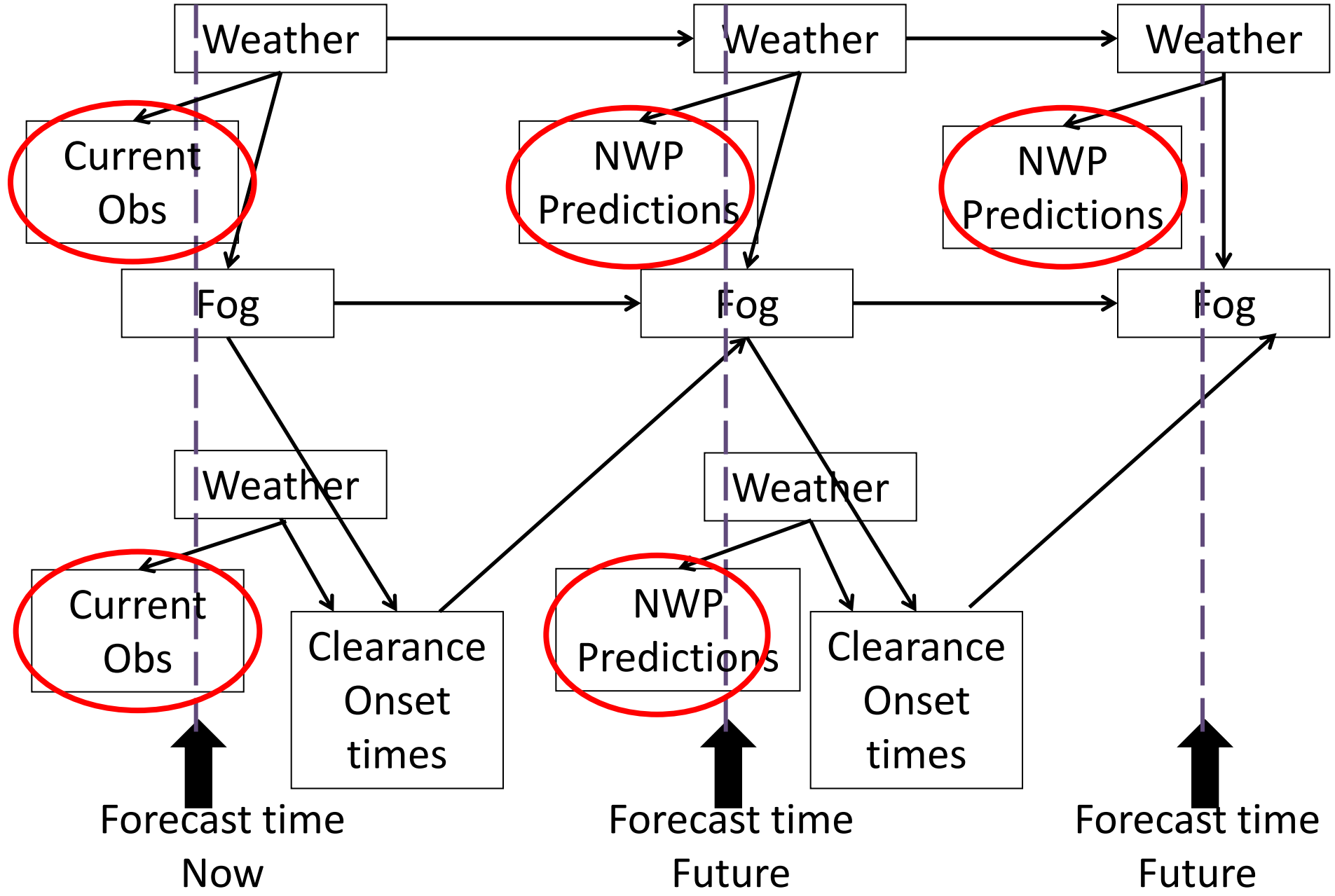
Dynamic BN

- DBN = BN0 + 2TBN (2 timeslice BN)
  - BN0 –> defines the prior probability distribution over the variables at time 0
  - 2TBN –> provides the transition model from time slice t to t+1
- DBNs model discrete fixed increments of time-slices

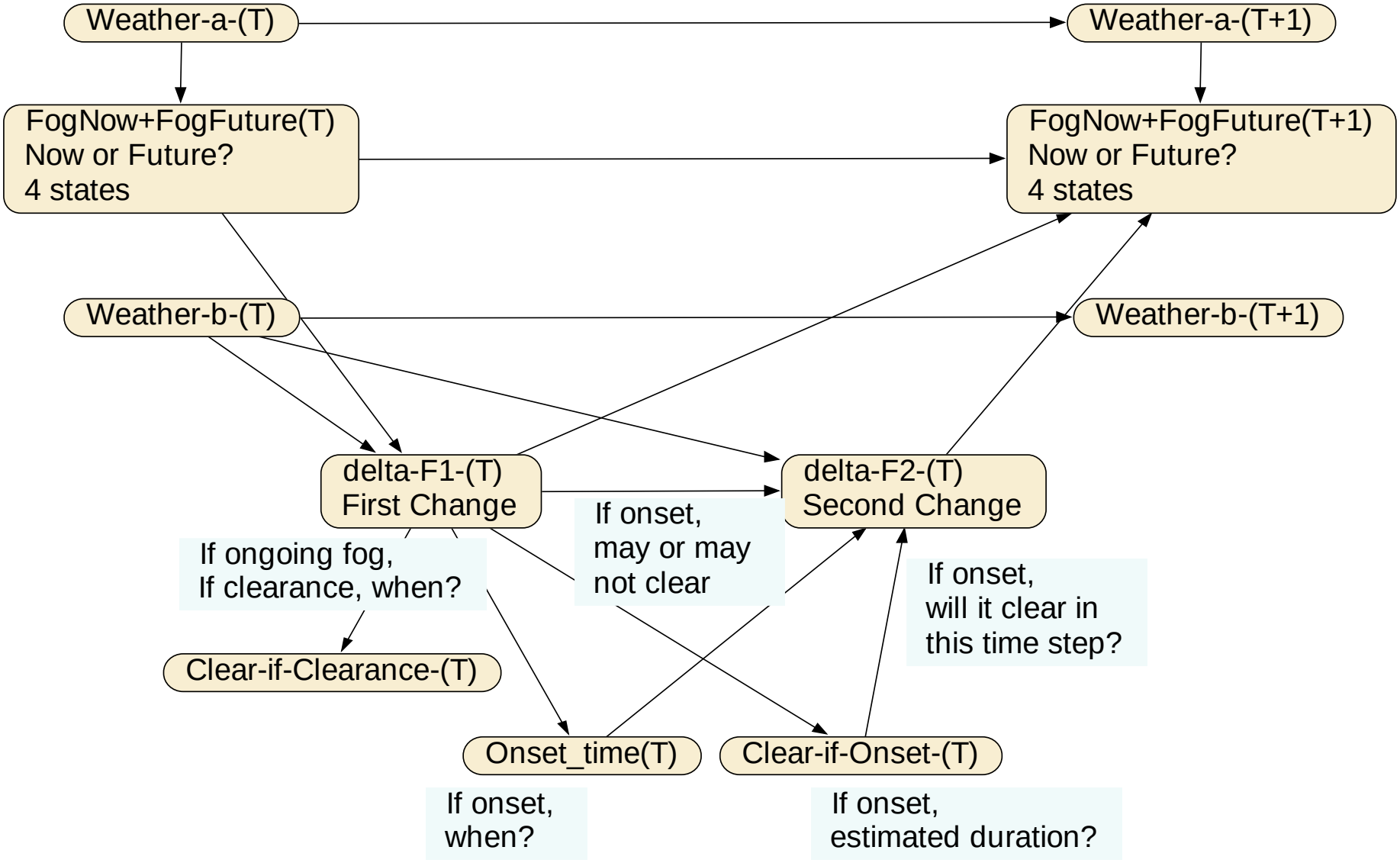
Fog DBN

- Delta-T is fixed and equal over time (3hr)
  - Conceptually can be 4hr, 6hr or 10min; limited by data and computational complexity
- Each slice T includes:
  - states of now (fog now, weather now)
  - states between T and T+1 (onset or clear within delta-T)
  - states of the future (fog sometime overnight)
- Each slice T is:
  - associated with specific time of day
  - modelled differently to other slices
    - variables and conditional distributions
- At all times, DBN includes all (8) slices from midday to next morning (9am)

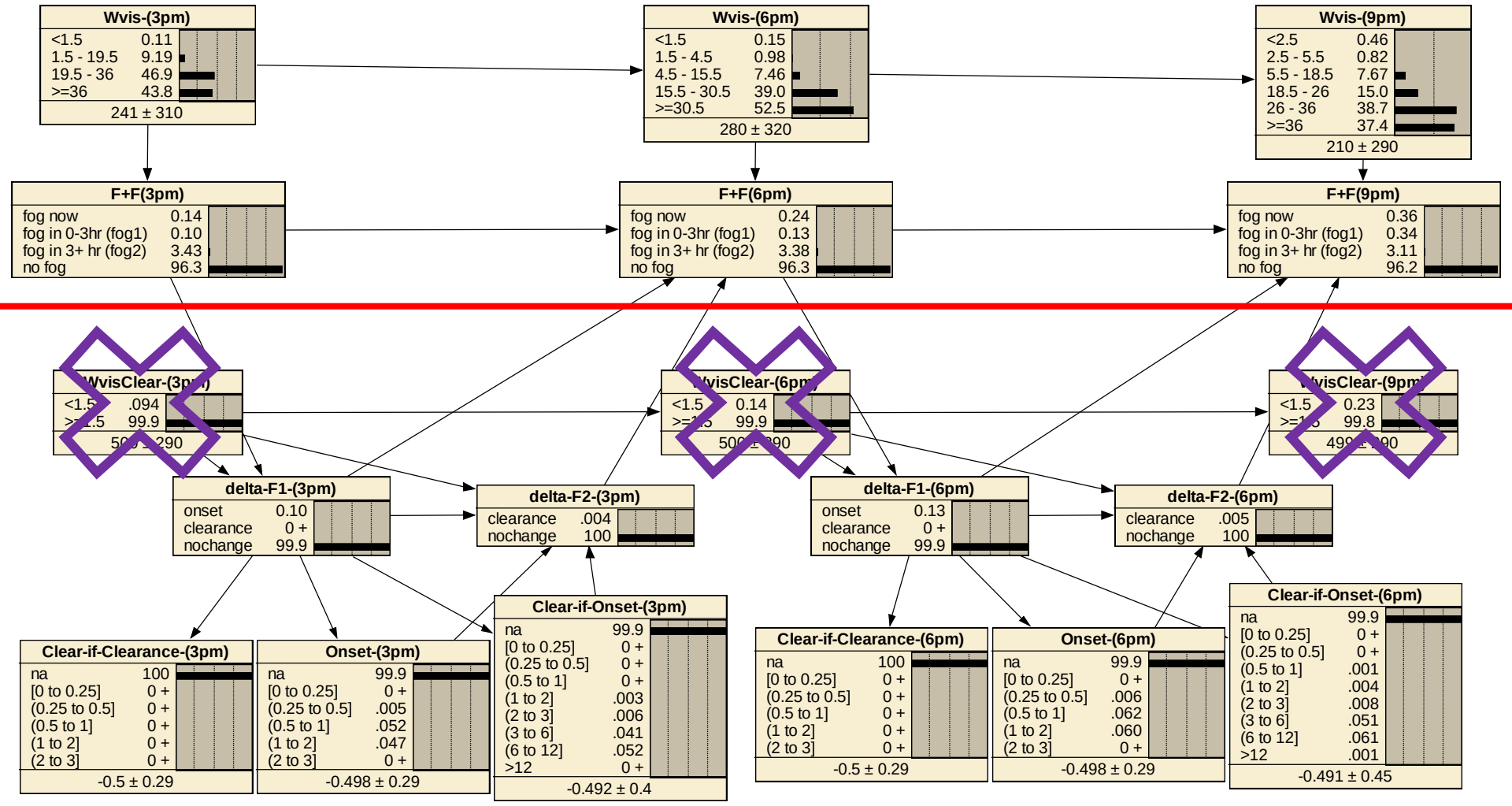
DBN Framework for Fog

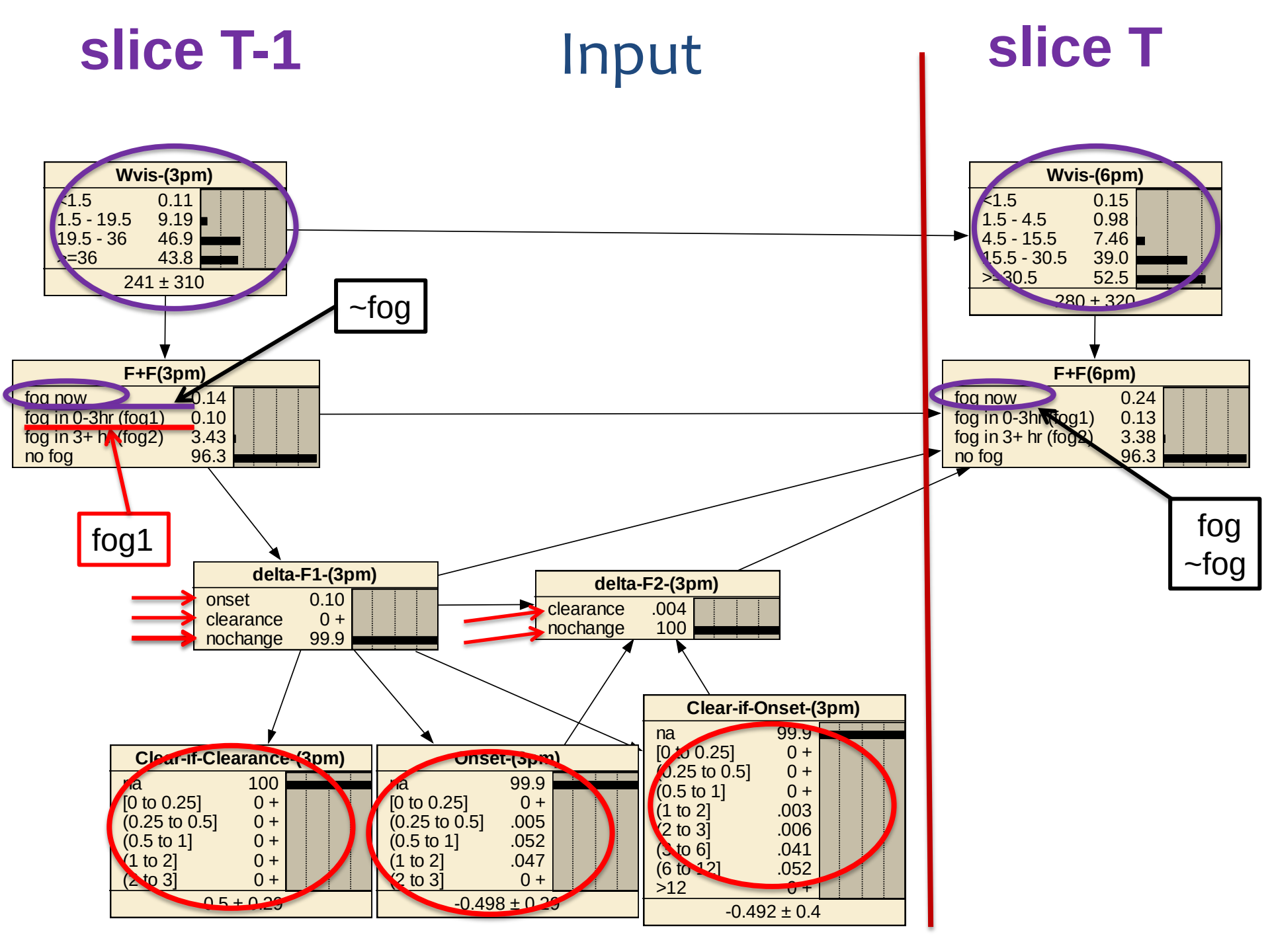


Initial DBN Prototype



Initial DBN Prototype
no clearance prediction




slice T-1
Input
slice T
Wvis-(3pm)
<1.5 0.11
1.5 - 19.5 9.19
19.5 - 36 46.9
>=36 43.8
241 ± 310
~fog
F+F(3pm)
fog now 0.14
fog in 0-3hr (fog1) 0.10
fog in 3+ hr (fog2) 3.43
no fog 96.3
fog1
delta-F1-(3pm)
onset 0.10
clearance 0 +
nochange 99.9
delta-F2-(3pm)
clearance .004
nochange 100
Clear-if-Clearance-(3pm)
na 100
[0 to 0.25] 0 +
(0.25 to 0.5] 0 +
(0.5 to 1] 0 +
(1 to 2] 0 +
(2 to 3] 0 +
0.5 ± 0.29
Onset-(3pm)
na 99.9
[0 to 0.25] 0 +
(0.25 to 0.5] .005
(0.5 to 1] .052
(1 to 2] .047
(2 to 3] 0 +
-0.498 ± 0.29
Clear-if-Onset-(3pm)
na 99.9
[0 to 0.25] 0 +
(0.25 to 0.5] 0 +
(0.5 to 1] 0 +
(1 to 2] .003
(2 to 3] .006
(3 to 6] .041
(6 to 12] .052
>12 0 +
-0.492 ± 0.4
Wvis-(6pm)
<1.5 0.15
1.5 - 4.5 0.98
4.5 - 15.5 7.46
15.5 - 30.5 39.0
>=30.5 52.5
280 ± 320
F+F(6pm)
fog now 0.24
fog in 0-3hr (fog1) 0.13
fog in 3+ hr (fog2) 3.38
no fog 96.3
fog
~fog

A fog case (fog 00:15 - 4:00)

	ForecastTime Info.		
Nodes	midN	3am	6am
F_F_TmidN	~{fog}	nofog1	nofog1
delta_F1_TmidN	*	onset	onset
delta_F2_TmidN	*	nochange	nochange
Onset_TmidN	*	0.25	0.25
Clear_if_Clearance_TmidN	*	*	*
Clear_if_Onset_TmidN	*	*	*
Wvis_TmidN	1	1	1
F_F_T3am	*	fog	fog
delta_F1_T3am	*	*	clearance
delta_F2_T3am	*	*	*
Onset_T3am	*	*	*
Clear_if_Clearance_T3am	*	*	1
Clear_if_Onset_T3am	*	*	*
Wvis_T3am	*	1	1
F_F_T6am	*	*	~{fog}
delta_F1_T6am	*	*	*
delta_F2_T6am	*	*	*
Onset_T6am	*	*	*
Clear_if_Clearance_T6am	*	*	*
Clear_if_Onset_T6am	*	*	*
Wvis_T6am	*	*	4

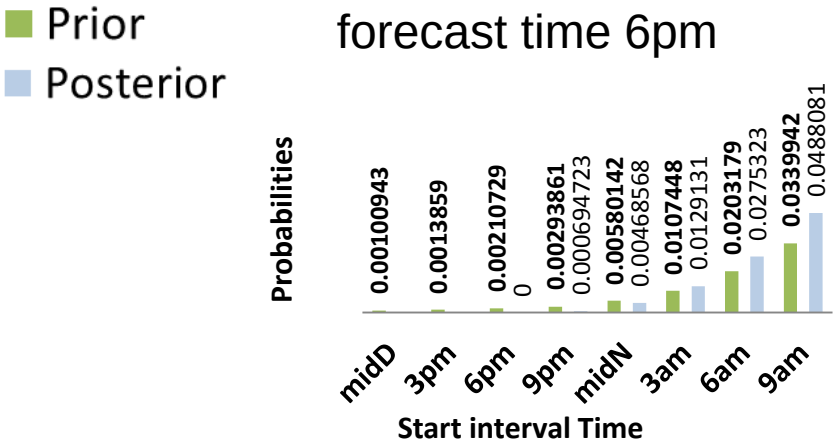
net slice

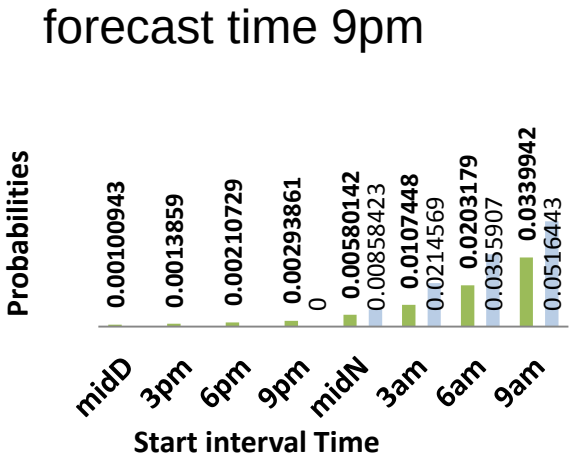
midN

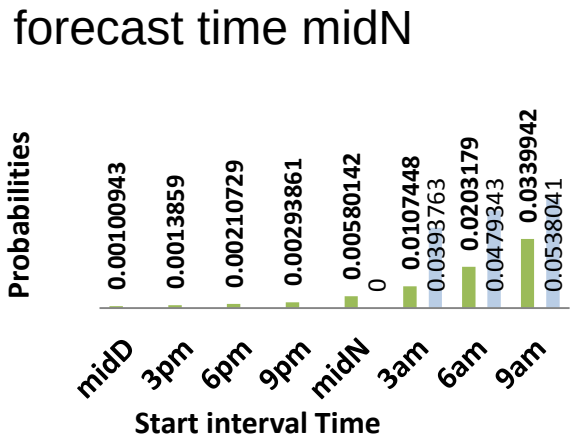
3am

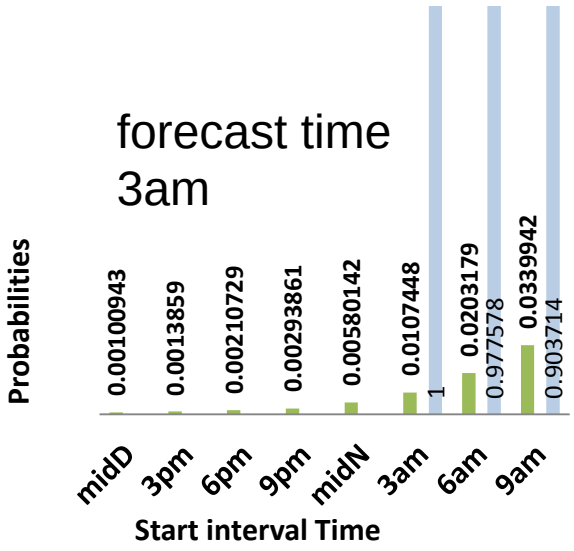
6am

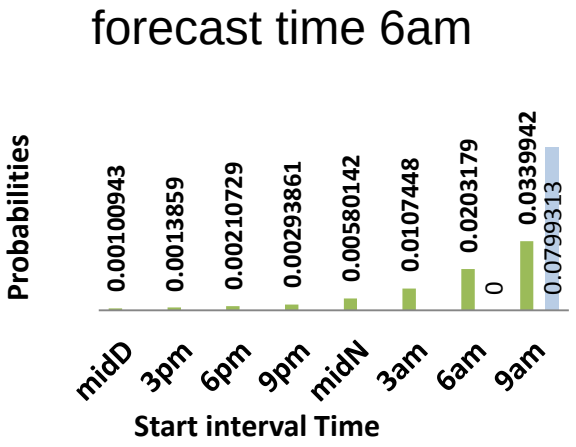
A fog case (fog 00:15 - 4:00)
probabilities of 'fog now' at different forecast times







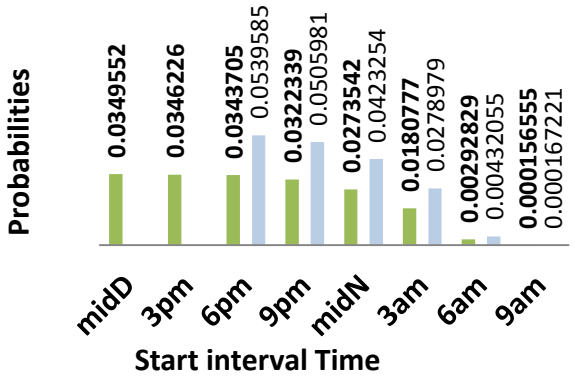




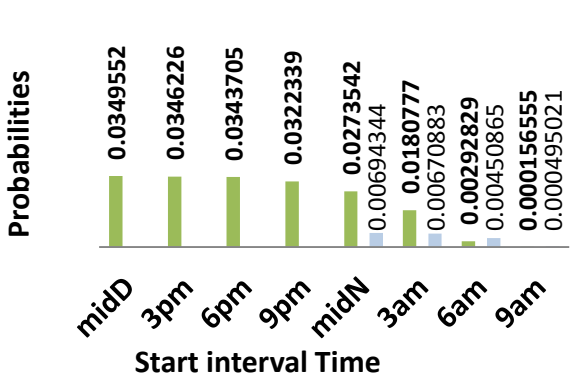
A fog case (fog 00:15 - 4:00)
probabilities of ‘fog tonight’ at different forecast times

Prior
Posterior

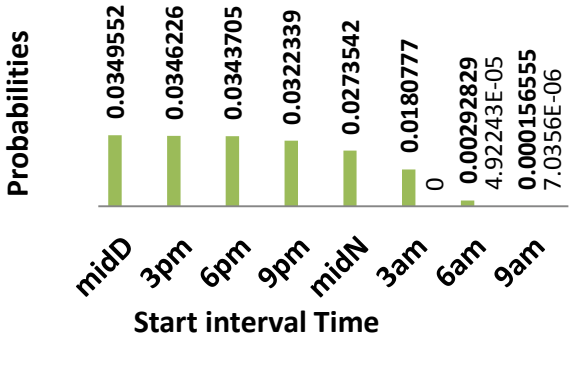
forecast time 6pm



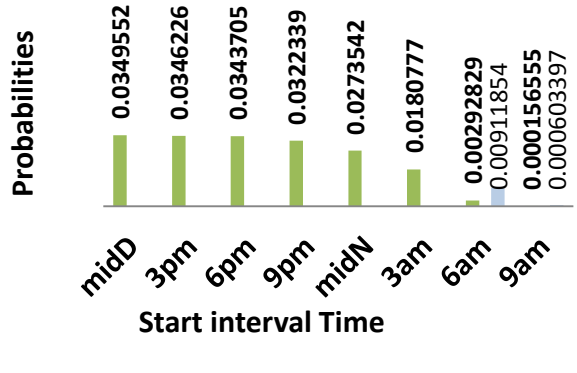
forecast time midN



forecast time 3am



forecast time 6am



What next

- Represent the weather
  - Identify fog/onset/clearance predictors
  - Discretisation
  - Find relationships / structures between the predictors
  - Incorporate into the template
- Test
- Repeat for other locations

Thank You