Using Probabilistic Forecasts in Decision Making

Devin Kilminster

Senior Scientist
Forecasting Research
Meteorological Service of New Zealand Limited

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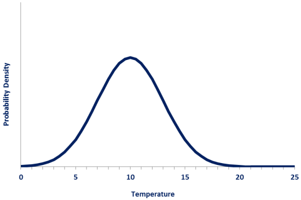
Why probabilistic forecasting?

- Not only does the forecaster predict what is most likely to happen,
- but they can also express their uncertainty in this prediction.



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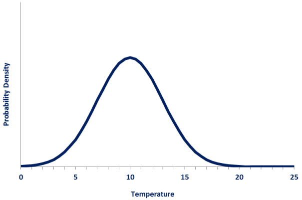

Why should you care about the forecaster's uncertainty?

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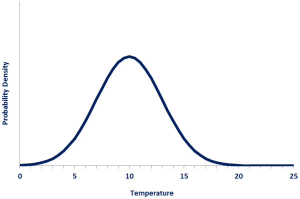

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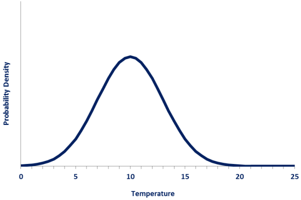

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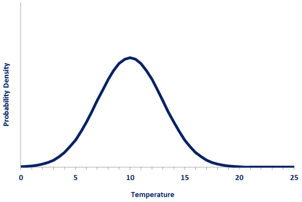

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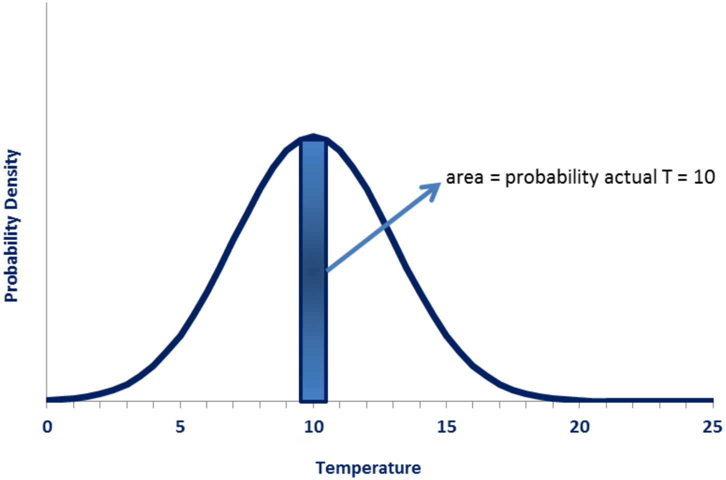
[Also:

- Contrast perspectives of the user vs. the provider of forecasts.]

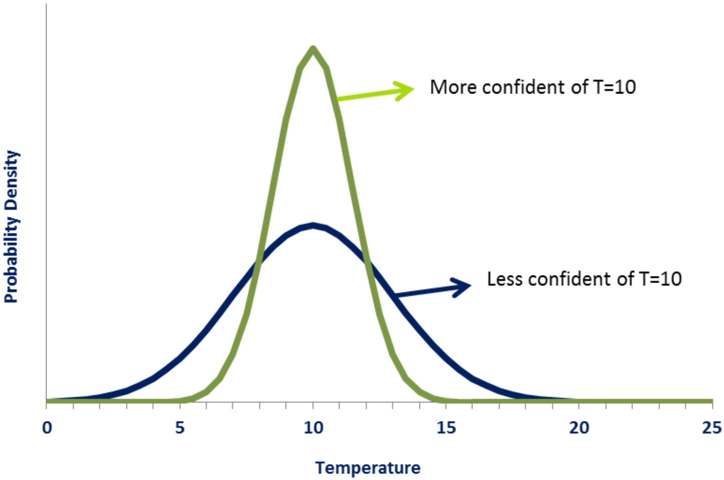
Basics of pdfs

area under curve = probability

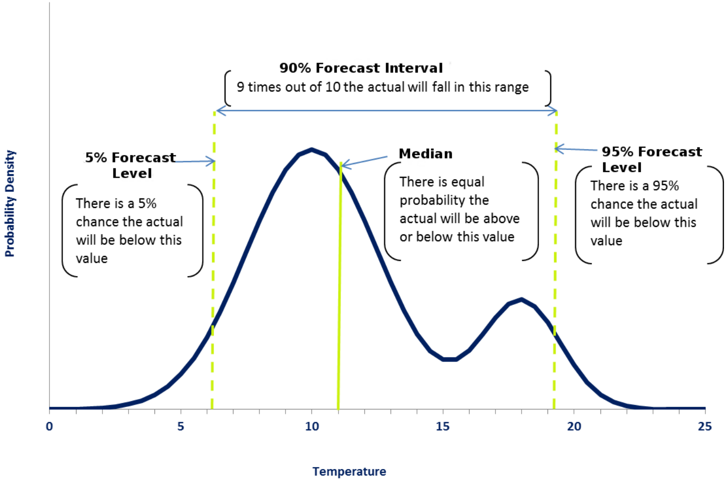


Basics of pdfs

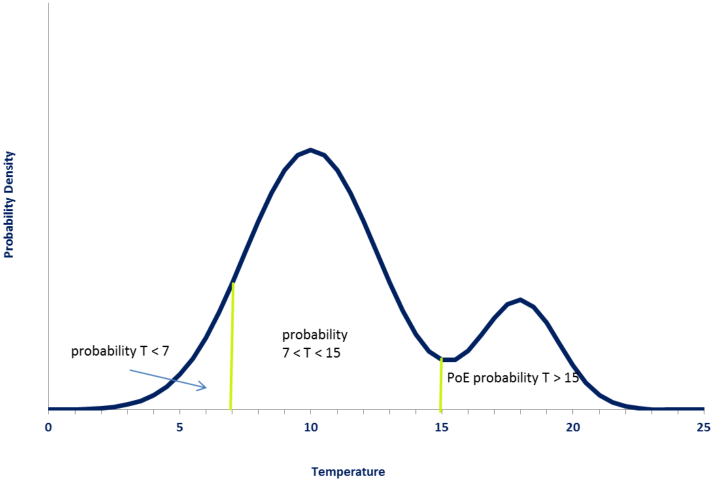
less spread $\Rightarrow$ more confidence



Basics of pdfs — levels and intervals



Basics of pdfs — range and exceedance probabilities



Example — Icing in CCGTs

When temperatures drop below 4C (humidity dependent), ice can form in CCGT turbine inlet region.

- Reduces efficiency (less power production).
- Increases wear and tear (increased maintenance costs).
- Potential for catastrophic damage (plant offline).

A de-icing agent can be applied:

- Best applied before ice begins to form (before T<4C):
  - less is needed to prevent than to remove ice.
- De-icing reduces profit by increasing operational costs.

Example — Icing in CCGTs

Simplifying our choices:

Tactic A 'Wait and See'

- If T stays above 4 — no cost.
- If T drops below 4 — high cost (eg $5000).

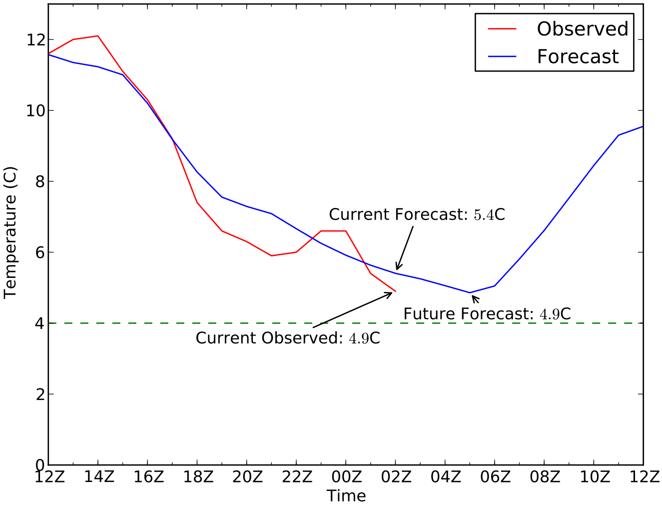
Tactic B 'Pre-empt'

- Before T goes below 4 — low cost (eg $1000).
- Chance we will be wrong and we have wasted agent/money.

[These costs are purely hypothetical.]

Asymmetry of the costs suggests we want to be 'conservative'.

UK CCGT — 2 am early October 2012



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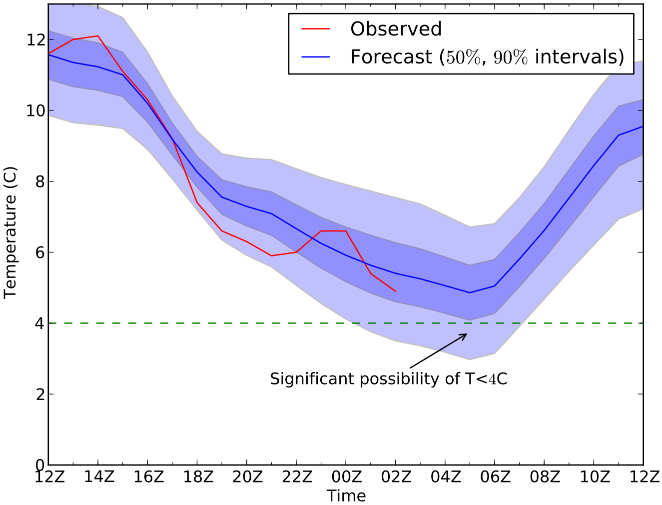

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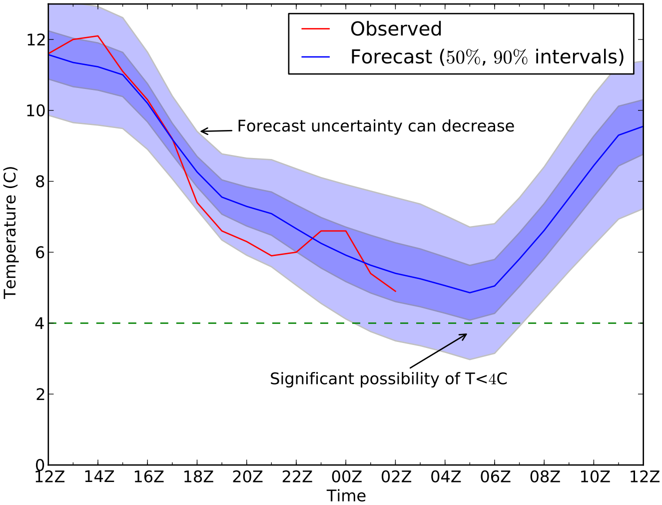
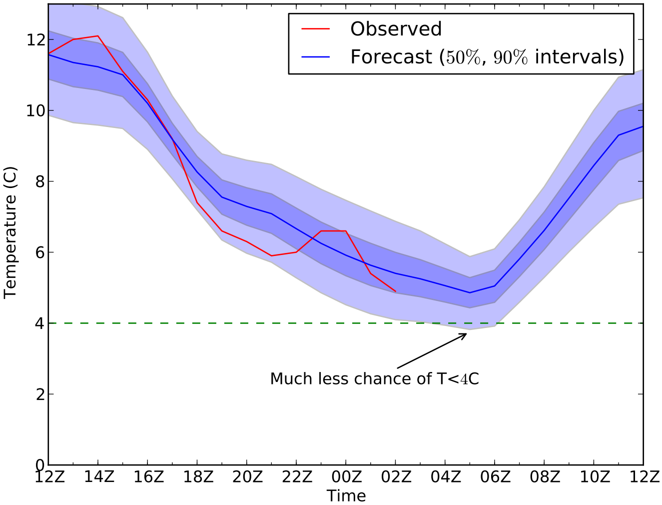


UK CCGT — Hypothetical possibility



Decision theory

1. Enumerate the possible actions.

Action
Wait
Pre-empt

Decision theory

1. Enumerate the possible actions.
2. For each action enumerate the relevant outcomes and consequences.

Action	Outcome	Consequence
Wait	T$<$ 4C	Lose $5000
	T$\geq$ 4C	None
Pre-empt	any	Lose $1000

Decision theory

1. Enumerate the possible actions.
2. For each action enumerate the relevant outcomes and consequences.
3. Using the forecast, find the distributions of the consequences for each action.

Action	Outcome	Consequence	Probability
Wait	T$<$ 4C	Lose \$5000	p
	T$\geq$ 4C	None	$1 - p$
Pre-empt	any	Lose \$1000	1

p is forecast probability that T$<$ 4C.

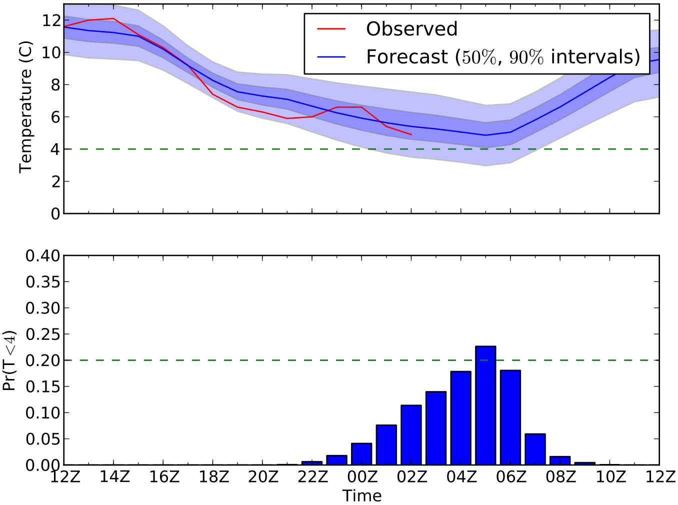
Decision theory

1. Enumerate the possible actions.
2. For each action enumerate the relevant outcomes and consequences.
3. Using the forecast, find the distributions of the consequences for each action.
4. Choose the action corresponding to the preferred distribution of consequences.

Action	Outcome	Consequence	Probability	$\mathbb{E}(\text{Loss})$
Wait	T$<$ 4C	Lose \$5000	p	$5000p$
	T$\geq$ 4C	None	$1-p$	
Pre-empt	any	Lose \$1000	1	1000

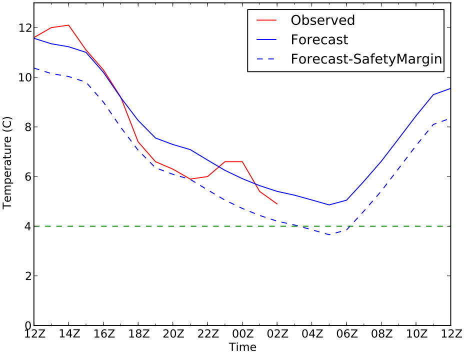
p is forecast probability that T$<$ 4C.
Pre-empt when $1000 < 5000p$, ie when $p > 20\%$.

Use Probability of Exceedance?



Solving the problem 'deterministically'

- Asymmetry of costs suggests choosing some 'safety margin':



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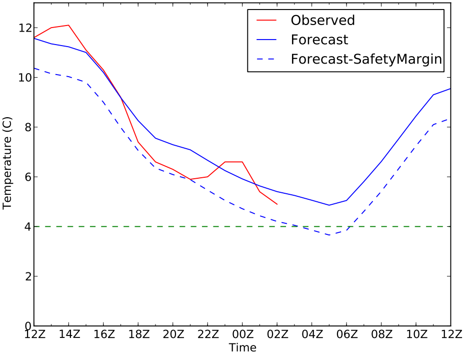

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  - Why not let the forecaster provide the uncertainty?

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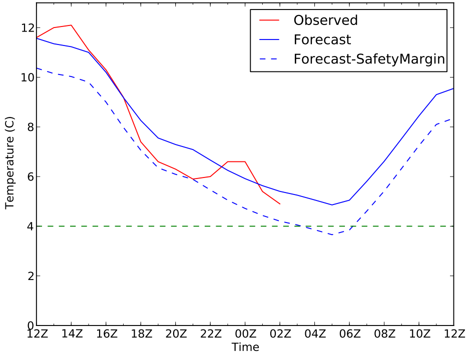
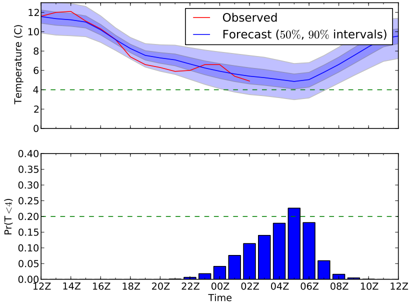


- Really just estimating a constant forecast uncertainty.
  - Why not let the forecaster provide the uncertainty?
- Sub-optimal if forecast uncertainty is actually non-constant.

Some other issues

1. Using hourly pdf forecasts, but really care about extreme across a range of time.
2. Information in observations made after forecast was issued.



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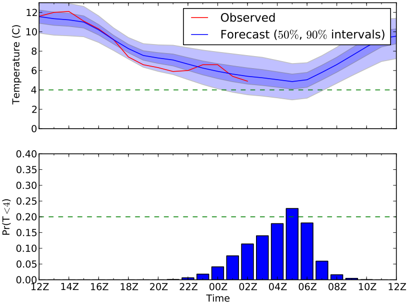

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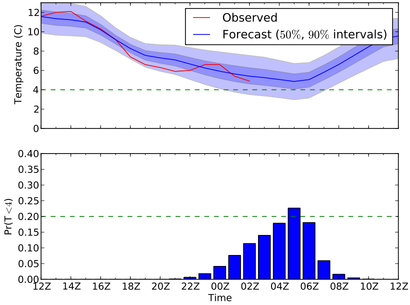

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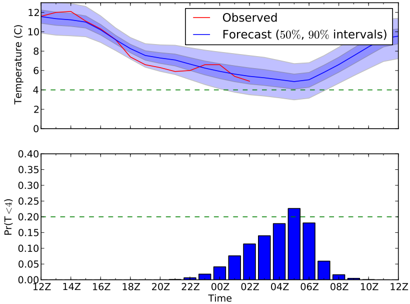

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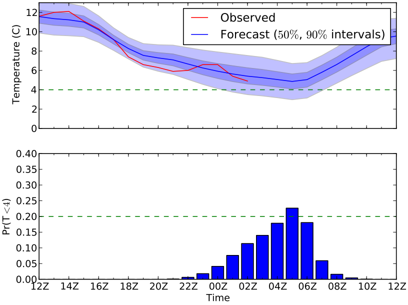

1. Joint uncertainty information.
   - Use information about correlations in observations wrt forecasts — high in this case.
   - Forecast the quantity directly relevant to the decision. (e.g. the minimum.)
2. Frequent updating of forecast.
   - Provide real-time observations to the forecaster?

When does decision theory work?

Reliability:[1]

$$p(\cdot|f) = f$$

- Roughly, that no ‘recalibration’ of the forecast is necessary to get probabilities.

[1] see for example *Scoring Probabilistic Forecasts: The Importance of Being Proper*, J. Bröcker and L. Smith, Weather and Forecasting, 22, 2007.

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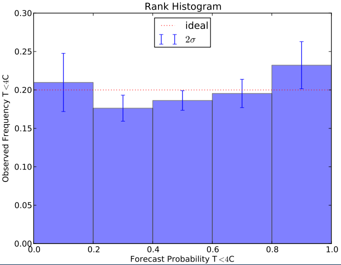

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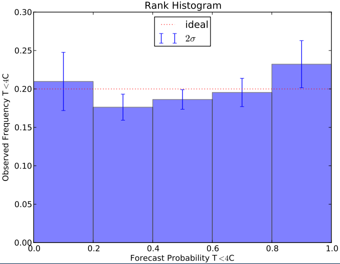

- Often used as test of reliability — but maybe something more relevant to the decision is appropriate. . . .

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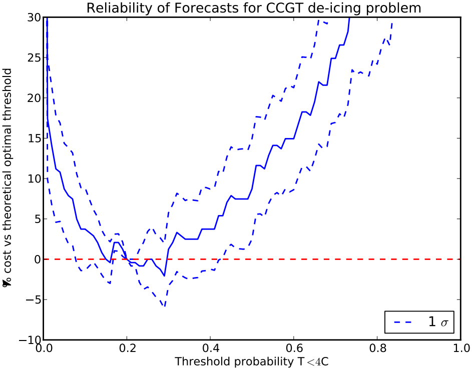
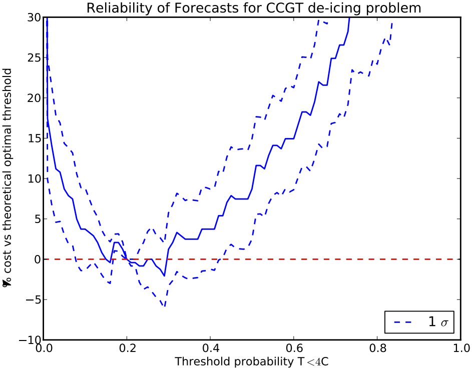

Reliability of Forecasts for CCGT de-icing problem
% cost vs theoretical optimal threshold
30
25
20
15
10
5
0
−5
−10
0.0
0.2
0.4
0.6
0.8
1.0
Threshold probability T <4C
1 σ



My goal as a forecast provider is to make probabilistic forecasts that:

- are reliable with respect to my customer's decision problems, and
- are accurate in the sense that they can help my customer make good decisions.

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- Are we forecasting the quantity most relevant to the decision? — Forecast of Minimum vs. Hourlies.
- Reliability and Accuracy.

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What happened?