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Evaluating the Accuracy of Weather Predictions for Melbourne Leading Up to the Heavy Rain Event of Early December 2017

ABSTRACT: *The opening four days of summer 2017 saw Melbourne city recording 73.4 mm of rain, with several places just 60 km to the northeast receiving totals ~200 mm. Prior to the event, on November 30, for the first four days of December, the Bureau of Meteorology predicted median rainfall totals of 25 mm, 30 mm, 20 mm and 1 mm, respectively, for a four day rainfall total of 76 mm. The Bureau also indicated the possibility (with a 25% chance of occurring) of rainfall totals for the first four days, in excess of 70 mm, 80 mm, 50 mm and 8 mm, respectively. This suggested a small (1 in 250 chance) of a four day rainfall total of ~200 mm (should each of these higher amounts be realised). The purpose of this paper is to evaluate the accuracy of the Bureau forecasts leading up to this event, as they prompted warnings of significant flooding across Melbourne.*

ABSTRACT (continued): *Assessing the probable maximum precipitation for any locality involves assessing whether one may legitimately spatially transfer heavy rainfall events from another place to that locality. Given that the event was characterised by a dominant role being played by dynamical processes, and that ~200 mm fell nearby, it is considered legitimate to propose that there was the potential for an unprecedented four day rainfall total of ~200 mm in Melbourne. A statistical relationship has been established between observed rainfall, and numerical and worded aspects of the next day's forecast. This relationship shows that the contribution from the next day's forecasts for the four days from November-30 is to lift the accumulated percentage variance of the observed rainfall explained by the predictions from 50% to 65%.*

Figure 1 Location of Melbourne and Kinglake West (Wallaby Creek)

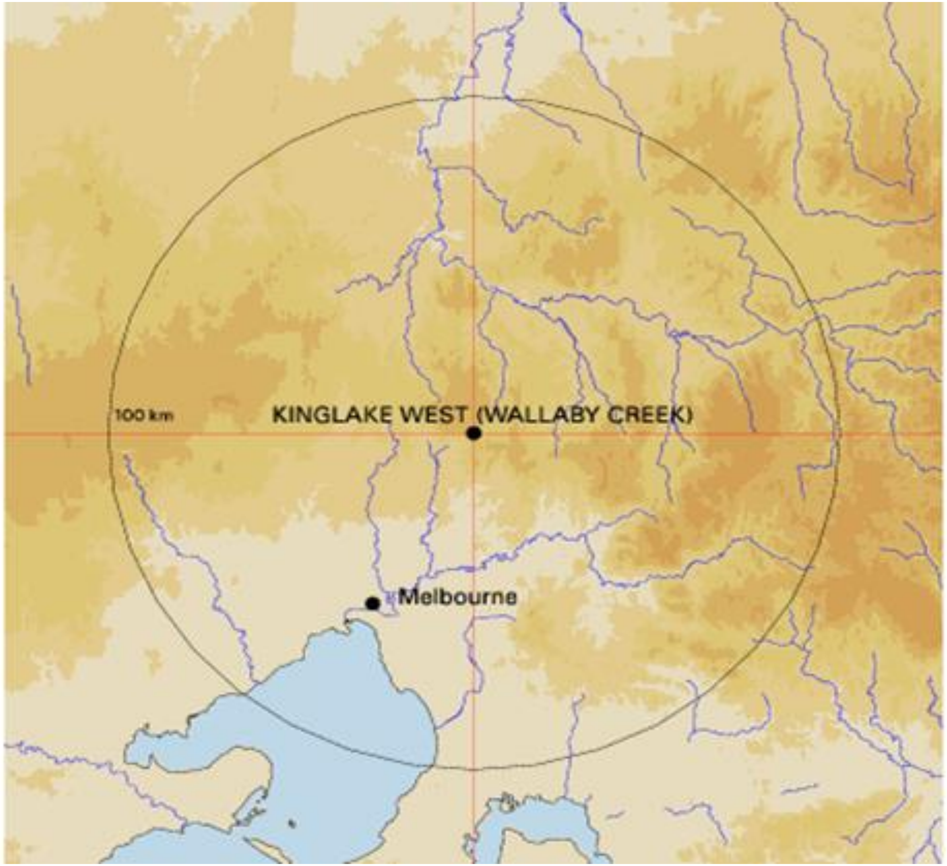

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Figure 2 Screen shot of a news item from the Australian Associated Press (AAP) website


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environment

Weather experts say warnings of dire flooding were justified

THERE were predictions in Melbourne of flooding so severe that lives were in danger. So what happened?

AAP DECEMBER 2, 2017 7:55PM

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Figure 3 Evolution of the Synoptic Situation (Surface)

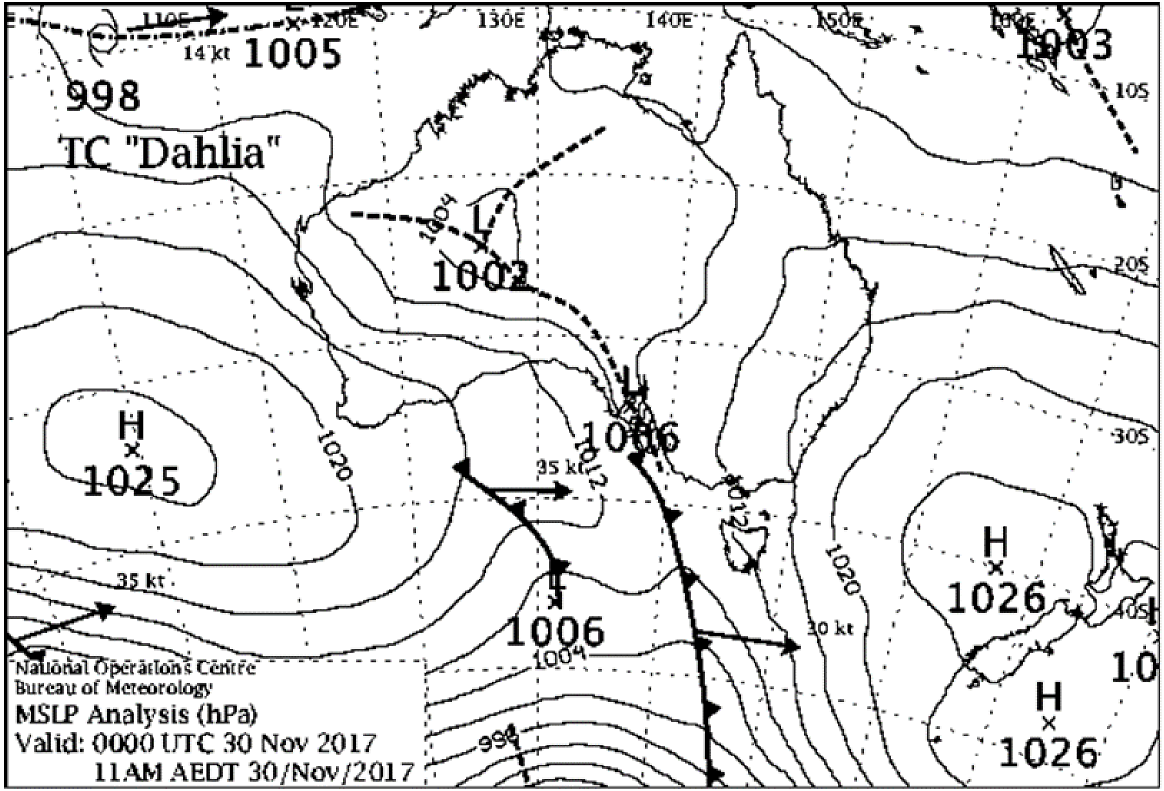

Figure 3 Evolution of the Synoptic Situation (Surface) (continued)

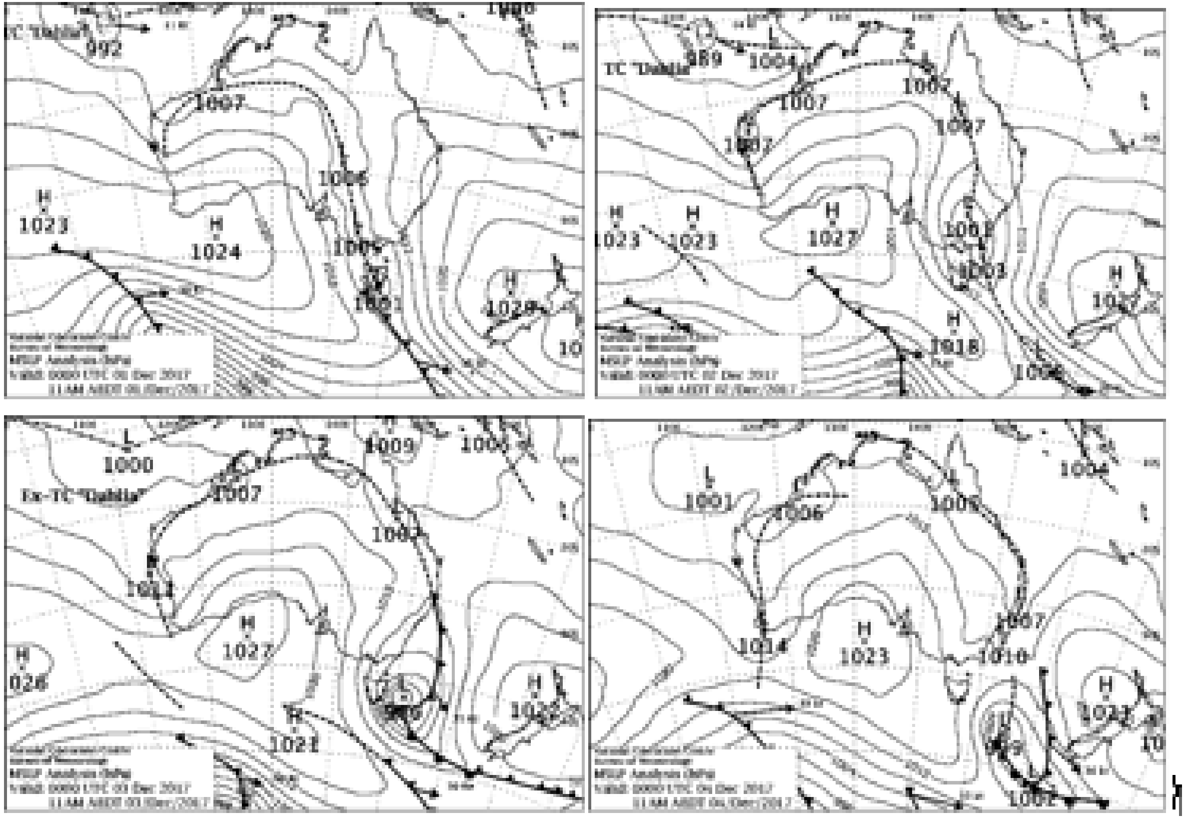

Figure 4 Evolution of the Synoptic Situation (Upper)

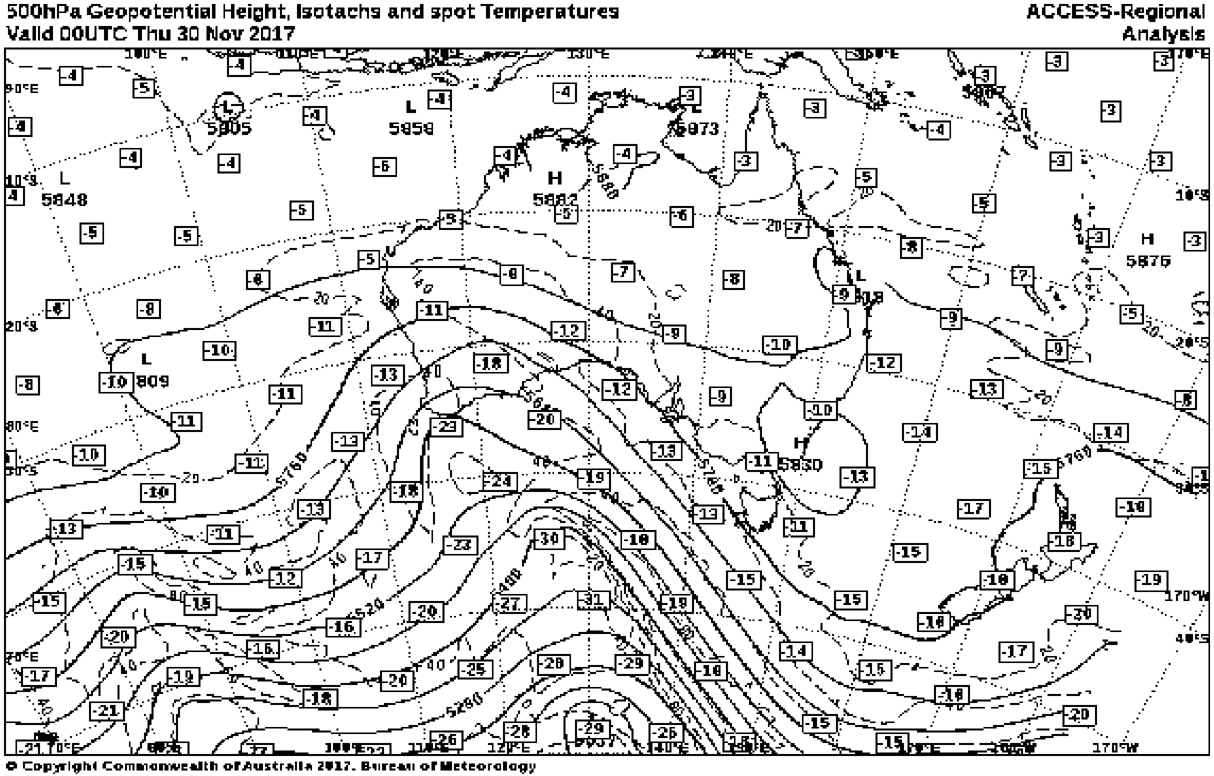

Figure 4 Evolution of the Synoptic Situation (Upper) (continued)

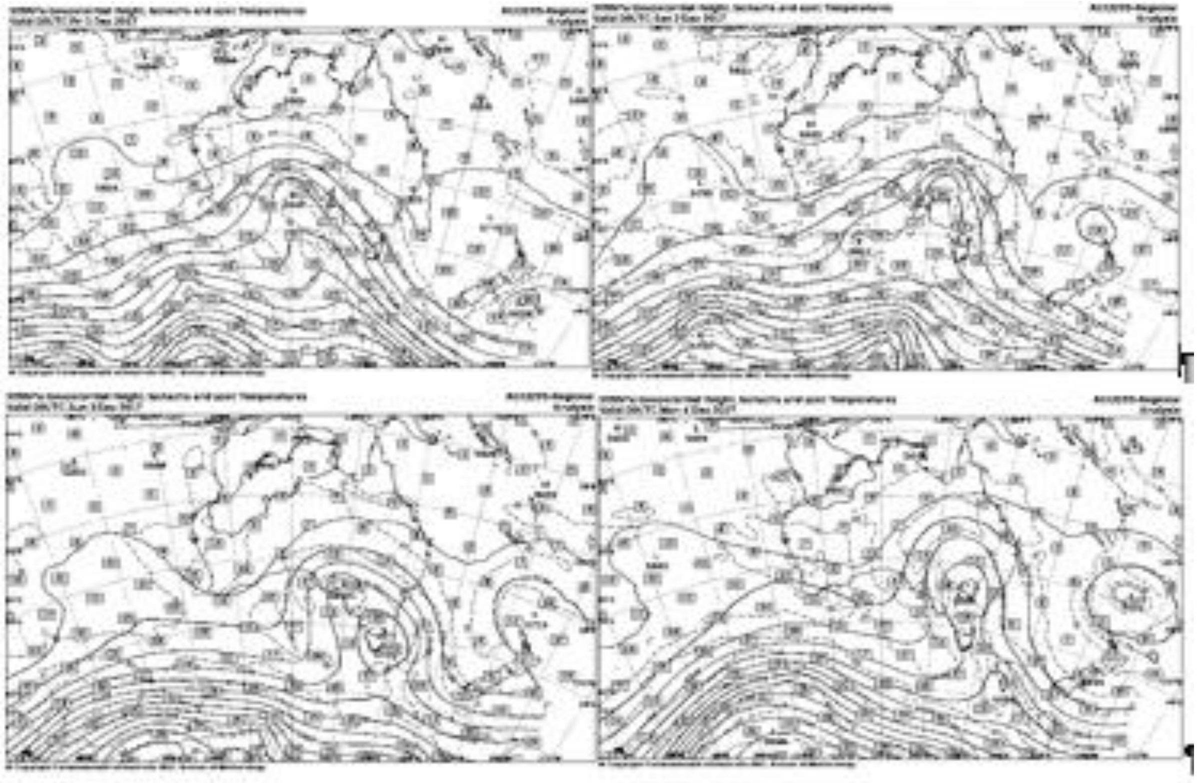

Figure 5 Impact of the ECMWF model predictions upon the *total* variance explained

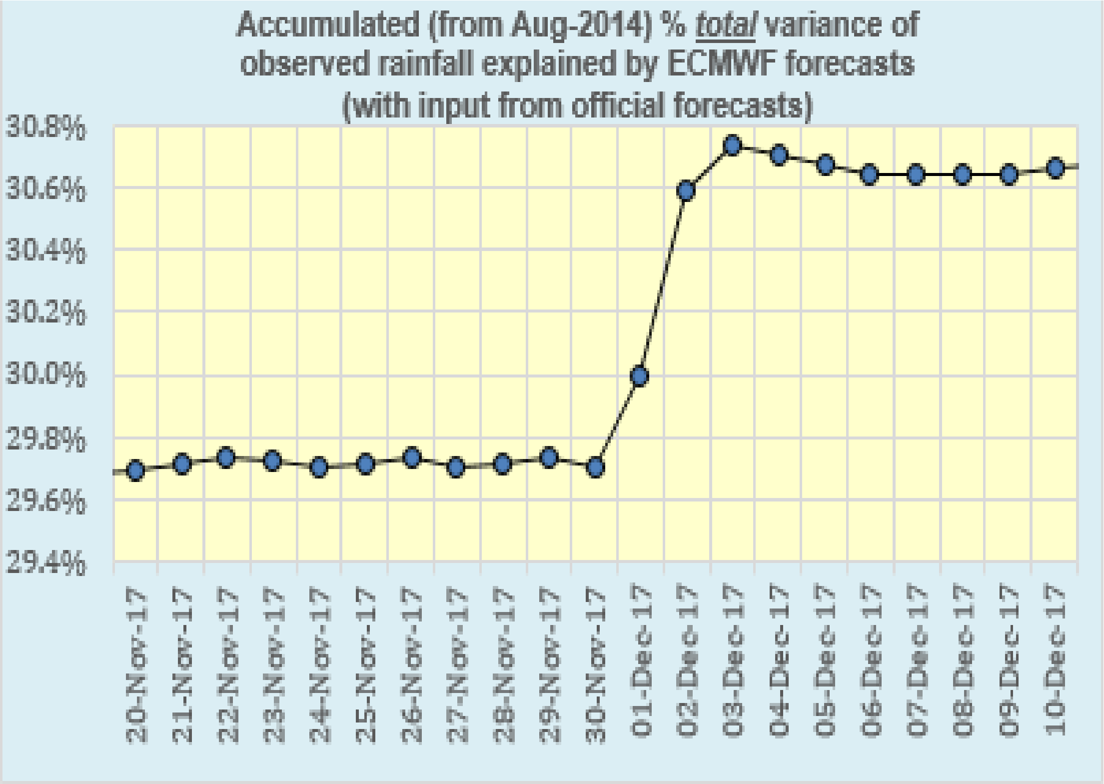

Figure 6 Impact of the ECMWF model predictions upon the *inter-diurnal* variance explained

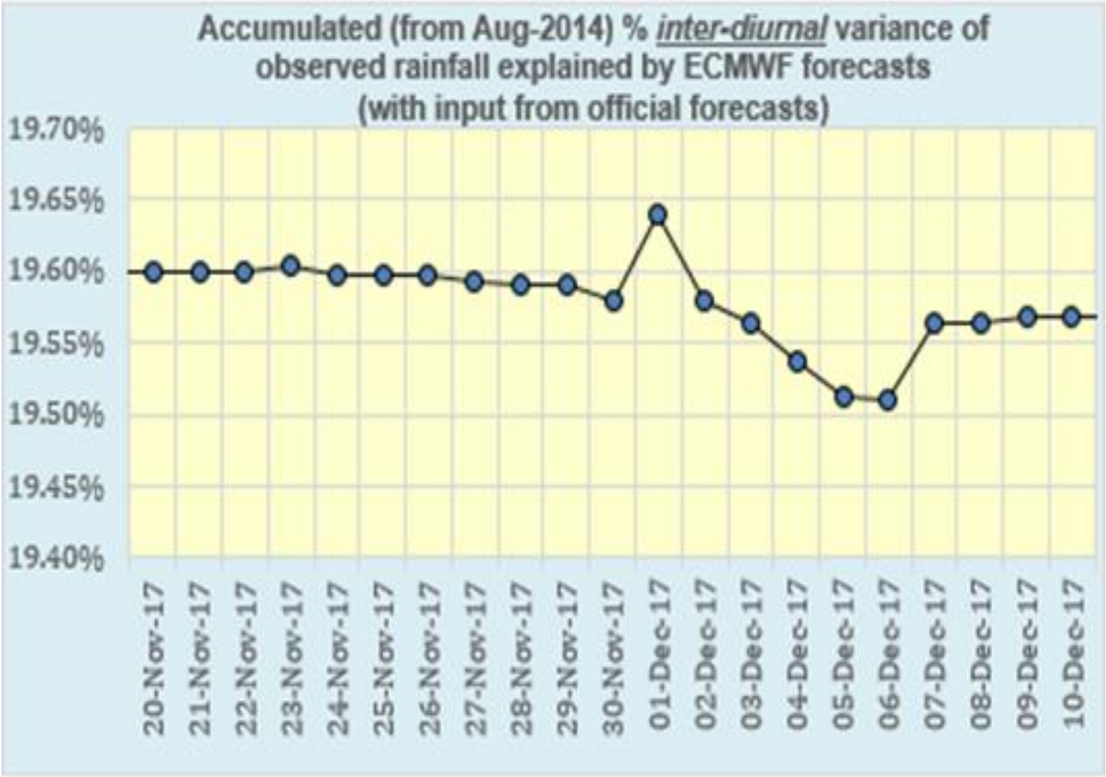

Figure 7 Impact of the GFS model predictions upon the *total* variance explained

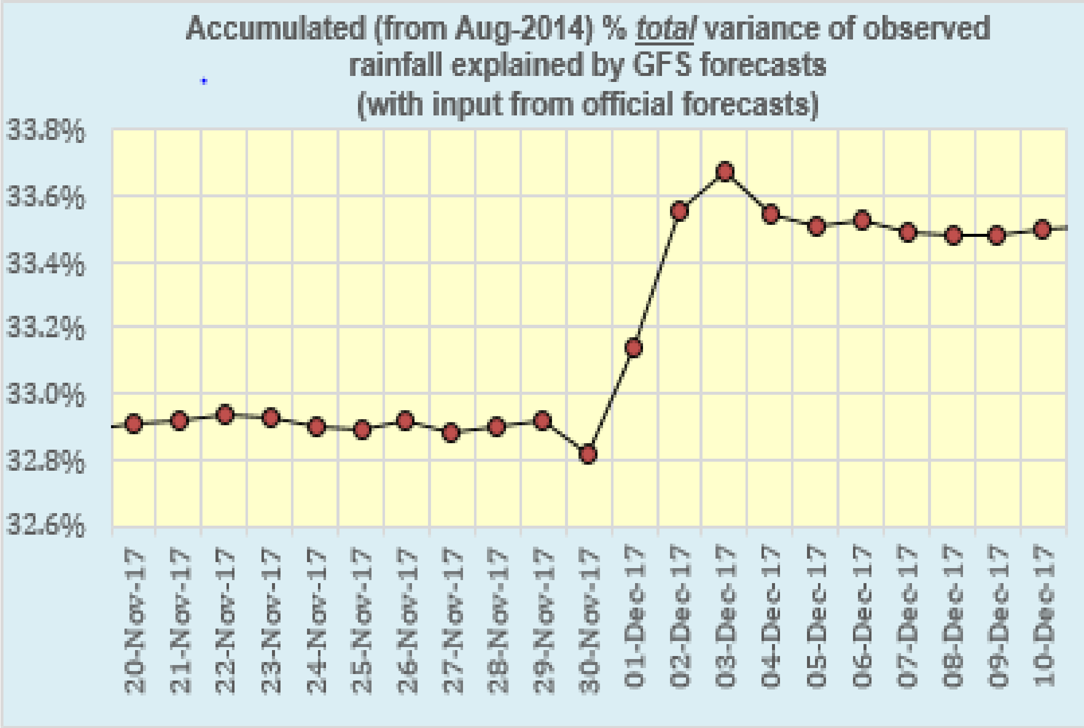

Figure 8 Impact of the GFS model predictions upon the *inter-diurnal* variance explained

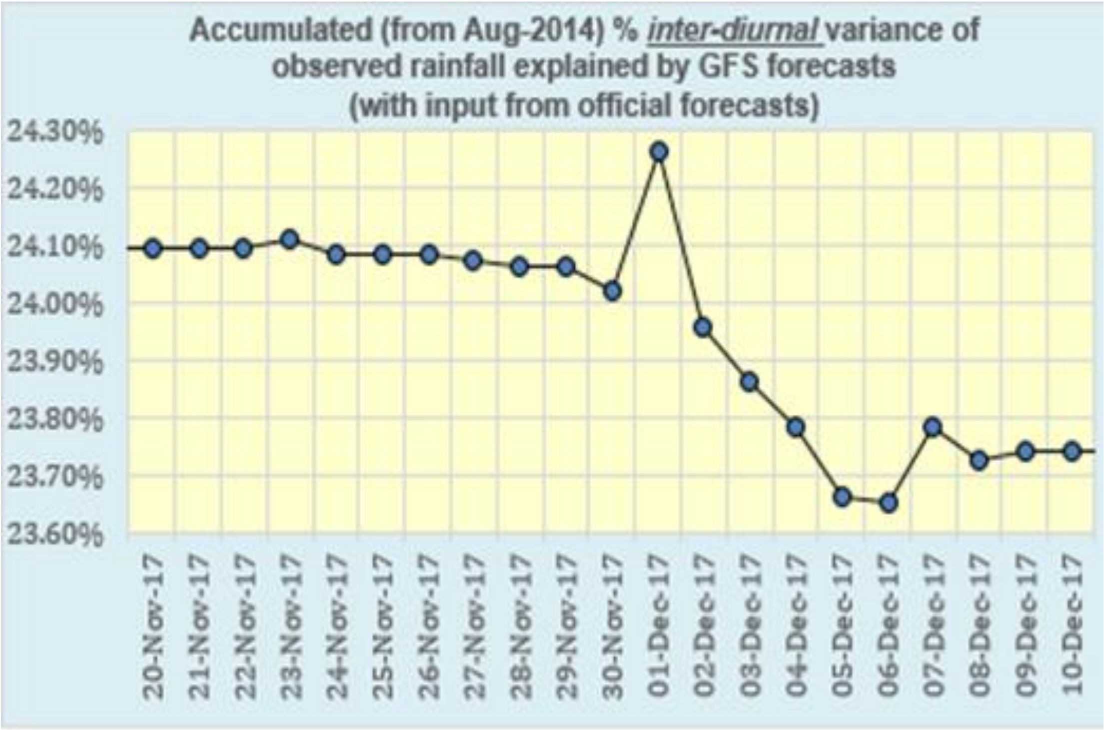

Figure 9 Impact of the Bureau official predictions upon the *total* variance explained

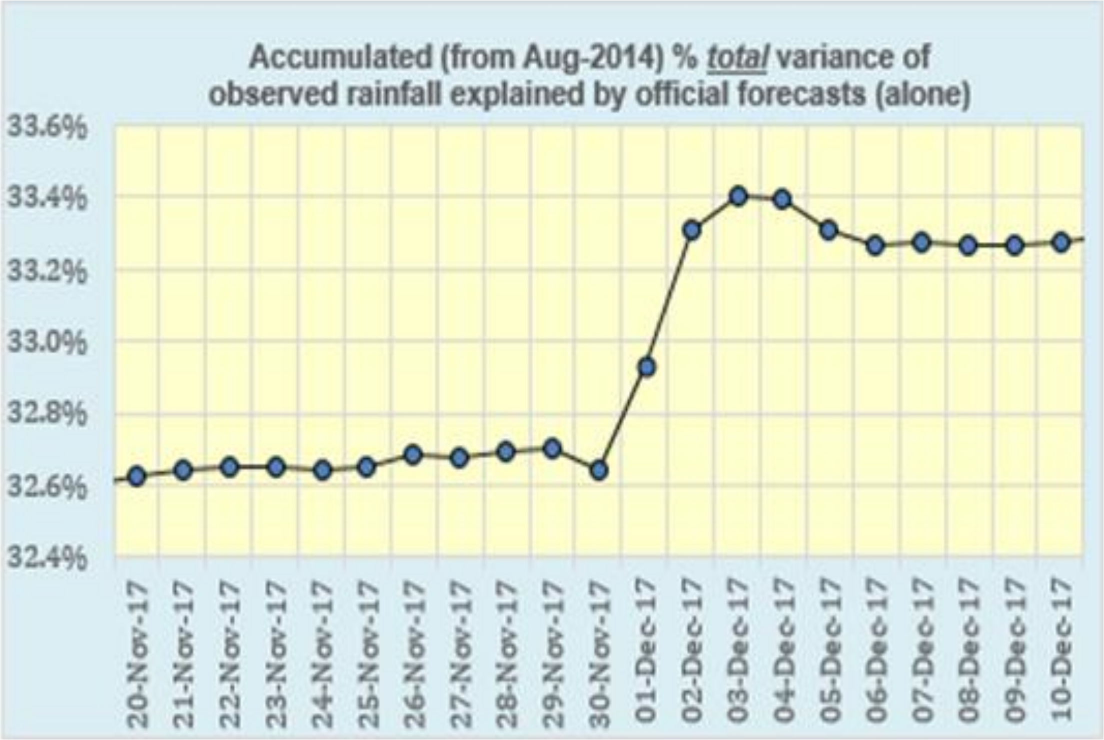

Figure 10 Impact of the Bureau official predictions upon the *inter-diurnal* variance explained

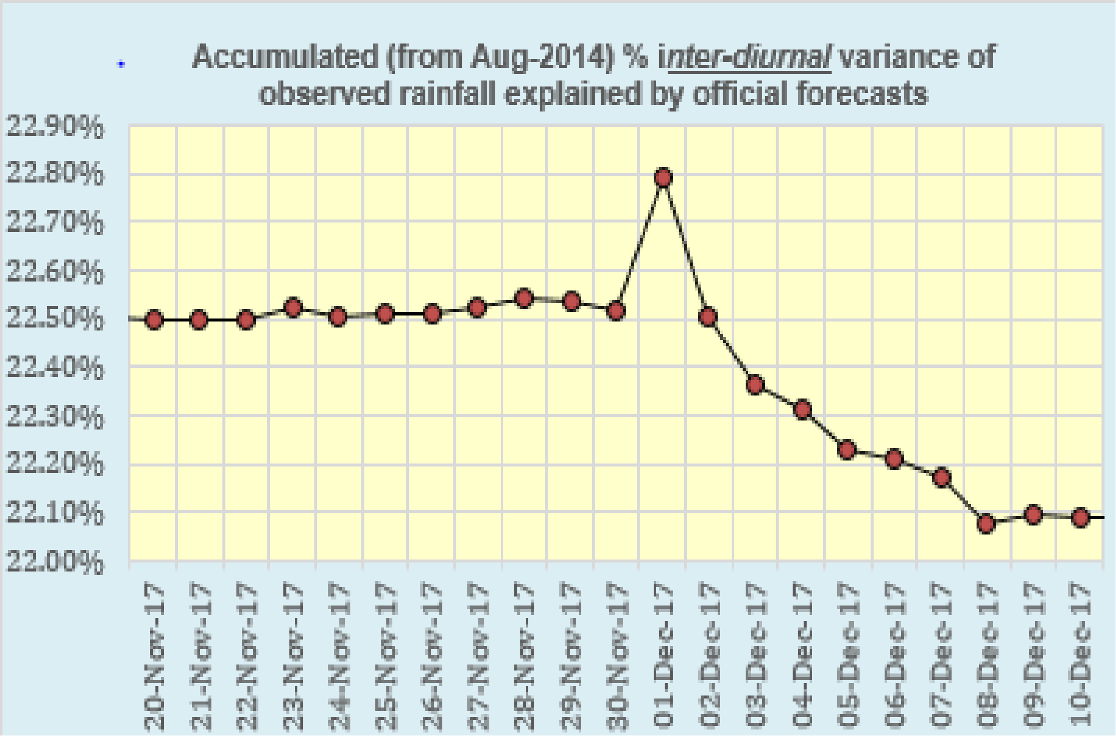

Figure 11 Impact of the *combined* predictions upon the *total* variance explained

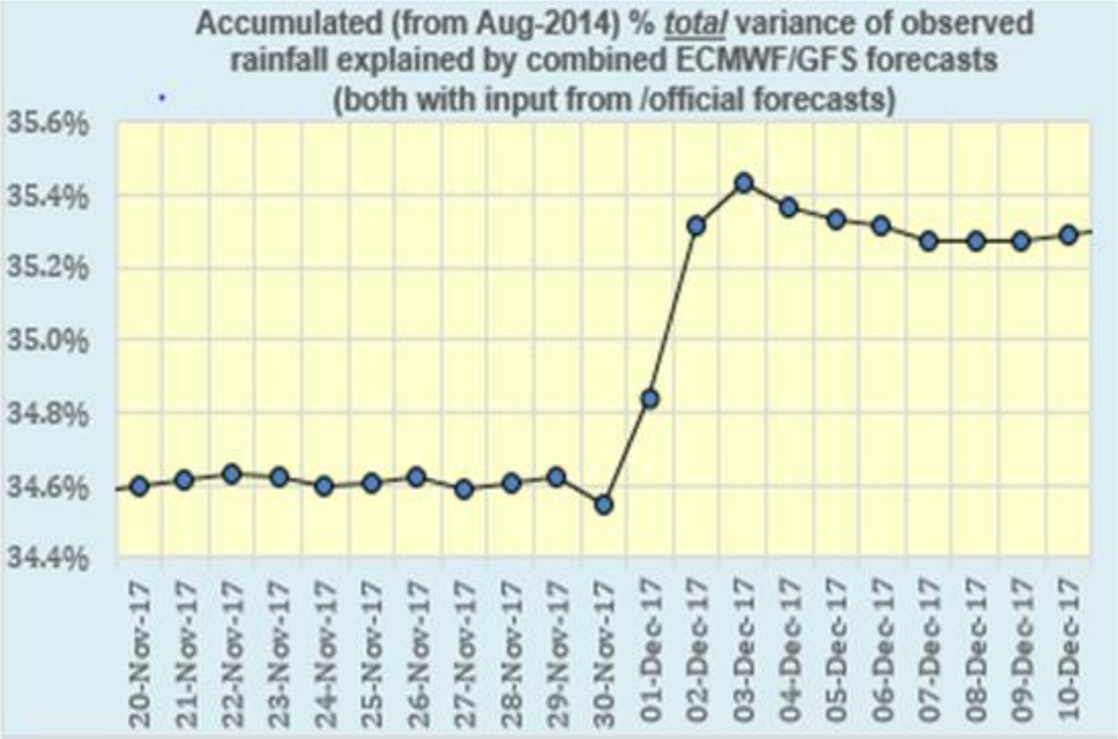

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Figure 12 Impact of the *combined* predictions upon the *inter-diurnal* variance explained

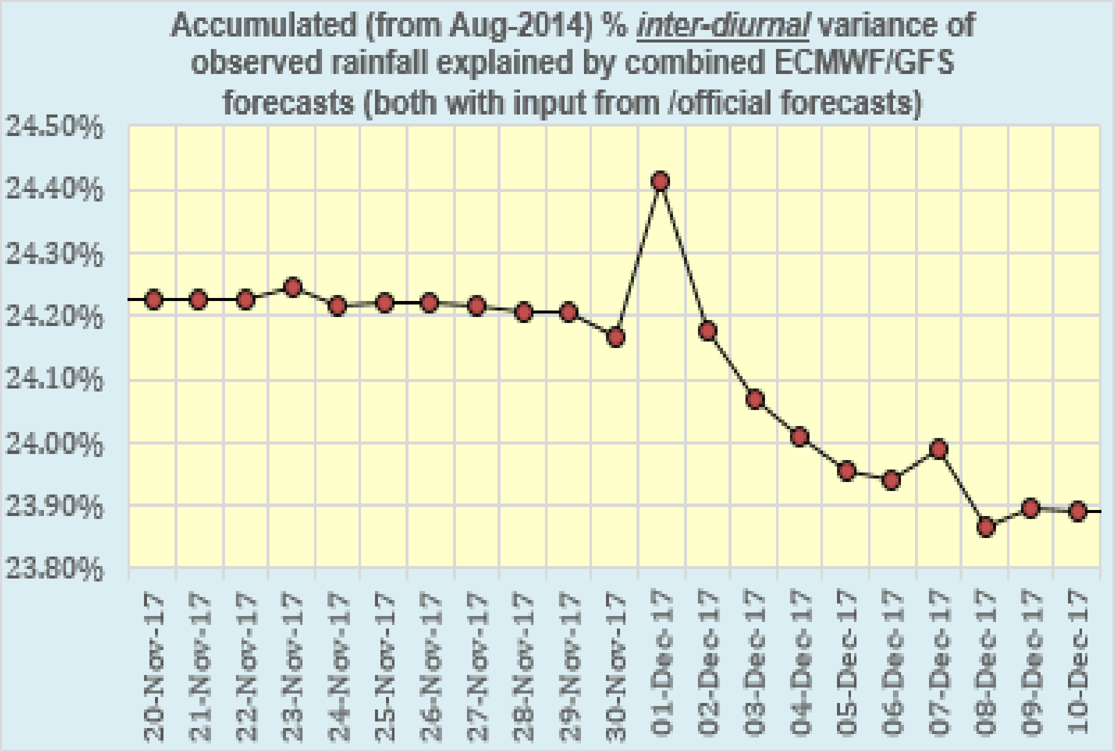


Figure 13 Day-to-day *experimental* predictions of rainfall amount out to Day-14, those generated between 20-November and 10-December, based upon the GFS model

DATE	AMT OBS	FCST Day-1	FCST Day-2	FCST Day-3	FCST Day-4	FCST Day-5	FCST Day-6	FCST Day-7	FCST Day-8	FCST Day-9	FCST Day-10	FCST Day-11	FCST Day-12	FCST Day-13	FCST Day-14
20-Nov-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Nov-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.4	0.0	0.0	0.0
22-Nov-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	1.4	1.0	0.0
23-Nov-17	1.0	0.2	0.0	0.6	0.6	2.1	1.3	0.0	0.0	2.2	0.0	0.0	0.0	0.0	1.4
24-Nov-17	0.4	2.4	1.5	1.8	2.3	1.2	0.0	0.0	0.0	3.9	0.0	1.4	0.0	0.0	0.0
25-Nov-17	1.4	4.1	2.8	2.4	2.5	1.6	0.0	0.0	0.0	3.6	2.5	0.0	3.2	3.4	0.0
26-Nov-17	2.8	8.2	7.8	3.6	3.9	3.4	4.3	0.0	0.0	0.0	2.0	0.8	0.0	0.0	1.5
27-Nov-17	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-Nov-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0
29-Nov-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	2.7	0.0	0.0	0.0
30-Nov-17	0.0	0.0	0.0	3.8	6.0	1.9	1.0	0.0	2.4	5.7	5.9	0.0	0.0	0.0	0.0
01-Dec-17	11.8	33.3	26.8	15.6	12.9	8.5	5.9	2.2	2.3	1.8	1.9	2.3	1.9	0.0	0.0
02-Dec-17	48.6	31.8	34.8	23.4	9.0	2.4	0.0	1.0	0.0	4.5	1.5	1.3	0.0	0.0	0.0
03-Dec-17	8.4	10.4	9.3	23.1	15.9	5.5	0.4	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
04-Dec-17	4.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
05-Dec-17	0.0	0.0	0.0	0.0	0.0	4.0	1.6	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
06-Dec-17	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	1.7
07-Dec-17	24.2	7.2	5.4	3.8	1.4	2.6	0.7	0.0	0.0	0.0	4.0	1.7	0.0	1.9	0.0
08-Dec-17	1.0	2.0	1.7	3.8	1.3	0.0	0.0	1.1	1.0	0.0	0.0	3.4	0.9	0.0	0.0
09-Dec-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	1.8	0.0	0.0	0.8	0.0
10-Dec-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3

Figure 14 Worded précis weather forecasts issued by the Bureau for the first four days of December 2017 between one and seven days in advance

Date	Day	Amt Obs	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7
01-Dec-17	Fri	11.8	HEAVY THUNDERY RAIN DEVELOPING	HEAVY THUNDERY RAIN	RAIN POSSIBLE STORM	SHOWERS	SHOWER OR TWO	SHOWER OR TWO	FEW SHOWERS
02-Dec-17	Sat	48.6	SHOWERS POSSIBLE HEAVY FALLS	RAIN POSSIBLE HEAVY FALLS	RAIN POSSIBLE HEAVY FALLS	A FEW SHOWERS	SHOWER OR TWO	CLOUDY	SHOWER OR TWO
03-Dec-17	Sun	8.4	RAIN EASING	SHOWERS EASING	RAIN POSSIBLE HEAVY FALLS	RAIN POSSIBLE HEAVY FALLS	A FEW SHOWERS	POSSIBLE SHOWER	POSSIBLE MORNING SHOWER
04-Dec-17	Mon	4.6	SHOWERS EASING	POSSIBLE SHOWER	SHOWER OR TWO CLEARING	SHOWER OR TWO	SHOWER OR TWO	POSSIBLE SHOWER	POSSIBLE MORNING SHOWER

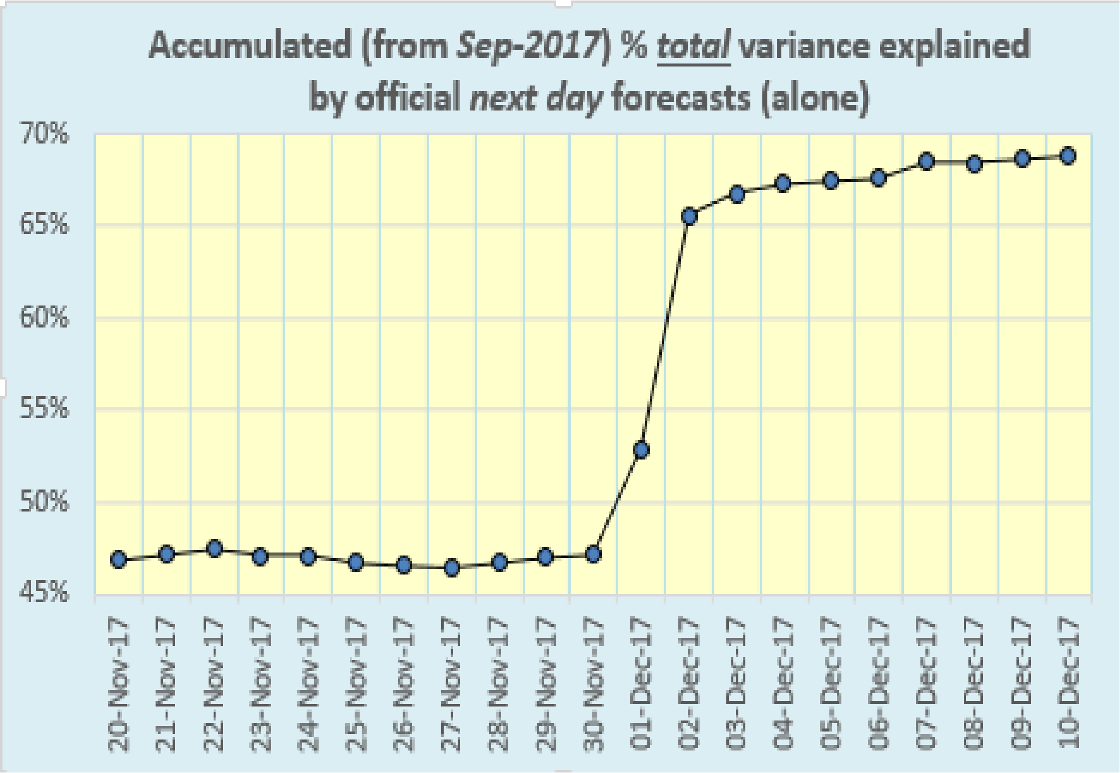
Figure 15 Multiple-linear regression relationship between the subsequent amount of precipitation (predictand) and the occurrence or otherwise of 16 different words (the VARIABLEs – which are the predictors) utilised in Day-1 précis weather forecasts issued by the Bureau for Melbourne over the twelve years 2005 to 2017.

VARIABLE	Coefficients	t Stat	P-value
CONSTANT	0.1417	5.43	3.0E-08
RAIN	2.0797	42.15	0.0E+00
SHOWERS	0.9540	19.16	5.8E-79
SHOWER	0.4994	14.27	1.8E-45
HEAVY	2.5934	9.42	3.4E-21
THUNDER	0.5546	8.24	1.1E-16
DRIZZLE	0.4940	5.64	8.9E-09
EASING	0.3008	4.93	4.3E-07
BECOMING	0.0888	1.64	5.0E-02
FOG	-0.0260	-0.42	3.4E-01
CLOUD	-0.0696	-1.70	4.4E-02
FINE	-0.1144	-3.13	8.7E-04
LATE	-0.1515	-3.99	3.3E-05
CLEARING	-0.1670	-4.11	2.0E-05
CHANCE	-0.2616	-5.42	3.2E-08
FEW	-0.4505	-8.19	1.6E-16
LITTLE	-0.8675	-12.10	1.9E-33

Figure 16 Multiple linear regression relationship between the subsequent amount of precipitation (predictand) and 15 predictors, namely, the Official LOW (lo) expected, the Official HIGH (hi) expected, the Official Probability of Precipitation (pop) given in the forecast, the number of days ahead (d), and combinations (products) thereof

Predictor	Coef	t Stat
const	-0.0071	-0.28
lo	-0.7282	-2.55
hi	0.3065	4.75
pop	-0.0009	-0.30
lo*hi	0.4238	4.21
lo*pop	0.0082	1.73
hi*pop	0.0075	3.72
lo*hi*pop	-0.0053	-4.39
d	0.0348	5.60
d*lo	0.0717	1.06
d*hi	0.0204	1.37
d*pop	0.0018	2.40
d*lo*hi	-0.0724	-2.98
d*lo*pop	0.0001	0.08
d*hi*pop	-0.0017	-3.31
d*lo*hi*pop	0.0007	2.05

Figure 17 Impact of the individual *next day official predictions* upon the *total* variance explained



SUMMARY: The opening four days of summer 2017 saw Melbourne city recording 73.4 mm of rain, with several places just to the northeast receiving totals of about 200 mm. The Bureau forecasts leading up to this event prompted warnings of significant flooding across Melbourne and, both during and after the event, considerable discussion in the media as to whether or not the warnings were justified. Specifically for Melbourne, the forecasts nicely anticipated both the onset and the overall severity of the event, notwithstanding some inadequacy in predicting its temporal variations. Furthermore, in view of the dynamic nature of the atmospheric processes driving the event, it is concluded that it would be legitimate to suggest that one could spatially transfer the extreme rainfall that fell in the Kinglake area to Melbourne, justifying both the warnings that were issued and the terminology that was utilised in the forecasts.

Before closing, it is worthwhile to observe that interestingly, at a workshop conducted as part of the American Meteorological Society's 98th Annual Meeting in Austin, Texas – *(In) consistency in a social media world: communication reflections of the 2017 hurricane season* – the issue of how sharing conflicting model information may promote inconsistent messages about uncertainty was addressed (Amer. Meteor. Soc., 2018).

Relevant to this event, is the reference in the introduction to the mixed sources of available advice. Inconsistency in the messaging can result in residents that are in danger, not taking the ameliorating actions that they need to take. The point was made at the aforementioned workshop that, where meteorologists identify that there is a substantial risk of an impending extreme event, the message delivered, both by forecasters and public officials, should be unambiguous.

To the credit of those involved in this case, it was.

Acknowledgement:

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