NIWA
Taihoro Nukurangi

An Updated Validation of Seasonal Fire Weather Climate Outlooks

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An Updated Validation of Seasonal Fire Weather Climate Outlooks

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Executive Summary

- Validations of National Institute of Water and Atmospheric Research (NIWA) fire-climate outlooks have been updated for the period 1999 to March 2004. Sixteen one-month forecasts and fifteen three-month forecasts are validated here.

- Validations are classed in terms of the five standard fire danger classes, from low to extreme. Forecasts were digitised manually from the published outlook maps and were compared to observed fire danger classes estimated from monthly severity rating (MSR) statistics. Various measures of forecast accuracy were then calculated, by comparing the relative frequencies of forecast and observed danger classes.

- The fire forecasts issued to NRFA show useful skill at the one and three-month lead (with a 49% and 37% hit rate, respectively), when assessing all regions of New Zealand. The forecast skill has increased slightly with the longer validation period, for both one-month and three-month forecasts. Including the ‘one-off misses’ (e.g. including the nearest category) as hits raised the overall hit rate to between 83% and 75%, for three-month and one-month forecasts, respectively, suggesting the forecasts continue to predict well the spatial distribution of fire danger in a qualitative sense, while not always projecting the severity exactly.

- Analysing for only eight regions of New Zealand that have been historically prone to high fire risk, the forecast skill reduces. The one-month forecasts for the high fire risk areas show skill (with a hit rate of 34%, or a “one-off miss” hit rate of 74%), and encouragingly, the extreme fire class is best predicted. However, three-month fire forecasts for these eight regions show negligible skill over the longer validation period, with a hit rate of 21%. However, the “one-off miss” hit rate is 61%, implying that the spatial distribution is again better forecast, even in these high-fire-risk regions. Overall, it appears that there has been a bias towards over-forecasting of seasonal fire risk in the regions traditionally prone to high fire risk. However, given the anomalously stormy climate of 2004 and improvements in fire forecasting techniques, this bias is expected to decline in future forecast periods.

- There remains more qualitative skill in spatial forecasting of fire risk at both the one-month and the three-month lead time (i.e. the forecast fire class pattern is correct, but fire class severity is not always quantitatively well forecast). Even though there is skill in categorical fire forecasts, it would be desirable to move towards forecasting quantitative MSR or SSR, rather than the danger classes. This will remove the remaining subjectivity from the validation process (during the transformation of MSR/SSR into danger classes) and would also allow for spatial validations for each fire region.

Introduction and validation methodology

This report contains an update of the validations in Renwick and Salinger (2003). The validation period for this study is from December 1999 to March 2004.

Monthly and seasonal outlooks for the National Rural Fire Authority (NRFA) are derived from the seasonal climate outlooks generated monthly/seasonally by the NIWA National Climate Centre for Monitoring and Prediction. The procedure is largely subjective, giving an indication of regional fire danger class (5 classes; low, moderate, high, very high, extreme).

Forecast validations have been carried out for the 15 fire regions (Table 1) defined by Heydenrych and Salinger (2002). For each region, one key station was identified from the set used in the regional definition, based largely upon the availability of Monthly Severity Rating (MSR) data.

Region Number	Location	Key Station	High Risk?
1	North Northland	Dargaville	
2	East Northland/Coromandel	Whangarei	
3	King Country	Hamilton	
4	Bay of Plenty	Tauranga	Y
5	Taranaki	Wanganui	
6	East Cape/Hawkes Bay	Napier	Y
7	Wairarapa/Manawatu	Masterton	Y
8	Marlborough/Wellington	Blenheim	Y
9	West Coast	Westport	
10	North Canterbury	Kaikoura	Y
11	Coastal South Canterbury	Christchurch	Y
12	Inland South Canterbury	Tara Hills	Y
13	Coastal Otago	Oamaru	Y
14	Central Otago - Inland Southland	Queenstown	
15	Fiordland/Coastal Southland	Invercargill	

Table 1: Fire Regions and associated climate stations used in forecast validations. The "high risk" regions are those where very high or extreme fire danger was most frequently observed.

MSR values for each key station were collated, and interpreted as fire danger classes using the definitions in Table 2.

MSR	Danger Class
< 1.25	Low
1.25 – 3.00	Moderate
3.00 – 5.00	High
5.00 – 9.00	Very High
> 9.00	Extreme

Table 2: Monthly Severity Rating (MSR) values and Fire Danger Class. Categories defined in discussion with K. Majorhazi, NZFS.

Forecast maps of monthly and seasonal fire danger class across New Zealand (e.g. Gosai and Salinger, 2003) were visually inspected and the equivalent forecast danger class extracted (by eye) from the Seasonal Fire Weather Climate Outlook monthly and seasonal forecast maps for the location of each of the key stations. In cases where strong gradients were forecast near a key station, a value was chosen to be representative of the region represented by that station.

Forecasts were made either one month ahead (at the start of the month, for conditions at the end of the month), or three months ahead. Forecast of conditions at the end of a specified month were compared to the interpreted MSR values for that month. Results were aggregated across all stations, and were also calculated only for the eight "high risk" stations/regions where very high or extreme fire danger was most frequently observed (Table 1).

Validations were calculated in terms of contingency tables: counting the occurrences of each forecast-observed danger class pair. Results are presented as the contingency tables themselves, plus the hit rate (percentage of forecasts correct) and related scores. The hit rate was calculated in two ways: first, in the exact sense by counting only exact category matches, and second in a broader sense by labelling one-category misses as correct. For example, a forecast of extreme would be counted correct if the outcome were very high or extreme, while a forecast of high would be counted correct for any of the outcomes moderate, high, or very high. The second approach may perhaps be justified on the basis that the forecast values were extracted subjectively by eye, and validations at individual points/stations are a little unfair on broad regional forecasts.

Outlooks have been produced by NIWA for the NRFA since late 1999. This report will validate sixteen one-month and fifteen three-month forecasts (issued during the fire season), up to and including March 2004.

Results of updated fire danger outlook validations

All results are displayed as contingency tables (tabulating the occurrences of each forecast-observed danger class pair), the observed outcomes across the columns and forecast categories down the rows. Outlooks are divided into one-month and three-month forecast intervals. Two sets of results are shown: one for all stations/regions, and one including only the 8 stations/regions with the highest observed fire danger.

The statistics are as follows (see Wilks, 1995, for more detail):

Hit rate — Percentage of forecasts correct (exactly, or one category off). Perfect forecasts have a hit rate of 100%.

Hanssen Score — Percent skill of the hit rate, compared to a forecast of "climatology" (random forecasts made with the observed relative frequency for each category). Perfect forecasts have a Hanssen score of 100%, no-skill forecasts score 0%.

False Alarm Ratio (FAR) — Percentage of times a category is forecast and not observed. Perfect forecasts have FAR values of 0%.

Probability of Detection (POD) — Single-category hit rate: number of times a category is correctly forecast, as a percentage of the number of times it is observed to occur. Perfect forecasts have POD values of 100%.

Updated One-Month Fire Forecast Validations

For all stations

Overall, one-month outlooks for all stations were correct nearly half of the time (with a 49% hit rate), a result that compares well with National Climate Centre seasonal climate forecast results (see The Climate Update, Issue 51, September 2003 - temperature forecasts averaged a hit rate of about 45-50%, while rainfall forecasts averaged a hit rate of around 40%), and with the hit rate seen in the previous (shorter) validation period (45%, in Renwick and Salinger, 2003). Fire forecasts have therefore improved slightly, over the longer validation period.

With five categories to choose from, a completely random forecast would be expected to be correct 20% of the time (one time in five). The Hanssen skill score of around 36% is relatively high, for climate forecasts. Including the one-off misses as hits raised the overall hit rate to 83 %, suggesting the forecasts predict well the spatial distribution of fire danger in a qualitative sense, while not always projecting the severity exactly.

The percentage of detection (POD) was highest for the low and extreme categories in this validation (57% and 58% for low and extreme fire danger classes, respectively). This implies good forecasting of both extreme fire danger, which is of critical importance to the NRFA and its management of its fire-fighting resources, and also of low fire danger class. The False Alarm Ratio (FAR) was lowest for the low fire danger class (10%), followed by the extreme fire danger class (56%). There remains a small bias towards over-forecasting of the middle categories of fire danger class.

Table 3: One month fire danger class forecasts for all stations: period 12/1999 to 3/2004 (240 cases)

FORECAST	OBSERVATION					
	LOW	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**	**FAR**
LOW	65	7	0	0	0	10
MODERATE	26	21	6	2	1	63
HIGH	19	22	13	2	0	77
VERY HIGH	4	8	4	8	7	74
EXTREME	1	3	4	6	11	56
POD	57	34	48	44	58	**49% Hits**

Hanssen Score: 35.9, Hits with off-diagonal: 83%

For the eight high fire danger stations

Choosing only those eight regions where fire danger is most frequently observed to be extreme did affect the one-month statistics, reducing the hit rate to 34%. Although this hit rate is still better than a completely random forecast (which would be correct 20% of the time), it is lower than the hit rate observed in the previous validation period (43%, in Renwick and Salinger, 2003).

The inclusion of the one-off misses as hits raised the overall hit rate to 74%, again suggesting the forecasts better predict the spatial distribution of fire danger in a qualitative sense, while not always getting the severity exactly right. The Hanssen skill score of around 21% remains skilful.

Encouragingly, the percentage of detection (POD) was highest for the extreme fire danger class (58%), with a lower corresponding False Alarm Ratio (FAR) of 52%. Although the high and very high fire danger classes were forecast with some skill, with a probability of detection of 56% and 44% respectively, the false alarm ratio was largest for these two categories, indicating many false alarms.

Table 4: One month fire danger class forecasts for 8 high danger stations: period 12/1999 to 3/2004 (128 cases)

Selected regions: Inland South Canterbury, Marlborough/Wellington, Coastal South Canterbury, East Cape/Hawkes Bay, Coastal Otago, Wairarapa/Manawatu, North Canterbury and Taranaki
Key stations: Tara Hills, Woodbourne, Christchurch, Napier, Oamaru, East Taratahi, Kaikoura and Wanganui

		OBSERVATION					
		LOW	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**	**FAR**
FORECAST	**LOW**	7	2	0	0	0	22
	MODERATE	10	8	2	2	1	65
	HIGH	13	19	10	2	0	77
	VERY HIGH	4	7	3	8	7	72
	EXTREME	1	2	3	6	11	52
	POD	20	21	56	44	58	**34% Hits**

Hanssen Score: 21.2, Hits with off-diagonal: 74%

Updated Three-Month Fire Forecast Validations

For all stations

Three-month outlooks showed lower skill than those made at the one-month lead, as would be expected. The hit rate is 37% for all stations (Table 5), which is an improvement since the last validation exercise (28% in Renwick and Salinger, 2003). The Hanssen skill score of around 21% remains skilful. The inclusion of the one-off misses as hits raised the overall hit rate to 75%, indicating qualitative if not quantitative forecast information.

Similarly to the one-month forecasts for all stations, the extremes are usefully forecast, which would beneficial to NRFA management and planning. The probability of detection (POD) is high for both low and extreme fire danger classes, and the false alarm ratio is lowest for these two classes.

Table 5: Three month fire danger forecasts for all stations: period 12/1999 to 3/2004 (210 cases)

FORECAST	OBSERVATION					
	LOW	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**	**FAR**
LOW	44	11	0	0	0	20
MODERATE	30	14	6	1	0	73
HIGH	19	11	5	8	5	90
VERY HIGH	9	11	7	8	5	80
EXTREME	1	4	2	2	7	56
POD	43	27	25	42	41	**37% Hits**

Hanssen Score: 20.5, Hits with off-diagonal: 75%

For the eight high fire danger stations

Choosing only those eight regions where fire danger is most frequently observed to be extreme, it is again evident that there is a reduction in forecast skill compared to all regions. The hit rate reduces to 21%, which is only marginally better than a random forecast. The Hanssen score shows only a 6% improvement on climatology. Again, this hit rate is lower than the hit rate observed in the previous validation period (28%, in Renwick and Salinger, 2003).

This lower overall hit rate reflects very low hit rates for low, moderate and high fire danger classes (between 3% and 19%). However, the highest probability of detection (POD) occurs in the very high and extreme fire danger classes (42 and 41% respectively), and these two classes also have the lowest (but still significant) false alarm ratios.

Overall, it appears that there has been a bias towards over-forecasting of seasonal fire risk in the regions traditionally prone to high fire risk. However, given the anomalously stormy climate of 2004 and improvements in fire forecasting techniques, this bias is expected to decline in future forecast periods.

Table 6 Three month fire danger forecasts for 8 high danger stations: period 12/1999 to 3/2004 (112 cases)

Selected regions: Inland South Canterbury, Marlborough/Wellington, Coastal South Canterbury, East Cape/Hawkes Bay, Coastal Otago, Wairarapa/Manawatu, North Canterbury and Taranaki
Key stations: Tara Hills, Woodbourne, Christchurch, Napier, Oamaru, East Taratahi, Kaikoura and Wanganui

		OBSERVATION					
		LOW	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**	**FAR**
FORECAST	**LOW**	1	2	0	0	0	67
	MODERATE	10	6	1	1	0	67
	HIGH	13	9	2	8	5	95
	VERY HIGH	8	10	7	8	5	79
	EXTREME	1	4	2	2	7	56
	POD	3	19	17	42	41	21%

Hanssen Score: 6.1, Hits with off-diagonal: 61%

Discussion and conclusions

This validation exercise, for an updated period 1999 to March 2004, shows useful forecast skill at the one and three-month lead (with a 49% and 37% hit rate, respectively), when assessing all regions of New Zealand. The forecast skill has increased slightly with the longer validation period, for both one-month and three-month forecasts.

Analysing for only eight regions of New Zealand, which have been historically prone to high fire risk, the forecast skill reduces. The one-month forecasts for the high fire risk areas show skill (with a hit rate of 34%), and encouragingly, the extreme fire class is best predicted. However, three-month fire forecasts for these eight regions show little skill over the longer validation period. Overall, it appears that there has been a bias towards over-forecasting of seasonal fire risk in the regions traditionally prone to high fire risk. However, given the anomalously stormy climate of 2004 and improvements in fire forecasting techniques, this bias is expected to decline in future forecast periods.

There remains more qualitative skill in spatial forecasting of fire risk at both the one-month and the three-month lead time (i.e. the forecast fire class pattern is correct, but fire class severity is not always quantitatively well forecast). Even though there is skill in categorical fire forecasts, it would be desirable to move towards forecasting quantitative MSR or SSR, rather than the danger classes. This will remove the remaining subjectivity from the validation process (during the transformation of MSR/SSR into danger classes) and also allow for spatial validations for each fire region.

References

Gosai, A. and Salinger, M.J. 2003: Seasonal Fire Weather Climate Outlook for November 2003 – January 2004. NIWA client report AKL2003-133, 16 pp.

Heydenrych, C. and Salinger, M.J. 2002: Climate and Severe Fire Seasons: Part II-New Zealand Fire Regions, NIWA client report AK02045, 47 pp.

Renwick, J. and Salinger, J. 2003: Validation of Seasonal Fire Weather Climate Outlooks, NIWA client report AKL2003-34, 6 pp.

Wilks, D. S., 1995: Statistical Methods in the Atmospheric Sciences. Vol. 59, International Geophysics Series, Academic Press, 467 pp.