MID-LEVEL STABILITY AND MOISTURE INDEX: LIKELIHOOD OF EXTREME FIRE BEHAVIOR[1]

by

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Introduction

Most fires that burn large areas do so as a result of major fire runs or "blow-ups" on only a few days within their lifetime. This extreme fire behavior is usually the result of severe fire weather conditions that combine with fuel and topographic characteristics to produce rapid rates of spread and sudden increases in fire intensity. The purpose of this paper is to describe a technique for predicting when such extreme fire behavior may occur in Manitoba.

A number of researchers have analyzed individual wildfires and related extreme fire behavior to various weather conditions (Alexander 1985). Brotak (1977), in an extensive study, examined the weather associated with 98 major fires in the United States and determined that:

1) nearly 90% of all runs on major fires were associated with regions of strong pressure gradients near frontal zones,

2) nearly 90% of all runs were associated with the eastern portion of a clearly discernable trough at 500 mb,

3) over 90% of all runs occurred when moisture advection at 850 mb was insufficient to produce precipitation, and

4) fire runs were associated with steep atmospheric lapse rates (i.e., air mass instability); 92% occurred when the temperature difference between 950-850 mb was 6°C or more,

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76% occurred when the temperature difference between 850-700 mb was 10°C or more and 70% occurred when the temperature difference between 850-500 mb was 26°C or more.

In addition, other factors such as low-level jets and various wind profiles may contribute to fire runs or blow-ups.

Stability and Moisture Indices

Haines (1988), building on the stability and moisture relationships delineated by Brotak (1977), investigated 0000 GMT upper-air soundings in the vicinity of 74 major fires in the United States - 29 in the west and 45 in the east. Low, middle and high level atmospheric indices were developed which indicate the relative potential for extreme fire behavior. These indices represent the stability and moisture of an air mass resulting from synoptic-scale processes. The particular index that is applicable to a given region is dictated by the area's overall elevation. The level chosen is the lowest index level that is still high enough above the surface to avoid significant diurnal variation.

Haines' mid-level index will be described here since it is the most applicable to Manitoba. The mid-level stability and moisture index was calculated by determining the temperature difference between the 850 and 700 mb levels and the atmospheric moisture content at the 850 mb level. A numerical value was assigned to each factor as follows:

850 mb T - 700 mb T	Factor (A)
Less than 6°C	1
6-11°C	2
Greater than/equal to 11°C	3

850 mb T - 850 mb Td	Factor (B)
Less than 6°C	1
6-13°C	2
Greater than/equal to 13°C	3

where T is temperature and Td is dewpoint temperature. The two factors were then added together to obtain an index of the likelihood of extreme fire behavior for the day.

Index = Factors (A + B)	Class of Day (Likelihood of Extreme Fire Behavior
2 or 3	Very low
4	Low
5	Moderate
6	High

In this study, Haines (1988) found that 6% of the major fires occurred when the mid-level index was very low while 58% of the days in the baseline fire season (1981) were in that class; 16% occurred under a low classification while 25% of the days fit that category; 78% of the major fires burned under a moderate to high index while only 17% of the baseline fire season's days were in that class. These results indicate that the mid-level index is a useful indicator of days when extreme fire behavior may occur. However, some major fire runs did occur on low and very low index days. This implies that the index only represents part of the overall fire weather picture. Therefore, it should be used in conjunction with other meteorological[5] and fire danger indictors to estimate the potential for extreme fire behavior.

Operational Mid-Level Stability and Moisture Index: Prairie Weather Centre

A procedure for calculating a mid-level stability and moisture index (MLI-Dex) has been developed at the Prairie Weather Centre (PRWC). The technique uses grid-point data at the standard atmospheric levels for a "prairie window". These data are received twice daily (1630 and 0430 GMT) from the Canadian Meteorological Centre for forecast-model times of t = 0, 6, 12, 18, 24, 30, and 36 hours. The fields transmitted include heights, temperatures and dewpoint depressions at the 1000, 850, 700 and 500 mb levels. At the PRWC, the data are automatically decoded and stored in a computer disk-file. A data access routine and Bessel interpolation (Haltiner 1971) are used to provide upper-air data over specified locations at selected forecast times (Raddatz and Atkinson 1982). Actual and forecast MLI-Dex values for specified locations are calculated from the interpolated grid-point data in the manner indicated by Haines (1988). However, in this operational application, Factor (B) is determined from relative humidity (RH) values rather than dewpoint temperatures.

That is,

850 mb RH	Factor (B)
Greater than/equal to 70%	1
45-70%	2
Less than 45%	3

[5] To obtain a more complete picture of the weather conditions, the mid-level index, which classifies a day's extreme fire potential according to air mass stability and moisture, should be used in conjunction with indicators of wind speed and direction such as pressure gradients and fronts.

MLI-Dex Verification for Manitoba and Conclusions

The mid-level stability and moisture index was calculated from t = 0 hour (0000 GMT) grid-point data interpolated to either The Pas (YQD) or International Falls (INL) for nineteen (19) major wildfire runs which were documented in or near Manitoba from 1986-89[6]. The index was also calculated for the entire 1988 fire season (April 1 - August 31) for INL and the entire 1989 season for YQD to provide baseline information on the relative frequencies of the various index classes. These two locations were used for the Manitoba verification since historical interpolated grid-point data had only been saved for radiosonde sites. In all cases either INL or YQD was the radiosonde station closest to the wildfire being investigated. In addition, only 0 hour (i.e., actual) grid-point data was considered to avoid any uncertainty introduced by the forecast process.

Verifications (Tables 1, 2, and 3) were comparable to the results obtained by Haines (1988). Therefore it was concluded that the MLI-Dex is applicable to Manitoba. Furthermore, it was assumed that the mid-level index, calculated from 12, 24 and 36 hour forecasts for 0000 GMT, will be a useful indicator of the potential for extreme fire behavior provided that the additional uncertainty introduced by the forecast process is not overlooked.

[6] Other undocumented fire runs may have occurred.

Table 1. Days of major wildfire runs in Manitoba during 1986-89.

Documented wildfire run days		Mid-level index	
Date	Fire name/location	1NL	YQD
May 21, 1986	Red Lake #7	M	
28	Red Lake #7	H	
29	Red Lake #7	H	
June 3	Red Lake #7	VL	
May 5, 1987	Wallace Lake	M	
8	Woodridge, Wallace Lake	M	
May 1, 1988	Breton Lake, Gull Lake, and Kenora #14	H	
2	Kenora #14	M	
3	Kenora #14	H	
May 11, 1989	Gowan, Ashern Sandy R.		M
12	Gowan, Ashern Sandy R.		L
13	Gowan, Ashern Sandy R.		L
14	Gowan, Ashern Sandy R.		M
15	Gowan, Ashern Sandy R.		M
16	Gowan, Ashern Sandy R.		L
JULY 21, 1989	Northern Manitoba		H
22	Northern Manitoba		H
23	Northern Manitoba		H
August 1, 1989	Northern Manitoba		M

Table 2. Summary of major wildfire run days and Mid-level index in Manitoba during 1986-89.

	Wildfire run days (19)	
Mid-level index	#	%
Very low	1	5
Low	3	16
Moderate/High	15	79

Table 3. Summary of major wildfire run days and fire season days in relation to the mid-level index during the 1988 and 1989 fire seasons (April 1 - August 31).

	Wildfire Run Days (13)		Fire season days (301)	
Mid-level index	#	%	#	%
Very low	0	0	76	25
Low	3	23	107	36
Moderate/High	10	77	118	39

References

Alexander, M.E. 1985. Bibliography of wildfire case histories and studies. Environ. Can., Can. For. Serv., North. For. Cent., Edmonton, Alberta. Study NOR-5-191. File Report No. 4.

Brotak, E.A. 1977. Meteorological conditions associated with major wildfires. Ph.D. Dissertation, Yale University, New Haven. Conn. 183 pp.

Haines, D.A. 1988. A lower atmosphere severity index for wildlife fires. National Weather Digest 13(2): 23-27.

Haltiner, G.J. 1971. Numerical weather prediction. John Wiley and Sons, Toronto. 252 pp.

Raddatz, R.L.; Atkinson, G.B. 1982. Automated weather element input to forest fire severity forecasting. Tech. Mem., TEC-877. Atmos. Environ. Serv., Environ. Can. 16 pp.

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