Volume 10 Number 4

Fire Weather

FIRE-WEATHER STATION OBSERVATIONS AND RECORDS — HOW GOOD ARE THEY?

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ABSTRACT

Personnel at fire-weather stations take daily weather observations for such purposes as calculating fire-danger rating, determining potential fire behavior, and generating climatic aids useful in long-term planning. These observations are transmitted via a computer information retrieval and management system, and archived in the National Fire Weather Data Library, but no one has documented the completeness or accuracy of the records. This paper reports an evaluation of a representative sample of these records taken at the 250 fire-weather stations in the northeastern United States.

1. INTRODUCTION

Land managers involved in fire management planning use the indices and components of the National Fire-Danger Rating System (NFDRS) as guidelines for day to day planning (3). They also use computer programs such as FIREFAMILY (4) for guidance in long-range management planning. These types of systems and programs depend on weather data as input. Consequently, it is essential to maintain fire-weather station instrumentation at high standards and to record complete, accurate observations. It is also essential to document and archive these data in a form that ensures accuracy and availability for retrieval. In previous reports, we evaluated the state of fire-weather station maintenance (5)—particularly anemometer performance (6). In this report, we evaluate the accuracy and completeness of weather observations taken at fire-weather stations in the northeastern United States and archived in the National Fire Weather Data Library (7).

2. METHODS

The geographic area represented by this study includes 20 states extending from Minnesota to Missouri and eastward to the east coast. Data from 14 national forests and four State agencies were used in the analysis representative of the 250 northeastern fire-weather stations. Observers take weather observations once daily, at 1 p.m. (LST) for varying periods before, during, and after the fire season. When daily observations begin, a station is expected to continue operations until fire danger is minimal.

Weather records for a representative year, 1981, were obtained from the archives of the National Fire Weather Data Library (7) as well as from individual stations. The primary source of library data is filed by participating agencies via a time-sharing computer system (8) called AFFIRMS [Administrative and Forest Fire Information Retrieval and Management System]. AFFIRMS is a user-oriented interactive computer system designed to permit entry of fire-weather observations from field stations. The program was designed for automatic archiving, as it takes current observations and adds them to an archive file. It can also detect some common errors, including bad syntax, impossible or inconsistent data values, and missing but required data. The system's error detection capability is not nearly as complete as the validation system used at NOAA, National Climatic Center. For example, 24-hour, maximum and minimum entries of temperatures and relative humidity are not checked by AFFIRMS because yesterday's observation is filed before today's observation is accessed.

The National Fire Weather Data Library was designed to facilitate the cataloguing and retrieval of large quantities of weather data, primarily from AFFIRMS. The period of record from some fire-weather stations archived in the library exceeds 25 years. In conjunction with AFFIRMS, data arriving at the library are also automatically edited. The library uses an editing technique that depends largely on determining if the element's value is outside a range of permissible values.

Our study is in three parts. First, we documented the percentage of missing records from 64 stations after grouping these data into four categories: the USDA Forest Service's regional network, the national forest's internal network, key State station, and non-key State stations. These data were further divided into two periods, within and outside of the fire season (Table 1).

In the second part of the study, we examined both station records and the library records for 36 stations during April-May 1981, the peak of the Northeast's spring wildfire season. Specifically we evaluated entries of:

State of the weather	(SW)
Dry-bulb temperature at observation	(DB)
Relative humidity at observation	(RH)
24-hour maximum temperature	(T_{max})
24-hour minimum temperature	(T_{min})
24-hour maximum relative humidity	(RH_{max})
24-hour minimum relative humidity	(RH_{min})
24-hour precipitation amount	(P_a)
24-hour precipitation duration	(P_d)
10-minute average wind speed	(WS)

In this phase of the study, we recorded all obvious errors—both in taking observations as well as in transmitting them to the library through AFFIRMS.

In the third part of the study, we validated maximum and minimum temperature observations by comparing them to those recorded at nearby NOAA cooperating stations. We were restricted to these two entries because most of the cooperating stations record temperature and precipitation data only, and fire-weather stations in the United States are usually far removed from the first-order stations of the National Weather Service that record complete, hourly observations. Therefore, this part of the study concentrated on a comparison of 24 fire-weather stations located within 25 miles of at least two cooperating stations that had records of T_{max}/T_{min} previously validated by NOAA's National Climatic Center. Precipitation data were not compared because of the large variations in rainfall that can occur over even short distances.

We used the National Climatic Center's method of comparing daily temperature extremes between stations (9). This method estimates a day's expected T_{max} or T_{min} by using a Z-value statistic of the general form:

$$Z = (x - \bar{x})/\sigma_x. \qquad (1)$$

Here Z is the difference between an individual value (x) and a variable's mean value ($\bar{x}$) divided by its standard deviation (σ_x). To extend this general form, we may write

$$Z = [(F - N) - (\overline{F - N})]/\ \sigma(F - N), \qquad (2)$$

where F is the fire-weather station T_{max} or T_{min} and N is a mean T_{max} or T_{min} computed from data recorded at neighboring cooperative stations. This definition of N allows comparison of entries from any grouped number of nearby stations. Using 10-day sets of data, we analyzed 1,420 fire-weather records of temperature to document this part of the study.

RESULTS AND DISCUSSION

3.a Missed Observations

Figure 1 shows the average number of archived library records missing per month per station for 64 fire-weather stations, presented as a cumulative percentage distribution. Figure 2 shows the average number of archived library records missing per month by station category. The percentage of these missing daily records differed widely among stations (Figure 1). Although 40 percent of all stations averaged less than one missing day per month, 10 percent missed an average of 25 percent or more per month. Portions of the NFDRS require antecedent values to compute the present day's value (3). For example, the 1000-hr time-lag fuel moisture calculation requires a fuel-moisture value computed using a 7-day average. It is difficult to reconstruct these values with incomplete records. Also, statistical programs that average historical weather data, such as FIREFAMILY (4), will produce questionable results when processing data sets with missing values.

A documentation of records for this same time period, obtained from the files of fire-weather stations, showed that in most cases, observations had been taken but records of the observations were not in the library. Copies of 85 percent of the library's missing record were filed at regional network stations meaning, of course, that these observations were taken. Eighty-two percent were filed at forest network stations, and 47 percent were filed within the state networks. In the regional network, all missed observations occurred at just one station; in the forest network, all missed observations occurred at just two stations. Most of the missed observations at state stations occured over weekends. It appears, consequently, that the major problem of missing records occurs not because the observation was not taken but rather because data transmittal and documentation procedures were faulty. Missing library records due to transmission could result from either of two situations. The obvious situation occurs when the originating organization fails to transmit the observation. The second situation is somewhat more subtle. The library's computer editing procedures will not allow an observation entry into the system if any of a number of items within the observation are in error. If the originating unit does not screen its library records for missing data at some future date, the records will remain incomplete.

Fire seasons in this study were defined by criteria given by Haines et. al (10). We anticipated that land managers would be more concerned with weather events during the fire season, and, consequently, this concern would be reflected in a more complete library record during that period. This did not appear to be the case. Less than 10 percent of the stations filed complete records during the fire season, but almost 25 percent of the stations filed complete records outside the fire season (Figure 1). Table 1 gives a tabulation of grouped stations taking observations in and outside of the fire season, and the average number of days of continuous record required within the fire season. Table 2 shows that the number of stations with complete or nearly complete records was larger outside the fire season for all station categories. In season, both the regional and forest network averaged about two missed library records per month

(Figure 2). The key and non-key State stations averaged between four and five missing library records per month. Out of season, the regional and forest network missed about one-and-a-half records per month. The other two networks missed three and four, respectively.

Thirteen of the regional network stations took observations both within and outside of the fire season. Four had a more complete library record within season. The other nine stations had the same (two stations) or a more complete record (seven stations) outside the fire season. The other three categories of stations had similar distributions. This difference in completeness of records generally held for all statistics examined. For example, Table 2 shows that for three station categories, the station with the lowest completion record had more complete records outside of the fire season than in. Again, this appears to be a problem of transmittal procedure during fire season, usually the busiest time of the year. Standards for documentation and transmission of weather observations may be less rigorous during that period.

3. b. Observation and Transmittal Errors

In the second phase of the study, we compared 36 station records with corresponding library records, looking for obvious errors. The examination did not uncover all possible errors, but rather it found obvious errors through careful editing. Because most data are recorded as instantaneous values at observation, it is difficult to question the observer's entry unless an error is obvious, such as number transposition, e.g., a mean wind speed entered as 81 mph instead of 18 mph.

Among other items, if the wet bulb value was higher than the DB, the observation was obviously wrong. If not, RH entries were recomputed using the DB and wet-bulb entries. Entries of T_{max}, T_{min}, RH_{min} were checked for possible transposition of maximum-minimum values on the data recording form. They also were compared with entries of present-day and previous-day values of DB and RH. Certain consistency was required of the data, for example, in all cases $T_{max} \geq DB \geq T_{min}$. If precipitation was reported at observation, but no amount was recorded and no explanation given in the remarks section, the entry was judged to be wrong. If an amount was entered but no PD recorded, or vice versa, this was also judged an error.

When the library record differed from the station record, and there was no good reason to doubt the observer's entry, we judged it a transmittal error. Figure 3 summarizes the observation/ transmission errors. RH_{min} was the biggest error source with an overall error rate of more than 3 percent. Observers read RH_{max}/RH_{min} from a hygrothermograph or use an appropriate table based on T_{max}/T_{min}. Because the hygrothermograph is sometimes inaccurate, observers can inadvertently enter an RH_{min} that is higher than the present RH if they do not compare the hygrothermograph value to the calculated psychrometric value. Of course, this does not explain why the RH_{min} transmittal error rate was twice the transmittal error rate for most of the other elements. Other combined observer/transmittal errors ranged from 0.8 to 1.9 percent per element (Figure 3). This error rate is comparable to a 3 percent error rate for southeastern United States found in an analysis by Paul (11). We found a total of 294 errors in the 2,067 observations examined in the daily record, or an observation error rate of about 14 percent. Roughly one-third of the errors were observational and two-thirds occurred during transmission from the originating unit into the library.

3.c. Comparisons of Library Temperature Records with Records from NOAA Cooperative Stations

In the third phase of the study we compared the library records of 1,420 maximum/minimum temperatures at 24 fire-weather stations with those recorded at nearby NOAA cooperating stations. The method used (see Methods section) determined if a questionable temperature value should be accepted or rejected by comparing it with verified values from NOAA-checked stations and confirming whether the questionable value was within three standard deviations of a computed mean. As Duchon (9) points out, the basis for using an areal editing procedure involving a group of neighboring stations rests on the assumption that station spacing (less than 25 miles) is sufficiently small so that a given synoptic situation provides a fairly uniform distribution over the area of these stations each day. This method uncovers large, random errors such as an occasional reading at the wrong end of the index in the minimum thermometer or a units-of-10°F misreading of a thermometer, e.g., reading a maximum temperature of 82°F when the actual value was 62°F. The method also uncovers ± errors, e.g., an entry of 8°F instead of -8°F. This method, of course, cannot uncover errors of systematic bias.

Our analysis found 18 maximum temperature errors and 9 minimum temperature errors within the sample, an error rate of 1.9 percent for maximum/minimum temperature data. Because this included two elements, this was an average error rate of about 1 percent per element—less than the 1.4 percent observation/transmission error rate per element shown in the previous section. Given the results of the previous section, we would expect that extrapolation to all elements might yield a similar pattern with station comparisons.

This is a corrected page from the article "FIRE-WEATHER STATION OBSERVATIONS AND RECORDS — HOW GOOD ARE THEY?" by Donald A. Haines and John S. Frost, page 41, Volume II, No. 4, November 1985. We regret the error.

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4. SUMMARY AND CONCLUSIONS

Library records of fire-weather station observations show a wide range of completeness and accuracy. Records from a majority of stations are nearly complete, but those from a significant percentage of stations are so incomplete as to be of questionable climatic value. The evidence strongly suggests that this problem could be reduced dramatically by introducing more rigorous transmittal and documentation procedures.

Some of the data in the National Fire-Weather Data Library are obviously in error; about one-third of the errors occurred during observation and two-thirds occurred during transmission. Again, the latter problem could be alleviated through procedural checks. Something as simple as requiring the transmittor to read the observation back to the observer after reception might help. Additional effort could include periodic checks by originating stations to see if records are missing from the National Fire Weather Data Library and to determine if the library's records match the original station records. This procedure would ensure complete records and corrected transmittal errors.

A comparison of fire-weather station observations of maximum/minimum temperature with observations taken at neighboring stations disclosed an additional average error rate of about 1 percent per element per observation. If this error extends to all, or even a majority of other element entries, it may mean a significant cumulative error term in addition to these already discussed.

Observations sent to the National Climatic Center are rigorously processed and edited before archiving. For the most part this results in complete and accurate records. Observations taken at fire-weather stations are subjected to a minimal edit and feedback system. As a result, quality and completeness of the latter appear to be less. Although an upgrading of weather observers' skills would appear to be a commendable but long-term task, significant results could be achieved quickly by correcting transmittal errors and completing the gaps in the library's records where possible.

Table 1. Number of stations by category and average number of days (in parentheses) the stations were maintained in and outside of fire season.

	In fire season	Outside fire season
Regional network	15 (160)	13 (109)
Forest network	10 (162)	7 (79)
All stations	64 (156)	55 (106)
Key State stations	13 (153)	11 (129)
Non-key State stations	26 (153)	24 (101)

Table 2. Range of completed observations by station category. The number of stations with complete or nearly complete records is given in parentheses.

	In fire season	Outside fire season
Regional Network	100% (4) - 75%	100% (5) - 76%
Forest Network	99% (2) - 70%	100% (3) - 83%
Key State stations	99% (2) - 51%	99% (3) - 69%
Non-key State stations	100% (1) - 42%	100% (5) - 38%

FOOTNOTES AND REFERENCES

1. Donald A. Haines received his graduate and undergraduate degrees in meteorology from the University of Wisconsin. He was a field forecaster with NWS, a research meteorologist and computer specialist with the National Weather Satellite Center, and the NOAA Climatologist for Minnesota. He is now principal research meteorologist with the USDA Forest Service and has authored 50 publications, mostly in the area of wildfire meteorology and climatology. He is a charter member of the NWA.

2. John S. Frost attended Lawrence College and Paul Smith College, majoring in forestry. He also received weather training in the U.S. Air Force. He is currently a meteorological technician with the USDA Forest Service, assigned to fire-weather station inspection and technology transfer in northeastern United States.

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SW - State of the weather

DB - Dry-bulb temperture at observation

RH - Relative humidity at observation

T_{max} - 24 hour maximum temperature

T_{min} - 24 hour minimum temperature

RH_{max} - 24 maximum relative humidity

RH_{min} - 24 minimum relative humidity

Pa - 24 hour precipitation amount

Pd - 24 hour precipitation duration

WS - 10 minute average wind speed

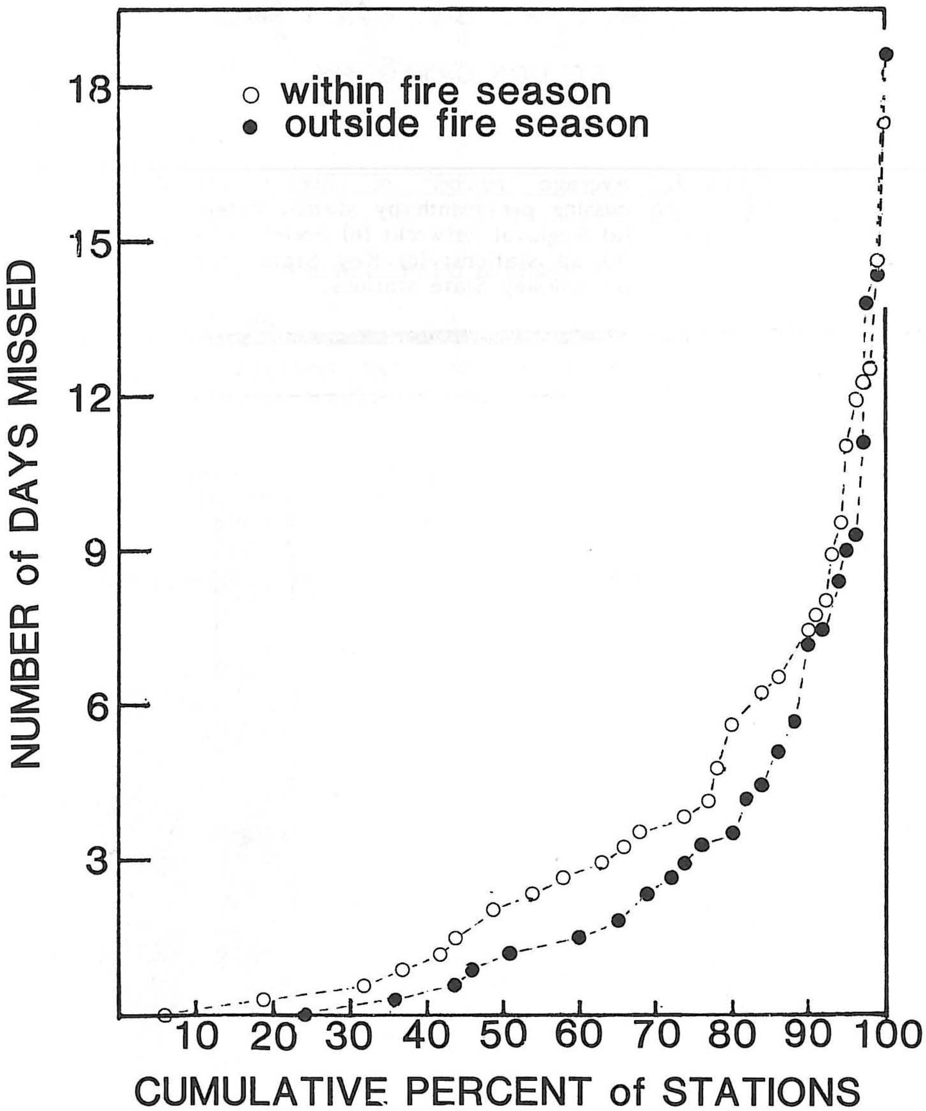

Figure 1. Cumulative distribution of the average number of library records missing per month.

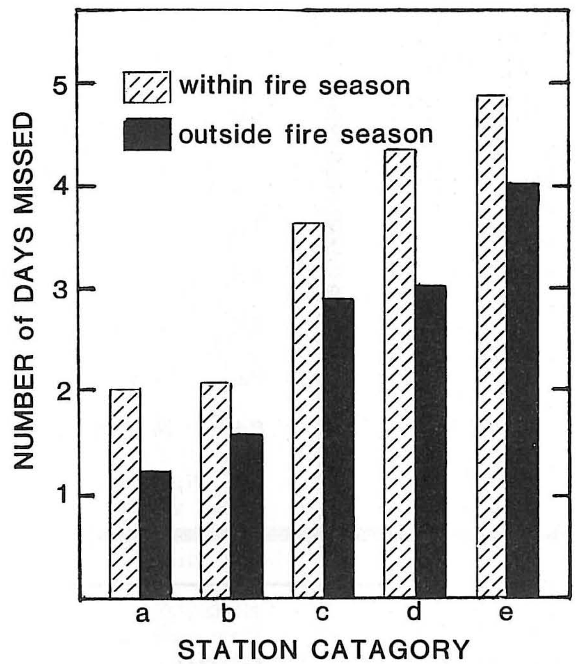

Figure 2. Average number of library records missing per month by station category: (a) Regional network; (b) Forest network; (c) all stations; (d) Key State stations; (e) Non-key State stations.

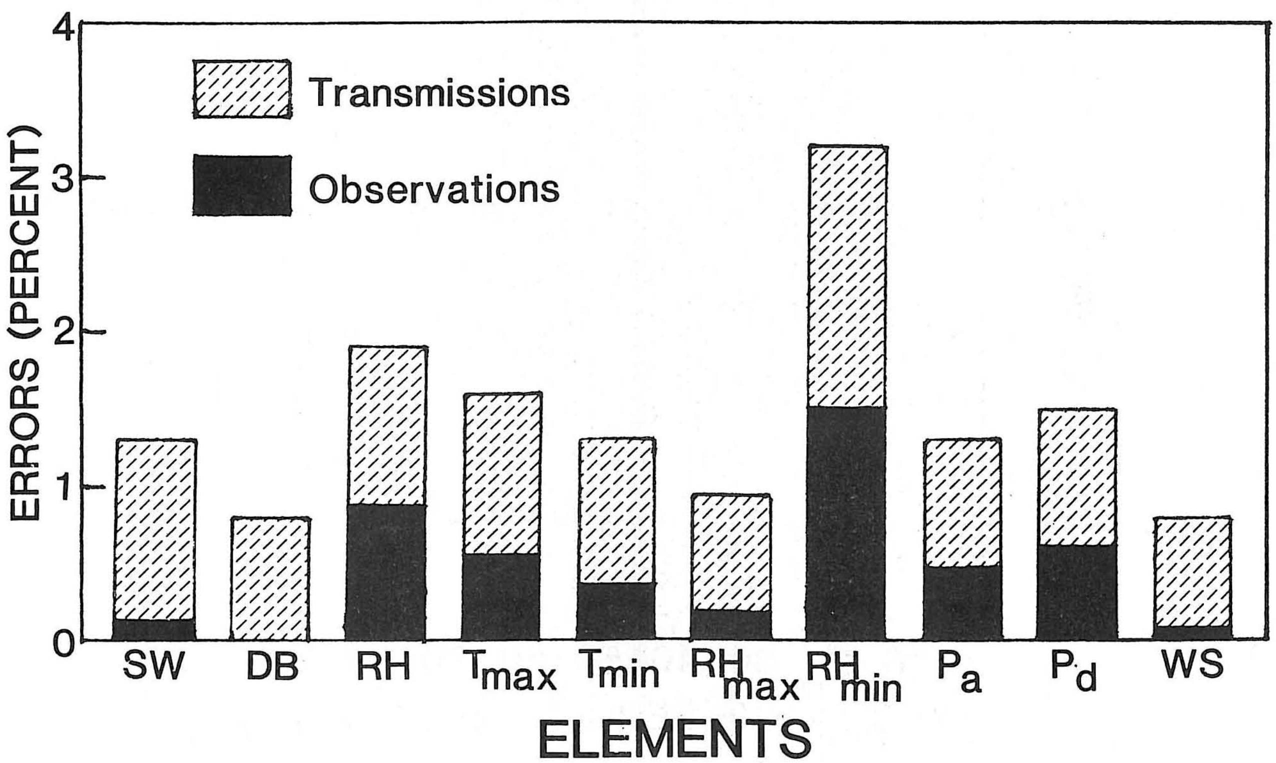

Figure 3. Percent of errors for selected data.