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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

A Comparison of Manual and Semi-automatic Methods of Digitizing Analog Wind Records.

GLENN E. RASCH

Western Region

SALT LAKE CITY,
UTAH

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U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NOAA Technical Memorandum NWSTM WR-83

A COMPARISON OF MANUAL AND SEMIAUTOMATIC METHODS OF DIGITIZING ANALOG WIND RECORDS

Glenn E. Rasch
Regional Warning Coordination Center
Salt Lake City, Utah

WESTERN REGION
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A COMPARISON OF MANUAL AND SEMIAUTOMATIC METHODS OF DIGITIZING ANALOG WIND RECORDS

ABSTRACT

Two methods for obtaining digitized hourly wind data from an analog wind trace are described and compared. The first method is a manual one. Hourly averages of wind direction and speed are obtained by manual inspection of the wind trace. Hourly averages are then key punched onto data cards and stored on magnetic tape. The second method is more automatic. The CALMA model 302 digitizer is used to trace over the analog wind trace and store digitized wind data at 0.01 inch intervals on magnetic tape. Hourly wind averages are then produced from this digitized data through a series of four data reduction programs, and the resulting hourly averages are stored on magnetic tape.

The more automatic method has the advantages of being slightly more accurate and slightly faster than the manual method. However, these advantages are off-set by its higher cost and greater technical problems.

I. INTRODUCTION

Due to differences in terrain, surface wind conditions observed at Las Vegas airport frequently differ from those observed on nearby Lake Mead [1]. Hence, a network of surface wind instruments was installed on small islands and reefs in the lake so that winds on the lake could be observed and compared to observations taken at Las Vegas.

From late 1967 to early 1971, about 105 station-months (one station-month equals one month of record for one station) of surface wind data were collected. The wind instruments used were German Woelfle type mechanical wind recorders distributed by Epic, Inc. A sample of the wind record from one of these instruments is shown in Figure 1.

The purpose of this study is to determine the best way to obtain digital one-hour averages of wind speed and direction from the analog wind traces and how best to store this digital information on magnetic tape. Once on magnetic tape, this wind data can be accessed readily by a digital computer for the purpose of making various statistical summaries and forecast studies.

After careful consideration, two methods of producing digitized wind data and storing it on magnetic tape were tried. One method is basically manual, while the other method is more automatic. The two methods are described in the following sections.

II. MANUAL DIGITIZING

The manual method consists of simply "eyeballing" one-hour averages of wind speed and direction directly from the wind trace and recording the averages on a coding form.

A wind direction average can usually be obtained with an accuracy to within about five degrees. However, sometimes the wind direction varies greatly within an hour, making it difficult to manually obtain an accurate average. For example in Figure 1 on September 1, the wind direction varies considerably between 0900 and 1000 hours, making an accurate determination of the average direction difficult. Large variations of wind direction are usually associated with very light winds.

The Epic wind instrument records the wind speed by a slope method. The flatter the slope of the wind trace, the greater the wind speed. The strip chart is divided into 10 equal increments labeled 0 to 10 (see Figure 1). Each increment that the trace crosses represents one kilometer. If the trace passes from the zero line to the 10 line in a one-hour time span (crossing all 10 increments), the average wind speed for that hour would be 10 kmph (kilometers per hour). Referring to Figure 1, on September 1 the average wind speed between 0900 and 1000 hours would be approximately 6.5 kmph (6.5 increments were crossed by the trace between 0900 and 1000). By 2000 hours the average wind speed has increased to about 29 kmph. (The trace crossed all ten increments twice and an additional 9 increments between 1900 and 2000.) Small wind speed averages can be determined with less absolute error than large wind speed averages. When the winds are strong, the trace crosses the horizontal hourly markings at a very small angle making the actual crossing point difficult to determine. However, percentage errors are about the same for strong winds as for light winds.

As mentioned previously, the hourly averages of wind speed and direction are written onto coding forms, and then the wind information is keypunched onto 80-column data processing cards. The format used in this study is shown in Table 1. Two cards are needed to record the wind information for one station for one day. Bookkeeping information is recorded in the first seven columns of the first card: columns 1 and 2 contain the station number (wind data was collected at 5 different locations); columns 3, 4 and 5 contain the Julian date; and columns 6 and 7 contain the last two digits of the year. The remainder of the first card contains wind speed information. Two columns are allocated for each of the 24 average wind speeds. The second card contains the wind direction information. Each direction value occupies three columns. If all or part of the wind data is missing, 99 is entered where the first wind speed normally goes, and the remainder of the first card and all of the second card are left blank. If any part of the data is missing, the entire day is omitted from the record.

Table 2 contains a listing of a program which will read the wind data from the cards and store it on a magnetic tape called MEADI. This program was written for use on the UNIVAC 1108 computer. It uses subroutines called INOUT from the University of Utah computer center program library to perform the transfer of data to magnetic tape. The same INOUT subroutines may be used to read the data from magnetic tape.

A manual digitizer can digitize and enter wind data onto a coding form at the rate of about seven station days per hour. In other words, it takes a little more than four man-hours of work to digitize one month of wind data for one station. The cost of having the data for one station-month keypunched onto data processing cards (assuming a keypunching rate of $5.00 per hour) would be about $3.25. It is estimated that it would take approximately 50 man hours of work plus $40 for keypunching cards and $10 for computer time (at present rates for computer time) to process the data for one year for one station.

III. DIGITIZING WITH THE CALMA MODEL 302 DIGITIZER

Another way to convert analog wind data to digital form is by using the CALMA Model 302 digitizer [2]. A sketch of the Model 302 is shown in Figure 2. To digitize analog data, the operator places the wind trace on the backlighted viewing area and traces the analog wind trace with a movable stylus/carriage assembly. The movements of the stylus are recorded directly onto magnetic tape at 0.01 inch intervals. The station number, Julian date, and year are recorded on the magnetic tape prior to digitizing each station-day via the manual entry keyboard. The Model 302 is capable of digitizing up to 125 inches of analog trace per minute. However, in order to follow the analog trace accurately, the operator would in general digitize at a slower rate.

After recording the wind trace information onto tape, hourly averages of wind speed and direction are obtained through a series of four data reduction programs. These four programs are too lengthy to list in this report, but are available from Scientific Services Division, Western Region Headquarters, Salt Lake City, Utah.

Once the magnetic tape is rewound on the Model 302 tape drive at the end of each day of digitizing, the tape cannot be repositioned the next day to the point where the operator left off. Because of this unfortunate characteristic of the Model 302, at the end of each day's work the data must be transferred to another storage tape so that the operator can begin recording at the beginning of the digitizing tape on the next day. Therefore, the first of the four programs simply transfers the digitized data from the digitizing tape to a larger storage tape. In addition the program produces a listing of data for each day digitized, which the digitizer operator must review each day for errors. After becoming proficient at digitizing, the average operator will make errors at the rate of about 10%, i.e., about 10% of the days digitized will have to be redigitized due to operator error.

The second program sorts the data that have been stored on tape and stores them in chronological order by Julian date on a new master data tape. This program could be eliminated if the digitizer operator could digitize without making errors. But this is simply impossible, and whenever an error is made, the day in error must be redigitized, which upsets the chronological order.

The Model 302 actually records the X, Y movement in inches of the stylus as the wind record is traced. The third data reduction program converts this X, Y position information to wind speed and direction information. The X, Y position information is read from the master data tape, 10-minute wind speed and direction values are computed, and these 10-minute averages are printed out by the computer and written onto another tape along with the station number and date.

The final program reads the 10-minute wind speed and direction averages from tape, computes one-hour averages both on printed page and on magnetic tape. The same INOUT routines discussed in Section II are used to perform the transfer of data to magnetic tape.

On the average a digitizer operator can digitize about 10 days of record in one hour. Digitizing rate is very strongly dependent upon wind speed. High wind-speed records take much longer to digitize than low wind-speed records. Assuming a 10% error rate and using the current cost of $5 per hour for use of the digitizer, one station-year would cost about $200 to digitize and would require about 40 man-hours of work. This cost does not include the cost of computer time for running the four data reduction programs discussed above. This cost amounts to about $90 for reducing the data for one station-year. In addition about $250 in digitizer rental fees and computer time was spent (wasted) getting proficient in the use of the Model 302 and working the "bugs" out of the data reduction programs.

IV. COMPARISON OF THE TWO METHODS

Automatic digitizing with the Model 302 has two main advantages over manual digitizing:

(1) It is faster. About 40 man-hours of work are required for one station-year compared to about 50 man-hours for the manual procedure.

(2) It is more accurate. The wind speed data digitized manually (hourly averages) were rounded to the nearest whole kilometer per hour, resulting in an average error of $\pm$ .5 kmph. The data digitized automatically are probably accurate to within about $\pm$ .2 kmph. Accuracy of the direction data is strongly dependent upon variability of the wind direction for the manual procedure. When the direction trace is highly variable, the manual method can easily be off by as much as $\pm$ 30 degrees. The average

error is probably about ± 5 degrees. The automatic method is probably accurate to within ± 2 degrees. Accuracy of the automatic method is somewhat dependent upon digitizing speed. If the digitizer operator tries to digitize too fast, he will sacrifice accuracy. The above accuracy figures are based on a digitizing rate of about 10 days per hours, and assuming wind speeds normally encountered in the Lake Mead area.

Automatic digitizing has three main disadvantages when compared to the manual method:

(1) It costs more. As discussed above, normal digitizing costs about $50 per station-year to produce hourly averages of wind direction and speed on magnetic tape. Automatic digitizing costs about $290.

(2) It is fraught with technical problems. There are numerous ways in which the digitizer operator can make an error. Frequently he cannot tell he has made an error until after the first data reduction program (transfer program) has been run. Any error results in a loss of the data for the day being digitized and frequently results in the loss of several days. Some errors result in improper execution of the transfer program, in which case it must be rerun with modifications. After running the transfer program, the data must be screened thoroughly for errors before executing the subsequent programs. If errors go undetected, the subsequent programs will not run successfully. On several occasions tape parity errors were encountered. When these errors occurred, the data causing the error had to be skipped over and redigitized.

(3) It takes more time to attain proficiency. The manual digitizer can become a proficient digitizer in a couple of hours. The data reduction program is simple and easy to understand. The Model 302 operator requries several days to become proficient at digitizing wind traces. In addition the data reduction programs are complex and the data from each program must be checked carefully before running the next program.

In summary, the manual method is a much better method for producing hourly averages of wind speeds and directions on magnetic tape. It is slightly less accurate and slower, but much less expensive and a great deal simpler.

V. ACKNOWLEDGMENTS

The author is indebted to Mr. Bill Normington, of the University of Utah Meteorology Department for loan of his data reduction programs and for providing instructions on the use of the CALMA Model 302 digitizer. The fine work of Mr. Rick Bourdeaux, who spent many hours digitizing wind rolls both manually and with the Model 302, is gratefully acknowledged.

VI. REFERENCES

[1] Augulis, R. P. A Study of Winds in the Lake M ad Recreation Area. Technical Memorandum WBTM WR-26, January 1968.

[2] CALMA Company, Model 302 Digitizer.

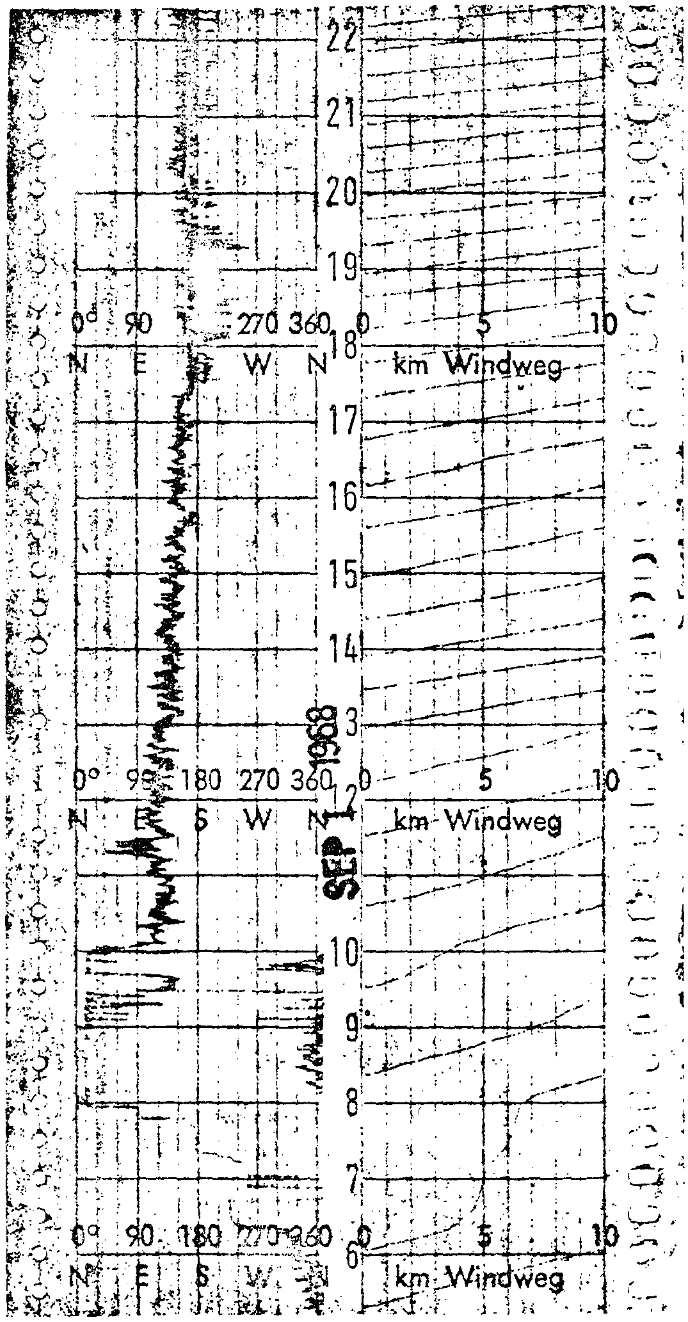

Figure 1. Portion of Wind Record from Epic Mechanical Wind Recorder

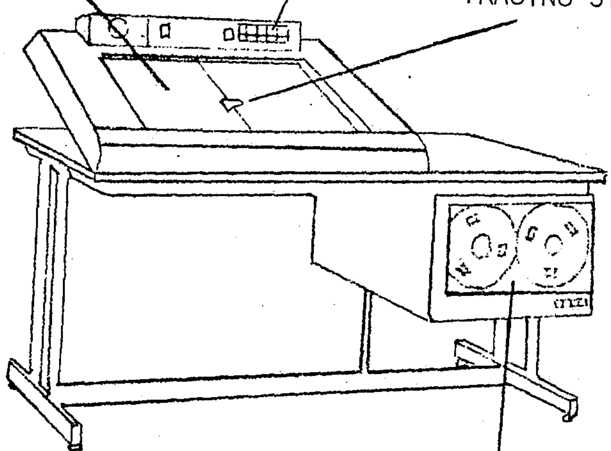

Figure 2. CALMA Model 302 Digitizer

FORTRAN CODING FORM

```
04108 7 1  182 2292 4 22241 51218 14242 53121 24131 42323 20201 21810
21018 0 1 5014 5150 1 45240 15015 02402 65280 28529 52702 60270 27030 03002 95275 25524 0
05108 7 1   19 1920 1 71413 08050 60715 19252 31510 09228 22181 71314 19
19519 5 1 9519 5195 2 10279 04527 02752 85285 34531 53002 95270 36034 53153 15330 33033 0
01199 7 1   99

02109 7 1   99

03109 7 1   101 3080 7 10090 50402 07081 10121 92218 11715 20252 21161 213
35035 0 3 6003 0020 0 45045 05010 01201 10105 07506 01201 13515 01180 18017 01160 19011 9018 5
04109 7 1   12 1104 0 61108 01502 05060 90906 07192 21150 81122 22117 21 27
05536 0 2 4025 5300 3 10032 51151 05075 08509 00600 65135 11352 15228 51351 35211 52101 951 50
05109 7 1   12 1415 1 71608 07050 70506 07061 01212 12201 51182 42522 13
33033 0 3 3033 0330 3 13034 50450 45040 06007 52192 40180 11951 90118 01651 80118 01901 80165
01110 1 1   99

02110 7 1   99

03110 7 1   99

04110 7 1  363 2344 0 42434 24040 45434 64751 15254 48453 03829 21419 17
15015 0 1 6516 5165 1 16515 01351 45135 11351 35150 15015 01150 15011 50155 16511 80210 21020 0
05110 7 1   14 1618 1 41141 12326 25303 03123 43031 32236 32221 23191 19221 8
16516 5 1 6515 9150 1 16518 01801 80195 11951 95180 18518 01180 18018 01801 8018 01180 18018 0
01111 1 1   99

02111 1 1   99

03111 7 1   99

04111 7 1  202 1222 1 11818 21171 51171 92736 40213 02122 12080 20405 09
21021 0 2 1022 5225 2 12522 52252 11021 02110 21021 02110 25521 70285 27027 01652 55285 25021 0
05111 7 1  090 9171 7 21262 32243 02724 23222 11120 19202 01912 01811 11107
21022 0 2 1012 5180 1 18519 01201 20180 21021 02512 01201 12010 51201 20120 13516 51651 80
```

Table I. Wind Coding Format

FORM INC-1071 (3-68)

```
      COMMON N
      DIMENSION LABLE(4),IVAVG(24),IDAVG(24),VAVG(24),DAVG(24)
      N=0
      PRINT 2
    2 FORMAT('0','IF VELOCITY AT 100 HRS IS 61.5 AND REMAINING POSITIONS
     X ARE ZERO FILLED, DATA IS MISSING')
      PRINT 4
    4 FORMAT('1')
      READ(5,18) MAXDAY,MAXSTN
      DO 100 NDAY=1,MAXDAY
      II=0
   10 II=II+1
      READ(5,16) (LABLE(J),J=2,4),(IVAVG(K),K=1,24)
      IF(LABLE(2).NE.II.OR.LABLE(3).NE.NDAY) GO TO 120
      READ(5,18) (IDAVG(K),K=1,24)
   16 FORMAT(I2,I3,I2,1X,24I2)
   18 FORMAT(24I3)
      DO 22 K=1,24
      VAVG(K)=IVAVG(K)
      VAVG(K)=VAVG(K)*.621
   22 DAVG(K)=IDAVG(K)
      CALL OUTPUT(LABLE,DAVG,VAVG)
      IF(II.EQ.MAXSTN) GO TO 90
      GO TO 10
   90 CALL ENFILE(2)
  100 CONTINUE
      GO TO 130
  120 PRINT 122,II,NDAY,LABLE(2),LABLE(3)
  122 FORMAT('1','STATION',I3,2X,'DAY',I4,2X,'WAS TO BE STUDIED, BUT STA
     XTION',I3,2X,'DAY',I4,2X,'WAS READ FROM CARD')
  130 STOP
      END

      SUBROUTINE OUTPUT(LABL,DAVG,VAVG)
      COMMON N
      DIMENSION LABL(28),DAVG(24),VAVG(24),ITIME(24)
      DATA ITIME/0100,0200,0300,0400,0500,0600,0700,0800,0900,1000,
     X  1100,1200,1300,1400,1500,1600,1700,1800,1900,2000,2100,2200,
     X  2300,2400/
      N=N+1
      IF((N-1)/4*4.EQ.(N-1)) PRINT 5
    5 FORMAT('1')
      PRINT 10
   10 FORMAT('0',T43,'ONE HOUR AVERAGE DIRECTION AND VELOCITY VALUES',/)
      PRINT 15,(LABL(I),I=2,4)
   15 FORMAT(' ','STATION NUMBER = ',I2,5X,'DAY = ',I3,5X,'YEAR = ',I2)
      PRINT 20
   20 FORMAT('0',T11,'TIME    DIRECTION    VELOCITY',12X,'TIME    DIRECTION
     X    VELOCITY',12X,'TIME    DIRECTION    VELOCITY')
      DO 40 I=1,8
      PRINT 30,ITIME(I),DAVG(I),VAVG(I),ITIME(I+8),DAVG(I+8),VAVG(I+8),
     XITIME(I+16),DAVG(I+16),VAVG(I+16)
   30 FORMAT(' ',T11,3(I4,4X,F6.1,5X,F6.1,14X))
   40 CONTINUE
      CALL INOUT(0,2,LABL(2),3)
      CALL INOUT(0,2,DAVG,24)
      CALL INOUT(0,2,VAVG,24)
      RETURN
      END
```

Table 2. Manual Storage Program

No. 45/2 Precipitation Probabilities in the Western Region Associated with Spring 500-mb Map Types. Richard P. Augulis. January 1970. (PB-189434)
No. 45/3 Precipitation Probabilities in the Western Region Associated with Summer 500-mb Map Types. Richard P. Augulis. January 1970. (PB-189414)
No. 45/4 Precipitation Probabilities in the Western Region Associated with Fall 500-mb Map Types. Richard P. Augulis. January 1970. (PB-189435)
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