NOAA Western Region Computer Programs and
Problems NWS WRCP - NO. 51

SUNRISE/SUNSET

Salt Lake City, Utah
August 1985

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

PREFACE

This Western Region publication series is considered as a subset of our Technical Memorandum series. This series will be devoted exclusively to the exchange of information on and documentation of computer programs and related subjects. This series was initiated because it did not seem appropriate to publish computer program papers as Technical Memoranda; yet, we wanted to share this type of information with all Western Region forecasters in a systematic way. Another reason was our concern that in the developing AFOS-era there will be unnecessary and wasteful duplication of effort in writing computer programs in National Weather Service (NWS). Documentation and exchange of ideas and programs envisioned in this series hopefully will reduce such duplication. We also believe that by publishing the programming work of our forecasters, we will stimulate others to use these programs or develop their own programs to take advantage of the computing capabilities AFOS makes available.

We solicit computer-oriented papers and computer programs from forecasters for us to publish in this series. Simple and short programs should not be prejudged as unsuitable.

The great potential of the AFOS-era is strongly related to local computer facilities permitting meteorologists to practice in a more scientific environment. It is our hope that this new series will help in developing this potential into reality.

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1 Standardized Format for Computer Series. REVISED January 1984. (PB85 109668)
2 AFOS Crop and Soil Information Report Programs. Ken Mielke, July 1979. (PB85 110419)
3 Decoder for Significant Level Transmissions of Raobs. John A. Jannuzzi, August 1979. (PB85 109676)
4 Precipitable Water Estimate. Elizabeth Morse, October 1979.
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19 DATAKEYØ Repair Program. Paul D. Tolleson, August 1980. (PB81-102543)
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23 Accessing the AFOS Data Base. Matthew Peroutka, January 1981.(PB81-190266)
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25 Automated Weather Log for Terminal Forecasting. John A. Jannuzzi, February 1981. (PB81-210999)
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28 AFOS Interactive Graphics. Jim Fors, Don Laurine, and Sandy MacDonald, April 1981(PB85 110401)
29 Computer Programs for Aviation Forecast Transmission. Kenneth B. Mielke and Matthew R. Peroutka, May 1981.(PB85 110518)
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35 F-6 Monthly Climatic Summary Program for AFOS. Peter G. Mueller, May 1982. (PB85 109858)

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SUNRISE/SUNSET

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This technical publication has been

reviewed and is approved for

publication by Scientific Services

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I. INTRODUCTION

This AFOS program, called SUN, allows the user to produce annual, monthly, or daily tables of sunrise and sunset for most latitude-longitude locations around the globe. As a result, it is possible to have sunrise and sunset times for those locations at which these data are not readily available. The program was developed to allow the forecasters to have sunrise and sunset data for any number of stations around their area of interest. This should make it quite easy to rapidly disseminate accurate information to those public interests requesting such data. These are the two main benefits of the program - speed and accuracy of information. It is much faster, for example, to run this program to find the sunrise/sunset at Idaho Falls than it is to find the sunrise/sunset at Boise and Salt Lake City and interpolate. It is also much more accurate.

II. METHODOLOGY

The sunrise/sunset program requires the following data:

1) the latitudinal position,

2) the longitudinal position, and

3) the date(s) desired.

From this data, the "base" sunrise and sunset times are determined using the angles created between the rotating location of the station and the "celestial latitude" of the sun (date dependent).

The program then corrects the sunrise and sunset based on three other features. These are:

1) the effect of the earth's wobble,

2) the effect of atmospheric refraction of the sun's rays, and

3) the correction for the top half of the sun.

The earth's wobble causes the sun to rise and set earlier or later than expected at different times of the year over the entire globe. The correction for this feature is known as the equation of time and is shown in Figure 1.

The refraction correction is necessary because an observer can actually see the sun before it is on the horizon. This is due to the physical laws of refraction, whereby the ray of light bends toward the normal as it enters a more dense medium (the atmosphere). Thus, light which normally would pass over the earth gets refracted toward the surface. As a result, we can see the sun while it is still below the horizon at both sunrise and sunset (see Figure 2).

The initial calculations are for the center of the sun. Since sunrise and sunset refer to the top of the sun, a correction is made for the top radius at both sunrise and sunset.

It is unnecessary to input the year since the year-to-year changes are very slight. Leap years cause errors in the final calculations; even so, those errors will be, at the most only 3 seconds at the equator, 25 seconds at 30 N/S, 70 seconds at 50 N/S, and 3 minutes at 75 N/S. These non-random errors are greatest for the dates around February 29th of leap years and are near zero around two years later (see examples in Table 1 and Figure 3). Leap year is accounted for in the calculations in that the average year lasts 365.2422 days as set up in the program. Still, it is not accounted for in the output. Therefore, one must make a mental note that the times presented are only approximations, albeit close approximations.

Total errors in the calculations (including the above mentioned errors), when compared to those published by the United States Naval Observatory, are up to 9 seconds at the equator, up to 1 minute at 30 N/S, up to 2 minutes at 40 N/S, and up to 4 minutes at 60 N/S. Basically, the longer the sun is near the horizon (generally, at the higher latitudes), the larger the potential error is. Even so, the increasing error with latitude is not as significant as it would appear, since the exact times of sunrise and sunset are more dubious at higher latitudes due to the increased length of time at which the sun is near the horizon. The values generated by this program are generally within a minute or two over the mid-latitudes of either hemisphere.

III. SOFTWARE STRUCTURE

A. Running the Program

The sunrise/sunset program is designed so that it may be run either from the dasher or from an ADM. The dasher run is designed to run sunrise/sunset calculations for a day, month, or year, with the option to store the data in the AFOS data base for future reference. The ADM run is designed to rapidly output the sunrise/sunset data on the ADM console for a single date only. Total run time for an ADM run is about 10-15 seconds. In contrast, the dasher run is interactive. Thus, time will be needed to read the commands, type in the response, and wait for the calculations. The calculations take about 5 seconds per month (1 minute for a year). The total run time for a dasher run depends on the speed of the operator (generally, add an extra 30 to 60 seconds to the calculation time). Output from an ADM run is not as neat, but it runs much faster. The run line inputs are different for each of these run types, so each will be discussed separately below.

1. Dasher Run

When run from a dasher, the program SUN requires a global switch /D (as in Dasher). In this mode, it becomes an interactive program. The forecaster is required to input the latitude and longitude of the station desired upon request, with very explicit instructions. It allows input of latitudes from 87.5 S to 87.5 N with a full 360 degree longitudinal coverage.

The dasher run allows three output format selections:

1) an annual table,

2) a monthly table, and

3) output for a specific date.

If option 2 or 3 is chosen, it will ask for the month (and date, if necessary).

This run creates an RDOS file named SUNRISE and gives instructions on how to access it from RDOS. An option to store the output in the AFOS data base is included. If desired, it will ask for the XXX of the product identifier and will store the product under the CCCSUNXXX, where CCC is the local WSFO and XXX is what you enter. This is a nice feature except for the annual output, which is slightly over 5 pages long. The FSTORE subroutine used by the program will only store up to 5 pages in the AFOS data base. The operator may rectify this problem by storing such a product manually, using the STORE:SUNRISE CCCSUNXXX command on the ADM; this will store the entire product into the product identifier and should be done following the program's completion. If your data base allows it, your station may wish to store the annual output for a number of nearby stations. This will allow immediate call-up of these products upon request for any day of the year. See Figures 4, 5, and 6 for examples of the annual, monthly, and specific date output for a dasher run.

2. ADM Run

When run from the ADM, the run line is as follows:

```
RUN:SUN/A XXX/S ##/M ##/D
```

where /A is the global switch necessary to activitate the ADM portion of the program, XXX/S is a station ID switch (used to get the station's latitude and longitude from the STDIR.MS file), ##/M is the month switch, and ##/D is the day of the month switch. If any of these switches are omitted or if the station ID doesn't exist in the STDIR.MS file, an error message will be returned.

The sunrise and sunset values are output to the operator via the FORKO subroutine when the alert light is pressed. Output format is as follows:

XXX MMM DD COMPLETED:OUTPUT IN FILE HHMMZ/HHMMZ

where XXX is the station, MMM is the month, DD is the date, and HHMMZ/HHMMZ are the sunrise/sunset times. If the sun is always up, down, or on the horizon, the response instead of HHMMZ/HHMMZ will be LIGHT, DARK, or HORIZON.

This output form was developed to flag a program's completion. It is used here for different reasons - those being speed and ease. The only other way to output the data on the ADM would be to store it in the AFOS data base. This would make the entire process much more laborious. Not only would the operator need to be sure that a correct PIL existed in the data base, but he would also have to call up the product once the programmed finished. The manner of output employed here bypasses these steps. All that is necessary is to hit the alert button when it flashes.

For examples of run lines and their output, see Figure 7.

B. Description of the Program Units

1. SUN

This is the main program. It contains all of the input data and output statements, searches the switches, examines the STDIR.MS file (for ADM runs) and controls the RDOS SUNRISE file (for dasher output). This is the only routine which yields different results for the ADM and dasher runs. Subroutines PROD and JASC are used only for the dasher output. All other subroutines described below were created for the purpose of calculating the sunrise and sunset times and are used by both the ADM and dasher runs.

2. CALC

a. Data passed to or from subroutine:

i. IDATE - date number for the year

ii. ALAT - latitude

iii. ALON - longitude

iv. RISE - sunrise time

v. SET - sunset time

b. Function:

Performs the actual number crunching to find the times of sunrise and sunset (based on the necessary astronomical information).

3. GETTM

a. Data passed to or from subroutine:

i. IDATE - date number for the year

ii. ALAT - latitude

iii. ALON - longitude

iv. IUP - array for sunrise times

v. IDWN - array for sunset times

vi. IFLAG - array designating when sun never rises, never sets, or is nearly always on the horizon

b. Function:

Transforms times returned by CALC into hours, minutes, and seconds, or sets ASCII messages with a flag. ASCII messages include ALWAYS LIGHT, ALWAYS DARK, and ON THE HORIZON.

4. JASC

a. Data passed to or from subroutine:

i. ITRANS(3) - array containing integer hour, minute, and second

ii. IDUM(4) - array containing ASCII time with colons inserted for output

b. Function:

Recreates time in ASCII format for easy output.

5. PROD

a. Data passed to or from subroutine:

i. NNN - ASCII string "SUN" to be inserted into middle 3 letters of product indentifier

ii. IPROD - "CCCNNNXXX".

b. Function:

Searches the local SKEL file for the CCC and XXX and then creates a local CCCSUNXXX into which the product may be stored. Note: the operator has the option to store the product into the AFOS data base. If so desired, he will have to enter an XXX upon request by the program (only on the dasher runs). This PIL (CCCSUNXXX) must be in the data base (or at least on the wish list) to store correctly.

6. ASIN (ACOS)

a. Data passed to or from subroutine:

i. X - angle in radians

b. Function:

Function subprogram to calculate the arc sine (arc cosine).

See Figure 8 for total program structure.

C. <u>Equations and Algorithms</u>

θ = station latitude

τ = calendar day (e.g. - Sept. 10 = 253)

T = calendar day at perihelion = 3.75

ε = eccentricity of orbit = 0.016728

ϕ = obliquity of tilt = 23.442 degrees

π = PI = 3.141592654 = number of radians per 180 degrees

M = mean anomaly = $2\pi(\tau - T)/365.2422$

Mve = mean anomaly at vernal equinox = 1.3197

V = true anomaly
= $M + (2\varepsilon - \varepsilon^3/4)\sin(M) + 5/4(\varepsilon^2)\sin(2M) + 13/12(\varepsilon^3)\sin(3M)$

Vve = true anomaly at vernal equinox
= $Mve + (2\varepsilon - \varepsilon^3/4)\sin(Mve) + 5/4(\varepsilon^2)\sin(2Mve) + 13/12(\varepsilon^3)\sin(3Mve)$

$\lambda = V - Vve$

$\sin(\sigma) = \sin(\phi)\sin(\lambda)$

$\cos(Hs) = -\tan(\theta)\tan(\sigma)$ where Hs = hour angle

Hs/15 = hours before (after) 12 noon of sunrise (sunset)

ΔH = refraction + top half of sun correction
= $10/3 \sec(\sigma)\sec(\theta)\mathrm{scs}(Hs)$

D. Files Required

1. Dasher Run

a. DPCMSKEL,
DCMSKEL,
WSOSKEL - finds local CCC node. Needed only if storing RDOS file SUNRISE to the data base.

2. ADM Run

a. STDIR.MS - standard station directory file to provide station latitude and longitude.

IV. GENERAL INFORMATION

A. Erroneous Entries in Interactive Section of the Dasher Run

To correct for erroneous entries, simply type a back slant (\) and reenter. Many sections of the interactive code have quality control checks built in which will accept only certain values. If such values are not returned, the program will repeat its request. However, such is not always the case, so some erroneous entries may slip by if the operator is not careful in typing the entry.

B. Should I Use the ADM or the Dasher?

1. If you want output for more than a single day, you must use the dasher.

2. If you want to store the data in the AFOS data base, you must use the dasher.

3. If you want the data in a nice neat output format, you should use the dasher.

4. If you want quick dissemination for a public request (one station, one date), you should use the ADM.

C. ADM Error Messages

1. SUN ABORTED! ERROR CONDITION: NO GLBL SWCH

   Check to see that you include the global switch /A.

2. SUN ABORTED! ERROR CONDITION: MSG SWITCH

   The run line requires the inclusion of switches /S, /M, /D.

3. SUN ABORTED! ERROR CONDITION: STNID NOT FND

   The station ID was not listed in the STDIR.MS file.

V. REFERENCES

1. Astronomical Phenomena for the Year 1985, The Nautical Almanac Office - U.S. Naval Observatory and Her Majesty's Nautical Almanac Office Royal Greenwich Observatory, Washington, D.C., and London, 1983, 74 pp.

2. Fath, E.A., 1934: Elements of Astronomy, New York, McGraw-Hill.

SUNRISE/SUNSET

PART A: PROGRAM INFORMATION AND INSTALLATION PROCEDURE

PROGRAM NAME: SUN

AAL ID:
REVISION NO.: 1.0

PURPOSE: SUN calculates sunrise and sunset times for nearly any location around the globe. Output may be for specific dates, months, or full years.

PROGRAM INFORMATION:

Development Programmer:
Glenn R. Lussky
Location: WRH/SSD
Phone: FTS 588-5131

Maintenance Programmer:
Glenn R. Lussky
Location: WRH/SSD
Phone: FTS 588-5131

Language: FORTRAN IV
Save File Creation Dates:
Original Version/Rev 1.00 - July 19, 1985

Running Time: 10 Seconds to 2 Minutes

Disk space: Program File - 70 RDOS Blocks
Output File - Up to 21 RDOS Blocks

PROGRAM REQIREMENTS:

Program Files:	Comments:
SUN.SV	SUNRISE/SUNSET Program

Data Files:	Comments:
SUNRISE	Output Data File

AFOS Products:

ID	Action	Comments
CCCSUNXXX	Alphanumeric STORED	CCC is the local WSFO node XXX is manually entered in the program command line

LOAD LINE:

```
RLDR SUN GETTM CALC JASC PROD ASIN ACOS UTIL.LB BG.LB FORT.LB AFOSE.LB
```

PROGRAM INSTALLATION:

- Put on DPO or link from DPOF; do not link from floppy to DPO, as program is too big for this and may cause system to crash.

SUNRISE/SUNSET

PART B: PROGRAM EXECUTION AND ERROR CONDITIONS

PROGRAM NAME: SUN

AAL ID:
REVISION NO.: 1.0

PROGRAM EXECUTION:

1. If run from the dasher, type SUN/D. Type in input data during the interactive portion of the program as requested. Output is in an RDOS file named SUNRISE. The operator has the option to output the data to the AFOS data base. An R-prompt signals program completion.

2. If run from an ADM, type RUN:SUN/A XXX/S #/M #/D where XXX is the station ID, #/M is the month switch, and #/D is the date of the month switch. Output is returned via the FORKO routine when the flashing alert button is pushed. Output format: XXX MMM DD COMPLETED: OUTPUT IN FILE HHMMZ/HHMMZ where XXX is the station ID, MMM is the month, DD is the date, and HHMMZ/HHMMZ are the sunrise/sunset times in GMT. If the sun is always up, down, or on the horizon, response instead of HHMMZ/HHMMZ will be LIGHT, DARK, and HORIZON, respectively.

ERROR CONDITIONS:

1. Dasher Messages

   The program normally checks to see if incorrect data are entered by the operator in the interactive portion of the program. If it flags bad data, it repeats its request. It will not always catch the bad inputs (i.e., if letters are entered instead of numbers), so care is advised when typing the entries.

2. ADM Messages

   SUN ABORTED! ERROR CONDITION: NO GLBL SWCH

      Need the global switch /A.

   SUN ABORTED! ERROR CONDITION: MSG SWITCH

      Need switches /S, /M, /D in the run line

   SUN ABORTED! ERROR CONDITION: STNID NOT FND

      The station ID was not in the STDIR.MS file.

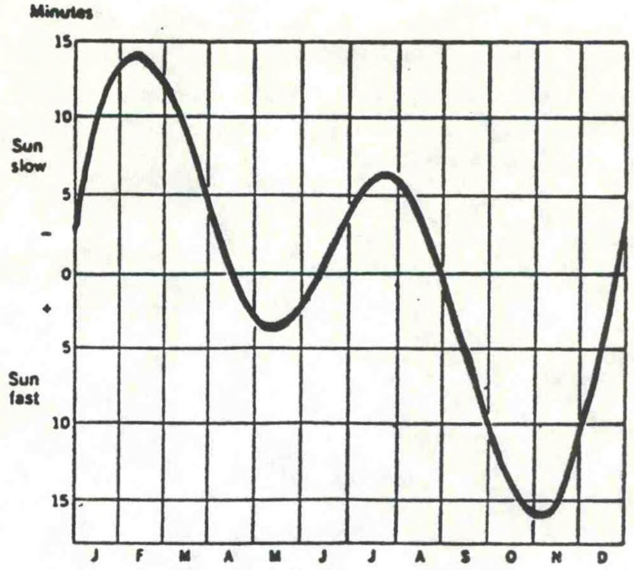

Figure 1. The equation of time throughout the year. [After E. A. Fath (1934)]

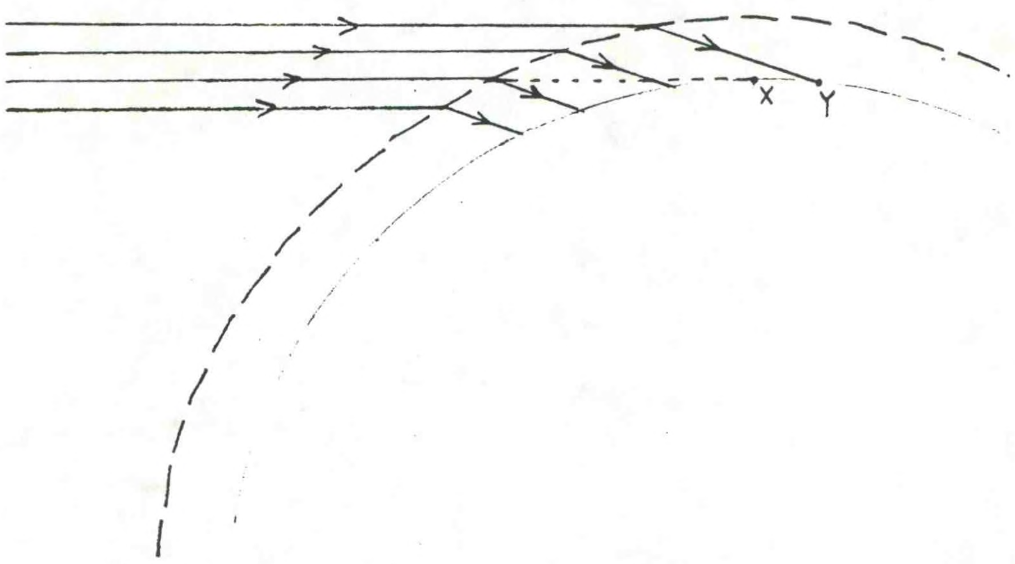

Figure 2. Exaggerated example of atmospheric refraction of light. Solid circle is the earth's surface, dashed circle is the top of the atmosphere, X indicates the true horizon for sunrise, Y indicates the apparent horizon for sunrise, straight horizontal lines indicate the sun's rays.

Y	1984	-:44	+:44	+:40	+:35	+:31	+:26	---> Leap year
E	1985	+:22	+:22	+:18	+:13	+:09	+:04	
A	1986	0	0	-:04	-:09	-:13	-:18	
R	1987	-:22	-:22	-:26	-:31	-:35	-:40	
	1988	-:44	+:44	+:40	+:35	+:31	+:26	---> Leap year
		2/28	3/1	5/13	7/25	10/6	12/18	
				DATE				

Table 1. Approximate sunrise/sunset errors in seconds due to leap year not in the output, at 40 N/S. Positive errors indicate values calculated are too fast; actual sunrise/sunset occurs later by number of seconds shown. Vice versa for negative values.

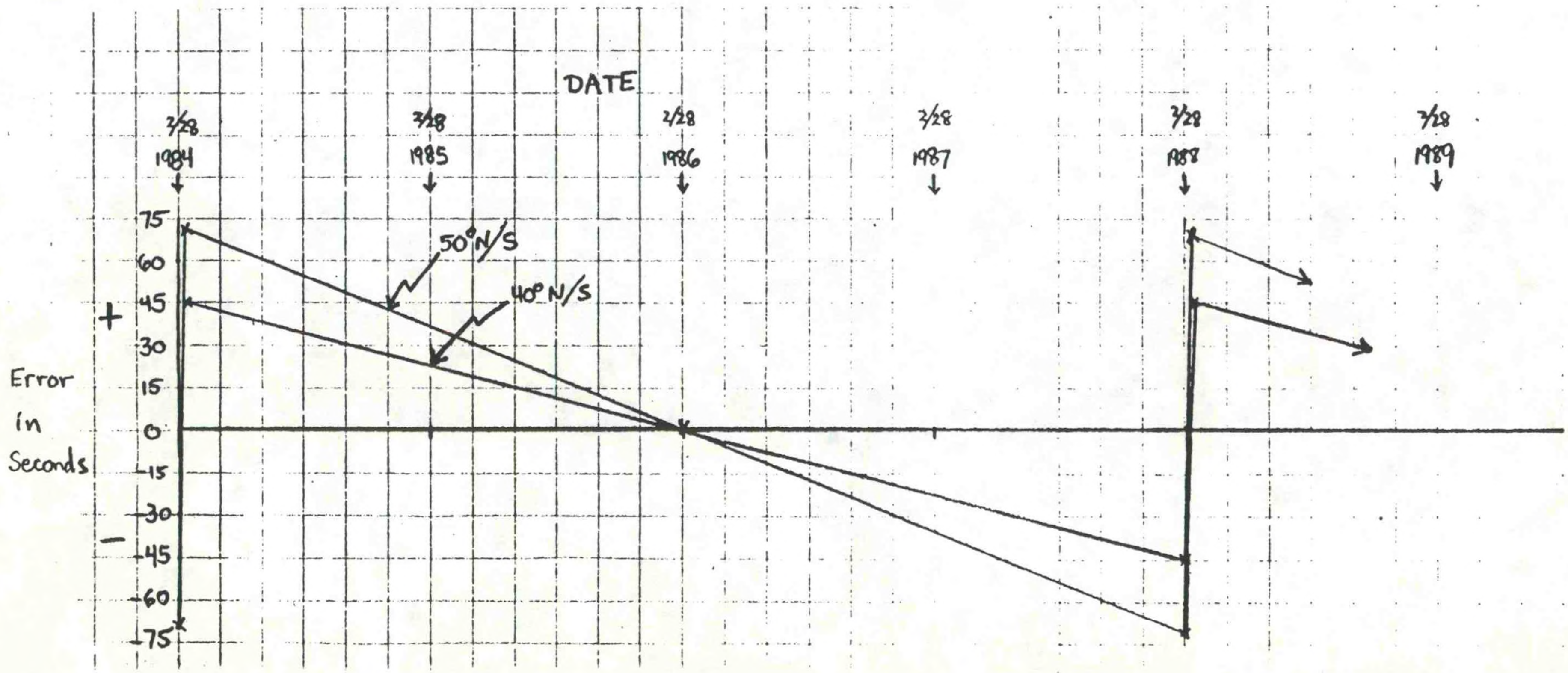

Figure 3. As in Table 1, except showing errors at both 40 N/S and 50 N/S. Note the largest errors occur directly around the leap dates.

ANNUAL SUNRISE/SUNSET TABLE FOR 44.9 DEGREES LATITUDE
93.2 DEGREES LONGITUDE

STATION NAME: MINNEAPOLIS, MN

ALL TIMES ARE GREENWICH MEAN TIME (GMT)

	JANUARY RISE	JANUARY SET		FEBRUARY RISE	FEBRUARY SET		MARCH RISE	MARCH SET
1	13:51:05	22:41:26	1	13:34:00	23:18:55	1	12:52:29	23:57:50
2	13:51:12	22:42:20	2	13:32:49	23:20:18	2	12:50:45	23:59:10
3	13:51:09	22:43:10	3	13:31:44	23:21:47	3	12:49:00	00:00:31
4	13:51:11	22:44:08	4	13:30:31	23:23:12	4	12:47:12	00:01:49
5	13:51:07	22:45:06	5	13:29:17	23:24:38	5	12:45:24	00:03:08
6	13:51:01	22:46:06	6	13:28:00	23:26:01	6	12:43:38	00:04:29
7	13:50:50	22:47:05	7	13:26:42	23:27:25	7	12:41:50	00:05:47
8	13:50:40	22:48:09	8	13:25:23	23:28:50	8	12:40:01	00:07:06
9	13:50:28	22:49:15	9	13:24:03	23:30:16	9	12:38:12	00:08:25
10	13:50:10	22:50:21	10	13:22:39	23:31:40	10	12:36:23	00:09:44
11	13:49:51	22:51:28	11	13:21:15	23:33:04	11	12:34:31	00:11:00
12	13:49:30	22:52:37	12	13:19:50	23:34:29	12	12:32:42	00:12:19
13	13:49:07	22:53:48	13	13:18:19	23:35:48	13	12:30:53	00:13:38
14	13:48:35	22:54:56	14	13:16:52	23:37:15	14	12:29:00	00:14:55
15	13:48:08	22:56:11	15	13:15:22	23:38:39	15	12:27:08	00:16:11
16	13:47:37	22:57:24	16	13:13:52	23:40:03	16	12:25:15	00:17:28
17	13:47:03	22:58:40	17	13:12:18	23:41:25	17	12:23:26	00:18:47
18	13:46:25	22:59:54	18	13:10:44	23:42:47	18	12:21:34	00:20:03
19	13:45:45	23:01:10	19	13:09:09	23:44:10	19	12:19:44	00:21:23
20	13:45:06	23:02:31	20	13:07:34	23:45:33	20	12:17:52	00:22:39
21	13:44:20	23:03:47	21	13:05:58	23:46:57	21	12:15:59	00:23:56
22	13:43:35	23:05:08	22	13:04:22	23:48:21	22	12:14:07	00:25:12
23	13:42:49	23:06:30	23	13:02:39	23:49:40	23	12:12:14	00:26:29
24	13:41:55	23:07:48	24	13:01:02	23:51:05	24	12:10:22	00:27:45
25	13:41:06	23:09:13	25	12:59:19	23:52:24	25	12:08:30	00:29:01
26	13:40:10	23:10:33	26	12:57:39	23:53:47	26	12:06:37	00:30:18
27	13:39:12	23:11:55	27	12:55:58	23:55:09	27	12:04:42	00:31:31
28	13:38:13	23:13:18	28	12:54:14	23:56:29	28	12:02:50	00:32:47
29	13:37:13	23:14:42				29	12:00:58	00:34:03
30	13:36:12	23:16:07				30	11:59:06	00:35:19
31	13:35:03	23:17:28				31	11:57:14	00:36:35

Figure 4.

	APRIL RISE	APRIL SET		MAY RISE	MAY SET		JUNE RISE	JUNE SET
1	11:55:23	00:37:50	1	11:04:06	01:15:49	1	10:30:35	01:50:32
2	11:53:31	00:39:06	2	11:02:38	01:17:05	2	10:30:01	01:51:24
3	11:51:40	00:40:21	3	11:01:11	01:18:20	3	10:29:29	01:52:14
4	11:49:46	00:41:33	4	10:59:45	01:19:34	4	10:29:02	01:53:05
5	11:48:01	00:42:54	5	10:58:19	01:20:48	5	10:28:30	01:53:49
6	11:46:10	00:44:09	6	10:56:54	01:22:01	6	10:28:06	01:54:37
7	11:44:19	00:45:24	7	10:55:33	01:23:16	7	10:27:45	01:55:22
8	11:42:35	00:46:44	8	10:54:13	01:24:30	8	10:27:25	01:56:06
9	11:39:15	00:46:28	9	10:52:51	01:25:40	9	10:27:08	01:56:47
10	11:39:10	00:49:27	10	10:51:36	01:26:55	10	10:26:52	01:57:27
11	11:37:23	00:50:44	11	10:50:16	01:28:03	11	10:26:39	01:58:04
12	11:35:34	00:51:57	12	10:49:03	01:29:16	12	10:26:27	01:58:40
13	11:33:51	00:53:16	13	10:47:51	01:30:28	13	10:26:18	01:59:13
14	11:32:02	00:54:29	14	10:46:40	01:31:39	14	10:26:11	01:59:44
15	11:30:17	00:55:44	15	10:45:30	01:32:49	15	10:26:06	02:00:13
16	11:28:31	00:57:00	16	10:44:21	01:33:58	16	10:26:03	02:00:40
17	11:26:50	00:58:17	17	10:43:14	01:35:05	17	10:26:02	02:01:05
18	11:25:05	00:59:32	18	10:42:10	01:36:15	18	10:26:07	02:01:30
19	11:23:21	01:00:46	19	10:41:08	01:37:23	19	10:26:08	02:01:47
20	11:21:41	01:02:02	20	10:40:08	01:38:29	20	10:26:20	02:02:11
21	11:20:01	01:03:18	21	10:39:08	01:39:34	21	10:26:28	02:02:27
22	11:18:21	01:04:34	22	10:38:14	01:40:41	22	10:26:38	02:02:41
23	11:16:42	01:05:49	23	10:37:17	01:41:44	23	10:26:51	02:02:52
24	11:15:03	01:07:04	24	10:36:22	01:42:45	24	10:27:08	02:03:05
25	11:13:28	01:08:21	25	10:35:32	01:43:47	25	10:27:28	02:03:15
26	11:11:53	01:09:38	26	10:34:43	01:44:48	26	10:27:48	02:03:19
27	11:10:16	01:10:51	27	10:33:55	01:45:48	27	10:28:09	02:03:22
28	11:08:43	01:12:06	28	10:33:09	01:46:46	28	10:28:33	02:03:22
29	11:07:10	01:13:21	29	10:32:31	01:47:48	29	10:28:58	02:03:21
30	11:05:40	01:14:39	30	10:31:49	01:48:42	30	10:29:26	02:03:17
			31	10:31:11	01:49:38			

Annual output from dasher run.

	JULY			AUGUST			SEPTEMBER	
	RISE	SET		RISE	SET		RISE	SET
1	10:29:56	02:03:11	1	10:57:03	01:41:16	1	11:33:13	00:52:43
2	10:30:28	02:03:03	2	10:58:11	01:40:02	2	11:34:24	00:50:55
3	10:31:03	02:02:52	3	10:59:20	01:38:47	3	11:35:36	00:49:07
4	10:31:36	02:02:37	4	11:00:26	01:37:29	4	11:36:49	00:47:18
5	10:32:12	02:02:19	5	11:01:34	01:36:09	5	11:37:55	00:45:24
6	10:32:52	02:02:03	6	11:02:43	01:34:48	6	11:39:08	00:43:35
7	10:33:34	02:01:45	7	11:03:52	01:33:27	7	11:40:21	00:41:46
8	10:34:13	02:01:18	8	11:05:00	01:32:01	8	11:41:29	00:39:50
9	10:34:59	02:00:56	9	11:06:08	01:30:35	9	11:42:42	00:38:01
10	10:35:42	02:00:25	10	11:07:20	01:29:11	10	11:43:50	00:36:05
11	10:36:32	01:59:59	11	11:08:27	01:27:40	11	11:45:04	00:34:15
12	10:37:18	01:59:25	12	11:09:41	01:26:14	12	11:46:12	00:32:19
13	10:38:06	01:58:49	13	11:10:49	01:24:42	13	11:47:26	00:30:29
14	10:38:59	01:58:14	14	11:11:58	01:23:09	14	11:48:34	00:28:33
15	10:39:50	01:57:35	15	11:13:08	01:21:35	15	11:49:49	00:26:42
16	10:40:43	01:56:54	16	11:14:18	01:20:01	16	11:50:57	00:24:46
17	10:41:38	01:56:11	17	11:15:29	01:18:26	17	11:52:12	00:22:55
18	10:42:32	01:55:23	18	11:16:41	01:16:50	18	11:53:20	00:20:59
19	10:43:30	01:54:37	19	11:17:53	01:15:14	19	11:54:32	00:19:05
20	10:44:30	01:53:49	20	11:19:06	01:13:37	20	11:55:44	00:17:11
21	10:45:25	01:52:54	21	11:20:13	01:11:54	21	11:56:56	00:15:17
22	10:46:28	01:52:03	22	11:21:27	01:10:16	22	11:58:08	00:13:23
23	10:47:26	01:51:05	23	11:22:35	01:08:32	23	11:59:17	00:11:26
24	10:48:29	01:50:08	24	11:23:50	01:06:54	24	12:00:20	00:09:23
25	10:49:33	01:49:11	25	11:24:59	01:05:08	25	12:01:44	00:07:41
26	10:50:35	01:48:08	26	11:26:08	01:03:23	26	12:02:56	00:05:47
27	10:51:39	01:47:04	27	11:27:27	01:01:46	27	12:04:08	00:03:53
28	10:52:43	01:46:00	28	11:28:31	00:59:54	28	12:05:21	00:01:58
29	10:53:44	01:44:47	29	11:29:42	00:58:07	29	12:06:36	00:00:07
30	10:54:51	01:43:40	30	11:30:53	00:56:20	30	12:07:48	23:58:13
31	10:56:00	01:42:32	31	11:32:04	00:54:33			

	OCTOBER			NOVEMBER			DECEMBER	
	RISE	SET		RISE	SET		RISE	SET
1	12:09:00	23:56:19	1	12:49:20	23:03:35	1	13:29:19	22:34:12
2	12:10:15	23:54:28	2	12:50:44	23:02:11	2	13:30:24	22:33:43
3	12:11:30	23:52:37	3	12:52:08	23:00:47	3	13:31:34	22:33:21
4	12:12:45	23:50:46	4	12:53:30	22:59:25	4	13:32:41	22:33:02
5	12:13:59	23:48:56	5	12:54:52	22:58:03	5	13:33:47	22:32:44
6	12:15:14	23:47:05	6	12:56:13	22:56:42	6	13:34:50	22:32:29
7	12:16:29	23:45:14	7	12:57:40	22:55:28	7	13:35:51	22:32:16
8	12:17:43	23:43:24	8	12:58:59	22:54:08	8	13:36:56	22:32:11
9	12:18:57	23:41:34	9	13:00:24	22:52:55	9	13:37:54	22:32:02
10	12:20:12	23:39:43	10	13:01:47	22:51:44	10	13:38:54	22:32:01
11	12:21:32	23:37:59	11	13:03:10	22:50:33	11	13:39:50	22:31:59
12	12:22:46	23:36:09	12	13:04:32	22:49:23	12	13:40:44	22:31:59
13	12:24:05	23:34:26	13	13:05:53	22:48:14	13	13:41:38	22:32:05
14	12:25:19	23:32:36	14	13:07:19	22:47:12	14	13:42:27	22:32:10
15	12:26:38	23:30:53	15	13:08:37	22:46:06	15	13:43:13	22:32:18
16	12:27:57	23:29:10	16	13:10:01	22:45:06	16	13:44:01	22:32:31
17	12:29:16	23:27:27	17	13:11:23	22:44:08	17	13:44:45	22:32:46
18	12:30:34	23:25:45	18	13:12:44	22:43:11	18	13:45:28	22:33:03
19	12:31:53	23:24:02	19	13:14:04	22:42:15	19	13:46:08	22:33:23
20	12:33:11	23:22:20	20	13:15:23	22:41:20	20	13:46:46	22:33:45
21	12:34:28	23:20:39	21	13:16:46	22:40:33	21	13:47:21	22:34:10
22	12:35:52	23:19:03	22	13:18:02	22:39:41	22	13:47:54	22:34:37
23	12:37:08	23:17:23	23	13:19:22	22:38:57	23	13:48:25	22:35:06
24	12:38:31	23:15:48	24	13:20:41	22:38:14	24	13:48:53	22:35:38
25	12:39:50	23:14:11	25	13:21:58	22:37:33	25	13:49:18	22:36:13
26	12:41:12	23:12:37	26	13:23:14	22:36:53	26	13:49:39	22:36:46
27	12:42:30	23:11:01	27	13:24:28	22:36:15	27	13:49:59	22:37:25
28	12:43:54	23:09:31	28	13:25:40	22:35:38	28	13:50:15	22:38:04
29	12:45:17	23:08:02	29	13:26:54	22:35:07	29	13:50:31	22:38:48
30	12:46:37	23:06:30	30	13:28:06	22:34:37	30	13:50:45	22:39:34
31	12:47:59	23:05:02				31	13:50:56	22:40:23

Figure 4

(continued).

```
SLCSUNWRH
TTAA00 KSLC 291707
MONTHLY SUNRISE/SUNSET TABLE FOR    71.3 DEGREES LATITUDE
                                   156.8 DEGREES LONGITUDE
STATION NAME: POINT BARROW, ALASKA

ALL TIMES ARE GREENWICH MERIDIONAL TIME (GMT)

MONTH: NOVEMBER

      RISE      SET
 1 19:06:09  01:15:18
 2 19:11:46  01:09:41
 3 19:17:28  01:03:59
 4 19:23:16  00:58:11
 5 19:29:09  00:52:18
 6 19:35:07  00:46:20
 7 19:41:19  00:40:20
 8 19:47:30  00:34:09
 9 19:53:55  00:27:56
10 20:00:26  00:21:37
11 20:07:03  00:15:13
12 20:13:41  00:08:46
13 20:20:13  00:02:26
14 ON THE    HORIZON
15 ON THE    HORIZON
16 ON THE    HORIZON
17 ALWAYS    DARK
18 ALWAYS    DARK
19 ALWAYS    DARK
20 ALWAYS    DARK
21 ALWAYS    DARK
22 ALWAYS    DARK
23 ALWAYS    DARK
24 ALWAYS    DARK
25 ALWAYS    DARK
26 ALWAYS    DARK
27 ALWAYS    DARK
28 ALWAYS    DARK
29 ALWAYS    DARK
30 ALWAYS    DARK
```

Figure 5. Monthly output from dasher run.

```
TTAA00 KSLC 291709
SUNRISE/SUNSET AT KEY WEST, FLORIDA
LATITUDE  =  24.6 DEGREES
LONGITUDE =  81.7 DEGREES
DATE = MARCH     21
SUNRISE AT: 11:30:46
 SUNSET AT: 23:37:25

TIMES LISTED ABOVE ARE GREENWICH TIME (GMT)
```

Figure 6. Specific date output from dasher run.

```
RUN:SUN/A SLC/S 7/M 19/D
SLC JUL 19 COMPLETED: OUTPUT IN FILE 1211Z/0256Z

RUN:SUN/A UMT/S 6/M 21/D
UMT JUN 21 COMPLETED: OUTPUT IN FILE LIGHT

RUN:SUN/A MSN/S 7/M 21/D
MSN JUL 21 COMPLETED: OUTPUT IN FILE 1033Z/0133Z

RUN:SUN/A MSP/S 7/M 21/D
MSP JUL 21 COMPLETED: OUTPUT IN FILE 1043Z/0154Z

RUN:SUN/A EKO/S 7/M 21/D
EKO JUL 21 COMPLETED: OUTPUT IN FILE 1226Z/0311Z
```

Figure 7. Examples of specific date run lines and the output from each for an ADM run.

```
MAIN PROGRAM
------------
                 SUBROUTINES
                 -----------
               ---            ---
SUN ---------> | GETTM ----> | CALC
               | JASC        | ASIN
               | PROD        | ACOS
               ---            ---

LOAD LINE
---------

RLDR SUN GETTM CALC JASC PROD ASIN ACOS UTIL.LB BG.LB FORT.LB AFOSE.LB
```

Figure 8. Program structure and load line.

36 Soaring Forecast Program. David S. Toronto, July 1982. (PB85 112274)
37 Program to Work Up Climatic Summary Weather Service Forms (F-6, F-52). Peter G. Mueller, August 1982. (PB85 109866)
38 The Hovmoller Diagram. Pamela A. Hudadoff, September 1982. (PB85 112159)
39 850-Millibar Charts Derived from Surface Data. Jeffrey L. Anderson, December 1982. (PB85 112175)
40 AFOS Vector Graphic to Grid Point Program. James R. Fors, December 1982. (PB85 109544)
41 A Pilot Briefing Program for the Background Partition. Kenneth B. Mielke and Joe L. Johnston, March 1983. (PB85 109551)
42 AEV Local Verification for Aviation, Precipitation, and Temperature Programs: AV, REl, TEM. Lawrence B. Dunn, Revised May 1985. (PB85 210342/AS)
43 OBLOG. Nancy Larsen, December 1983. (PB85 109528)
44 Communications Software for Olympics Micromation Computer System. Glen Sampson, June 1984. (PB85109510)
45 PLOTFILE Appender. Wendy L. Wolf, July 1984. (PB85 109502)
46 Spectral Wave Data Analysis (Non-directional). Lawrence Dunn, August 1984. (PB85 109577)
47 Isentropic Objective Analysis. Jeffrey L. Anderson, August 1984. (PB85 112167)
48 Hurricane Plotting Program. Paul D. Tolleson, October 1984. (PB85 121432)
49 Hemispheric Spectral Wave Analysis (Waves 0 to 7). Mary Milkovich, August 1985.
50 AOS Graphic to Grid Point Conversion and Departure from Normal Programs. Jeffrey L. Anderson and Mark A. Mathewson, August 1985.
51 Sunrise/Sunset. Glenn R. Lussky, August 1985.

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