TILT CHANGES OF SHORT DURATION

1) A Classification Scheme for Short Period Tilt Events,
2) Some Coseismic Tilt Data from Four Central California
   Tiltmeters During 1974–1975, and
3) Documentation of Some Programs Used in the Analysis
   of Short Period Tilt Data

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

Menlo Park, California
1976
ABSTRACT

Section I of this report contains a classification scheme for short period tilt data. For convenience, all fluctuations in the local tilt field of less than 24 hours duration will be designated SP (i.e., short period) tilt events. Three basic categories of waveshape appearance are defined, and the rules for naming the waveforms are outlined. Examples from tilt observations at four central California sites are provided.

Section II contains some coseismic tilt data. Fourteen earthquakes in central California, ranging in magnitude from 2.9 to 5.2, were chosen for study on four tiltmeters within 10 source dimensions of the epicenters. The raw records from each of the four tiltmeters at the times of the earthquakes were photographed and are presented in this section.

Section III contains documentation of computer programs used in the analysis of the short period tilt data. Program VECTOR computes the difference vector of a tilt event and displays the sequence of events as a head-to-tail vector plot. Program ONSTSP 1) requires two component digitized tilt data as input, 2) scales and plots the data, and 3) computes and displays the amplitude, azimuth, and normalized derivative of the tilt amplitude. Program SHARPS computes the onset sharpness, (i.e., the normalized derivative of the tilt amplitude at the onset of the tilt event) as a function of source-station distance from a model of creep-related tilt changes. Program DSPLAY plots the digitized data.
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1) Introduction

2) Access and Use

3) Input

4) Program Operation

5) Output

6) Example of DSPLAY Operation

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E) References
CLASSIFICATION SCHEME FOR
SHORT PERIOD TILT EVENTS
INTRODUCTION

The U.S. Geological Survey maintains an array of approximately 40 biaxial borehole tiltmeters in central California. The data from four of these tiltmeters (Libby, LIB; Sage South, SAS, Melendy, MEL; and Bear Valley, BVY - see Figure I-1) was selected for this investigation. The station-to-fault and interstation distances are recorded in Table I-1. The instrument resolution is about $10^{-8}$ rad., although under ideal noise-free conditions somewhat smaller changes can be detected if they occur within a few minutes. The data, passed through a 20 second output filter, is sampled at 10 second intervals. A description of tiltmeter installation and operation is contained in Johnston and Mortensen (1974) and Mortensen and Johnston (1975).

For convenience, all fluctuations in the local tilt field of less than 24 hours duration will be designated short period (ie, SP) tilt events. Visual examination of the raw records discloses that many of the perturbations in the tilt field may be classed as SP events. Preliminary analysis of the data indicates 1) that there are many different physical processes capable of affecting the local tilt field, and 2) that there may be a large variety of waveshapes associated with a particular physical process.

Often the source of the event is unknown or only tentatively identified, so that reference to the SP event must be made without implying a physical mechanism. Although the SP event waveshapes are quite variable, there are some waveforms that repeatedly occur. Thus it would be useful to refer to a particular event type without reference to the event source.
**Classification of Short Period Events**

The following notation is proposed for SP tilt events based upon their appearance in the raw records (ie, monitoring tilt component amplitude versus time and sampled at 10 second intervals with a chart speed of 0.5 inch/hour; the tilt data in figures I-2 through I-5 were taken from enlarged copies of the Rustrak records that were digitized and computer processed to a common scale - see Section III-D; Program DSPLAY):

SPI: Impulsive events. These events are characterized by a very rapid onset and decay, typically appearing as "spikes" in the tilt amplitude (figure I-2a).

SPS: Step-like events. These events are characterized by a very rapid onset resulting in a permanent (or apparently permanent) offset in tilt amplitude. (figure I-2b).

SPO: Oscillatory tilt signatures. These events are quasi-sinusoidal in appearance, and may have one or many zero crossings after the onset of the event (figures I-2c, d,e). In some cases it may be convenient to distinguish between events with different numbers of zero crossings, in which case "0" followed by the number of zero crossings, or "m" (ie,"many") can be used. (e.g., the waveshape in figure I-2c can be designated SP01; figure I-2d, SP02; and figure I-2e, SP0m).

Waveshapes combining the above features can be designated by combining the appropriate symbols, using the convention that I will be placed before S and 0, and S before 0 (the number of "zero crossings" in the case of a combined event can be taken as the number of half-periods existing in the "0" part of the event). For example, waveshapes can be designated SPIS (figure I-3a), SPII (figure I-3b), SPSO (figure I-3c),SPIS01 (figure I-3d), SPSO2 (figure I-3e), SPSS (figure I-3f), and SPS0m (figure I-3g).
Subsets of this classification scheme may be defined when the physical origin of the SP tilt event is known, e.g., creep-related, coseismic. The following scheme establishes the basic categories and is capable of further extension:

I) SR events - These events are produced by episodic, nonseismic slip on a fault or fracture (i.e., slip-related tilt events). The actual waveshapes may be quite variable depending upon the source-station geometry and the type of slip occurring. Two subgroups have been identified:

a) SRN events - These are SP tilt events with residual offsets that are suspected to have been produced by a slip process - either at depth on the San Andreas fault or on a fracture subsidiary to the San Andreas fault, but that could not be related to events on nearby creepmeters. (This category would include the SR events discussed in McHugh and Johnston (1976).)

b) SRC events - These are SP tilt events associated with, or caused by, surface creep episodes. Included in this category, are the creep-related tilt events discussed in Mortensen et al. (1975), Johnston et al., (1976), and McHugh and Johnston, (1976).

II) CS events - These are coseismic tilt signatures, i.e., SP tilt events produced by a slip process that radiates seismic energy.

a) $CS_L$ events - Coseismic signatures produced by local earthquakes (figure I-2a.2, I-4a, magnitude and source-station distance indicated by $M_L$ and $D$ respectively).

b) $CS_T$ events - Tilt signatures produced by teleseisms (figures I-2e, I-4b: body wave and surface wave magnitude indicated by $M_b$ and $M_s$ respectively, earthquake occurrence time in hours GMT is in parentheses).
III) R- tilt signature produced by rainfall. Figure I-5 shows examples of R events at MEL for the amounts of precipitation indicated in parentheses.

IV) P- tilt signature produced by barometric pressure fluctuations, such as may occur with the passage of a major storm front. The tilt amplitude change expected for a major storm can be estimated from Savino and Rynn (1972):

\[
\omega = \frac{LP}{4 \pi \mu} \left[ \frac{\lambda + 2\mu}{\lambda + \mu} + \frac{2\pi Z}{L} \right] e^{-2\pi Z/L}
\]

where \( \omega \) is the vertical deflection at depth \( Z \), \( L \) is the wavelength of the pressure wave, and \( P \) is the pressure. Estimating the tilt, \( \Theta \), at the surface to be \( \omega/(L/2) \), the change in tilt caused by a change in pressure becomes:

\[
\Delta \Theta = \frac{3 \Delta P}{(4\pi \mu)}\quad \text{with} \quad \lambda \omega \mu.
\]

Pressure changes of up to 0.1 to 0.2 in .Hg occurring within 3 hours have been recorded at the San Francisco International Airport (National Climatic Center, NOAA), thus reversible tilt changes of up to \( 5.4 \times 10^{-9} \) rad within 3 hours (SPP events) may be associated with major storm fronts. A visual examination of tilt records from the stations shown in Figure I-1 at times of major barometric pressure changes (and excluding times of rainfall—figure I-6) failed to reveal any perturbations above the instrument resolution (\( 10^{-8} \) rad). It is expected, therefore, that P events will not be seen above the \( 10^{-8} \) rad level; they may be significant on instruments with greater resolution.
In addition to cultural noise and solid earth tides, tiltmeters may be influenced at the $10^{-8}$ rad level, or greater, by ground water fluctuations and thermal changes; however, these would generally have a duration greater than 24 hours and so would not be properly classed as SP events.
REFERENCES


TABLE I-1

Interstation and Station-to-Fault Distances

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<th>Distance (km)</th>
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<tr>
<td>BVY - MEL</td>
</tr>
<tr>
<td>SAS - fault</td>
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<tr>
<td>LIB - fault</td>
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<tr>
<td>MEL - fault</td>
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<td>BVY - fault</td>
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Instrument Locations

LIB: 36°41.67'N, 121°20.60'W
SAS: 36°41.00'N, 121°16.08'W
MEL: 36°35.38'N, 121°10.63'W
BVY: 36°34.27'N, 121°11.23'W
Figure I - 1
Figure I-2D

Figure I-2E

Figure I-3A.1

Figure I-3A.2
Figure I-3B

Figure I-3C

Figure I-3D

Figure I-3E.1
Figure I-3E.2

Figure I-3F

Figure I-3G

Figure I-4A.1
Figure I-4A.2

Figure I-4B

Figure I-5.1

Figure I-5.2
No rainfall from Dec. 4 through Dec. 12.

Pressure changed 17 in-Hg. between 0700 and 1000 GMT.

Atmospheric pressure change.

Figure 1-6a. Tilt data from SAS (11 Dec. 1973) during time of major
Figure I-6b. Tilt Data from LIB (28 Jan. 1974) During Time of Major Atmospheric Pressure Change.

Pressure changed .19 in-Hg. between 1600 and 1900 GMT.
Pressure changed .18 in-Hg. between 1900 and 2200 GMT.

(No rainfall was recorded between 22 Jan. and 31 Jan. 1974 in this area.)
Figure I-6c. Tilt Data from SAS (28 Jan. 1974) During Time of Major Atmospheric Pressure Change.

Pressure changed .19 in-Hg between 1600 and 1900 GMT.
Pressure Changed .18 in-Hg between 1900 and 2200 GMT.

(No rainfall between 22 Jan. and 31 Jan. 1974)
II

SOME COSEISMIC TILT DATA FROM FOUR CENTRAL CALIFORNIA TILTMETERS DURING 1974-1975
INTRODUCTION

Fourteen earthquakes in central California, ranging in magnitude from 2.9 to 5.2, were chosen for study on four tiltmeters (Figure 2-1) within 10 source dimensions of the epicenters. Routine location of the epicenters places the events west of the San Andreas fault (Group I events, Figure 2-1). Therefore, 6 of the epicenters were relocated by inspection onto the fault (Group II events, Figure 2-1). Four of the remaining events were relocated using a computer routine developed for this purpose (Group III events, Figure 2-1). Tables 2-1 and 2-2 list the source data for the 14 events, and tables 2-3 and 2-4 list the source-station distances and directions.

Figure 2-2 is composite sketch of a typical coseismic tilt change. The impulse is designated 'I' and the residual offset 'S'. Table 2-4 lists the observed amplitudes, subscript _a, and directions, subscript _z, of the coseismic impulses and residual offsets. Photographs of the tiltmeter records from each of the four sites, shown in Figure 2-1, at the time of the earthquake occurrence are shown in Figures 2-3a through 2-3n.
Table 2-1

Earthquake Data for Group I Events

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<tr>
<th>No.</th>
<th>Date</th>
<th>Time (GMT)</th>
<th>Latitude (°)</th>
<th>Longitude (°)</th>
<th>Ho (Depth) (km)</th>
<th>M_L</th>
<th>ERH (km)</th>
<th>ERZ (km)</th>
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M_L: local magnitude.

ERH, ERZ: one standard deviation in the horizontal and vertical locations respectively.
<table>
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* ERH, ERZ estimated from RMS value (Engdahl and Lee (1976)).
+ ERH, ERZ are 2 standard deviations in the earthquake position.

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Azimuth computed clockwise from north at station
### TABLE 2-3

Station-Epicenter Distance and Azimuth for Group I Events

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<th>BVY</th>
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Azimuth computed clockwise from north at station.
Table 2-4

Station-Epicenter Distance and Azimuth for Group II and III Events

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<td>D(km)</td>
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Table 2-4
Station-Epicenter Distance and Azimuth for Group II and III Events

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<td>Az(°)</td>
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2-6
### Table 2-5

#### Observed Coseismic Tilt Data

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<td>SA</td>
<td>SB</td>
</tr>
<tr>
<td>(ur)</td>
<td>(°)</td>
<td>(ur)</td>
<td>(°)</td>
<td>(ur)</td>
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<tr>
<td>1 10 Jan 74</td>
<td>.43</td>
<td>241</td>
<td>0.0</td>
<td>-</td>
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<tr>
<td>2 8 Mar 74</td>
<td>0.0</td>
<td>-</td>
<td>0.0</td>
<td>-</td>
</tr>
<tr>
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<td>270</td>
<td>.01</td>
<td>90</td>
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<td>-</td>
<td>0.0</td>
<td>-</td>
</tr>
<tr>
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<td>*</td>
<td>*</td>
<td>*</td>
<td>&gt; 1.18</td>
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<td>-</td>
</tr>
<tr>
<td>13 26 Mar 75</td>
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<td>*</td>
<td>*</td>
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<td>.62</td>
<td>115</td>
<td>.07</td>
<td>207.</td>
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</table>

0.0 : Deflection less than 0.01 µrad.
* : No data available
- : No azimuth computed - one tilt component offscale, zero, or initial sense of deflection uncertain.
+ : Estimated
I : Impulse, S: Residual Offset
Subscripts: amplitude, A; azimuth (clockwise from north), Z
Figure 2-1
Figure 2-2
NOTE -

All events were retimed for this investigation. Some of the times shown in the photographs may not necessarily correct. In sections where confusion may arise, the earthquake occurrence time is marked by the arrow superimposed on the photograph.

The dashed trace is east-west (+X=east), the continuous trace is north-south (+y=north). The only exception to this orientation is SAS prior to 19 Dec. 1974 (when +x=south, +y=east).

Amplitude scale at LIB, SAS, and BVY: 1 microrad. = 17 small divisions; at MEL: 1 microrad. = 3.4 small divisions. Time scale is 1 hour between the time marks (the short horizontal bars in the middle of the record).
| OZ | 1 | 200 OZ | 3/3 |

SAS
3 Mar 1975
III

DOCUMENTATION OF SOME PROGRAMS

USED IN THE ANALYSIS OF SHORT PERIOD

TILT DATA
A: PROGRAM VECTOR
Introduction

VECTOR takes tilt component data in (x, y) form and displays it as a series of head-to-tail vectors. Although any vector component data may be used as input (with the appropriate modifications made in the main program), this program has been specifically designed to compute the vector difference between initial and final (x, y) values. The output consists of 1) a listing of the input data and the amplitude and azimuth of the difference vector and 2) a plot of the input data in head-to-tail vector form. With VECTOR, the user may examine the temporal variation of a vector quantity and determine, for example, 1) trends in the difference vector's amplitude or direction, 2) the cumulative change in the vector's position, and 3) the rate of change of the vector's amplitude or azimuth.

Access and Use

This program is intended for use on the LBL 6600B or C computer and the Tektronix (4010-1) terminal. VECTOR may be accessed using the command:

```
.LOAD, VECTOR, MCHUGH
```

The program operation requires approximately 50K of core. VECTOR will automatically link to the appropriate plotting routines. Consequently, the .LOAD command may be followed by .RUN.
Unless line 6 in the program listing is changed, the input data will be read from TLTEVN in library MCHUGH. No input from the operator is required until the program is ready to start plotting the data.

**Input**

It is assumed that the data stored on TLTEVN is in the form:

1) \( N \) = number of data blocks (e.g., from individual stations), I2 format
2) Header card with station name, A10 format
3) Data block:

   Each line (card image) must consist of the date and time of the event, the initial and final \((x, y)\) coordinates, and the scale factor. It is assumed that \(+x = \text{EAST}\) and \(+y = \text{NORTH}\). The Sage South data prior to 19 December 1974 (when \(+x = \text{SOUTH}\) and \(+y = \text{EAST}\)) is automatically corrected.

   The variable sequence and format is:

   \[
   \text{NMONTH, NDAY, NYEAR, TIME, XIN, YIN, XFN, YFN, FACTOR}
   \]

   (e.g., 04/12/74-2230 22.3 -3.7 21.8 -4.3 17.)

   I2, 1X, I2, 1X, I2, 1X, A4, 1X, 4(F7.21X), F10.3

   The month, day, and the last two digits of the year are in integer form. XIN and YIN are the initial \((x,y)\) position of the vector, and XFN and YFN are the final \((x,y)\) position. It is assumed that the \(x,y\) data must be changed from their input scale to microadians by dividing by FACTOR.
4) End card:

The end of the data block is a card with XIN, YIN, XFN, and YFN set equal to +999.99.

5) The number of "header card and data block" sequences must equal N. That is, the data is arranged as follows:

```
N
  \{ Header Card
    \{ Data Block
      \{ End Card
          \} \} \} \}
```

If a different input format is desired, lines 32, 35, and 38 may be changed. The Sage South (SAS) data prior to 19 December 1974 is affected by lines 54 through 59. The month in integer form is changed to an alphabetic code by lines 42 through 53.

Output

The output for each station consists of 1) a listing of the input data and the amplitude and azimuth of the difference vector and 2) a head-to-tail vector plot of all the data in each data block.
The list is written out in the form:

```
DAY, MONTH, YEAR, TIME, XIN, YIN, XFN, YFN, AMP, AZM
```

If one or more of the (x, y) data points is unknown (i.e., equal to +999.99), the azimuth is set equal to +999.99 and that vector is not plotted. The Tektronix screen is automatically cleared prior to the data list and after every 25 lines of data have been displayed. A hard copy is automatically made of the screen after 25 lines of data have been printed. The program sums the x and y coordinates of each vector (with an azimuth not equal to +999.99), and computes the amplitude and azimuth of this cumulative vector. This information is displayed and hard copied after the data listing is terminated.

Immediately prior to the vector plot, the computer will list the total amplitude of the vectors (that is, the sum of the individual amplitudes), and ask if any scaling is required for the plot. If an N (no) is entered, the distance from the center of the screen to the margins is set equal to the total amplitude of the vectors. If scaling is desired, enter Y (yes); the computer will respond:

```
Enter right- and left-hand margin coordinates,
Then lower and upper margin coordinates.
```

The four numbers corresponding to the margin positions must be entered. The vector plot is displayed once the scaling information is entered (the start and end times of the plot are also listed). After the plotting is finished, the computer responds:
If a 1 is entered, the computer asks for new scaling information; and the plot is re-drawn. If a 0 is entered, a hard copy of the plot is automatically made, and data from the next data block is written.

Results and Discussion

Pages 3-A.9 through 3-A.30 show the short period tilt event data from four central California sites (Libby - LIB, Sage South - SAS, Melendy - MEL, and Bear Valley - BVY; Figure 3-A1). Each vector represents the change in tilt produced by an SR event (Figures 3-A2a and 3-A2b). Each SR event and the associated (x,y) data from June 1973 through June 1975 at LIB and SAS and April 1974 through May 1975 at MEL and BVY were read from the Rustrak records, and are listed and plotted by VECTOR: The cumulative change in tilt represented by the SR events is 2.6 μrads and 219° from north at LIB, 2.9 μrads and 76° at SAS, 7.0 μrads and 342° at MEL, and 0.3 μrads and 6.8° at BVY. In general, these trends are fairly well established at each station. Although the vectors appear to change in random directions at MEL initially, the trend for the last half of the data is north by northwest.

The SR event data indicate that there is a systematic, long-term trend to the short-period changes at each station. Although the trend at each station is different, it is clear that the SR events do not represent random changes in the tilt field. The systematic trends may indicate the SR event source is slip-related. Models for SR events have been discussed in McHugh and Johnston (1976) and McHugh (1976a and 1976b). Further discussion of SR events follows in the next section.
Figure 3-Al

3-A.7a
EXAMPLE OF VECTOR OPERATION
<table>
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<th>Change</th>
<th>Pressure</th>
<th>Change</th>
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AMPLITUDE OF VECTOR SUM = 2.556E+00 MICRORADIANS

AZIMUTH OF VECTOR SUM = 2.194E+82 DEGREES
LIBBY
TOTAL AMPLITUDE OF VECTORS = 6.2E+08
SET MARGINS? YES(Y) OR NO (N)
N
START TIME JUN/16/73-2030
END TIME JUN/1/75-0900

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
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LIBBY
TOTAL AMPLITUDE OF VECTORS = 6.264E+80
SET MARGINS? YES(Y) OR NO (N)
Y!
ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,
THEN LOWER AND UPPER MARGIN COORDINATES
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AZIMUTH OF VECTOR SUM = 7.638E+01 DEGREES
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TOTAL AMPLITUDE OF VECTORS = 4.044E+00
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END TIME MAY/11/75-1930
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3-A.21
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3-A.22
STATION = NELENODY

X,Y COORDINATES OF VECTOR SUM = -2.147E+00  6.647E+00

AMPLITUDE OF VECTOR SUM = 6.965E+00 MICRORADIANS

AZIMUTH OF VECTOR SUM = 3.421E+02 DEGREES
MELENDY
TOTAL AMPLITUDE OF VECTORS = 2.263E+01
SET MARGINS? YES(Y) OR NO (N)
N!
START TIME MAY/31/74-0323
END TIME JUN/13/75-0525

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
1

3-A.24
MELENDEY
TOTAL AMPLITUDE OF VECTORS = 2.263E+01
SET MARGINS? YES(Y) OR NO (N)
Y!
ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,
THEN LOWER AND UPPER MARGIN COORDINATES
10 -10 -10 10!
START TIME MAY/31/74-0323
END TIME JUN/13/75-0525
0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
1
TOTAL AMPLITUDE OF VECTORS = 2.263E+01
SET MARGINS? YES(Y) OR NO (N)
Y!
ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,
THEN LOWER AND UPPER MARGIN COORDINATES
5 -5 -5 5
0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
0!
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<th>Code</th>
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<th>Temp 2</th>
<th>Temp 3</th>
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STATION = BEARVALLEY

X,Y COORDINATES OF VECTOR SUM = 3.529E-02 2.941E-01

AMPLITUDE OF VECTOR SUM = 2.962E-01 MICROGRADIANS

AZIMUTH OF VECTOR SUM = 6.843E+00 DEGREES
BEARVALLEY
TOTAL AMPLITUDE OF VECTORS = 6.841E-01
SET MARGINS? YES(Y) OR NO (N)
N!
START TIME APR/11/74-0115
END TIME MAY/24/75-0638

0=RETURN TO MAIN PROGRAM, 1=NEW PLOT
0!
PROGRAM VECTOR (TAPE5, TAPE7 = TAPE7, TAPETTY = TAPETTY)
COMMON/TVPOOL/TVPUL(8)
COMMON/TVTUNE/ITUNE(30)
COMMON/JPLCT/XLT, XRT, YLC, YUP, MAJX, MAJY, XX(2), KY(2), LTITL(8), LUG.
DIMENSION IFET(8)
DIMENSION STA(10), NYEAR(1000), NDAY(1000)
DIMENSION NMONTH(1000), TIME(1000), XIN(1000), XFN(1000), YIN(1000)
DIMENSION YFN(1000), A(30), AMP(1000), AZM(1000)
CALL FET(5LTAPE7, IFET, 8)
IFET(2) = IFET(2) .OR. 0000 0010 0000 0000 0000
IFET(8) = IFET(8) .OR. 0000 0000 0000 0000 0000
CALL FET(5LTAPE7, IFET, -8)
TVPUL(5) = -0.32 $TVPUL(6) = 1. $TVPUL(7) = 0. $TVPUL(8) = 1.
DO 10 I = 1, 1000
NMONTH(I) = NDAY(I) = TIME(I) = XIN(I) = XFN(I) = YIN(I) = 0.
YFN(I) = NYEAR(I) = 0.
10 CONTINUE
PI = 3.1415926 $READ (5, 1) N
1 FORMAT (I2)
DO 2 IJ = 1, N
READ (5, 3) STA(IJ) $K = 1 $SUM1 = SUM2 = 0.
3 FORMAT (A10)
4 READ (5, 5) NMONTH(K), NDAY(K), NYEAR(K), TIME(K), XIN(K), YIN(K), XFN(K)
5 YFN(K) = FACTOR
6 FORMAT (I2, 1X, I2, 1X, A4, 1X, 4(F7.2, 1X), F10.3)
7 IF(XIN(K) .EQ. 999.99 .AND. YIN(K) .LE. 70) GOTO 20
8 IF(YFN(K) .EQ. 999.99 .AND. XFN(K) .EQ. 999.99 .AND. XFN(K) .EQ. 999.99 .AND.
9 YFN(K) .EQ. 999.99 .EQ. 0.9) GOTO 20
10 A = XIN(K) $B = YIN(K) $C = XFN(K) $D = YFN(K) $LMC = NMONTH = NMONTH(K)
11 IF(NMONTH(K) .EQ. 1) $NMONTH(K) = 3HJAN
12 IF(NMONTH(K) .EQ. 2) $NMONTH(K) = 3FEB
13 IF(NMONTH(K) .EQ. 3) $NMONTH(K) = 3MAR
14 IF(NMONTH(K) .EQ. 4) $NMONTH(K) = 3APR
15 IF(NMONTH(K) .EQ. 5) $NMONTH(K) = 3MAY
16 IF(NMONTH(K) .EQ. 6) $NMONTH(K) = 3JUN
17 IF(NMONTH(K) .EQ. 7) $NMONTH(K) = 3JUL
18 IF(NMONTH(K) .EQ. 8) $NMONTH(K) = 3AUG
19 IF(NMONTH(K) .EQ. 9) $NMONTH(K) = 3SEP
20 IF(NMONTH(K) .EQ. 10) $NMONTH(K) = 3OCT
21 IF(NMONTH(K) .EQ. 11) $NMONTH(K) = 3NOV
22 IF(NMONTH(K) .EQ. 12) $NMONTH(K) = 3DEC
23 IF(STA(IJ) .EQ. 10) $HSAGE SOUTH .AND. NYEAR(K) .LE. 74) GOTO 20
24 GOTO 12
25 IF(LMONTH .LT. 12) GOTO 11
26 IF(LMONTH .EQ. 12 .AND. NDAY(K) .LE. 19) GOTO 11
59  GOTO 12
60  11  A=YIN(K)  B=-XIN(K)  C=YFN(K)  D=-XFN(K)
61  12  IF(A.EQ.999.99) A=0.  IF(B.EQ.999.99) B=0.
62  13  IF(C.EQ.999.99) C=0.  IF(D.EQ.999.99) D=0.
63  AMP(K)=(SQRT(((C-A)**2)+(D-B)**2))/FACTOR
64  IF(XIN(K).EQ.999.99.OR.YIN(K).EQ.999.99.OR.XFN(K).EQ.999.99.OR.YFN(K).EQ.999.99) GOTO 7
65  1(K).EQ.999.99  GOTO 0
66  SUM1=SUM1+((C-A)/FACTOR)  SUM2=SUM2+((D-B)/FACTOR)
67  DELTAY=D-B  IF(DELTAY.EQ.0.) DELTAY=1.E-20
68  AZM(K)=(ATAN((C-A)/DELTAY))*180./PI
69  IF(DELTAY.LT.0.) AZM(K)=AZM(K)+180.
70  IF(AZM(K).GT.360.) AZM(K)=AZM(K)-360.
71  IF(AZM(K).LT.0.) AZM(K)=AZM(K)+360.
72  K=K+1  GOTO 4
73  7  AZM(K)=999.99
74  6  NEND=K-1
76  CALL TVNEXT
77  DO 8 J=1,NEND,25
78  M=J+24  IF(M.GT.NEND) M=NEND
79  WRITE(7,3) STA(IJ)
80  WRITE(7,9) (NDAY(I),NMONTH(I),NYEAR(I),TIME(I),XIN(I),YIN(I),XFN(I),YFN(I),AMP(I),AZM(I),I=1,M)
81  9 FORMAT (12X,A3,19H 1A,1H- A,IX,F6.2,IX,F7.3,IX,F7.2)
82  8 CONTINUE
83  CALL REPRO CALL TVNEXT
84  8 CONTINUE
85  TAMP=SQRT((SUM1**2)+(SUM2**2))
86  IF(SUM2.EQ.0.) SUM2=1.E-20
87  TAZM=(ATAN(SUM1/SUM2))*180./PI
88  IF(SUM2.LT.0.) TAZM=TAZM+180.  IF(TAZM.LT.0.) TAZM=TAZM+360.
89  IF(TAZM.GT.360.) TAZM=TAZM-360.
90  WRITE(7,13) STA(IJ),SUM1,SUM2,TAMP,TAZM
91  13 FORMAT (/,/*STATION = *,A10,/,*,X,Y COORDINATES OF VECTOR SUM = *,E10.3,5X,E10.3,/,*,AMPLITUDE OF VECTOR SUM = *,E10.3,* MICRORADIANS*,/,*,AZIMUTH OF VECTOR SUM = *,E10.3,* DEGREES*)
92  CALL REPRO
93  CALL VCTCRS(STA,IJ,SUM1,SUM2,NMONTH,NDAY,NYEAR,TIME,AMP,AZM,NEND)
94  CALL REPRO
95  2 CONTINUE
96  STOP
97  END
98  SUBROUTINE REPRO
99  A=00000001000000000B $CALL ENDREC(7)  $CALL FET(7,A,2*64)
100  3=0033002700000000000B $WRITE(7,7)  $CALL FET(7,A,-2*64)
101  CALL ENDREC(7) $WRITE(7,1)  $RETURN
102  1 FORMAT (100(/))
103  ENC
104  SUBROUTINE VCTORS(STA,IJ,SUM1,SUM2,NMONTH,NDAY,NYEAR,TIME,AMP,AZM,NEND)
105  1 DIMENSION NDAY(50),NMONTH(50),NYEAR(50),TIME(50),AMP(50),AZM(50)
106  12 COMMON/TVPOL/TVPUL(8)
107  12 CONTINUE
108  SUM=0.
109  DO 30 J=1,NEND
110  IF(AMP(J).EQ.999.99.OR.AZM(J).EQ.999.99) GOTO 30
111  30 CONTINUE
112  3-A.33
21 JUL 76 10.48.06 MCHUGH .VECTOR PAGE 3

```
117 SUM=AMP(J)+SUM
118 30 CONTINUE
119 CALL TVNEXT $WRITE (7,99)STA(IJ)
120 99 FORMAT(A10)
121 WRITE (7,31)SUM
122 31 FORMAT(*TOTAL AMPLITUDE OF VECTORS = *,E10.3)
123 TVPUL(1)=SUM $TVPUL(2)=SUM $TVPUL(3)=-SUM $TVPUL(4)=SUM
124 WRITE (7,34) $READ (7,35)CHECK $IF(CHECK.EQ.1HY)GOTO36
125 34 FORMAT(*SET MARGINS? YES(Y) OR NO (N)*)
126 35 FORMAT(A)
127 36 WRITE(7,33) $CALL GETNUM(A) $TVPUL(2)=A(1) $TVPUL(1)=A(2)
128 33 FORMAT(*ENTER RIGHT- AND LEFT-HAND MARGIN COORDINATES,*,/)
129 37 IF(AMP(I).LE.999.99.AND.AZM(I).EQ.999.99)GOTO102
130 38 BEGIN1=BEGIN2=0.
131 DO 2 I=1,NEND
132 IF(AMP(I).EQ.999.99)IF(AZM(I).EQ.999.99)GOTO102
133 X=BEGIN1 $Y=BEGIN2
134 DX=AMP(I)*SIN(AZM(I)*(PI/180.))
135 CALL ARROW(X,Y,DX,DY)
136 BEGIN1=X+DX $BEGIN2=Y+DY
137 2 CONTINUE
138 write(7,39) $CALL GETNUM(A) IF(A(I).EQ.1)GOTO40
139 39 FORMAT(*Q=RETURN TO MAIN PROGRAM, 1=NEW PLCT*)
140 RETURN $END
141 $--ARROW----------------------------------
142 $PARAMS -- ABSOLUTE X,Y AND DELTA X,Y
143 SUBROUTINE ARROW(X,Y,DX,DY)
144 REAL A(6),B(6)
145 A(1)=A(3)=A(5)=X $ B(1)=B(3)=B(5)=Y
146 A(2)=A(4)=A(6)=X+DX $ B(2)=B(4)=B(6)=Y+DY
147 ARWLEN=SQR(DX*DX+DY*DY) $ HOLEN=ARWLEN/5
148 IF(ARWLEN.EQ.0)GOTO 20 $ ARWANG=ACOS(DX/ARWLEN)
149 IF(DY.LT.0)ARWANG=6.2832-ARWANG $ ARWANG=ARWANG+3.1416
150 DO 10 I=1,2 $ ANG=ARWANG+(I-1.5) $ J=I*2+1
151 A(J)=X+DX*HOLEN*COS(ANG)
152 $10 B(J)=Y+DY*HOLEN*SIN(ANG)
153 END
154 SUBROUTINE GETNUM(R)
155 DIMENSION R(1),L(80)
156 READ (7,9)I,J=R
157 9 J=J+1 $ N=P=S=0 $ M=F=1
158 5 I=I+1 $ IF(I.GT.80)RETURN $ D=L(I) $ K=4
159 IF(D.EQ.38)K=2 $ IF(D.EQ.27.AND.LE.36)K=1
160 IF(D.EQ.47)K=3 $ K=K+S $ GOTO (1,2,3,5,1,4,3,4)K
161 1 N=N*10+D-27 $ S=F=4 $ GOTO 5
162 2 M=I $ S=F=4 $ GOTO 5
163 3 P=I $ S=F=4 $ GOTO 5
164 4 IF(M.EQ.0)F=10.* (M-P-1) $ R(J)=N/F*M $ GOTO 6
165 9 FORMAT(80R1)
```

B: PROGRAM ONSTSP
Introduction

ONSTSP displays 1) the amplitude and azimuth of short period tilt events computed from digitized, two-component data and 2) the "sharpness" (i.e., the normalized derivative) of the amplitude versus time graph. The input consists of digitized x, y versus time data. The sample interval of the x trace need not be the same as the y trace, nor is it necessary that their start and end times be the same. The program automatically converts the x and y traces to a common time base and sample interval, and then computes the amplitude and azimuth change from the x, y data. The "sharpness" quantity is computed from the amplitude data as follows:

\[ [S] = \left( \frac{d\Theta}{dt} \right) / \left[ \frac{\Theta_f - \Theta_i}{(t_f - t_i)} \right] \]

where \([S]\) is the sharpness, \(\Theta\) is the tilt amplitude, \(t\) is the time, and the subscripts \(i\) and \(f\) represent the initial and final quantities respectively.

Access and Use

ONSTSP is intended for use on the LBL 6600B or C computer and the Tektronix (4010-1) terminal. It requires 55K of core and is accessed using:

\[ \text{LOAD, ONSTSP, MCHUGH} \]

The program links automatically to the plotting routines, so that the \(\text{LOAD}\) command may be followed by \(\text{RUN}\). The data are assumed (line 6 in the program) to be stored on EVENTS in library MCHUGH.
Input

The data, stored on EVENTS, must be arranged with the y trace (north-south component) leading the x trace. Each data block must have its own header card. The arrangement is as follows:

Event #1

Header card for north-south data

Data block (x1, y1)

Header card for east-west data

Data block (x2, y2)

...

...

...

Event N

Header card for north-south data

Data block (x1, y1)

Header card for east-west data

Data block (x2, y2)

There is no limit to the number of events (N) that may be operated on with this program. The number of points in each data block is limited to 1000.

The header card's information is in the form:

LTITL (1), LTITL (2),..., LTITL (7), RA, B, C

(e.g., LIBNO4-01-74 .163 .821 .172)

A3, A1, A2, A1, A2, A1, A2, 8x, 3F10.3

LTITL (1) is the 3-letter code of the station and LTITL (2) must be either N (for the north-south component) or E (for the east-west data). The
remainder of the title is the date of the event (LTITL(3) must be the month, LTITL(5) the day, and LTITL(7) the year). RA is the scale factor to change the digitized time scale to hours, B sets the absolute time, and C scales the amplitude. That is, if \( u \) is the digitized time base (in thousandths of an inch) and \( v \) the digitized amplitude (in thousandths of an inch), and if \( T \) is the absolute time (in hours GMT) and \( S \) is the amplitude (in microradians), the relation between these quantities is assumed to be (lines 63 through 66 in the listing):

\[
S_n = (C \times v_n) + D \\
T_n = (RA \times u_n) + B
\]

where \( D \) is the first value of \( v \) (\( D = C \times v_1 \)) and \( n \) is the number of the data point in the data block. If \( B \) is not included in the header card (\( B = 0 \)), the first point in the time series is zero (i.e., \( T_1 = 0 \)).

The data following the header card must be in the format 12F6.3, i.e.,

\[
\begin{align*}
  u_1 & \quad v_1 \\
  u_2 & \quad v_2 \\
  \vdots & \quad \vdots \\
  u_6 & \quad v_6
\end{align*}
\]

If \( u \) or \( v \) equals 999.999, the data block is ended. To change formats, line 37 (for the header card) or line 50 (for the data block) may be altered. All Sage South data prior to 19 December 1974 (with +x = south, +y = east) will be automatically converted to +x = east, +y = north.
Program Operation

Both tilt components of each event (x versus time, y versus time, and the two header cards) are displayed in the form \((S, T)\) prior to the computations that reduce the components to a common time base.

The program uses a linear interpolation scheme to convert the digitized data to a common sample interval. If \((S^x, T^x)\) is the x (east-west) trace versus time and \((S^y, T^y)\) is the y (north-south) trace versus time, it may happen that \(T^x_1 \neq T^y_1\) and \(T^x_{\text{end}} \neq T^y_{\text{end}}\). That is, the time of the first x data point may not be equal to the time of the first y data point, and similarly for the final x and y data points. In addition, it may happen that \(\Delta T^x \neq \Delta T^y\) or that \(T_{k+1} - T_k \neq T_{k+1} - T_{k-1}\); i.e., that the sample intervals of the x and y traces are not the same or that the sample interval within a particular trace is not constant (equivalent to missing data points). The program will determine a beginning and end time common to both traces and use a linear interpolation scheme (lines 135-138) to ensure a common sample interval (Figure 3-B1). This corrected x, y data \((\hat{S}^x, \hat{T}^x), (\hat{S}^y, \hat{T}^y)\) is also displayed by the program.

After computing \((\hat{S}, \hat{T})\), the amplitude and azimuth (from north) of the tilt vector is determined. This data is also displayed. The final step in the program is the computation of the sharpness quantity, \([S]\). The sharpness is the time rate of change of the tilt amplitude normalized by the duration of the event and the total change in event amplitude. Unless otherwise specified, the initial and final times and amplitudes of the digitized data are used by the program. \([S]\) is also displayed.
Output

After reading in the event data (two data blocks, north-south and east-west), the computer writes the contents of the header card and "0 = Re-start." If a zero is entered, the next two data blocks are read, and the new header card information and re-start statement is written. If any non-zero number is entered, the data is converted to the (S, T) form, and the minimum and maximum amplitudes are determined. The information is then written as follows:

\[
\begin{align*}
\text{min/max values of NS component} & = \text{(numerical values)} \\
\text{min/max values of EW component} & = \text{(numerical values)} \\
\text{min/max values of time (NS)} & = \text{(numerical values)} \\
\text{min/max values of time (EW)} & = \text{(numerical values)} \\
\end{align*}
\]

The min/max time values should be the same for both the north-south (NS) and east-west (EW) components. This provides a check on the accuracy of the computer's selection of an initial and final time for the two components. The input data in (S, T) form is then displayed (north-south component versus time first).

The computer next converts the (S, T) data to (\(\hat{S}, \hat{T}\)) form and writes:

\[
\begin{align*}
\text{min/max values of NS data} & = \text{(numerical values)} \\
\text{min/max values of EW data} & = \text{(numerical values)} \\
\text{min/max values of time} & = \text{(numerical values)} \\
\end{align*}
\]

These values should be essentially the same as written previously. The computer then displays the (\(\hat{S}, \hat{T}\)) data, north-south (NS) component first.
The component data is next converted to amplitude and azimuth (from north) versus time. The computer writes:

min/max values of amplitude  = (numerical values)
min/max values of azimuth    = (numerical values)
min/max values of time       = (numerical values)

The amplitude data is displayed first, followed by the azimuth data.

Because the sharpness quantity is scaled by the event duration it is necessary to set the initial and final event times. The computer writes:

Set initial and final times for sharpness plot?
Yes (Y) or No (N)

If an N is entered, the initial and final event times are set equal to the start and end times of the digitized data. If a Y is entered, the computer writes:

Enter initial and final times

The initial and final times of the event must be entered. These times must be in the same units (e.g., hours and fractions of an hour) as the times written by the computer. If the initial and final values of the event are equal, the quantity \( \frac{\left( \Theta_f - \Theta_i \right)}{t_f - t_i} \) is zero, and the computer will use an "average sharpness" quantity computed using

\[
\left[ \frac{\left( \left( \left( \Theta_f - \Theta_i \right)/2. \right) + \Theta_i \right)}{\left( \left( (t_f - t_i)/2. \right) + t_i \right)} \right]
\]
If this is also zero, indicating that $\Theta_f = \Theta_i = 0$, the computer will write:

Average sharpness is zero

Enter value for use in sharpness plot

A value for the "average sharpness" should be entered. The sharpness, $S$, is then determined, and the computer writes:

min/max values of sharpness = (numerical values)
min/max values of time = (numerical values)

The sharpness quantity versus time is displayed next. After displaying the sharpness, the computer will write:

Re-compute sharpness? Yes (Y) or no (N).

If an N is entered, a new data set will be read, and the procedure is repeated. If a Y is entered, the sharpness will be re-computed.

Results and Discussion

Examples of the program operation are given on pages 3-B.10 through 3-B.37. The fluctuations in azimuth prior to the beginning of the event are caused by numerical errors. The values of tilt component amplitude are zero or near zero before the event, causing division by zero, or numbers near zero, to occur when the azimuth is computed. The fluctuations are
due to noise in the original digitized data. Discontinuities in the azimuth represent a rotation through 180° or 360°. Notice, too, that for the step-like event, the sharpness is a maximum near the event onset.

The onset sharpness (assumed to be the maximum value of $[S]$) of the 27 October 1974 LIB SRN event is 115 (page 3-B.21). However, this value was computed using an event duration equal to the difference between the initial and final times of the digitized record. A more realistic estimate of the event duration is the time during which the derivative of the amplitude is non-zero (approximately 0.2 hours). Re-computing $[S]$ using this duration (page 3-B.22), the onset sharpness is reduced to 9.2.

The onset sharpness was assumed to be the maximum sharpness because of the small decrease in tilt amplitude at approximately 22.1 hours (page 3-B.18), just prior to the large increase in amplitude after 22.2 hours. This small decrease in amplitude is most likely produced by small timing errors on the original record that cause the event on the two components to start at slightly different times.

In principle, the greater the time rate of change of the amplitude at the event onset, the closer the source of the event is to the station. A method for estimating the source-station distance from the onset sharpness is discussed in the next section.
\[ \dot{S} = \left( \frac{S_2 - S_1}{T_2 - T_1} \right) \left[ T(K) - T_i \right] + S_i \]

\[ \dot{T} = T(K) \]

Figure 3-B1
EXAMPLE OF ONSTSP OPERATION
LOAD, ONSTSP, MCHUGH!
LOAD COMPLETE, ENTERING ^EDIT
OK^- ^EDIT
^RUN!
LIB 10-27-74 .147 21.000 .113
0=RE-START
1!
MIN/MAX VALUES OF NS COMPONENT = -4.375E+92 5.164E+01
MIN/MAX VALUES OF EW COMPONENT = -3.663E+02 9.955E+01
MIN/MAX VALUES OF TIME (NS) = 2.022E+01 2.345E+01
MIN/MAX VALUES OF TIME (EW) = 2.022E+01 2.345E+01
SET HORIZONTAL SCALE? Y OR N<=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N<=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF NS COMPONENT ?
LIB

10 - 27 - 74

1000. 0.

NS COMPONENT

1 = NEW PLOT, 2 = RETURN
0=RE-START
SET HORIZONTAL SCALE? Y OR NK=BLANK)
MIN/MAX X VALUES
29 25!
SET VERTICAL SCALE? Y OR NK=BLANK)
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF EW COMPONENT

TIME (GMT)
1 = NEW PLOT, 2 = RETURN
0 = RE-START
MIN-MAX VALUES OF NS DATA = -4.375E+02
MIN-MAX VALUES OF EW DATA = -3.663E+02
MIN-MAX VALUES OF TIME = 2.823E+01
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX Y VALUES
-1000 1000!
SKIP PLOT OF NS COMPONENT
1 = NEW PLOT, 2 = RETURN

2

SET HORIZONTAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES
-1000 1000!
SKIP PLOT OF EW COMPONENT
MIN/MAX VALUES OF AMPLITUDE = 1.965E-02 5 705E+02
MIN/MAX VALUES OF AZIMUTH = 1.844E-01 3 447E+02
MIN/MAX VALUES OF TIME = 2.823E+01 2.344E+01
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
-1060 1060!
SKIP PLOT OF AMPLITUDE
1 = NEW PLOT, 2 = RETURN
0 = RE-START

SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?
YES (Y) OR NO (N)
N
MIN-MAX VALUES OF SHARPNESS = -2.23E+01 1.152E+02
MIN-MAX VALUES OF TIME = 2.023E+01 2.343E+01

SET HORIZONTAL SCALE? Y OR N (BLANK)
Y
MIN-MAX X VALUES
20 25

SET VERTICAL SCALE? Y OR N (BLANK)
Y
MIN-MAX Y VALUES
-150 150

SKIP PLOT OF SHARPNESS QUANTITY?
RE-COMPUTE SHARPNESS? YES(Y) OR NO (N)

Y!

SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?
YES (Y) OR NO (N)

Y!

ENTER INITIAL AND FINAL TIMES
22.2 22.4!

MIN/MAX VALUES OF SHARPNESS = -1.783E+09 9.185E+09
MIN/MAX VALUES OF TIME = 2.623E+01 2.343E+01

SET HORIZONTAL SCALE? Y OR NK=BLANK!

Y!

MIN/MAX X VALUES
20 25!

SET VERTICAL SCALE? Y OR NK=BLANK!

Y!

MIN/MAX Y VALUES
-25 25!

SKIP PLOT OF SHARPNESS QUANTITY ?
1 = NEW PLOT, 2 = RETURN

SET HORIZONTAL SCALE? Y CR NX = BLANK

MIN/MAX X VALUES
22 23

SET VERTICAL SCALE? Y CR NX = BLANK

MIN/MAX Y VALUES
-10 15

SKIPPLOT OF SHARPNESS QUANTITY?
MIN/MAX VALUES OF NS COMPONENT = -1.846E+92 7.276E-12
MIN/MAX VALUES OF EW COMPONENT = -2.086E+02 0
MIN/MAX VALUES OF TIME (NS) = 7.450E+00 1.016E+01
MIN/MAX VALUES OF TIME (EW) = 7.450E+00 1.016E+01
SET HORIZONTAL SCALE? Y OR N (= BLANK) Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N (= BLANK) Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF NS COMPONENT
1 = NEW PLOT, 2 = RETURN
3 = RE-START
2!
SET HORIZONTAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF EW COMPONENT
1 = NEW PLOT, 2 = RETURN
0 = RE-START
2
MIN-MAX VALUES OF NS DATA = -7.276E-12 1.848E+02
MIN-MAX VALUES OF EW DATA = -2.006E+02 -2.914E-01
MIN-MAX VALUES OF TIME = 7.455E+00 1.015E+01
SET HORIZONTAL SCALE? Y OR N (= BLANK)
Y!
MIN-MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR N (= BLANK)
Y!
MIN-MAX Y VALUES
-500 500!
SKIP PLOT OF NS COMPONENT
1 = NEW PLOT, 2 = RETURN
0=RE-START
SET HORIZONTAL SCALE? Y OR NK=BLANK?
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR NK=BLANK?
Y!
MIN/MAX Y VALUES
-500 500!
SKIP PLOT OF EW COMPONENT
MIN/MAX VALUES OF AMPLITUDE = 2.914E-01  2.365E+02
MIN/MAX VALUES OF AZIMUTH  = 1.808E+02  3.355E+02
MIN/MAX VALUES OF TIME      = 7.455E+08  1.015E+01
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX Y VALUES
0 500!
SKIP PLOT OF AMPLITUDE
1 = NEW PLOT, 2 = RETURN
2!
@ = RE-START
2!
SET HORIZONTAL SCALE? Y OR NK=EL,KYK)
Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX Y VALUES
0 360!
SKIP PLOT OF AZIMUTH
SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?

YES (Y) OR NO (N)

Y!

ENTER INITIAL AND FINAL TIMES

8 5 9!

MIN-MAX VALUES OF SHARPNESS = -4.754E+01 1.433E+02

MIN-MAX VALUES OF TIME = 7.453E+20 1.014E+01

SET HORIZONTAL SCALE? Y OR NK=BLANK)

Y!

MIN-MAX X VALUES

6 11!

SET VERTICAL SCALE? Y OR NK=BLANK)

Y!

MIN-MAX Y VALUES

-250 250!

SKIP PLOT OF SHARPNESS QUANTITY?
MIN-MAX VALUES OF SHARPNESS  = -3.759E+01  1.132E+02
MIN-MAX VALUES OF TIME     = 7.455E+03  1.014E+01
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX X VALUES
6
8 9
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX Y VALUES
-100 150!
SKIP PLOT OF SHARPNESS QUANTITY?
DELETE (LGO, LG05, ONSTSP)
ONSTSP.
EXIT
LIBCOPY (GRAPHIC, TXLGO/RK, TXLGO)
LIBCOPY (JORDAT, NPLGO/RK, NPLGO)
LIBCOPY (MCHUGH, EVENTS/RK, EVENTS)
DELETE (LGO, LG05, ONSTSP)
RUN 76(S)
LINK (F=LGO, F=TXLGO, F=NPLGO, B=ONSTSP)
ONSTSP (EVENTS)
ONSTSP.
FIN.

PROGRAM ONSTSP (TAP=5, TAPE7=201, FILM=TAPE7, TAPE7=TAPE7)
COMMON / TVPOOL, TVPOOL, (6)
COMMON / TVTUNE, TVTUNE, (30)
COMMON / JPLCT/XLT, XRT, YLO, YUP, MAJX, MAJY, XX(2), YY(2), LTIL(8), LU,
1 LTIF, LNCGY, LNLGY, NCLX, NCLY, LTIL2(8)
DIMENSION IFET(N)
DIMENSION T(1000), AMP(1000), AZM(1000), A(30)
DIMENSION DELTX1(1000), DELTX2(1000)
DIMENSION XI(1000), X2(1000), Y1(1000), Y2(1000)
CALL FLT(DLTAP7, IFET, 8)
IFET(0)=IFET(2), OR, 0.000, 0.000, 0.000, 0.000
IFET(0)=IFET(5), OR, 0.000, 0.000, 0.000, 0.000
CALL FLT(DLTAP7, IFET, -8)
10 CONTINUE
10 PI=3.1415926 &NNTAL=500 &MTOTAL=NTOTAL=1
DO 30 I=1, 1000
30 AMP(I)=AZM(I)=T(I)=XI(I)=X2(I)=Y1(I)=Y2(I)=0.
30 CONTINUE
DO 31 I=1, 10
31 LTIL(1)=10H
LU=7 &LNCLX=LNLGY=1 &NCLX=NCLY=2 &MAJX=5 &MAJY=10
LU=2L MK=1, 2
IF (LTIL(1), EQ, 3 HSAS) GOTO 102
CMON / TVTUNE, TVTUNE, (30)
45 FORMAT (A3, A1, A2, A1, A2, A1, A2, 8X, 3F10.3)
LTIL(8)=10H
IF (LTIL(1), EQ, 3 HSAS) GOTO 1000
40 IF (LTIL(1), EQ, 3 HSAS) GOTO 1000
41 GOTO 91
42 IF (LTIL(7), GT, 7.4) GOTO 91
43 IF (LTIL(7), LT, 12.0) AND, LTIL(3), EQ, 12.0, AND, LTIL(5), GT, 19.0) GOTO 91
44 IF (LTIL(2), EQ, 1HN) KARO=1HE &IF (LTIL(2), EQ, 1HE) KARO=1HN
45 LTIL(2)=KARO
46 CONTINUE
DO 17 I=2, 1000, 6
17 READ (5, 31) (X2(K), Y2(K), K=1, J)
31 FORMAT (6(2F6.3))
1 DO 180 M=I, J
2 IF (X2(M) .EQ. 999.999 .OR. Y2(M) .EQ. 999.999) KK=M
3 IF (X2(M) .EQ. 999.999 .OR. Y2(M) .EQ. 999.999) GO TO 190
4 CONTINUE
5 DO 170 I=2, 1000, 6
6 READ (5, 31) (X2(K), Y2(K), K=1, J)
7 IF (M , EQ, 1) NN1=NE1C &IF (M, EQ, 2 ) NN2=NE2
8 IF (LTIL(1), EQ, 3 HSAS) GOTO 102
GOTO111
102 IF (LTITL(7).GT.7) GOTO101
103 IF (LTITL(7).EQ.7.AND.LTITL(3).EQ.12.AND.LTITL(5).GT.19) GOTO101
104 IF (LTITL(2).EQ.1HN) C=-C
105 CONTINUE
106 U=26 I=2.NEND
107 X2(I)=(RA*X2(I))**B & Y2(I)=(1000*.Y2(I)*C)-D
108 IF (MR.EQ.0) X1(I)=X2(I) $IF (MR.EQ.1) Y1(I)=Y2(I)
109 CONTINUE
110 X2(I)={RA*A2(I) +B SY2(I)=(1000.*Y2(I)*C) -D
111 l r (MR.EQ.1) XI(I)=X2(I) BIF (MR.EQ.1) f i (I ) =Y2(I)
112 CONTINUE
113 WRITE (*,53) SCALL GLTNUM(A) S IF ( A ( 1 ) .EQ. 0 . ) GOTO 100
114 53 FORMAT (*=REA=START*)
115 IF (LTITL(1).EQ.3.KS4S) GOTO33 6GOT0300
116 IF (LTITL(7).GT.7) GOTO300
117 D$=35 I=1,N10
118 AMP(I)=X1(I) &AZM(I)=Y1(I) &X1(I)=X2(I) &Y1(I)=Y2(I)
119 CONTINUE
120 $X2(I) =AMP(I) &Y2(I)=AZM(I)
121 CONTINUE
122 WRITE(*,53) SCALL GLTNUM(A) S IF ( A ( 1 ) .EQ. 0 . ) GOTO 100
123 53 FORMAT (*=REA=START*)
124 IF (XI(I).LT.X2(2)) GOTO3
125 IF (X2(I).GT.X1(I)) TF minority=x2(2)+((X2(I)-X1(I))/NTOtal)
126 Y1(I)=Y1(I) $X1(I)=X2(I) $N1=NN1 $N2=NN2-1
127 CONTINUE
128 WRITE(*,53) SCALL GLTNUM(A) S IF ( A ( 1 ) .EQ. 0 . ) GOTO 100
129 53 FORMAT (*=REA=START*)
130 IF (X1(I).LT.X2(N2)) GOTO0
131 I={X2(N2)+K*X1(N1)}$FINAL=x1(N1) -((X1(N1)-X1(I))/NTOtal)
132 Y2(N1)=Y2(N2) $X2(N2)=X1(N1) $M2=N2+1 $M1=N1 $GOT07
133 CONTINUE
134 WRITE(*,53) SCALL GLTNUM(A) S IF ( A ( 1 ) .EQ. 0 . ) GOTO 100
135 53 FORMAT (*=REA=START*)
136 WRITE(*,53) SCALL GLTNUM(A) S IF ( A ( 1 ) .EQ. 0 . ) GOTO 100
137 53 FORMAT (*=REA=START*)
138 WRITE(*,53) SCALL GLTNUM(A) S IF ( A ( 1 ) .EQ. 0 . ) GOTO 100
139 53 FORMAT (*=REA=START*)
140 CALL AGRAPH (Y1,X1,13,31,B1,32,33,30
141 CALL AGRAPH (Y2,X2,37,38)
DJ 11 J=1,M1
126 IF (DELTX1(J).LT.0 .AND. DELTX1(JK) .GE. 0.) IX1UP=JK
127 IF (DELTX1(J).LT.0 .AND. DELTX1(JK) .GE. 0.) IX1DN=J
128 CONTINUE
129 DJ 12 J=1,M2
130 IF (DELTX2(J).LT.0 .AND. DELTX2(JK) .GE. 0.) IX2UP=JK
131 IF (DELTX2(J).LT.0 .AND. DELTX2(JK) .GE. 0.) IX2DN=J
132 CONTINUE
133 ALP(I)=(XI(IX1UP)-XI(IX1DN))/(XI(IX1UP)-XI(IX1DN))*T(I)
134 1 -X1(IX1DN)))+Y1(IX1DN)
135 AZM(I)=((Y2(IX2UP)-Y2(IX2DN))/(Y2(IX2UP)-Y2(IX2DN)))*(T(I)
136 1 -Y2(IX2DN)))+Y2(IX2DN)
137 CONTINUE
138 CALL AMINMX(AMP,NTOTAL,B1,B2)
139 CALL AMINMX(AZM,NTOTAL,B3,B4)
140 WRITE(7,13) B1,B2,B3,B4,TINITL,TFINAL
141 13 FORMAT(*MIN/MAX VALUES OF NS DATA = * ,E10.3,5X,31.3,/,&
142 *MIN/MAX VALUES OF EW DATA = * ,E10.3,5X,E10.3,/,&
143 *MIN/MAX VALUES OF TIME = * ,E10.3,5X,E10.3)
144 KTERM=10HNS COMPOH KTER2=10HNT
145 CALL AGRAPH(AMP,T,81,62,NTOTAL,KTER1,KTER2)
146 WRITE(7,55) CALL GETNUM(A) IF (A(1) .EQ. 0.) GOTO100
147 KTERM=10NEW COMPOH
148 CALL AGRAPH(AZM,T,83,B4,NTOTAL,KTER1,KTER2)
149 WRITE(7,55) CALL GETNUM(A) IF (A(1) .EQ. 0.) GOTO100
150 DJ 14 I=1,NTOTAL
151 ZI=AMP(I) $Z2=AZM(I)
152 AMP(I)=SQRT((Z1**2)+(Z2**2))
153 IF (Z2 .EQ. 0.) Z2=1.E-20
154 AZM(I)=(4*TAN(Z1/Z2))/180.P1
155 IF (Z1 .LT. 0.) AZM(I)=AZM(I)+180.
156 IF (AZM(I) .LT. 0.) AZM(I)=AZM(I)+360.
157 IF (AZM(I) .GT. 360.) AZM(I)=AZM(I)-360.
158 CONTINUE
159 CALL AMINMX(AMP,NTOTAL,B1,B2)
160 CALL AMINMX(AZM,NTOTAL,B3,B4)
161 WRITE(7,15) B1,B2,B3,B4,TINITL,TFINAL
162 15 FORMAT(*MIN/MAX VALUES OF AMPLITUDE = * ,E10.3,5X,E10.3,/,&
163 *MIN/MAX VALUES OF AZIMUTH = * ,E10.3,5X,E10.3,/,&
164 *MIN/MAX VALUES OF TIME = * ,E10.3,5X,E10.3)
165 KTERM=10HAMPLITUDE KTER2=10HNT
166 CALL AGRAPH(AMP,T,81,62,NTOTAL,KTER1,KTER2)
167 WRITE(7,55) CALL GETNUM(A) IF (A(1) .EQ. 0.) GOTO100
168 KTERM=10HAZIMUTH
169 CALL AGRAPH(AZM,T,83,B4,NTOTAL,KTER1,KTER2)
170 WRITE(7,55) CALL GETNUM(A) IF (A(1) .EQ. 0.) GOTO100
171 CONTINUE
172 WRITE(7,16) BREAD(7,17) CHECK $IF(CHECK .EQ. 1HY) GOTO18
173 22 CONTINUE
174 WRITE(7,16) BREAD(7,17) CHECK $IF(CHECK .EQ. 1HY) GOTO18

3-B.41
FORMAT(*SET INITIAL AND FINAL TIMES FOR SHARPNESS PLOT?*,/, 175 1 *YES (Y) OR NO (N)*)
176 FJRMAT(A1)
177 KLM1=1 $KLM2=MTOTAL $GOTO19
178 WRITE(7,123) $CALL GETNUM(A) $TON=A(1) $TUP=A(2)
179 123 FJRMAT(*INTER INITIAL AND FINAL TIMES*)
180 IF (TON.LT.TINITL) TON=TINITL  IF (TUP.GT.TFINAL) TUP=TFINAL
181 IF (TON.GT.TFINAL.OR.TUP.LT.TINITL)WRITE(7,21)
182 IF (TON.GT.TFINAL.OR.TUP.LT.TINITL)GOTO22
183 21 FJRMAT(*INITIAL AND/OR FINAL TIME ERROR, TRY AGAIN*)
184 DO 23 I=1,MTOTAL
185 XI(I)=T(I)-TDN $X2(I)=T(I)-TUP
186 CONTINUE
187 23 KLM1=1 $KLM2=MTOTAL
188 DO 24 I=1,MTOTAL
189 J=I+1 IF (X1(I).LE.0..AND.X1(J).GT.0.) KLM1=I
190 IF (X2(I).LE.0..AND.X2(J).GT.0.) KLM2=I
191 CONTINUE
192 24 CALL FJRMAT(*INITIAL AND/OR FINAL TIME ERROR, TRY AGAIN*)
193 25 FJRMAT(*AVERAGE SHARPNESS IS ZERO*,/, 200 1 *ENTER VALUE FOR USE IN SHARPNESS PLOT*)
201 U) 26 I=1,MTOTAL
202 AZM(I)=((AMP(I+1)-AMP(I))/(T(I+1)-T(I)))/BETA
203 CONTINUE
204 CALL AMINAX(AZM,MTOTAL,B1,B2) $B3=T(1) $B4=T(MTOTAL)
205 WRITE(7,27) B3,B4
206 27 FJRMAT(*MIN/MAX VALUES OF SHARPNESS = *,E10.3,5X,E10.3,/, 207 1 *MIN/MAX VALUES OF TIME = *,E10.3,5X,E10.3)
208 KTER1=10HSHARPNESS $KTER2=10HQUANTITY
209 CALL AGRAPH(AZM,T,B1,B2,MTOTAL,KTER1,KTER2)
210 WRITE(7,55) $CALL GETNUM(A) $IF(A(1).EQ.0.)GOTO100
211 WRITE(7,36) $READ(7,17) CHECK $IF(CHECK.EQ.1HY)GOTO22
212 30 FJRMAT(*RE-COMPUTE SHARPNESS? YES(Y) OR NO (N)*)
213 GOTO100
214 110 WRITE(7,900) $READ(7,17) CHECK $IF(CHECK.EQ.1HY)REWIND 5
215 900 FJRMAT(*END OF DATA, RE-START?*)
216 IF(CHECK.EQ.1HY)GOTO100
217 STOP
218 END
219 SUBROUTINE AGRAPH(R,T,A1,A2,NRECPH,K1,K2)
220 1=14-1 IF (I.GT.14)RETURN S D=L(I) S K=H
221 IF (U.JE.1) K=2 $ IF (O.GE.27.A.6.IE.36).X=1
222 IF (U.LT.-7) K=3 $ K=K+3 $ GOTO(1,2,3,5,1,4,3,4)K
223 1=N+1.I=L(U+U-27) $ S=+ $ GOTO 5
224 2 M=1 $ S=+ $ GOTO 5
225 3 P=1 $ S=+ $ GOTO 5
226 4 IF(P.NE.0)F=10.**(I-P-1) $ R(J)=N/F*M $ GOTO 6
227 5 FORMAT(8UR1)
228 END
229 SUBROUTINE AGRAPH(R,T,A1,A2,NRECPH,K1,K2)
DIMENSION R(50), T(50), A(20)

KX(1)=10H

YLO=A1

WRITE(7,3) $READ(7,4) CH $IF(CH.EQ.1H)OR.CH.EQ.1H)GOTO5

WRITE(7,6) SCALL GETNUM(A) $XLT=A(1) $XRT=A(2)

WRITE(7,7) $READ(7,4) CH $IF(CH.EQ.1H)OR.CH.EQ.1H)GOTO8

WRITE(7,9) SCALL GETNUM(A) $YLO=A(1) $YUP=A(2)

WRITE(7,10) KY(1), KY(2)

WRITE(7,11) IJVAR

IF (IJVAR.EQ.1H, OR.IJVAR.EQ.1H) CALL PLOTS(R, T, 1, NRECPT)

WRITE(7,12) $CALL GETNUM(A) $IRS=A(1) $IF(IRS.EQ.1H)GOTO13

RETURN $ENC

SUBROUTINE AMINMX(R, NRECPT, S, A)

DIMENSION K(S)

AMOPT=((K(NRECPT)-R(1))/2)+R(1)

A = B = AMOPT

IF (R(I).GT.A) A=R(I)

IF (R(I).LT.B) B=R(I)

CONTINUE

RETURN $ENC
C. PROGRAM SHARPS
INTRODUCTION

A model for slip-related tilt events has been discussed in McHugh (1976b). Briefly, the model assumes a rectangular, vertically oriented, dislocation loop expanding quasi-statically in a homogeneous elastic medium with a spatially and temporally variable displacement distribution across the slipping region (Model II). This model demonstrates that a slip zone very close to the station will produce a more rapid change in tilt amplitude than a distant slip zone. Model II allows the source-station distance to be estimated from the onset sharpness (i.e., the time rate of change of the tilt amplitude). The program input consists of the slip zone geometry, and the output is a graph of onset sharpness versus source-station distance.

Access and Use

The program requires approximately 70K of core and is intended for use on the LBL 6600B or C computer and the Tektronix (4010-1) terminal. To access and operate the program, enter an \texttt{LOAD, SHARPS, MCHUGH} followed by \texttt{RUN}. The program links automatically to the appropriate plotting routines.

Input

The input, source-station configuration, and program options are identical to those described for Model II (McHugh, 1976b) and will not be repeated here. Program SHARPS computes the gradient of the tilt amplitude change as a function of source-station distance. Consequently, in addition to the source configuration, the X1 position of the station (X1), the initial
X2 position (X2IN), and the increment in the X2 position (DELTAX) must be entered (Figure 3-C1). These three parameters are entered after the slip zone coordinates when the computer writes:

Enter X1, X2IN, and DELTAX

**Program Operation**

The program computes the quasi-static tilt amplitude as a function of time at a station in position(X1, X2) as the slip zone expands from its initial to final positions. The sharpness quantity, \( [S] \), is computed by numerically differentiating the tilt amplitude and normalizing by the event duration and residual offset. The maximum sharpness at the onset of the event (the onset sharpness, \( \hat{\Theta} \)) is computed for the station position, X2. The X2 coordinate of the station is normalized by the final length of the dip-slip zone (unless the length of the dip-slip zone is zero, in which case the length of the strike-slip zone is used - Figure 3-C1). The program then increments X2 (using DELTAX) and computes the onset sharpness produced by the slip zone at the new station position.

By definition, the sharpness quantity is:

\[
[S] = \frac{d\Theta}{dt} \left/ \left[ (\Theta_f - \Theta_i) / (t_f - t_i) \right] \right.
\]

where \( \Theta \) is the tilt amplitude, \( t \) is the time (determined by the position of the zone, as discussed in McHugh, 1976a, b), and \( i \) and \( f \) refer to the initial and final quantities. The derivative is normalized by the residual offset \( (\Theta_f - \Theta_i) \) because the tilt amplitude is proportional to the slip, which in general cannot be determined from the records of a single station.
The duration of the event is also used to normalize the derivative because
the correspondence between time as a model parameter and time on the station's
record cannot be precisely determined.

The onset sharpness (\(0\)) is the maximum sharpness of the event within the
first few time units (defined by \(N_1 = (.075 \times \text{NRECPT}) + 1\) in line 73, and \(\text{NRECPT}\)
(line 190)) to avoid the possibility of a global maximum, not coincident
with the onset, contaminating the results. The onset sharpness is determined
for 20 station positions (i.e. \(X_1\) constant, \(X_2 = X_2\text{IN} + (\text{DELTAX} \times K), K = 1\n\) to 20, line 194 in the program listing) and plotted as a function of \(D/L\)
(D is the perpendicular source-station distance - the absolute value of \(X_2\), \(L\) is
the length (in the \(X_1\) direction) of the dip-slip or strike-slip zone -
Figure 3-C1).

Output

After the computations of \(\hat{0}\) versus \(D/L\) are completed the program writes:

\[
\begin{align*}
\text{Min/Max values of sharpness} &= \text{(numerical values)} \\
\text{Min/Max values of (D/L)} &= \text{(numerical values)}
\end{align*}
\]

These statements are followed by requests for scaling information pertaining to
the graph of \(\hat{0}\) versus \(D/L\). The scales are set in the same fashion as in
programs discussed elsewhere (McHugh, 1976a) and will not be described here.
After the plot of \(\hat{0}\) versus \(D/L\) has been displayed, the graph can be re-scaled
and displayed (option 1), or the computer will move to the next section of the
program (option 2). If option 2 is selected, the computer will write:

\[
0 = \text{Re-start, 1 = Specify new DELTAX and continue.}
\]

Entering a zero causes the program to be re-started, and 1 causes the computer
to write:

Enter new \(\text{DELTAX}\)
The new value of DELTAX must be entered; the computer will respond:

0 = Re-start with all new values
1 = Re-start with previous values and new DELTAX

Entering a zero causes the program to be re-started (i.e., new input values must be specified), a 1 causes the program to be re-started with the new DELTAX and the previous slip zone geometry.

Results and Discussion

As an example of how this technique and program may be used to interpret a tilt event, consider the 27 October 1974 LIB event (Figure 3-C2) with onset sharpness equal to 9.2 (using program ONSTSP - page 3-B.22). The observed tilt component amplitudes and the sharpness, $S$, computed from the observed tilt (using ONSTSP) as functions of time are shown in Figure 3-C2a. If it is assumed that the observed tilts are produced by an expanding dip-slip zone (which is known to be capable of producing a step-like tilt event), the source-station configuration may be estimated from the tilt amplitude versus time waveshape; and the onset sharpness may be used as a constraint on the source-station distance.

The assumed source-station configuration shown in Figure 3-C1 will produce a waveshape and deflection similar to the event observed at LIB, but in general the displacement and source-station distance (D) will not be known. The amplitude of the offset is affected by the amount of displacement across the slip zone as well as D. However, the source-station distance may be estimated using the onset sharpness, which allows the displacement to be determined directly from the event amplitude. Figure 3-C2c is a plot of onset sharpness ($\hat{o}$) versus D/L computed using program SHARPS for the model in Figure 3-C1. An onset sharpness of 9.2 (determined for the observation at LIB on 27 October 1974 using ONSTSP) implies that D/L = .85
(page 3-C.9) for the configuration in Figure 3-C1. If \( L = 100 \text{m} \), then the X2 coordinate of the station is 85 m. The observed deflection at LIB is 0.6 \( \mu \text{rad} \) to the southwest, consequently the displacement must be 0.36 mm (determined by using the source-station configuration in Figure 3-C1 as input to program SLPPRP and adjusting U3IN and U3FN until the theoretical residual tilt offset equals the observed residual tilt offset).

Program SLPPRP was used to generate the tilt component amplitudes and sharpness versus time plots in Figure 3-C2b (with the time scale adjusted so that the theoretical event duration was similar to the observed duration). Although it was assumed that the source of the LIB event was a bilaterally propagating dip-slip zone (because this type of source will produce a step-like tilt waveform), 100 m in length, the source-station distance and amount of displacement (85 m and 0.36 mm respectively) were estimated directly from the observations.

Comparing Figure 3-C2b to 3-C2a, it is seen that the model in Figure 3-C1 reproduces: 1) the observed sense of deflection (i.e. southwest), 2) the general, step-like, appearance of the waveform, 3) the amplitude of the deflection (about 0.6 \( \mu \text{rad} \)), 4) the correct onset sharpness (about 9.0), and 5) the basic features of the sharpness, \([S]\), versus time curve. Although the theoretical solutions are not in complete agreement with the observations, the basic features of the data can be interpreted with the model and techniques presented.

NOTE: The observed tilt component amplitudes versus time profiles (Figure 3-C2a) were processed using program ONSTSP; the sharpness versus time (Figure 3-C2a) was computed by ONSTSP. The theoretical tilt component amplitude (Figure 3-C2b) were generated by program SLPPRP (McHugh, 1976b), the theoretical tilt sharpness (Figure 3-C2b) by a modification of SLPPRP. The onset
sharpness versus D/L (Figure 3-C2c) was determined using program SHARPS. The theoretical curves (Figures 3-C2b,c) were generated for the model in Figure 3-C1.
LIB 27 OCTOBER 1974 EVENT

a) OBSERVED

b) THEORETICAL

c) Figure 3-c2
EXAMPLES OF SHARPS OPERATION
LOAD COMPLETE, ENTERING ^EDIT
OK - ^EDIT
^RUN!
1=ZONE EXPANDS, 2=ZONE CONTRACTS
1
1/2=SLIP INCREMENTED EXPONENTIALLY/LINEARLY
STRIKE-SLIP/DIP-SLIP
1 1!
0=INCREMENT CORNERS SEPARATELY
1/2=INCREMENT ALL CORNERS EXPONENTIALLY/LINEARLY
STRIKE-SLIP/DIP-SLIP
1 1!
'U1>0' = LEFT-LATERAL STRIKE-SLIP
'U3>0' = 'X2>0' SIDE DOWN
U1IN, U1FN, U3IN, U3FN
0 0 1 1!
'TRIGGER' OPTION DESIRED?
N!
D1X1IN, D1X3IN, D2X3IN, D3X1IN, D1X1FN, D1X3FN, D2X3FN, D3X1FN
.05 .1 .05 .1 0 .1 0!
ENTER X1, X2IN, AND DELTAX
.05 0000000 01!
MIN-MAX VALUES OF SHARPNESS = 7.421E+03 1.022E+03
MIN-MAX VALUES OF (D/L) = 1.070E-03 1.998E+00
WRITE PLOT TITLE, 88 CHARACTERS
SHARPS-BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT!
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX X VALUES
0 2!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX Y VALUES
0 2500!
1 = NEW PLOT, 2 = RETURN
SET HORIZONTAL SCALE? Y OR N ( = BLANK ) Y!
MIN/MAX X VALUES
.25 .5!
SET VERTICAL SCALE? Y OR N ( = BLANK ) Y!
MIN/MAX Y VALUES
0 160!
SKIP PLOT OF ONSET SHARPNESS
SHARPS/BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT

1 = NEW PLOT, 2 = RETURN
SET HORIZONTAL SCALE? Y OR NK=BLANK
MIN/MAX X VALUES
.5 1
SET VERTICAL SCALE? Y OR NK=BLANK
MIN/MAX Y VALUES
0 10
SKIP PLOT OF ONSET SHARPNESS

ONSET SHARPNESS

X2/(FAULT LENGTH)
SHARPS/BILATERAL PROPAGATION/27 OCT. 1974 LIB EVENT

\[ \frac{X_2}{(\text{FAULT LENGTH})} \]
1 = NEW PLOT, 2 = RETURN
0=RE-START, 1=SPECIFY NEW DELTAX AND CONTINUE
OK - ~EDIT
DELETE (LGO, OUTPUT, SHARPS)
SHARPS.
CXT.
LIBCOPY (GRAPHIC, TXLGO/RR, TXLGO)
LIBCOPY (JOGRAT, NPLGO/FP, NPLGO)
DELETE (LGO, OUTPUT, SHARPS)
RUN 76 (S)
LINK (F = LGO, F = TXLGO, F = NPLGO, B = SHARPS)
SHARPS.
FIN.

PROGRAM SHARPS (TAPf.TTY = 201, FILM = TAPf.TTY, TAPE7 = TAPf.TTY)
COMMON / TVPCOL / TVPUL (8)
COMMON / TVTUNE / ITUNE (30)
COMMON / JPLCT / XL T, XRT, YLC, YUP, MAJX, MAJY, KX (2), KY (2),
1L TITL (8), LL, LTF, LNLGX, LNLGY, NCLX, NCLY, LT IT L (8)
DIMENSION IFET (4)
DIMENSION TX (100), TY (100), T (100)
DIMENSION C (40), A (30), IT (4), IC F A R (16)
DIMENSION TAMP (100), SHARPS (20), COL (20)
CALL FET (ELTAP7, IFET, 8)
IFET (2) = IFET (2) .OR. 0000 0100 0100 0000 0000 0000
IFET (8) = IFET (8) .OR. 0000 0000 0000 0000 0000
CALL FET (ELTAP7, IFET, -8)

IFTEST = 1

CC 101 J = 1, 18
0 (J) = 0. $C(J+18) = 0. $C(J) = 0.
CONTINUE
WRITE (*)
1 FORMAT (*1 = ZONE EXPANDS, 2 = ZONE CONTRACTS*)
CALL GETNUM (A) $IFLAG = A (1) $WRITE (7, 2)
2 FORMAT (*1/2 = SLIP INCREASED EXponentially/LINEARLY*,/,
1 *STF/1 = SLIP/DIF- SLIP*);
CALL GETNUM (A) $KFlagS = A (1) $KFlag = A (2) $WRITE (7, 3)
3 FORMAT (*0 = INCREASEMENT CORNERS SEPARATELY*,/,
1 *1/2 = INCREMENT ALL CORNERS EXponentially/LINEARLY*,/,
1 *STF/1 = SLIP/DIF-SLIP*)
CALL GETNUM (A) $LFLAG = A (1) $MFLAG = A (2)

C (110) I = 1, 10
IT(I) = 5
CONTINUE
DO 4 I = 1, 16
4 ICRNP (I) = 1
IF (LFLAG .EQ. 0 .OR. MFLAG .EQ. 0) CALL SLPCHR (LFLAG, MFLAG, IC F A R)
IF (LFLAG .EQ. 2) GOTO 5 $GCT06
5 DO 7 I = 9, 16
7 ICRNP (I) = 2
6 IF (MFLAG .EQ. 2) GOTO 8 $GCT09
8 DO 10 I = 1, 8
10 ICRNR (I) = 2
9 WRITE (7, 11) $CALL GETNUM (A) $C (33) = A (1) $C (34) = A (2)
11 FORMAT (*U1 > 0* = LEFT-Lateral Strike-SLIP*,/,
1 *U3 > 0* = 'X2 > 0' SIDE DOWN*,/,
1 *U1IN, U1FN, U3IN, U3FN*)
C (35) = A (3) $C (36) = A (4) $WRITE (7, 12)
12 FORMAT (**TRIGGER* OPTION DESIRED?*)
READ (7, 13) TRIG $IF (TRIG .EQ. 1) CALL TRIGGR (IT)
IF(C(33).EQ.0..AND.C(34).EQ.0.)*GOTO14
WRITE(7,15) $CALL GETNUM(A) $C(17)=C(19)=A(1)
FORMAT(*C1X3IN,C1X3IN,C2X3IN,C3X1IN,C1X1FN,C1X3FN,C2X3FN,C3X1FN*)
C(18)=C(24)=A(2) $C(20)=C(22)=A(3) $C(21)=C(23)=A(4)
C(29)=C(31)=A(8)
IF(C(35).EQ.0..AND.C(36).EQ.0.)*GOTO16
WRITE(7,17) $CALL GETNUM(A) $C(1)=C(3)=A(1) $C(2)=C(8)=A(2)
FORMAT(*C1X3IN,C2X3IN,C3X1IN,C1X1FN,C1X3FN,C2X3FN,D3X1IN*)
WRITE(7,18) $CALL GETNUM(A) $X1=A(1) $X2IN=A(2) $DELTA X=A(3)
FORMAT(*ENTER X1, X2IN, AND DELTAX*)
X3=0. $NRECP=100 $N=(.075*NRECP) $X2=X2IN
N1=N+1 $N2=NRECP-(.075*NRECP)-1
N3=N2+1 $PI=3.1415926 $RN1=N1 $RN2=N2 $TIM=99999
CONTINUE
DO 21 J=1,8
D(J)=C(J) $D(J+8)=C(J+16)
CONTINUE
D(17)=C(33) $D(18)=C(35)
DO 19 I=1,N
CALL CMPLTL(D,X1,X2,X3,T1,T2)
T(I)=I $TX(I)=T2 $TY(I)=T1
CONTINUE
DO 24 J=1,8
CONTINUE
D(17)=C(34) $D(18)=C(36)
DO 23 I=N3,NRECP
CALL CMPLTL(D,X1,X2,X3,T1,T2)
T(I)=I $TX(I)=T2 $TY(I)=T1
CONTINUE
IFGREC=0
DO 25 I=N1,N2
T(I)=I $RI=I
IF(TRIG.EQ.1.HY)GOTO26
CONTINUE
DO 27 J=1,8
J8=J+8 $A1=C(J) $B=C(J8) $E=C(J8+8) $F=C(J+24)
CALL XPNSHL(A1,B,RN1,RN2,RI,Y1)
CALL XPNSHL(E,F,RN1,RN2,RI,Y2)
IF(ICRNR(J).EQ.2)CALL ALINAR(A1,B,RN1,RN2,RI,Y1)
IF(ICRNR(J).EQ.2)CALL ALINAR(E,F,RN1,RN2,RI,Y2)
CONTINUE
IF(ICRNR(J).EQ.2)CALL ALINAR(A1,B,RN1,RN2,RI,Y1)
DO 102 J=1,8 $C(J8)=Y2
CONTINUE
CALL XPNSHL(C(33),C(34),RN1,RN2,RI,Y1)
CALL XPNSHL(C(35),C(36),RN1,RN2,RI,Y2)
IF(KFLAGS.NE.1)CALL ALINAR(C(33),C(34),RN1,RN2,RI,Y1)
IF(KFLAGS.NE.1)CALL ALINAR(C(35),C(36),RN1,RN2,RI,Y2)
D(17)=Y1 $C(18)=Y2 $GOTO28
CONTINUE
CALL XPNSHL(C(33),C(34),RN1,RN2,RI,Y1)
IF(IT(2).EQ.1.AND.KFLAGS.EQ.1)CALL XPNSHL(C(33),C(34),RN1,1)
1 RN2,RI,Y)
111 IF(IT(2).EQ.1.AND.KFLAGS.NE.1)CALL ALINAR(C(33),C(34),RN1,1)
1 RN2,RI,Y)
113 IF(IT(2).EQ.0.AND.KFLAGS.EQ.1)CALL XPNSHL(C(35),C(36),RN1,1)
1 RN2,RI,Y)
115 IF(IT(2).EQ.0.AND.KFLAGS.NE.1)CALL ALINAR(C(35),C(36),RN1,1)
1 RN2,RI,Y)
117 IF(IT(2).EQ.1.AND.KFLAGS.EQ.1)CALL XPNSHL(C(33),C(34),RN1,1)
1 RN2,RI,Y)
119 IF(IT(2).EQ.1.AND.KFLAGS.NE.1)CALL ALINAR(C(33),C(34),RN1,1)
1 RN2,RI,Y)
121 IF(IT(2).EQ.0.AND.KFLAGS.EQ.1)CALL XPNSHL(C(35),C(36),RN1,1)
1 RN2,RI,Y)
123 IF(IT(2).EQ.0.AND.KFLAGS.NE.1)CALL ALINAR(C(35),C(36),RN1,1)
1 RN2,RI,Y)
125 IF(IT(2).EQ.1.AND.KFLAGS.EQ.1)CALL XPNSHL(C(33),C(34),RN1,1)
1 RN2,RI,Y)
127 IF(IT(2).EQ.1.AND.KFLAGS.NE.1)CALL ALINAR(C(33),C(34),RN1,1)
1 RN2,RI,Y)
129 IF(IT(2).EQ.0.AND.KFLAGS.EQ.1)CALL XPNSHL(C(35),C(36),RN1,1)
1 RN2,RI,Y)
131 IF(IT(2).EQ.0.AND.KFLAGS.NE.1)CALL ALINAR(C(35),C(36),RN1,1)
1 RN2,RI,Y)
117 IF(IT(2) .EQ. 0) D(18) = Y
118 DO 32 J = 1, 6
119 J8 = J8 + 8 $A1 = C(J) $B = C(J8) $E = C(J8 + 8) $F = C(J + 24)
120 CALL XPNSHL(A1, B, RN1, RN2, RI, Y1)
121 CALL XPNSHL(E, F, RN1, RN2, RI, Y2)
122 IF(ICRNR(J) .EQ. 2) CALL ALINAR(A1, B, RN1, RN2, RI, Y1)
123 IF(ICRNR(J8) .EQ. 2) CALL ALINAR(E, F, RN1, RN2, RI, Y2)
124 DO (J) = Y1 ID (J8) = Y2
125 CONTINUE
126 MIT3 = IT(3) $MIT4 = IT(4) $IF(IT(1) .EQ. 1) GOTO 29
127 IF(IT(MIT3) .LT. C(MIT4)) AND IT(2) . EQ. 0) C(17) = C(33)
128 IF(IT(MIT3) .LT. C(MIT4)) AND IT(2) . EQ. 0) D(18) = C(35)
129 IF(IT(MIT3) .LT. C(MIT4)) AND IT(2) . EQ. 1) GOTO 33
130 IF(IT(MIT3) .GE. C(MIT4)) GOTO 35
131 DO 34 J = 9, 16
132 (J) = C(J8)
133 GOTO 28
134 IF(IT(MIT3) .GT. C(MIT4)) AND IT(2) . EQ. 0) D(17) = C(33)
135 IF(IT(MIT3) .GT. C(MIT4)) AND IT(2) . EQ. 0) D(18) = C(35)
136 IF(IT(MIT3) .GT. C(MIT4)) AND IT(2) . EQ. 1) GOTO 33
137 IF(IT(MIT3) .LE. C(MIT4)) GOTO 35
138 DO 34 J = 5, 16
139 (J) = C(J8)
140 GOTO 28
141 DO 36 J = 1, 8
142 (J) = C(J)
143 GOTO 28
144 IFGREC = IFGREC + 1
145 IF(IFGREC .EQ. 1) ITIME = I
146 IF(IFGREC .EQ. 1) RITIME = ITIME
147 IF(IT(2) .EQ. 0) AND KFLAGS .EQ. 1) CALL XPNSHL(C(33), C(34), RTIME,
148 1 RN2, RI, Y)
149 IF(IT(2) .EQ. 0) AND KFLAGS .EQ. 1) CALL ALINAR(C(33), C(34), RTIME,
150 1 RN2, RI, Y)
151 IF(IT(2) .EQ. 1) AND KFLAGS .EQ. 1) CALL XPNSHL(C(35), C(36), RTIME,
152 1 RN2, RI, Y)
153 IF(IT(2) .EQ. 1) AND KFLAGS .EQ. 1) CALL ALINAR(C(35), C(36), RTIME,
154 1 RN2, RI, Y)
155 IF(IT(2) .EQ. 1) GOTO 37
156 IF(IT(2) .EQ. 0) GOTO 38
157 DO 38 J = 9, 16
158 A1 = C(J8) $B = C(J + 18) $CALL XPNSHL(A1, B, RITIME, RN2, RI, Y)
159 IF(ICRNR(J) .EQ. 2) CALL ALINAR(A1, B, RITIME, RN2, RI, Y)
160 CONTINUE
161 DO 38 J = 1, 8
162 E = C(J) $F = C(J8) $CALL XPNSHL(E, F, RITIME, RN2, RI, Y)
163 IF(ICRNR(J) .EQ. 2) CALL ALINAR(E, F, RITIME, RN2, RI, Y)
164 CONTINUE
165 (J) = Y
166 CALL CMPTLT(D, X1, X2, X3, T1, T2)
167 TX(I) = T2 $TY(I) = T1
168 CONTINUE
169 IF(IFLAG .EQ. 2) GOTO 46
170 AR = TX(I) $B = TY(I)
171 DO 47 I = 1, NRECEPT
172 TX(I) = TX(I) - AR
173 CONTINUE
174 TY(I) = TY(I) - 8
175 GOTO 48

3-C.20
DO 50 I=1,NRECPT
TAMP(I) = SQRT(TX(I)**2)+(TY(I)**2)
50 CONTINUE
NEND=NRECPT-1
BETA=TAMP(NRECPT)-TAMP(1) $ IF(BETA.EQ.0.) BETA=TAMP(NRECPT)
1 -TAMP(1)/2.+TAMP(1)
AIOTA=T(NRECPT)-T(1) $ IF(AIOTA.EQ.0.) AIOTA=1.E-20
ZETA=BETA/AIOTA $ IF(ZETA.EQ.0.) ZETA=1.E-20
DO 51 I=1,NEND
ALPHA=T(I+1)-T(I) $ IF(ALPHA.EQ.0.) ALPHA=1.E-20
TAMP(I)=((TAMP(I+1)-TAMP(I))/ALPHA)/ZETA
51 CONTINUE
NNEND=N1+1*NRECPT $ CALL AMINMX(TAMP,NNEND,AMIN,AMAX)
SHARP(KTEST)=AMAX $ ALNGL = C(13)-C(9) $ ALNG2 = C(29)-C(17)
RLNGTH=ALNG1 $ IF(ALNGTH.EQ.0.) RLENGTH=ALNGTH
DOL(KTEST)=ABS(X2/RLNGTH)
X2=X2IN*(DELTAX*KTEST) $ IF(KTEST.LE.20) GOTO 75
KTEST=20 $ CALL AMINMX(SHARP,KTEST,A1,A2)
CALL AMINMX(DOL,KTEST,B1,B2) $ WRITE(7,57)A1,A2,B1,B2
57 FORMAT(*MIN/MAX VALUES OF SHARPNESS = * ,E12.3 ,5X,E10.3 ,/)
1 $ IF(ALG.EQ.0.) ALG=1.E-20
54 FORMAT(8A1)
MAJX=5 $ MAJY=10 $ KTER1=10H $ INFSET SHA $ KTER2=10HRFNESS
CALL AGRAPH(SHARP,DOL,A1,A2,KTEST,KTER1,KTER2)
WRITE(7,1234) $ CALL GETNUM(A) $ IF(A(1).EQ.1.) WRITE(7,1235)
1234 FORMAT(*0=RE-START, 1=SPECIFY NEW CELTAX AND CONTINUE*)
1235 FORMAT(*ENTER NEW CELTAX*)
KTEST=1 $ IF(A(1).EQ.1.) GOTO 57 $ IF(A(1).EQ.1.) GOTO 1236
GOTO 73
1236 CALL GETNUM(A) $ DELTAX=A(1) $ KTEST=1 $ WRITE(7,1237)
X2=X2IN $ CALL GETNUM(A) $ IF(A(1).EQ.0.) GOTO 73 $ GOTO 75
1237 FORMAT(*0=RE-START WITH ALL NEW VALUES*,/)
1 $ IF(KTER.EQ.0.) KTER=1
1238 FORMAT(*1=RE-START WITH PREVIOUS VALUES AND NEW CELTAX*)
STOP $ END
177 49 TY(I)=TY(NRECPT)-TY(I)
178 48 DO 50 I=1,NRECPT
179 TAMP(I)=SQRT((TX(I)**2)+(TY(I)**2))
180 50 CONTINUE
181 NEND=NRECPT-1
182 BETA=TAMP(NRECPT)-TAMP(1) $ IF(BETA.EQ.0.) BETA=TAMP(NRECPT)
1 -TAMP(1)/2.+TAMP(1)
184 AIOTA=T(NRECPT)-T(1) $ IF(AIOTA.EQ.0.) AIOTA=1.E-20
185 ZETA=BETA/AIOTA $ IF(ZETA.EQ.0.) ZETA=1.E-20
186 DO 51 I=1,NEND
187 ALPHA=T(I+1)-T(I) $ IF(ALPHA.EQ.0.) ALPHA=1.E-20
188 TAMP(I)=((TAMP(I+1)-TAMP(I))/ALPHA)/ZETA
189 51 CONTINUE
190 NNEND=N1+1*NRECPT $ CALL AMINMX(TAMP,NNEND,AMIN,AMAX)
191 SHARP(KTEST)=AMAX $ ALNGL = C(13)-C(9) $ ALNG2 = C(29)-C(17)
192 RLENGTH=ALNG1 $ IF(ALNGTH.EQ.0.) RLENGTH=ALNGTH
193 DOL(KTEST)=ABS(X2/RLNGTH)
194 X2=X2IN*(DELTAX*KTEST) $ IF(KTEST.LE.20) GOTO 75
195 KTEST=20 $ CALL AMINMX(SHARP,KTEST,A1,A2)
196 CALL AMINMX(DOL,KTEST,B1,B2) $ WRITE(7,57)A1,A2,B1,B2
197 57 FORMAT(*MIN/MAX VALUES OF SHARPNESS = * ,E12.3 ,5X,E10.3 ,/)
198 1 $ IF(ALG.EQ.0.) ALG=1.E-20
199 LU=7 $ LNLYX=1 $ LNLYY=1 $ NCX=2 $ NCY=2
200 DO 200 KM=1,3
201 200 LTITL2(KM)=10H
202 WRITE(7,53) $ READ(7,54) (LTITL(I),I=1,8)
203 53 FORMAT(*WRITE PLOT TITLE, 8Q CHARACTERS*)
204 54 FORMAT(8A1)
205 MAJX=5 $ MAJY=10 $ KTER1=10H $ INFSET SHA $ KTER2=10HRFNESS
206 CALL AGRAPH(SHARP,DOL,A1,A2,KTEST,KTER1,KTER2)
207 WRITE(7,1234) $ CALL GETNUM(A) $ IF(A(1).EQ.1.) WRITE(7,1235)
208 1234 FORMAT(*0=RE-START, 1=SPECIFY NEW CELTAX AND CONTINUE*)
209 1235 FORMAT(*ENTER NEW CELTAX*)
210 KTEST=1 $ IF(A(1).EQ.1.) GOTO 57 $ IF(A(1).EQ.1.) GOTO 1236
211 GOTO 73
212 1236 CALL GETNUM(A) $ DELTAX=A(1) $ KTEST=1 $ WRITE(7,1237)
213 X2=X2IN $ CALL GETNUM(A) $ IF(A(1).EQ.0.) GOTO 73 $ GOTO 75
214 1237 FORMAT(*0=RE-START WITH ALL NEW VALUES*,/)
215 1 $ IF(KTER.EQ.0.) KTER=1
216 STOP $ END
217 SUBROUTINE XFNSHL(F,Q,R1,S1,T,Y)
218 $ S=(T-R1)*6. $ R=S1-R1 $ IF(R.EQ.0.) R=1.E-20 $ ALPHA=-S/R
219 Y=((Q-P)*(1.-EXP(ALPHA)))+P
220 RETURN $ END
221 SUBROUTINE ALNAR(P,Q,R,S,T,Y)
222 $ Y=((Q-P)*(T-F)/(S-P)) + P
223 RETURN $ END
224 SUBROUTINE SLPCRN(LFLAG,MFLAG,ICFNR)
225 DIMENSION A(20),ICRNR(16)
226 WRITE(7,1)
227 1 FORMAT(*1=VARIABLE INCREASED EXPONENTIALY*,/)
228 1 $2=VARIABLE INCREASED LINEARLY*)
229 IF(MFLAG.NE.0) GOTO 2
230 WRITE(7,3) $ CALL GETNUM(A) $ ICRNR(1)=ICRNR(3)=A(1)
231 3 FORMAT(*D1X1, D1X3, D2X3, D3X1*)
232 ICRNR(2)=ICRNR(8)=A(2) $ ICRNR(4)=ICRNR(6)=A(3)
SUBROUTINE TRIGGR(IT)
DIMENSION A(20), T(*)
WRITE(7,1) $CALL GETNUM(A) $IT(1)=A(1) $WRITE(7,2)
1 FORMAT(*Q(I) = *(II)), C(I2) = D(ii) (Ii*)
WRITE(7,3) $IF (IT.EQ.1) THEN
2 FORMAT(*SET HORIZONTAL SCALE? Y OR N(=BLANK)*)
WRITE(7,4) $READ(7,^) CH $IF (CH .EQ. 'Y') GOTO 5
3 FORMAT(*SET VERTICAL SCALE? Y OR N(=ELANK]*)
WRITE(7,5) $YUP = YU +1. $IF (YLO.EQ.YU) YLO = YU -1.
4 FORMAT(*SKP PLOT OF *,2AlO)*
READ(7,^) JVAR
5 IF(JVAR.EQ.1) THEN CALL PLOTS(R, T, 1, NRECP1)
WRITE(7,6) $IR$=A(I) $IF (IR$ .EQ. 1) GOTO 13
6 FORMAT(*1 = NEW PLCT, 2 = RETURN*)
RETURN $ENC
SUBROUTINE AINMX(R, NRECP1, B, A)
DIMENSION R(50)
AMINPT=((R(NRECP1) -R(1))/2.) + R(1)
A = B =AMINPT
DO 1 I=1, NRECP1
1 A(I) =R(I)
RETURN $ENC
SUBROUTINE CMPILT(D, X1, X2, X3, T1, T2)
DIMENSION C(20)
A1=A2=A3=A4=B1=B2=B3=B4=0.
D1=D2=D3=D4=0.
U1=0(17) $US=0(18)
IF(U1.EQ.0.) GO TO 1
2 CALL TILT(D(17), X1, X2, X3, D(11), D(12), A1, B1)
3 CALL TILT(D(17), X1, X2, X3, D(9), D(10), A2, B2)
4 CALL TILT(D(17), X1, X2, X3, D(13), D(14), A3, B3)
5 CALL TILT(D(17), X1, X2, X3, D(15), D(16), A4, B4)
IF(U3*FG(*))GO TO 2
CALL DPSFTL(D(I)),X1,X2,X3,O(3),O(4),CA1,DE1)
CALL DPSFTL(D(I)),X1,X2,X3,O(1),O(2),CA2,DE2)
CALL CPSFTL(D(I)),X1,X2,X3,O(5),O(6),CA3,DE3)
CALL DPSFTL(D(I)),X1,X2,X3,O(7),O(8),CA4,DE4)

T1=A1-A2-A3+A4+DA1-DA2-CA3+DA4
T2=B1-B2-B3+B4+DB1-DB2-CB3+CB4

RETURN $ENC
SUBROUTINE TILT(U1,X1,X2,X3,P1,P3,T1,T2)
R=SORT((X1-P1)**2+X2**2+(X3-P3)**2)
RP=R+P3
T1=(U1/12.5664)*(X2*(X1-P1)*((R*RP-(R+*P3)*(2*R+P3))}
T2=(U1/12.5664)*(X2**2*(R*RP-(P2+*P3)*(2*R+P3))/(R**3*RP**2)

RETURN $ENC
SUBROUTINE DPSFTL(U3,X1,X2,X3,P1,P3,DT1,DT2)
R=SORT((X1-P1)**2+X2**2+(X3-P3)**2)
DT1=(U3/6.28318)*((X2*P3/P)*((1./(P**2))-(1/((P1-P1)
DT2=(U3/6.28318)*((X1-F1)*P3)/(X2**2*(P3**2))(*(P3**2)
1/(P*3))+(X2**2*(P3**2))/(P*3*(P**2))
RETURN $ENC
SUBROUTINE GENUM(R)
DIMENSION F(1),L(30)
READ(7,9)L I=J=0
6 J=J+1 N=P=S=0 M=F=1
5 I=I+1 IF(I.GT.10)GOTO 10 RETURN ; C=L(I) ; K=4
IF(D.EQ.38)K=2 IF(D.GE.27.A.GE.36)K=1
9 FORMAT(8CF,1)
1 IF(D,EQ.,47)K=3 $ K=K+S $ GOT0 (1,2,3,5,1,4,7,1)
2 N=N*10+D-27 $ S=4 $ GOT0 5
3 M=M+1 $ S=4 $ GOT0 5
4 IF(P**1,EQ.0)F=10.**((P-1)) $ P(J)=N/F*M $ GOT0 6
9 FORMAT(8CF,1)
ENC
D. PROGRAM DISPLAY
Introduction

It has often been necessary to display digitized tiltmeter and creep-meter data, particularly when enlarged copies of short period events made from the raw records have been digitized. The method used to display the data must be sufficiently flexible that scale changes can be made easily and that portions of the data set can be enlarged or compressed. Program DSPLAY was developed to meet these requirements.

Access and Use

The program is intended for use on the LBL 6600B or C computer and the Tektronix 4010-1 terminal and required 50K of core. The program requires a data set labelled 'EVENTS' on library MCHUGH; if the data is stored elsewhere lines 6 and 10 in the program must be altered. DSPLAY is accessed using the command .LOAD, DSPLAY, MCHUGH; and the .LOAD command may be followed by a RUN.

Input

The data is assumed to be in the form:

Header Card
Data Block
.
.
N
.
Header Card
Data Block
EOR

There is no limit to the number of events, N, that may be read, but each data block must contain no more than 1000 data points (i.e. 1000 (x,y) pairs).
The Header Card is assumed to contain the following variables
with the format indicated:

\[ \text{LTITL}(1), \text{LTITL}(2), \ldots, \text{LTITL}(7), \text{RA}, \text{B}, \text{C} \]

(eg. SASN01/03/74 .163 12.0 .192)

\[ \text{A3, A1, A2, A1, A2, A1, A2, 8x, 3F10.3} \]

\text{LTITL}(1) \text{ is the station code (3 characters); LTITL}(2) \text{ is the component—north or east (1 character) in the case of tilt data; LTITL}(3), LTITL(5),
and LTITL(7) are the month, day, and year respectively (2 characters each); \text{LTITL}(4) \text{ and LTITL}(6) \text{ are ignored in the program; RA, B, C are scale
factors used in the program and will be explained below. If it is
desired to structure the Header Card differently, lines 25 and 26 in the
program must be altered.}

Each line in the data block is assumed to have a format of \((6(2F6.3))\); for example:

\[ x_1, y_1, x_2, y_2, \ldots, x_6, y_6 \]

\[-15370+04204-15330+04200 \ldots -14990+04190 \]

If a different format is desired, lines 39 to 42 may be altered. The
data block is terminated when either \(x(I)\) or \(y(I)\) is equal to 999.999.
The upper limit of the array index, \(I\), need not be specified, the computer
will automatically determine the number of data points it reads.

Unlike the input to program ONSTSP, the input to DSPLAY need not be
arranged such that the north-south component of the tilt data is read
prior to the east-west component data. Each component is treated independ­
ently of all others. Consequently, creepmeter data or tiltmeter data with
only one component present may be displayed.
Program Operation

The data is assumed to be in x, y form (e.g., north-south tilt amplitude versus time). In addition to displaying this data as a plot of 'y' versus 'x', the computer will rescale the data. If the input is digitized data, the units of x and y are typically hundredths or thousandths of an inch. The scale factors RA, B, and C are used to convert the data to microradians, millimeters, hours, or whatever other units are desired. The conversion is assumed to be of the form:

\[
x(I) = RA \times x(I) + B \\
y(I) = C \times y(I) \times 1000.
\]

(lines 54 through 59)

If B = 0. on the Header Card, the computer sets B = -RA*x(I). If Sage South tiltmeter data prior to 19 December 1974 (when +x = south, +y = east) is submitted, the computer automatically converts the coordinate system to +x = east, +y = north (lines 29 to 35 and lines 50 to 55). The minimum and maximum amplitude (y) and initial and final x values are determined in lines 60 to 67.

Output

The contents of the Header Card are written, followed by: TO SKIP, PUT 1 IN COL 1. Entering a 1 causes the computer to skip that data block. Any other number entered will cause the data to be read. After reading and re-scaling the data, the computer writes:

- min/max x values (numerical values)
- min/max y values (numerical values)

The computer then requests plotting information:

Set horizontal scale ? y or N (= blank)

If an N (no) or blank (space) is entered, the computer requests information for the vertical scale (described below). If a Y (yes) is entered,
the computer responds:

min/max x values

The endpoints of the x axis must be entered. Then the computer writes:

Set vertical scale? Y or N (= blank)

If an N or blank is entered, the endpoints of the vertical axis are the minimum and maximum y values determined from the input. If a Y is entered, the endpoints of the vertical axis must be entered. The plot is displayed after the scaling information is provided. The plots are titled using the information on the Header Card. The axes are labelled with the information in lines 68 through 71.

After the plot is displayed, entering a blank (space) causes the computer to return to the main program. The computer will write:

New plot = 1

Entering a 1 allows new scaling information to be provided and a new graph to be plotted. Any other number causes a new data set to be read.

Examples of the program operation are provided on pages 3-D.6 through 3-D.40. The program listing is on pages 3-D.41 through 3-D.44.
EXAMPLE OF DISPLAY OPERATION
LOAD, DISPLAY, MCHUGH!
LOAD COMPLETE, ENTERING ~EDIT
OK - ~EDIT
~RUN!
LIBN18-27-74 .147 21.000 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 2.022E+01 2.345E+01
MIN/MAX Y VALUES 8.391E+02 1.328E+03
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES
20 25!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES
0 2500
! NEW PLOT=1
2!
LIBE10-27-74 .147 21.000 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 2.026E+01 2.256E+01
MIN/MAX Y VALUES -1.600E+03 -1.135E+03
SET HORIZONTAL SCALE? Y OR N=BLANK) Y!
MIN/MAX X VALUES 20 25!
SET VERTICAL SCALE? Y OR N=BLANK) Y!
MIN/MAX Y VALUES -2500 0

3-D.9
NEW PLOT=1
SASE88-26-74 .152 8.
080 .109
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 7.450E+08
1.016E+01
MIN/MAX Y VALUES -5.596E+02
3.512E+02
SET HORIZONTAL SCALE? Y OR MX=BLANK)

Y!
MIN/MAX X VALUES
6 11!
SET VERTICAL SCALE? Y OR MX=ELAIXD)
Y!
MIN/MAX Y VALUES
-1000 500

TIME (HOURS)
NEW PLOT=1
2
SASE07-05-73  .152
000  .566
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES  1.107E+01
  1.664E+01
MIN/MAX Y VALUES  -5.548E+03
  4.498E+03
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
  10 28!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX Y VALUES
  -16000  8

TIME (HOURS)
NEW PLQT-1
21
SASE01-22-74
759 .113
TO SKIP, PUT 1 IN COL. 1
21
MIN/MAX X VALUES 1.797E+01
2.157E+01
MIN/MAX Y VALUES 9.356E+02
1.380E+03
SET HORIZONTAL SCALE? Y OR NK=BLANK) Y!
MIN/MAX X VALUES
21
16 22!
SET VERTICAL SCALE? Y OR NK=BLANK) Y!
MIN/MAX Y VALUES
0 2500

TIME (HOURS)
0 2500
NEW PLOT=1
SASN01-22-74 .152 19.
750 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.805E+01
2.162E+01
MIN/MAX Y VALUES 7.492E+01
3.426E+02
SET HORIZONTAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX X VALUES 16 22!
SET VERTICAL SCALE? Y OR N(=BLANK)
Y!
MIN/MAX Y VALUES -1000 1500

TIME (HOURS)
BUYE03-06-74

NEW PLOT=1

TO SKIP, PUT 1 IN COL. 1

MIN/MAX X VALUES 1.335E+01
 1.696E+01
MIN/MAX Y VALUES -1.396E+02
 8.046E+01

SET HORIZONTAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX X VALUES
 13
18!
SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES

TIME (HOURS)
BUY E 03 - 06 - 74

NEW PLOT=1
LIBN06-04-74 000 123
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 4.922E+00
8.537E+00
MIN/MAX Y VALUES -7.468E+02
6.737E+02
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y! MIN/MAX X VALUES 4 9!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y! MIN/MAX Y VALUES
-1000 0

COMPONENT AMPLITUDE

TIME (HOURS)
LIB   E06 -  1 -  04 -  74
NEW PLOT=1
2!
LINE01 06 75,
000
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES  9.741E+00
1.327E+01
MIN/MAX Y VALUES  4.372E+02
5.253E+02
SET HORIZONTAL SCALE? Y OR N (BLANK)
Y!
MIN/MAX X VALUES  9.14!
SET VERTICAL SCALE? Y OR N (BLANK)
Y!
MIN/MAX Y VALUES  6 1000

TIME (HOURS)
NEW PLOT=1
21
SAS NOV-12-74 1.147
000 100
TO SKIP, PUT 1 IN COL. 1
21
MIN/MAX X VALUES 1.682E+01
2.042E+01
MIN/MAX Y VALUES -1.092E+00
1.436E+02
SET HORIZONTAL SCALE? Y OR NK=BLACK
Y!
MIN/MAX X VALUES

SET VERTICAL SCALE? Y OR NK=BLANK
Y!
MIN/MAX Y VALUES
-500 1000


TIME (HOURS)
NEW PLOT=1

TO SKIP, PUT 1 IN COL. 1

MIN/MAX X VALUES 6.73E+00
1.82E+01
MIN/MAX Y VALUES 5.78E+03
6.62E+03

SET HORIZONTAL SCALE? Y OR N=BLANK)
Y!
MIN/MAX X VALUES
5.91
SET VERTICAL SCALE? Y OR N=BLANK)
Y!
MIN/MAX Y VALUES
4E00 6E00

TIME (HOURS)

COMPONENT AMPLITUDE

-600.
-700.
-800.
-900.
-1000.
-1200.
-1300.
-1400.
-1500.
-1600.

17. 18. 19. 20. 21. 22.
NEW PLOT=1
MELN10-15-74
169
189
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 1.446E+01
1.794E+01
MIN/MAX Y VALUES 1.895E+03
2.443E+03
SET HORIZONTAL SCALE? Y OR X=BLANK)

\\
Y!
MIN/MAX X VALUES
13 18!
SET VERTICAL SCALE? Y OR X=BLANK)
Y!
MIN/MAX Y VALUES
500 4000

TIME (HOURS)
NEW PLOT=1

TO SKIP, PUT 1 IN COL. 1

MIN/MAX X VALUES 1.046E+01
1.833E+01
MIN/MAX Y VALUES 4.823E+03
5.391E+03

SET HORIZONTAL SCALE? Y OR (X=BLANK)

MIN/MAX X VALUES
13 18!

SET VERTICAL SCALE? Y OR (X=BLANK)

MIN/MAX Y VALUES
30 0000 7000
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<td>MELE09/29/74</td>
<td>.164</td>
<td>-0.</td>
<td>.639</td>
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MELE11/05/74
TO SKIP, PUT 1 IN COL. 1

MELE11/29/74
TO SKIP, PUT 1 IN COL. 1

MELE11/29/74
TO SKIP, PUT 1 IN COL. 1

MELE07/11/74
TO SKIP, PUT 1 IN COL. 1

MELE07/11/74
TO SKIP, PUT 1 IN COL. 1

MELE08/03/74
TO SKIP, PUT 1 IN COL. 1

MELE08/03/74
TO SKIP, PUT 1 IN COL. 1

SAS 09-07-74
TO SKIP, PUT 1 IN COL. 1

MELE03-25-75
TO SKIP, PUT 1 IN COL. 1

MIN-MAX X VALUES 9.733E+09 1.331E+01
MIN-MAX Y VALUES 2.222E+03 4.471E+03
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN-MAX X VALUES 9.14!
MIN-MAX Y VALUES 2100 4500
SET VERTICAL SCALE? Y OR NK=BLANK)
TO SKIP, PUT 1 IN COL. 1

MIN/MAX X VALUES 3.885E+03
3.428E+03

MIN/MAX Y VALUES -3.428E+03
3.885E+03

SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES

SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX Y VALUES
-7500 7500
NEW PLOT=1
MELE84-85-75 .147 5.
609 .113
TO SKIP, PUT 1 IN COL. 1
2!
MIN/MAX X VALUES 4.731E+00
1.020E+01
MIN/MAX Y VALUES -3.916E+02
3.421E+02
SET HORIZONTAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX X VALUES
5>
3.5 11.5!
SET VERTICAL SCALE? Y OR NK=BLANK)
Y!
MIN/MAX Y VALUES
-1000 1000

TIME (HOURS)

COMPONENT
AMPLITUDE

7500.
6000.
4500.
3000.
1500.
0.
-1500.
-3000.
-4500.
-6000.
-7500.
PROGRAM LISTING
DELETE (LGO, LGLOB, VECTOR)
VECTOR.
EXIT.
LIBCOPY (GRAPHIC, TXLGO/RR, TXLGO)
LIBCOPY (JORAT, NPLGO/RR, NPLGO)
LIBCOPY (MCHUGH, TLEV/RR, TLEV)
RUN76(S)
LINK (F=LGO, F=TXLGO, F=NPLGO, B=VECTOR)
VECTOR (TLEV)
FIN.

PROGRAM VECTOR (TAPE 5, TAPE 7 = TAPE 5, TAPE 7 = TAPE 7)
COMMON /TVPOOL/, TVPUL(8)
COMMON /TVTUNE/, ITUNE(30)
COMMON /JPLCT/ XLT, XRT, YLC, YUC, MAJX, MAJY, KX(2), KY(2), LITTL(8), LU,
1 DIMENSION IFET(8)
2 DIMENSION STA(10), NYEAR(1000), NDAY(1000)
3 DIMENSION NMTH(1000), TIME(1000), XIN(1000), XFN(1000), YIN(1000)
4 DIMENSION YFN(1000), A(30), AMP(1000), AZM(1000)
5 CALL FET (5LTAPE7, IFET, 8)
6 IFET(2) = IFET(2). OR. 0000 0000 0000 0000 0000
7 CALL FET (5LTAPE7, IFET, -8)
8 TVPUL(5) = -.32 TVPUL(6) = TVPUL(7) = TVPUL(8) = 1.
9 DO 10 I = 1, 1000
10 NMTH(I) = NDAY(I) = TIME(I) = XIN(I) = XFN(I) = YIN(I) = 0.
11 YFN(I) = NYEAR(I) = 0.
12 CONTINUE
13 PI = 3.1415926 $READ (5, 1) N
14 FORMAT (I2)
15 DO 2 I = 1, N
16 READ (5, 3) STA(IJ) $K = 1 $SUM1 = SUM2 = 0.
17 FORMAT (A10)
18 READ (5, 4) NMTH(K), NYEAR(K), NMTH(K), TIME(K), XIN(K), XFN(K), YIN(K),
19 YFN(K), FACTOR
20 FORMAT (I2, 1X, I2, 1X, A4, 1X, F7.2, 1X, F7.3)
21 IF (XIN(K) .EQ. 999.99 .AND. YIN(K) .EQ. 999.99) GOTO 12
22 IF (YFN(K) .EQ. 999.99) GOTO 20
23 A = XIN(K) $B = YIN(K) $C = XFN(K) $D = YFN(K) $LMCNTH = NMTH(K)
24 IF (NMTH(K) .EQ. 1) $NMTH(K) = 3HJAN
25 IF (NMTH(K) .EQ. 2) $NMTH(K) = 3HJAY
26 IF (NMTH(K) .EQ. 3) $NMTH(K) = 3HAUG
27 IF (NMTH(K) .EQ. 4) $NMTH(K) = 3HAUJ
28 IF (NMTH(K) .EQ. 5) $NMTH(K) = 3HSEF
29 IF (NMTH(K) .EQ. 6) $NMTH(K) = 3HSEP
30 IF (NMTH(K) .EQ. 7) $NMTH(K) = 3HSEF
31 IF (NMTH(K) .EQ. 8) $NMTH(K) = 3HSEP
32 IF (NMTH(K) .EQ. 9) $NMTH(K) = 3HSEF
33 IF (NMTH(K) .EQ. 10) $NMTH(K) = 3HSEF
34 IF (NMTH(K) .EQ. 11) $NMTH(K) = 3HSEF
35 IF (NMTH(K) .EQ. 12) $NMTH(K) = 3HSEF
36 IF (STA(IJ) .EQ. 10) $HSAGE SOUTH . AND. NYEAR(K) .LE. 74 GOTO 20
37 GOTO 12
38 20 IF (NYEAR(K) .LT. 74) GOTO 11
39 IF (LMONTH .LT. 12) GOTO 11
40 IF (LMONTH .EQ. 12 .AND. NDAY(K) .LE. 19) GOTO 11
20 Y(I)=1000.*Y(I)
60 YMID=Y(I)
61 YLC=YMID $ YUP=YMIC
62 DO 160 I=1,NEND
63 IF(Y(I) .LT. YLO) YLO=Y(I)
64 160 IF(Y(I) .GT. YLP) YUP=Y(I)
65 LU=7 $ NLG=1 $ NLGY=1 $ NCLX=2 $ NCLY=2
66 MAJX=5 $ MAJY=10 $ TLTL2(1)=1 $ XLT=X(1) $ XRT=X(NEND)
67 PR1=XL $ PR2=XR $ PR3=YLO $ PR4=YUP
68 85 XX(1)=10HTIME
69 XX(2)=10H(HOURS)
70 KY(1)=10HCOMPONENT
71 KY(2)=10HAMPLITUDE
72 WRITE(7,88) PR 1,PR2,PR3,PR4
73 88 FORMAT(*MIN/MAX X VALUES*,5X,E10.3,5X,E10.3,/,5X,E10.3,5X,E10.3)
74 WRITE(7,70)
75 70 FORMAT(*SET HORIZONTAL SCALE? Y OR N (=BLANK)*)
76 READ(7,66)CHARAC $ IF(CHARAC .EQ. 1H . CR. CHARAC .EQ. 1H)GOT071
77 66 FORMAT(A1)
78 WRITE(7,72)
79 72 FORMAT(*MIN/MAX X VALUES*)
80 CALL GETNUM(A) $ XL=A(1) $ XRT=A(2)
81 71 WRITE(7,73)
82 73 FORMAT(*SET VERTICAL SCALE? Y OR N (=BLANK)*)
83 READ(7,66)CHARAC $ IF(CHARAC .EQ. 1H . CR. CHARAC .EQ. 1H)GOTC74
84 WRITE(7,75)
85 75 FORMAT(*MIN/MAX Y VALUES*)
86 CALL GETNUM(A) $ YLC=A(1) $ YUP=A(2)
87 74 IF(YLC.NE.YUP)GOT087
88 74 IF(YLC.EQ.YUP)RG=YLO
89 IF(YLC.EQ.YUP)YLC=YUP-1.
90 IF(YUP.EQ.RG)YUP=RG+1.
91 87 CALL PLOTS(Y,X,1,NEND)
92 WRITE(7,89)
93 89 FORMAT(*END OF DATA*)
94 CALL GETNUM(A) $ C1=A(1)
95 IF(C1.NE.1)GOTO90
96 11 WRITE(I,12)
97 12 FORMAT(*ENC OF DATA*/)
98 13 FORMAT(I1)
99 IF(LFLAG .EQ. 1) REWIND 5
100 STOP
101 ENC
102 SUBROUTINE GETNUM(F)
103 DIMENSION F(80)
104 READ(7,9) L $ I=J=0
105 6 J=J+1 $ N=P=S=0 $ M=F=1
106 5 I=I+1 $ IF(I.GT.80)RETURN $ D=L(I) $ K=4
107 104 IF(D.EQ.38)K=2 $ IF(D.GE.27. A.0.LE.36)K=1
108 113 IF(D.EQ.47)K=3 $ K=K+S $ GOTO(1,2,3,5,1,4,3,4)K
109 114 1 N=N*10+D-2; $ S=4 $ GOTO 5
110 115 2 M=-1 $ S=4 $ GOTO 5
111 116 3 P=I $ S=4 $ GOTO 5
117  4  IF(P.\text{\textasciitilde}E.0) F=10.**((I-P-1)) $ R(J)=N/F*M $ GOTO 6
118  9  FORMAT(80R1)
119     ENC
REFERENCES

