Chapter 1. Introduction to HYPOELLIPSE

➢ *1.1 Program summary*

HYPOELLIPSE is a computer program for determining the hypocenters of local or near regional earthquakes and for each event the ellipsoid that encloses the 68 per cent confidence volume. The program was originally developed on the Lawrence Berkeley Laboratory CDC7600 computer and was subsequently modified to run on the U.S. Geological Survey (USGS) Honeywell MULTICS (Lahr, 1980), the Stanford Linear Accelerator Center IBM 168, the USGS DEC VAX11/785, the IBM PC, and most recently on the SUN SPARCstation. Travel times are determined from a horizontally-layered velocity-structure, from a linear increase of velocity with depth, from a linear increase of velocity over a half-space, or from a previously generated travel-time table. With the travel-time-table option, gradients are allowed in all layers, but there can be no velocity discontinuities. Arrival times for the first arrival of P waves and S waves, and S-minus-P interval times can be used in the solutions. Arrival times for refractions, such as Pn, even at distances where they do not arrive first, can also be used. Each arrival can be weighted according to the reading clarity, the epicentral distance to the station, and the deviation of its residual from the mean. The hypocenter is found using Geiger's method (Geiger, 1912) to minimize the root-mean-square (RMS) of the travel-time residuals. The magnitude of each event is calculated from the maximum amplitude and/or the signal duration. The program includes a station history database, so that magnitudes will always be computed with the correct response function and gain. First motions can be plotted on the printer using an equal-area, lower-hemisphere, focal projection. The azimuth and apparent velocity of a plane wave crossing the array from a distant source can also be determined.

If a copy of the HYPOELLIPSE program is desired, it can be obtained through the Internet (http://lahr.org/iaspei/northam/ak/s_ak/programs/hypoel/hypoel.html)

➢ *1.2 Changes from previous version*

This report documents the current version of HYPOELLIPSE which is operating on SUN SPARCstation computer systems at the University of Alaska Geophysical Institute (UAGI) in Fairbanks, Alaska, and at the USGS in Menlo Park, California. This version supersedes HYPOELLIPSE Version 2 (Lahr, 1989) and incorporates many changes, including:

January 1989

Changed the input keyword for velocity specification (see 2.2.2) from 'CRUSTAL' MODEL to 'VELOCITY' MODEL. 'CRUSTAL' MODEL will still work, however.

April 1989

Removed the DIST option from the INSTRUCTION record. Added the option of specifying the event type and processing state on the INSTRUCTION (see 2.2.6.3) and SUMMARY

(see 2.4.1) records. Changed the default, relative standard-errors for weight codes 1-3 from 3.0, 7.5, and 15.0 to 5.0, 10.0, and 20.0, respectively (see 2.2.3.13)

June 1989

Increased the delay-array dimensions to allow up to 10 delay models. Allow added delay models (6-10) to be read after the station list (see 2.2.5.5). Decreased the station arrays from 500 to 400 stations. Added three subroutines called by USEDLY to apply spatially varying station delays (see Chapter 7). Added the processing status and the event type to the summary and the instruction records (see 2.4.1 and 2.2.6.3**).**

August 1989

Modified the format of the station list to allow joint processing of historic and current data from the USGS and the UAGI. Two different telemetry delays are now allowed for a given station at one time and six independent polarity histories can be maintained.

May 1990

Added a simple linear increase with depth velocity-model option with a user-specified reference elevation. For networks in areas with great relief, such as on volcanoes, this allows earthquake travel times to be correctly calculated, even for stations that are at a lower elevation than the hypocenter.

March 1991

Revised the travel-time routines to allow the stations to be "embedded within the model," (see TEST(8) and TEST(9) in section 2.2.4). This was necessary for regions of shallow seismicity with large topographic variations, such as near volcanoes, to allow earthquakes to be located at elevations above some or all of the recording stations. The travel-time-table subroutines have been modified based on suggestions J.A. Snoke.

April 1991

Added option for scaling the normal equations (TEST(34)) and made the minimum damping value a variable (TEST(35)). See 2.2.4.

May 1992

Added computation of median amplitude-magnitude (MDXM) and median coda-magnitude (MDFM) to the printed summary line (see 2.3.6). Modified the station-list records to allow control over which stations are used in computing the average magnitude (see 2.2.5.3).

September 1992

Added the computed depth field to the end of the summary record. Original depth field in cols. 30-34 may be optionally set to 0.0 for negative depths (see TEST(9)).

June 1994

Three-letter station codes are now right justified within the program. Either upper or lower case letters are allowed. The order of the stations in the stations list file must still be alphabetical with the 3-letter codes prior to the 4-letter codes. For example, the following stations would be entered in this order:

ab1 abc abz zzz abcd bcde zzzz.

November 1994

Added TEST(51) (see 2.2.4) to set distance beyond which travel-time tables will be used. This allows for P- or S-arrivals at distances beyond the limit for the flat-earth approximation.

June 1996

Increase array dimensions to allow up to 25 velocity models.

November 1998

Made Y2K changes for HYPOELLIPSE following the plan that Fred Klein is using with HYPOINVERSE.

The summary records are the same, except every column is pushed to the right by two spaces to allow for the century. When an event is run that starts with a summary record:
1) if the summary record is in the new format, with / in column 83, then the century is set to the first two columns.
2) If the summary record is in the old format, with / in column 81, then the century is set to TEST(55) (see 2.2.4). TEST(55) is a new variable, which sets the default century.

If the event does not start with a summary record, which will be the case on the first run, then the century is determined by TEST(55). In every case, the output summary and archive files will include the century in columns 1-2 and a '/' in column 83.

The phase (arrival time) records are unchanged. The century is set by the summary record, if available and if in the new format, or by TEST(55).

The format of the time-dependent station records (see 2.2.5.3) has been changed. In the columns where the expiration date was set by yrmody hrmn, which were read by (i6, i4) the new format has cnyrmody hr, which is read by (i8, i2). No other columns on these records are modified.

Events spanning the end of a month or the end of a year. The phase records for a given event must all have the same year and month. If the arrivals do include times on the last day of the month (and/or year) and the first day of the next month, increasing the number of seconds beyond 59.99 accommodates this situation. A phase-record for an event near the end of 1999, for an arrival on January 1, 2000, at 0 hours, 0 minutes, and 13.11 seconds would look like this:

RED IPU0 991231235973.11

A set of events can also span the 1999 - 2000 time boundary, but not if events in both 1999 and 2000 have no summary records, as TEST(55) will have to be either 19 or 20.

For the transition from 1999 to 2000 one could:

Run all of the events up until the end of 1999 with TEST(55) (see 2.2.4) set to 19. Once all of the 1900's data has been run once, the summary record that precedes the phase records will be in the new format and have 19 in the first two columns.

When first-time processing of data for 2000 begins, change TEST(55) to 20.

The "begin station list" record used to have yrmody for the date of the first event in the run. This has been changed to cnyrmody (century-year-month-day).

The file y2ksta.f is the source for a simple filter program to converts old station list into the new format. The SUN executable is y2ksta. This program is a filter that reads standard input and writes to standard output. To run the program on stations.old to produce stations.new:

y2ksta <stations.old >stations.new

January 1999

Corrected the vp/vs calculations in subroutine line3 to prevent divide by zero errors should the computed vp/vs ratio equal 1.0.

➢ *1.3 Notes for programmers*

Some of the array dimensions are set via parameter statements in the file params.inc. These include:

NSN, the maximum number of stations in the station list.

NPA, the maximum number of phases per earthquake.

LMAX, the maximum number of velocity records allowed to define velocity models.

MMAX, the maximum number of velocity models.

The setting for these parameters for SUN and PC versions are:

	SUN	PC
NSN	1,501	70
NPA	1,024	140

LMAX	96	36
MMAX	25	10

The number of calibration records allowed in the UAGI magnitude subroutine (MX_REC in UAMAG.FOR) is reset from 1,000 for the SUN version to 100 for the PC version to save additional array-memory space.

A binary search of the station list is used in the function PHAIND. If the search does not work on your computer, then another version of PHAIND, which is commented out, can be used.

The subroutines PHAGT and NPUNCH use the back slash character (\), which must be doubled (\\) on UNIX systems.

The subroutines DUBL, ERSET, JDATE, OPENFL, OPFLS, and TIMIT use non-standard FORTRAN code that will work only on SUN systems and must be modified for use with a PC or VAX system. The alternate code is included in each subroutine, and is enclosed in 'C PC', 'C UNIX', or 'C VAX' comment statements. For UNIX systems, HYPOELLIPSE works with the program XPICK, which stops and starts HYPOELLIPSE by communicating through sockets. For this reason, the main program HYMAIN.FOR and subroutine INIT.FOR are replaced with the main program HYPOE.C and subroutines INITIAL.F, SETUP_SERVER.C, LISTEN_SERV.C, FDGETSTR.C, and CLEANUP.FOR. For UNIX systems, the subroutine GETBIN.F is used to read calibrations data in binary format for the UAGI stations.

The .EXE code provided for an IBM PC or compatible computer requires that an 8087 coprocessor be installed. With the current array dimensions, at least 575 Kbytes of free memory must be available for program execution.

The files used by HYPOELLIPSE are:

FILE UNIT NO.	READ	WRITE	CONTENTS	TYPICAL SUFFIX
8	X		Input control parameters and earthquake data (Program prompts for name of this file).	.DAT
4		X	SUMMARY record file optionally generated.	.SUM
6		X	Final summary showing warning messages and the average residual for each station.	.LOG
9		X	Printed output from execution.	.OUT

2	X	X	Station parameter scratch file.	.1ST
3	X	X	Station parameter scratch file.	.2ST
11		X	Archive-phase file optionally generated.	.ARC
12		X	Alternate input file used with the JUMP option (see 2.2.6.5).	
13		X	Final station corrections when automatic revision has been used (see 2.2.3.17).	.NST
14	X	X	Scratch file for SUMMARY and input records.	.3SC
15	X	X	Scratch file for archive records.	.4SC
16	X	X	Scratch file for temporary message storage.	.5SC
17	X		Definition of cylindrical delay-regions.	
21	X		Travel-time tables for velocity model 26.	.C26
22	X		Travel-time tables for velocity model 27.	.C27
23	X		Travel-time tables for velocity model 28.	.C28
24	X		UAGI calibration data file.	