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 percent confidence volume. The program was originally developed on the Lawrence Berkeley Laboratory CDC7600 computer and subsequently modified to run on the USGS Honeywell MULTICS, the Stanford Linear Accelerator Center IBM 168, the USGS DEC VAX11/785, the IBM PC, and most recently on the SUN. Traveltimes 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 traveltime 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, epicentral distance to the station, and the deviation of its residual from the mean. The hypocenter is found using Geiger's method to minimize the root mean square (RMS) of the traveltime 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 focal hemisphere 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, or send the author two blank, formatted 1.2 MB IBM floppy disks for the PC version. My email address is lahr@fm.gi.alaska.edu.

1.2 Changes from previous version

This report documents the current version of HYPOELLIPSE which is operating on the SUN UNIX-based computer systems in Fairbanks, Alaska, and Menlo Park, California, and supersedes the VAX version (Lahr, 1989). Many changes have been made since the previous version was published in 1989 (Lahr, 1989).

January 1989
Changed 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 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 station arrays from 500 to 400 stations. Added three subroutines called by USEDLY to apply spatially varying station delays (see Chapter 7). Added processing status and event type to the summary and 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 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 travel-time routines to allow 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. J.A. Snoke has made some modifications to the travel-time table subroutines and is working on a program to generate teleseismic travel-time tables.

April 1991
Added option for scaling the normal equations (TEST(34)) and made the minimum damping value a variable (TEST(35)).

May 1992
Add computation of median xmag and fmag and allow control within station list as to which stations to use in computing the average magnitude.

September 1992
Added computed depth field to end of 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 names 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:
abc abz zzz abcd bcde zzzz.

November 1994
Added test(51) to set distance beyond which travel time tables will be used. This allows for P- or S-arrivals at distances beyound the limit for the flat-earth approximation.

1.3 Notes for programmers

The maximum number of stations in the station list, NSN, and the maximum number of phases per earthquake, NPA, are set in PARAMETER statements in the include file params.inc. NSN and NPA are set to 1,501 and 1,024, respectively, for the SUN version and to 70 and 140 for the PC version of the program. The maximum number of velocity model records, lmax, is also set in params.inc. Currently lmax equals 96 for the SUN version and 36 for the PC. In the PC version, the number of calibration records allowed in the University of Alaska magnitude subroutine (MX REC in UAMAG) is reset from 1,000 to 100 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.

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

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. 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 University of Alaska 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 K bytes of free memory must be available for program execution.

The files used by HYPOELLIPSE are:

FILE 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 JUMP OPTION.	

FILE NO.	READ	WRITE	CONTENTS	TYPICAL SUFFIX
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		Traveltime tables for velocity model 11.	.C11
22	X		Traveltime tables for velocity model 12.	.C12
23	X		Traveltime tables for velocity model 13.	.C13
24	X		University of Alaska calibration data file.	