U.S. DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

ANALYST'S MANUAL FOR USGS SEISMIC HAZARD PROGRAMS ADAPTED TO THE MACINTOSH COMPUTER SYSTEM

by

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INTRODUCTION

The construction of a probabilistic ground-motion hazard map for a region follows a sequence of analyses beginning with the selection of an earthquake catalog and ending with the mapping of calculated probabilistic ground-motion values.

This manual is a step-by-step guide to the U.S. Geological Survey (USGS) programs that have been developed specifically for the purpose of those analyses. The programs, originally written in FORTRAN for a mainframe computer, have been used and developed over several generations of national probabilistic ground-motion maps for the United States. Various versions of the programs contained herein are maintained at the USGS. The versions selected for inclusion into this manual were chosen on the bases of their ease of operation and their compatibility with the Macintosh computer systems. The primary distinction between this system and that of the mainframe system is the difference in memory capacities between the mainframe and the “desk-top” Macintosh computer. This distinction means only that very large mapping projects need to be broken down into smaller pieces for the Macintosh. The Macintosh system can calculate, in a single run, about 1,600 data points consisting of six ground-motion values each throughout a region. For comparison, a probabilistic ground-motion hazard map of the United States consists of about 25,000 data points of six ground-motion values each.

The recommended minimum requirements for the Macintosh computer system hardware are at least 2MB of memory for data processing, a 68882 math co-processor, and at least a 40MB hard disk for data storage. Minimum requirements for software are, a FORTRAN shell, compiler is optional, a good word processor, a statistical software package; and one or two good graphics packages, one for illustrations and graphs, and the other for geographic mapping.

In the interactive “user windows” shown in this manual, the analyst’s responses to program queries are shown in boxes. Explanations are given in the text and are keyed to the appropriate items by letter designations. Within some illustrations, items of special interest may have additional notes added with leader lines to direct the analysts attention to the specific location or detail. In the flow chart diagrams shown in this manual the input and output files to the various programs will be shown as typical Macintosh icons.

Perhaps most important is that probabilistic ground-motion mapping cannot be performed by merely pushing the buttons of a computer. Once the basic system of the programs’ inputs and outputs is mastered, attention will focus naturally on the many scientific and technical decisions that need to be made to arrive at a final ground-motion map.

BRIEF SYSTEM DESCRIPTION

The system flow chart (figure 1) illustrates the primary steps involved in probabilistic ground-motion hazard mapping. At each of the six major steps of the system flow chart, a brief description of the step and the program or programs used within the step is given.

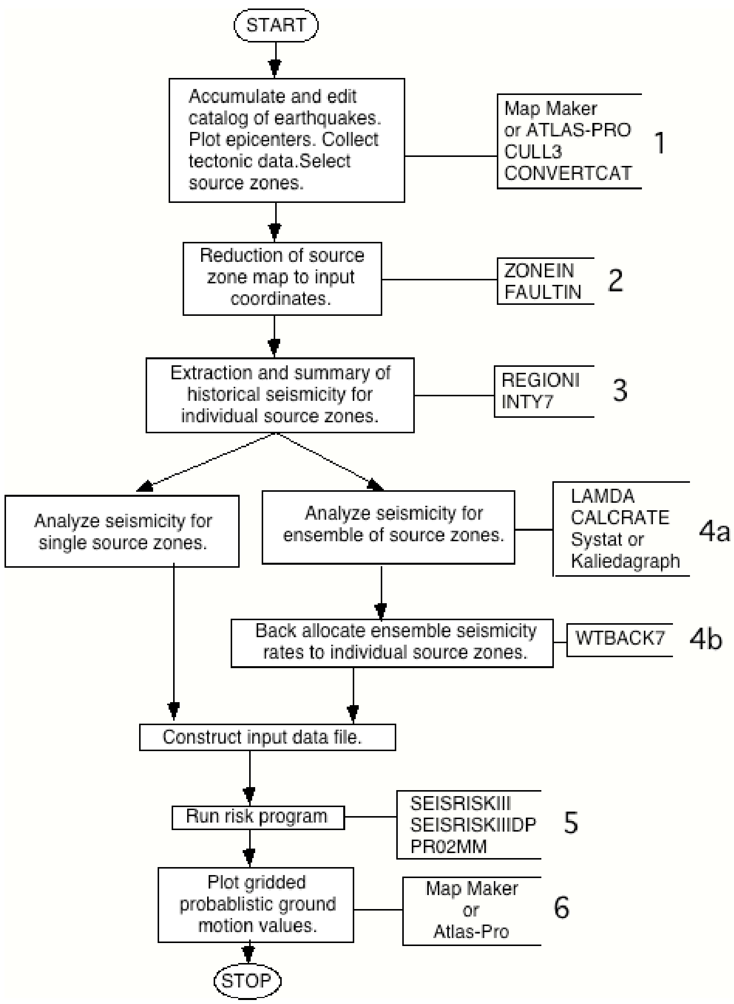


Figure-1 *A brief system flow chart describing the hazard analyses process including the names of the programs used at each of the 6 steps in the system.*

STEP 1

As indicated in figure 1 this phase of the system deals with earthquake data collection, and source zones design based on tectonic and geologic information. The following three programs are useful tools for analyzing and displaying seismic data.

CULL3: A USGS FORTRAN program for extracting data from earthquake catalogs or from any list of data.

CONVERTCAT. A USGS FORTRAN program that reads an earthquake catalog and produces the two files necessary for input to either MapMaker or Atlas-Pro. The program produces an indexed file of latitudes and longitudes, and an indexed file of data to be plotted at the corresponding latitude and longitude.

MapMaker, Atlas-Pro. (trademarks of Strategic Mapping, Inc.): Two commercial software packages for plotting geographic data. Atlas-Pro is an enhanced version of MapMaker and either one will suit the needs of the analyst for the geographic plotting. Plotting the epicentral data provides the analyst with useful information for designing source areas.

Step 2

The programs in this step provide the avenue by which the coordinates of the sources and faults the analyst has designed may be entered into a file which has the proper input format for the hazard program.

ZONEIN and **FAULTIN**: Two USGS FORTRAN programs for inputting coordinates for areal seismic source zones and coordinates for linear fault segments to build an input file in the proper format for the USGS risk programs SEISRISKIII or SESIRISKIIIDP.

Step 3

Two programs are used in this step, one to break down the seismicity of the study area into the individual source areas, and two to provide summary statistics for each source.

REGIONI: A USGS FORTRAN program which sorts the regional earthquake catalog into sub catalogs corresponding to seismic source zones (that have been previously defined by ZONEIN).

INTY7: A USGS FORTRAN program which converts catalog magnitudes to a uniform magnitude measure to be used in SEISRISKIII or SEISRISKIIIDP and creates decade tables summarizing in ten year intervals the earthquake history by magnitude category for each seismic source zone or any chosen combination of zones. The tables are useful in identifying aftershock sequences and provide a qualitative assessment of catalog completeness by magnitude categories.

Step 4a

In this step the seismicity is analyzed and recurrence rates are calculated either for an ensemble of sources or for individual sources. Two USGS programs and one of two commercial programs provide the tools necessary for this analysis.

LAMDA: A USGS FORTRAN program which creates decay-rate table of earthquake activity by ten year intervals from the present through the earliest decade of recorded earthquakes in the catalog. Output can be plotted with commercial statistical software. Quantitative estimates of raw annual rates of earthquake occurrence, and completeness times for magnitude categories can be determined from the plots.

CALCRATE: A USGS FORTRAN program that uses Weichert's (1980) method of estimating earthquake occurrence rates accounting for catalog completeness times. Input is derived from LAMDA and consists of the number of earthquakes observed over some estimated completeness time, and the value of that completeness time for each magnitude category chosen. The application can also use estimated raw annual occurrence rates with a completeness time of 1 year.

Systat, and Kaliedagraph (trademarks of Systat Inc., Synergy Software): Two commercial software packages to perform statistical analyses and graph plotting.

Step 4b

This step in the system is only necessary if the analyst has combined several sources to do the statistical analyses and compute recurrence rates. The one program here reallocates the computed rate of the ensemble of sources into the individual sources.

WTBACK7: The USGS FORTRAN program WTBACK7, provides 4 statistical procedures for allocating the overall rate into the constituent source zones of an ensemble of sources. This application operates on the decade table sums of the ensemble source zones and the computed rate from CALCRATE above.

NOTE: <u>To have sufficient earthquakes for meaningful statistical analyses, requires about 40 earthquakes.</u>

NOTE: <u>All source zones will have the same Richter b-value and estimated maximum magnitude, only a-values will differ among the zones.</u>

The program is interactive and the user must use his own judgment in choosing which of the results are appropriate to characterize the seismicity of the individual zones.

Step 5

At this point the input file containing the sources, their rates, and an attenuation table is compiled and the risk program is executed to compute ground motion values.

SEISRISKIII: This USGS FORTRAN program is the heart of the hazard mapping procedure and is described in detail by Bender and Perkins (1987). The program calculates the ground-motion hazard at points on a geographic grid using as input the results of the foregoing analyses.

SEISRISKIIIDP: This USGS FORTRAN program is the same as SEISRISKIII with the addition of an algorithm to calculate the ground-motion hazard resulting from dipping-plane seismic source zones. Such zones are useful and sometimes required to adequately model features as subduction zone interface earthquakes, Benioff zone seismicity, or shallow-dipping thrust faults. Input format for these types of source zones is slightly different than those of source areas and source faults.

Step 6

A post processing program is used to prepare the output ground motion data values from either of the risk programs for plotting, and the plotted values are contoured.

PRT02MM: This USGS FORTRAN program reads the binary output from the SEISRISKIII or SEISRISKIIIDP program (the N-A-M-E.002 file, see Bender and Perkins, 1987) and creates two ASCII files required for the MapMaker or Atlas-Pro application.

MapMaker, **ATLAS Pro** (trademarks of Strategic Mapping, Inc.): Two commercial plotting software packages used to create maps of gridded ground motion values from the two output files of PRT02mm for hand-contouring. Base maps and source zone coordinates may also be digitized using either of these programs and a compatible digitizing tablet.

HAZARD ASSESSMENT FOLDER

Below is a directory or an open Macintosh folder (figure 2) containing the USGS seismic hazard programs. Files in the folder are arranged in the general order of application in the hazard assessment procedure from left to right. The folder used for any hazard mapping project can become quite cluttered with many input and output files. It is recommended that a system of organization for these files be worked out before venturing too far within the process.

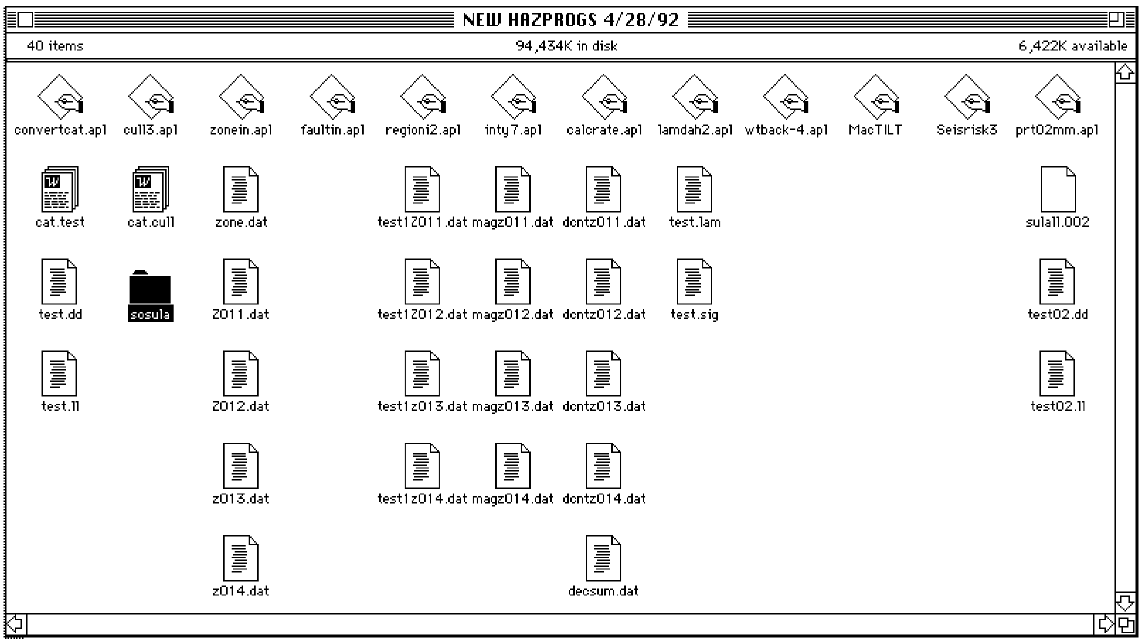


Figure--2 *An example of a typical hazard mapping folder on a Macintosh computer system. The top row of files are the applications programs. The remaining files are the various input and output files for a typical hazard mapping project.*

Executable files (Macintosh application files) have a ".apl" file name extension with the diamond shaped icon. Double-clicking with the mouse on these icons will start or "launch" the program. Files with a ".F" file name extensions are the FORTRAN source codes for the programs. These files do not need to be opened for normal operation. They should only be opened to modify the programs' FORTRAN code, and can be done so using MICROSOFT WORD or some other text editor. If changed, the FORTRAN code must be recompiled using the FORTRAN compiler. The remaining documents, aligned vertically below each of the application icons, are the various input and output files associated with their respective application program. In some cases the input and/or output file names are fixed by the program(s), but in some cases the file names are variable inputs and are defined by the user. Distinctions of file names will become clear later in this documentation. Application programs should be run under the system program FINDER with the system program MULTI-FINDER turned off. See the Macintosh operators manual for further information about these two system programs.

Notice some of the input and output files have different icons, in particular those data files with a large "W" overlaying the icon. These files have been edited or have their formats changed with MICROSOFT WORD, for further processing in other applications.

DETAILED DESCRIPTION OF PROGRAMS

Referring to the system flow chart (figure 1) which illustrates the primary steps involved in probabilistic ground-motion hazard mapping, we will now look at each of these steps in more detail. For each of the six major steps of the system flow chart, a detailed description of that step's program or programs and their input and output files will be given.

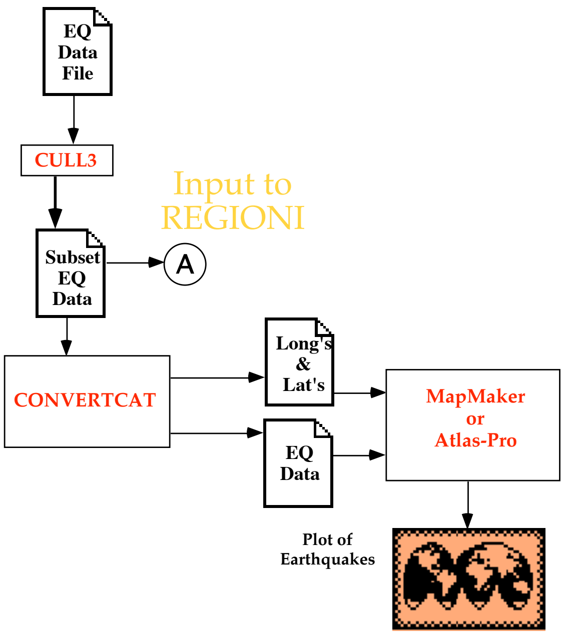


Figure--3 *An expanded look at the first step in (figure 1) detailing the beginning of the data reduction process. NOTE:* CULL3 *is used to reduce the overall regional earthquake catalog to a subset for further analysis.*

STEP 1

The initial step of a seismic hazard mapping endeavor is the collection and analysis of geographically related seismologic and geologic data. Programs associated with step 1 (figure 1) are for collecting and plotting these types of data.

The National Earthquake Information Service, (NEIS), catalog format will be followed throughout this system for seismicity input. (see Table 3) If any other catalogs are used, they must conform to the NEIS catalog format before any further processing can be performed.

CULL3

The program CULL3 is a general utility program for selecting earthquake records from a larger regional data file and writing them to a new file (figure 3). The input and output file names are specified by the user at execution time. Figure 4 illustrates the selection of earthquakes from the regional catalog of a study area by latitude and longitude. Point (**A**) (figure 4) specifies the FORTRAN format of the two fields or columns on which the search will be performed (skip 26 columns, read 7 columns with 3 decimal places, (field one), read 8 columns with 3 decimal places, (field two)). The FORTRAN format of the input data catalog must be known before using this program. In this case field one in the catalog is latitude and field two is the longitude. We want to collect all earthquakes between 4 degrees south and 2 degrees north latitude (**B**) (figure 4), and between 118 degrees and 126 degrees east longitude (**C**) (figure 4). We want all the earthquakes between the specified latitudes **AND** the specified longitudes, so a "0" is entered in response to the last question (**D**) (figure 4). The new catalog, "haz.cat" which is specified by the user, will be created as a new file with all of the earthquakes between the specified latitudes and longitudes selected from the base catalog. Specifying other fields in (**A**) would allow one to search on earthquake magnitudes, depths, or any other pair of <u>numeric</u> fields that are present in the catalog. The output file from this program is a repeat of the input catalog for those records within the specified range of input parameters.

Extraction of records for a single data field still requires the specification of two fields (as in (**A**) (figure 4)) with the limits of either field 1 or 2 ((**B**) or (**C**) (figure 4)) set beyond those present in the catalog. No selections will therefore be made on that data field.

NOTE: <u>If the data collected by CULL3 is to be used as input to other programs in this system the output data file from CULL3 must be edited to remove the first two lines. These two lines contain the extraction parameters CULL3 used to create the data file and will cause errors if not removed.</u>

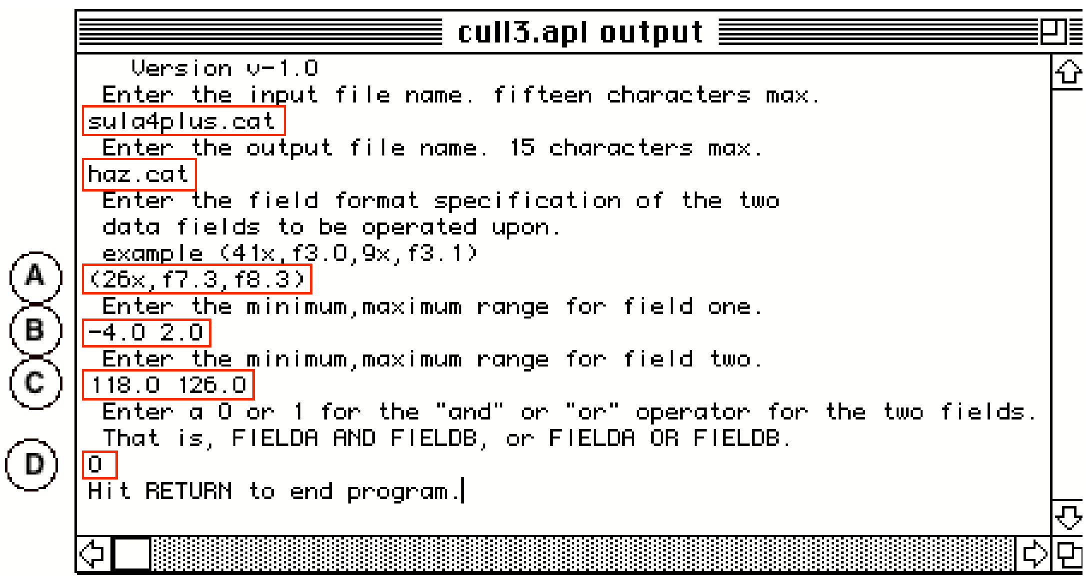


Figure--4 *Example of the users window for* CULL3. *Responses to program queries are contained in the boxes. The first two responses are input and output file names, while the next four are responses to search specifications.*

CONVERTCAT

CONVERTCAT is an interactive program (figure 3) that reads an earthquake catalog data file and produces the two input files necessary for plotting with either MapMaker or Atlas-Pro. The first of these two files contain an index number and the latitude and longitudes of the data record that will be plotted. The second file contains the same index number and the data to be plotted, that is date, time, depth, magnitudes, intensity, etc. MapMaker and Atlas-Pro use these index numbers to link the location, latitude and longitude, with the data to be plotted at that location. CONVERTCAT accepts as input (figure 5) file names for the latitude and longitude file, (**A**), the data file, (**B**), and the earthquake catalog file name (**C**), that the program will search. The final input parameter is the starting index number which is applied to each output file and incremented for each data record output (**D**). Since CONVERTCAT reads a specific input format and outputs specific data fields to these two files, <u>any differently formatted input catalogs will require reformatting the input data set to conform to the current program specifications</u>. The input data FORTRAN format is as follows (6x,a4,1x,a15,f7.3,f8.3,i3,9x,f3.1,2x,f3.1,3x,f4.2,7x,f4.2,36x,f4.2) where the fields are from left to right the reporting organization, year, time, (month, day, hour, minute, second, tenths of second), latitude, longitude, depth, m_b, m_s, another magnitude value, its type, another magnitude value, and its type, and the computed uniform magnitude. (see Table 3)

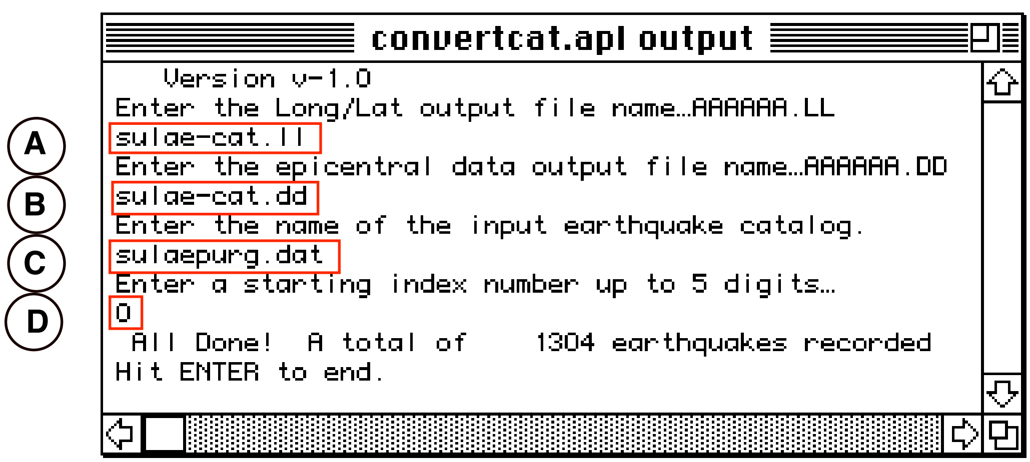


Figure--5 *Example of the users window for* CONVERTCAT. *Responses to program queries are contained in the boxes. The first three responses are input and output file names, while the next is the starting index number for this data set.*

FORTRAN FORMAT

A simple knowledge of FORTRAN formats is required for selecting catalog fields to be operated on by CULL3. Below (figure 6) is an example taken from a catalog of earthquakes. The top row of numbers that repeat 1 through X were inserted to mark the columns of the catalog obtained from the National Earthquake Information Service of the USGS. The columns run from 1 to 120. A FORTRAN format specification is shown below the catalog listing. The only part of this line of code that is input to CULL3 is that between, and including, the parentheses (... ...). The leaders show the columns or characters to which each part of the code applies (see example in the previous section). In this case, CULL3 is instructed to extract earthquake entries by latitudes and longitudes. FORTRAN programs read and perform operations from left to right. The analyst or user should always start from the left-most column or character when counting characters to be skipped or read and account for every column until all of the necessary fields, containing the desired data, have been completely defined. Simple combinations of skipped and read numeric data fields will allow data records to be extracted from any data file with numeric fields. FORTRAN programming manuals can provide more detailed information about format specifications.

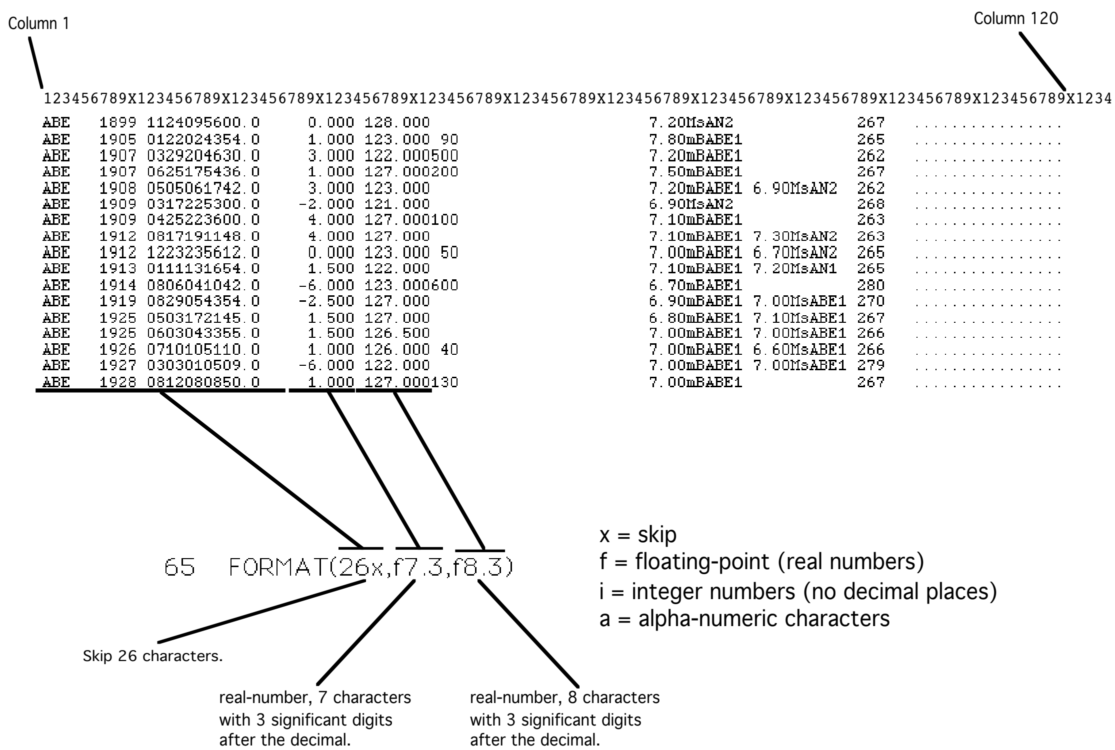


Figure--6 *A sample illustration of a typical input data file, top, with a simple example of what a typical* FORTRAN *format statement would look like, bottom. The row of numbers at the top serve to illustrate the column numbers and are not part of the input data.*

STEP 2

After careful study of the geology, geophysics, and the seismicity of the study area, the analyst is now ready to make decisions on how to partition the study region into source areas or "source zones". The next step is to subdivide the given source zones into the quadrilaterals, which geometrically define the source zones for input to SEISRISKIII or SEISRISKIIIDP. Program SEISRISKIIIDP is a modified version of SEISRISKIII that allows the definition of dipping plane sources (see Appendix B). From this point on we will refer to either of these programs as the "Risk-Program". The source zones provide geographical limits to the distribution of earthquakes in two dimensional space and are based on a number of geological and seismological considerations (Thenhaus, 1983). Source zones are not limited to horizontal areas at the surface, but may also be modeled as sub-surface dipping planes. The "dipping-plane" sources can only be input to the SEISRISKIIIDP risk program.

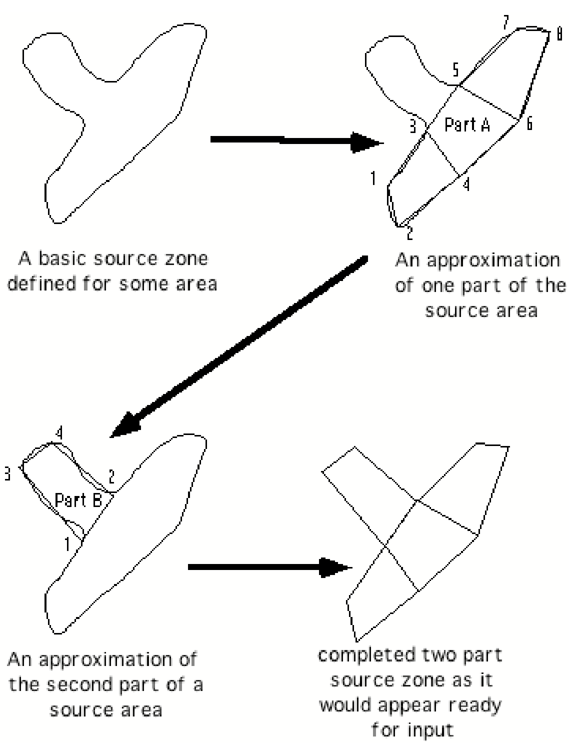


Figure--7 *Shown is an example of the quadrilaterals of a source area. In this case the source area has two parts that comprise the entire source zone.*

These source zones, including the dipping planes, are also used as input to the program REGIONI to extract source zone earthquakes from a regional earthquake data catalog. The quadrilaterals within a source zone should be planned and laid out in such a manner as to minimize their total number, and so as to best approximate the source zone (figure 7). The quadrilaterals, through any given source zone, must form a continuous chain from one end to the other of the source zone, much like the rungs of a ladder (figure 7). If a continuous chain of quadrilaterals is not possible, then the source zone must be divided into two or more sets of quadrilaterals (figure 7). This break, or new starting point, is signaled in the input as set 1 of 3, 2 of 3, 3 of 3, etc. so as to include all of the sets defining a particular source zone. Upon completion, the quadrilaterals within the source zones should be checked for any obvious defects, such as quadrilaterals inadvertently drawn with 3, 5, or more sides, or quadrilaterals that do not form a continuous chain.

The dipping planes, when seen in plan view, are single rectangular sources whose vertices are projected to the surface. The depths of the upper edge and the lower edge will be added later to define the source as a three dimensional dipping plane.

The dipping plane input format for the Risk-Program is slightly different than that of the surface source areas. The program ZONEIN may be used to enter the dipping plane source and the program REGIONI may use this format to collect the seismicity for this source as if it were a surface source, however the format of the dipping plane source **MUST** be changed before it can be used as input to the Risk-Program. (see Appendix B)

At this time, faults that will be modeled in the Risk-Program should be approximated as articulated line segments. To collect seismicity that has occurred in the vicinity of these faults, narrow source zones could be designed around these faults. The quadrilateralized source zones and articulated fault lines, if any, are now ready for input, either by digitizing or picking coordinate values from a map. In lieu of digitizing the coordinate points, two programs, ZONEIN and FAULTIN, exist for the purpose of entering source zones and faults in the proper input format for the Risk-Program.

ZONEIN

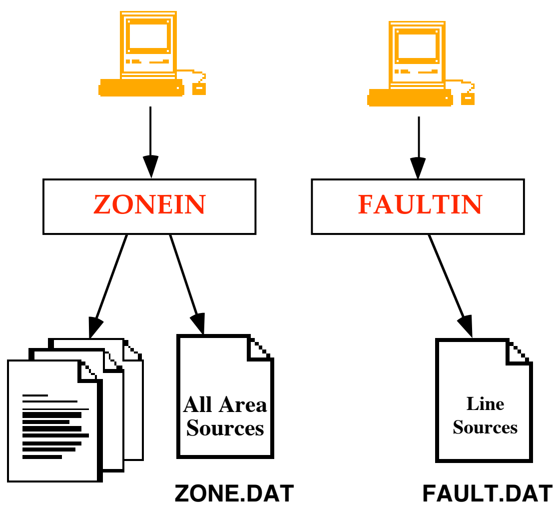


Figure--8 *Input and output diagrams for the programs* ZONEIN *and* FAULTIN *in Step 2.. Terminal icons indicate inputs for both programs are from the terminal and outputs are to files which are in the input format of the* Risk-Program. *The additional set of output files contain individual source zones, one source zone per file.*

ZONEIN is an interactive program for building the source zone input data-file for the Risk-Program (figure 8). Care should be taken in designing quadrilaterals for input to ZONEIN, (see discussion of quadrilaterals in the previous section (figure 7)). Be sure to follow a systematic pattern of "left-to-right" or "right-to-left" entries for the longitude-latitude pairs for each quadrilateral of a source zone.

Although the Risk-Program doesn't care about sign convention for east, and west longitudes or north, and south latitudes (unless the user is modeling across the Greenwich Meridian, the International Date Line, or across the equator), the plotting software must have the coordinate data points entered with negative values for southern latitudes and western longitudes. Sources crossing the International Date Line (180°) meridian should be recast to give values greater than 180° in a consistent east or west system, for use as input to the Risk-Program, but must be modified to reflect the proper sign convention for plotting.

ZONEIN (figure 9) uses a fixed output file name of "zone.dat" and as such this file will be over written with every execution of the program. The first 15 lines of this output data file are the input parameters and an abbreviated attenuation table used by the Risk-Program. These parameters are variable and **MUST** be modified to suit the users specific application. The annotations found to the right of the data fields serve only as an aid to the user and may be removed with the use of a text editor.

NOTE: <u>This file is the beginnings of the risk program input file and should be renamed to some name, N-A-M-E.015.</u>

```
zone.dat
·First·of·three·lines·of·descriptive·text·up·to·80·character·maximum¶
······Second·of·three·lines·of·descriptive·text·up·to·80·character·maximum¶
············Third·line·of·three·lines·of·descriptive·text·up·to·80·character·maximum.¶
0·0.·--------------------FIRST·OF·7·LINES·OF·MODELING·INPUT·PARAMETERS.¶
.90·3·10·50·250··········PARAMETERS·MUST·BE·RESET·FOR·YOUR·SPECIFIC·NEEDS.¶
1.0·0.·.21·0.············SEE·BENDER,PERKINS·1987¶
118.0·-2.0·128.0·-2.0¶
119.0·3.0·127.0·-6.0·······.25·······.25¶
1·32··1·37¶
0¶
2··3·-----------------------------Size·of·attenuation·table,·3·rows·X·2·columns¶
'ATTN-TAB'·······8.5·······7.9·····Sample·of·2X2·attenuation·table.¶
······1.0···0.57853···0.50077······Replace·this·table·later.¶
······2.0···0.57798···0.50017¶
······4.0···0.57579···0.49776¶
00···1.0····-1··········z001¶
··3··1··1¶
·122.75··-3.20·123.25··-2.80¶
·119.25··-1.50·120.25··-1.00¶
·119.25···2.00·120.25···2.00¶
¶
¶
00···1.0····-1··········z002¶
··3··1··1¶
·120.25···2.00·120.25··-1.00¶
·124.00···2.00·122.00··-2.00¶
·126.00···2.00·126.00··-2.00¶
¶
¶
Num. Lock          Normal+...
```

Figure--9 *A look at the output data file created by* ZONEIN. *This example is shown using* MICROSOFT-WORD. *Each character of the proper format is accounted for by either an actual character, numeral, or dot (to indicate a space). Note that southern latitudes are indicated with negative signs, and blank lines have been reserved for rates and magnitudes to be added later .*

In the example in (figure 10) we have input two source zones, Z001 and Z002, (**A**). It is important to know in advance the number of pairs of points that define each source zone. In this case, both of the zones are defined by three 3 pairs (**B**). The first zone has a total of six points that define the zone. The response here is "3 1 1" indicates, three pairs of coordinates, the first of one part(s). These points are input as coordinate pairs from "left-to-right" or "right-to-left" through the zone (**C**). Using the source zone described in figure 7 as an example, the response at the first encounter of (**B**) would be "4 1 2"; indicating four pairs, the first set of data for a two part zone. Input of the four pairs of data points then follows. At this point the program is looking for, in this case, coordinate pairs of part two of the two part source zone. Therefore, the program asks not for a source name but for the number of coordinate pairs, to which the user responds with "2 2 2", or, two pairs of points, the second of two parts. The program will continue to accept input data until the word "quit" is entered as a new source name.

```
zonein.apl output
    Version V-2.0
  Enter name of source zone or quit
  Four (4) characters maximum.
  Example  Z001,  Z005,  beta,  or quit
(A) z001
  Enter number of pairs of points
  the number of the zone  segment
  the total number of zone segments
```

FAULTIN

FAULTIN performs for faults (articulated line sources; figure 11), the same task that ZONEIN performs for source zones. The Risk-Program requires different formats for seismic source zones (areas) and faults (lines). A source may contain more than one fault up to a maximum of 26 and any of these faults may have up to 24 segments. (See Appendix B, Fault Input)

For the example in figure 11, responses to the program FAULTIN (figure 12), (**A**) indicates that the source is made up of one modeled fault, and that fault has one vertex, resulting in three points that describe the fault. (**B**) shows the three longitude-latitude pairs that define the line source. At (**C**) the program requests the number of faults for the next set of faults; in this case, the response, zero, terminates the program.

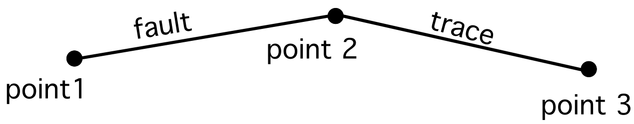


Figure-11 *Articulated line source showing a fault trace defined by three points.*

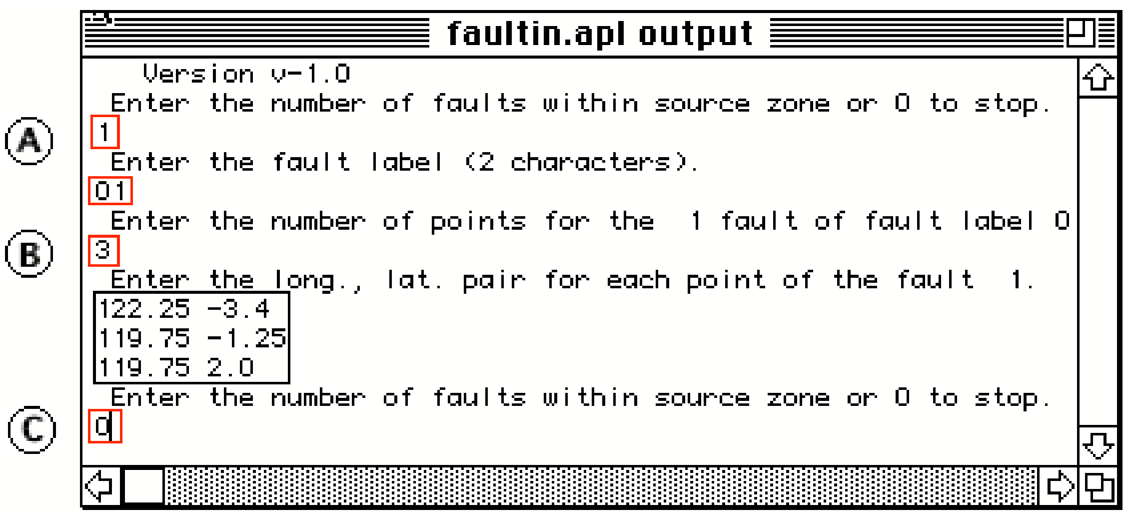


Figure-12 *User window showing the responses, (in the boxes) for the program* FAULTIN. *At response* (**A**) *the user could have responded with any number, depending on how many line sources he may want grouped together with a set of rates.*

STEP 3

Step 3 in the overall system deals with collecting statistical information for the computation of recurrence rates for the individual source zones (figure 13). After the analyst has verified the source zone and fault-source inputs, the program REGIONI reads these inputs along with a catalog or catalogs of earthquakes and produces a catalog of earthquakes for each input source zone.

Note: <u>Because the results for each catalog is appended to the results from previous catalogs, the analyst **MUST** sort the individual source zone catalogs into chronological order if more than one catalog is used as input to REGIONI.</u>

The catalogs can be easily examined for foreshock and aftershock sequences, earthquake swarm activity, or other characteristic traits of seismicity within the source zones. Foreshock and aftershock sequences and events which are less than some minimum magnitude of interest can be removed at this time with the use of an editor or word processor. Most commonly, hazard analyses assume a Poisson model of earthquake occurrence. In such models probabilistic ground motions are based on independent events and not time series or time-dependent events such as foreshocks or aftershocks.

The individual zone catalogs, output from REGIONI, are the input to the program INTY7 (figure 16) where each event is converted to a uniform magnitude. The uniform magnitude must be a magnitude that is common to the attenuation function used for the computation of ground motions. This magnitude is usually a surface wave magnitude (M_S). A table (Table 1) of earthquake activity for each source zone is produced for future computer processing. This table shows, decade-by-decade, the number of earthquakes as a function of the uniform magnitude category and will be the input to the program LAMDA later in this system. We will subsequently refer to these tables as "decade tables". They will be used for the estimation of completeness times and seismic rates later in the system. Table 1 shows the most recent decade in the first row to the oldest decade in the last row, with the magnitudes intervals centered around the values 4.3, 4.9, 5.5, 6.1, 6.7, 7.3, 7.9, 8.5, in columns from left to right. Each of these magnitude intervals is ±.3 magnitude unit, inclusive at the low end of the interval and exclusive at the high end of the interval.

Table 1

68	54	5	0	0	0	0	0
13	36	6	1	1	0	0	0
8	28	8	5	1	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0

We have found the second output file of decade table summaries (Table 2) useful in assessing the presence of foreshock and aftershock sequences to be removed from the catalogs. These summary decade tables are much easier for the user to read and evaluate since each is annotated, and the decades with no events are omitted for clarity.

As can be seen from Table 2, not all of the magnitude categories are completely reported for the entire length of the catalog. Lower magnitudes, say 4.3, are more frequently reported for more recent decades and reflect more complete reporting at these levels due perhaps to increased settlement of a region, or improved seismic monitoring techniques, or both. A significant bias would be introduced if a rate of earthquake activity were to be calculated by averaging the higher activity of recent decades with previous decades of no reported activity of this size.

Table 2

Decade	4.3	4.9	5.5	6.1	6.7	7.3	7.9	8.5	Total
1900-1909	0	0	0	0	1	0	0	0	1
1930-1939	0	0	0	0	0	0	1	0	1
1960-1969	8	28	8	5	1	1	0	0	51
1970-1979	13	36	6	1	1	0	0	0	57
1980-1989	68	54	5	0	0	0	0	0	127
Totals	89	118	19	6	3	1	1	0	237

We therefore need to identify the period of time for which each magnitude category is completely reported and calculate average rates of occurrences on this complete set of data. A procedure for doing this is given by (Stepp, 1973).

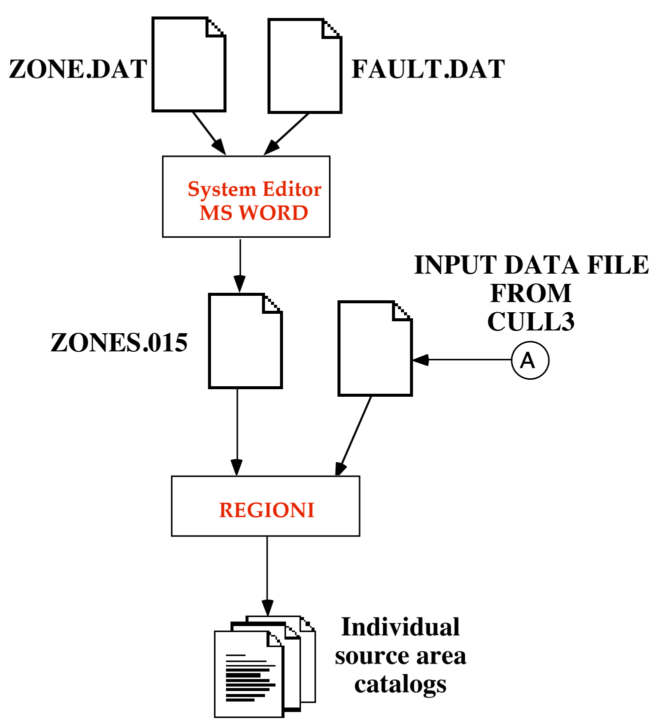


Figure-13 *Expanded view of the system diagram showing the inputs and outputs for* REGIONI *Step 3 of the overall system.* ZONE.DAT *and* FAULT.DAT, *if there are any, are merged together using some editor, spaces for other* Risk-Program *input parameters are reserved at this time. This new file and the earthquake*

REGIONI

REGIONI is an interactive program (figure 13) which takes the output of ZONEIN and the regional catalogs and separates the earthquakes into sub-catalogs, one for each seismic source zone.

The output files from ZONEIN and FAULTIN when merged together form the basic sources of an input file for the Risk-Program, (figure 14). Upon examination of this input file, (**A**) is the input parameters used by the Risk-Program where the modeling input parameters, location information for sites to be calculated, and an attenuation table are defined. (**B**) is the coordinates defining the source zones from

ZONEIN. The "99's" (**C**) mark the end of source area input and the beginning of any fault sources, they also mark the end of any fault sources and the beginning of any dipping plane source inputs. The last "99" marks the end of file.

This newly formed file should now be saved and named with a file name having a ".015" file name extension. By convention, 15, and .015 have been used to indicate to the user that such named files are input files to the Risk-Program. The first name of the file name typically should be something indicating the region in which the sources are contained. The user should select the "save as" option when exiting the editor at which time this file can be renamed. The name chosen for this file is "sulazones.015".

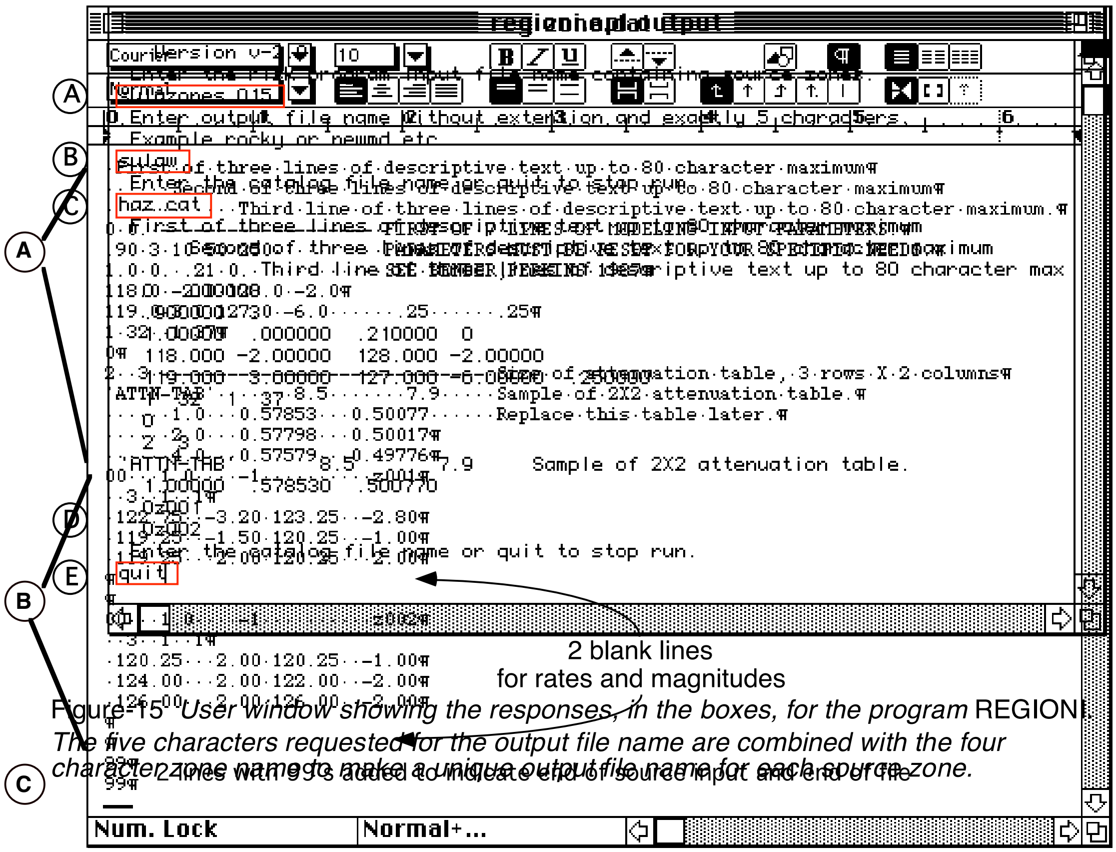


Figure-15 *User window showing the responses, in the boxes, for the program* REGIONI. *The five characters requested for the output file name are combined with the four character zone name to make a unique output file name for each source zone.*

Figure-14 *A sample input data set for* REGIONI, *as edited by* MICROSOFT WORD. *The first three lines in section* ***A*** *should be altered to describe the users input. The blank lines between sources will be left blank for now but will eventually be replaced with seismic rates and magnitudes. The two lines of 99's are added to indicate the end of area sources and end of file.*

Once this input file has been edited as shown in figure 14, REGIONI can be executed. REGIONI is an interactive program that solicits input and output parameters from the user (figure 15). At (**A**) the program has asked for the source area input file name, in this case "sulazones.015". REGIONI will produce an earthquake catalog for each source zone it processes. To make these catalog file names unique, the program asks the user for a five character name (**B**) that will be combined with the source zone name to make the catalog file name. The five character name is usually some abbreviated name associated with the area the source zones cover. As an example, "NCENT" could stand for north central and when combined with a source zone name, "z001", would result in

"NCENTz001.dat". At (**C**) the file name of the earthquake catalog is input. This catalog can be the regional catalog or some sub-set catalog from the program CULL3. **Remember**, should this input catalog have come from the program CULL3, the first two lines **must** be removed. (**D**) is simply the source zone names output to the monitor as they are processed from the ".015" input file. Finally (**E**) allows for an additional earthquake catalog to be input or, in this case, quit is entered to terminate the program. If more than one earthquake catalog is used as input (say, catalogs from different historical time periods), REGIONI will divide these catalogs among the source zones. The data from these catalogs are appended to each of the individual source zone catalogs and this requires that each of the source zone catalogs to be sorted into chronological order before further processing.

INTY7

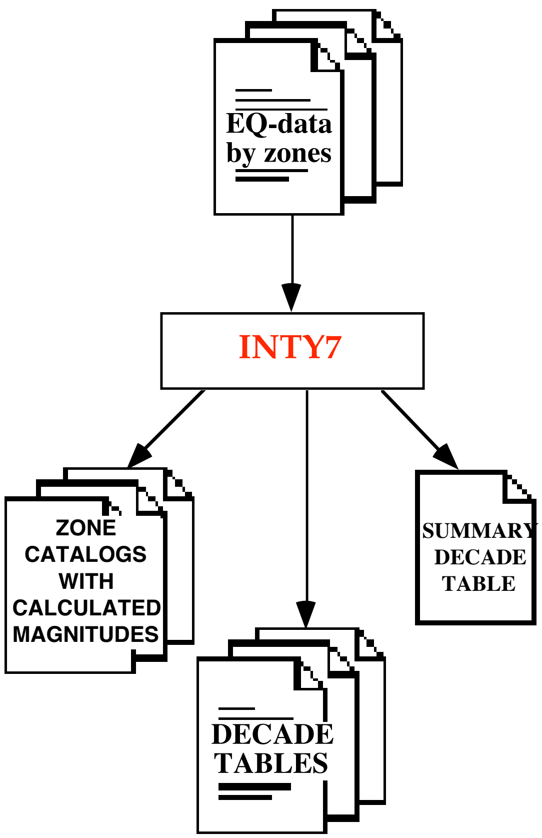


Figure-16 *Expanded view of the inputs and outputs to the program* INTY7 *in Step 3 of the overall system. This program reads the individual zone catalogs and calculates a universal magnitude for each data record.*

INTY7 (figure 16) converts m_b catalog magnitudes to a uniform magnitude scale and produces a decade-by-decade summary of the seismicity for each source zone. The uniform magnitudes must be compatible with the magnitudes of the attenuation function that will be used later for the ground motion computations. For this demonstration, catalog m_b magnitudes are converted to a surface wave magnitude (M_S) using regression results from the northern Sulawasi, Indonesia.

$$M_S=-.845+1.201*m_b$$

In actual analyses, regressions on local catalog data would define the proper regional magnitude conversions. It will be these regression formuli of the local catalogs that are inserted into the source code of the program INTY7 at which time the program must be recompiled. DECSUM.DAT is one output file used in catalog quality and completeness assessments and is shown in (figure 17). Catalog output files are also made for each source zone with the name "magXXXX.dat", where "XXXX" is the four character zone name. These catalogs contain the earthquake data records with the computed uniform magnitude appended to the end of each record. (see Table 3) An additional set of files, the "decade tables" are produced, one for each source zone and will be used later as input to the program

LAMDA. These files have names of the form "dcntXXXX.dat" where the "dcnt" indicates that these files are decade table files.

```
 Enter the earliest completion decade ie 1530
1900
 Enter the entire input file name (XXXXXNNNN.dat) or quit to stop the run.
sulawz001.dat
 sula   z001
 decade      4.3     4.9      5.5     6.1     6.7    7.3      7.9     8.5   TOTAL

 1900-1909     0       0        0       0       1       0       0       0      1
 1930-1939     0       0        0       0       0       0       1       0      1
 1960-1969     8      28        8       5       1       1       0       0     51
 1970-1979    13      36        6       1       1       0       0       0     57
 1980-1989    68      54        5       0       0       0       0       0    127
 total number of earthquakes with magnitude Ms > or = 4.0 =  244
 Enter the entire input file name (XXXXXNNNN.dat) or quit to stop the run.
sulawz002.dat                See note below.
 sula   z002
 decade      4.3     4.9      5.5     6.1     6.7    7.3      7.9     8.5   TOTAL

 1900-1909     0       0        0       0       0       0       1       0      1
 1910-1919     0       0        0       0       1       1       0       0      2
 1930-1939     0       0        0       0       0       0       1       0      1
 1940-1949     0       0        0       0       3       2       0       0      5
 1960-1969    26     110       43      10       0       0       0       0    189
 1970-1979    61     202       62       8       0       0       0       0    333
 1980-1989   307     331       45       9       0       0       0       0    692
 total number of earthquakes with magnitude Ms > or = 4.0 = 1365
 Enter the entire input file name (XXXXXNNNN.dat) or quit to stop the run.
quit
                              Note that M=4.3 decrease in number from M=4.9
                              indicating that they are not completely reported
                              for all decades of the catalog.
```

Figure-17 *User window showing summary decade tables for the example zones z001 and z002. The first user response to earliest completion decade is the earliest complete decade of the entire regional catalog. For each of the source zones only those decades which have had earthquakes are output, notice for sulawz001.dat that the decades 1910-1919, 1920-1929, 1940-1949, and 1950-1959 are not output this is done for clarity and ease of reading.*

The uniform magnitude computed for each data record that is appended to the end of each output record is based on one of three magnitude categories. The program is designed to accept 3 magnitude data fields and accept first the magnitude of column **A** in Table 3. If this magnitude is designated as an M_S then the uniform magnitude will be this magnitude, if this magnitude is designated as m_b then the uniform magnitude will be converted according to the above formula. Any other magnitudes in column **A** Table 3 are ignored. If there is no magnitude in this preferred column, the program goes through the same process for the magnitude column **B** of Table 3, which is the second preferable magnitude column of the data set. Again, if no magnitude is listed in column **B** the program will use magnitude column **C** of Table 3, which is designated for m_b magnitudes only and convert that magnitude to the uniform magnitude according to the above formula. Any acceptance of any other magnitudes, will require extensive editing and recompiling of the program INTY7.

TABLE 3 HERE

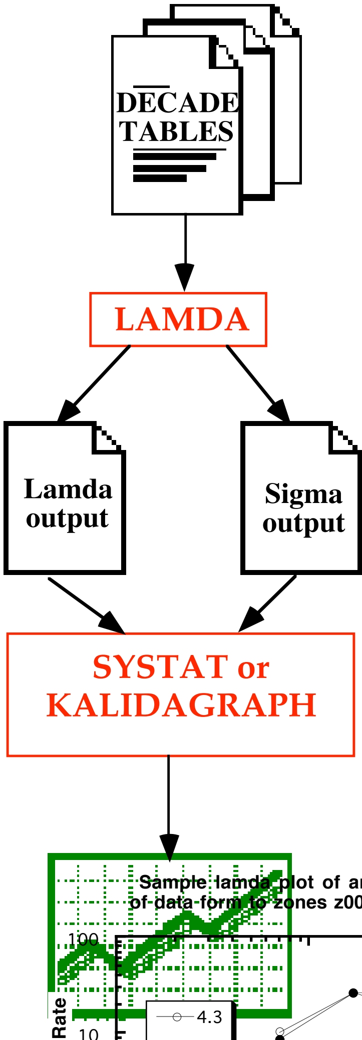


Figure-18 Expanded view of the input and output for the program LAMDA in step 4a of the overall scheme. The output from this program is the input to a plotting program, in this case SYSTAT or KaliedaGraph. The plots produced will be Log-Log plots of Time vs. Occurrence rates.

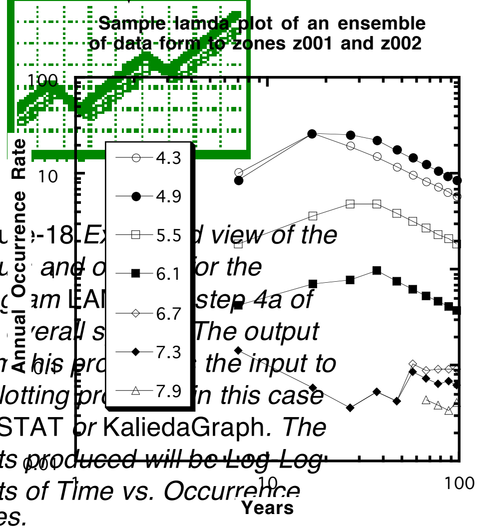


Figure-19 *Sample plot of the combined decade tables of z001 and z002. Each curve plotted represents a different magnitude.*

STEP 4a

The program LAMDA was developed to calculate the mean rate of occurrence and standard deviation for each magnitude level. The program LAMDA uses the decade tables (Table 1), with filenames of the form "dcntXXXX.dat" output from INTY7, as input to calculate the mean and standard deviation of the rates and produces a table of mean rates per decade for each of the magnitudes considered. These tables are then plotted, rate vs. time, for the analyst to evaluate and estimate completeness times and annual rates for each magnitude (see figure 19).

CALCRATE is a statistical program that will compute an a-value and a b-value, for the Gutenberg-Richter relation LogN=a+bM from the input expected rates selected from the previously mentioned plots. The program uses a maximum likelihood method (Weichert, 1980) to calculate the annual occurrence rates using several magnitude categories having varying completeness times.

LAMDA

LAMDA (figure 18) creates a table of mean annual occurrences values for the decade tables output by INTY7.

NOTE: <u>At this time the user may want to consider combining several source areas together to accumulate enough earthquakes to obtain a statistically reliable estimate of the annual occurrence rates.</u>

The users window in (figure 20) illustrates the input of two source area decade tables (**A**), named dcntz001.dat, and dcntz002.dat (**B**). The mean annual occurrence rates for this combination of source areas is output to two files, in this case lamda.out, and sigma.out, (**C**). The theoretical background for the procedure was published by (Stepp, 1973). The value of Lambda (λ) is λ=N/year. Where N equals the number of observed earthquakes. As this mean occurrence value is calculated backwards in time (from the present to the earliest decade in the earthquake catalog), a significant decrease in the occurrence rate with time indicates that earthquakes are being lost in the historic record due to incomplete reporting. Sigma (σ) is also calculated and tabulated. σ is the standard deviation of λ and behaves in a similar manner as λ. It is our experience that plotting λ values vs. time on a Log-Log graph eases the task of estimating magnitude completeness times.

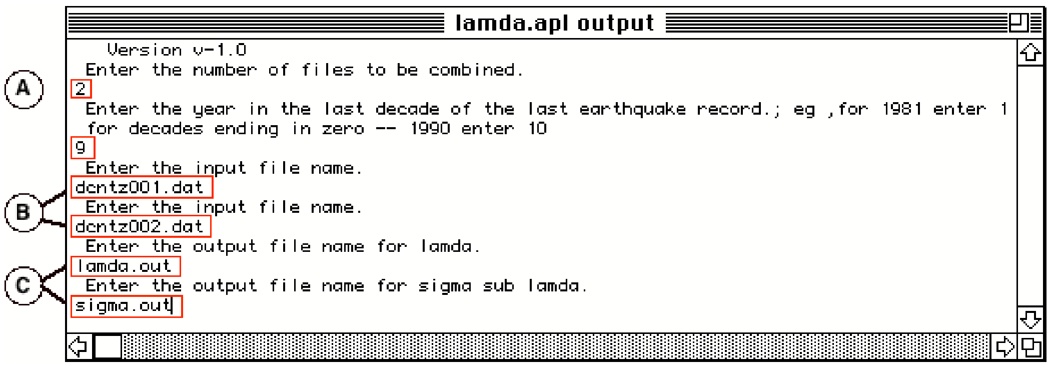


Figure-20 *This example user window for* LAMDA *shows how an ensemble of source zones can be created for a proper statistical analysis. Responses to program queries are in boxes.*

The table of values, say lamda.out, is then imported or read into a commercial software plotting program (such as SYSTAT or KALIEDAGRAPH) to create graphs that aid in the analysis of earthquake catalog completeness (figure 19).

CALCRATE

CALCRATE (figure 21) is an easy and straight-forward program for calculating earthquake occurrence rates using the method proposed by Weichert (1980). The procedure is most useful for individual source zones having a large number of earthquakes (say, around 100 or more) from which stable estimates of "a" and "b" values (LogN=a+bM) will result. From 1.) the decade summary plots (figure 19), 2.) the decade summary table (DECSUM output from INTY7) (figure 17), and 3.) any historical information on a region, estimates of completeness times can be made for the magnitude categories being used in the analysis. CALCRATE uses the observed number of earthquakes in each magnitude category through the time period that each magnitude category is judged to be completely reported. Magnitude categories that are judged <u>not</u> to be completely reported for the duration of the catalog are <u>not</u>

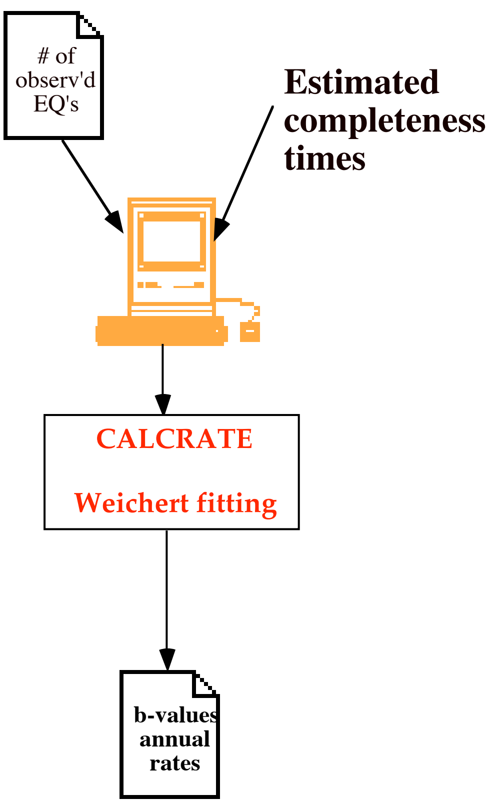


Figure-21 *Expanded view of the inputs and outputs for* CALCRATE *used to determine annual occurrence rates in step 4a of the overall system. The program is interactive with terminal inputs and file outputs.*

used in this analysis. Note at point (**A)** and (**B)** (figure 22), that magnitude category 4.3 is not included in this analysis because we have already determined that M_S=4.3 is incompletely reported throughout the catalog (see decade table from INTY7, Table 2). In our example catalog no M_S=8.5 earthquakes have been reported historically, (Table 2), however the b-value depends on maximum magnitude, and if an 8.5 is considered possible in the source zone(s) then this category should be included in the computations. The program will calculate the "a" and "b" values for the Gutenberg-Richter relation LogN=a+bM based on the incremental magnitude data (**C**) and will give annual occurrence rates for each magnitude interval (**D**). From this information, the analyst can extrapolate up or down in magnitude to calculate the occurrence rates of maximum magnitude earthquakes or minimum magnitude earthquakes that are outside of the magnitude limits of the completely reported earthquakes used in the analysis. Smoothed annual occurrence rates could be obtained by specifying annual occurrence rates and completeness times of one year for each magnitude entry.

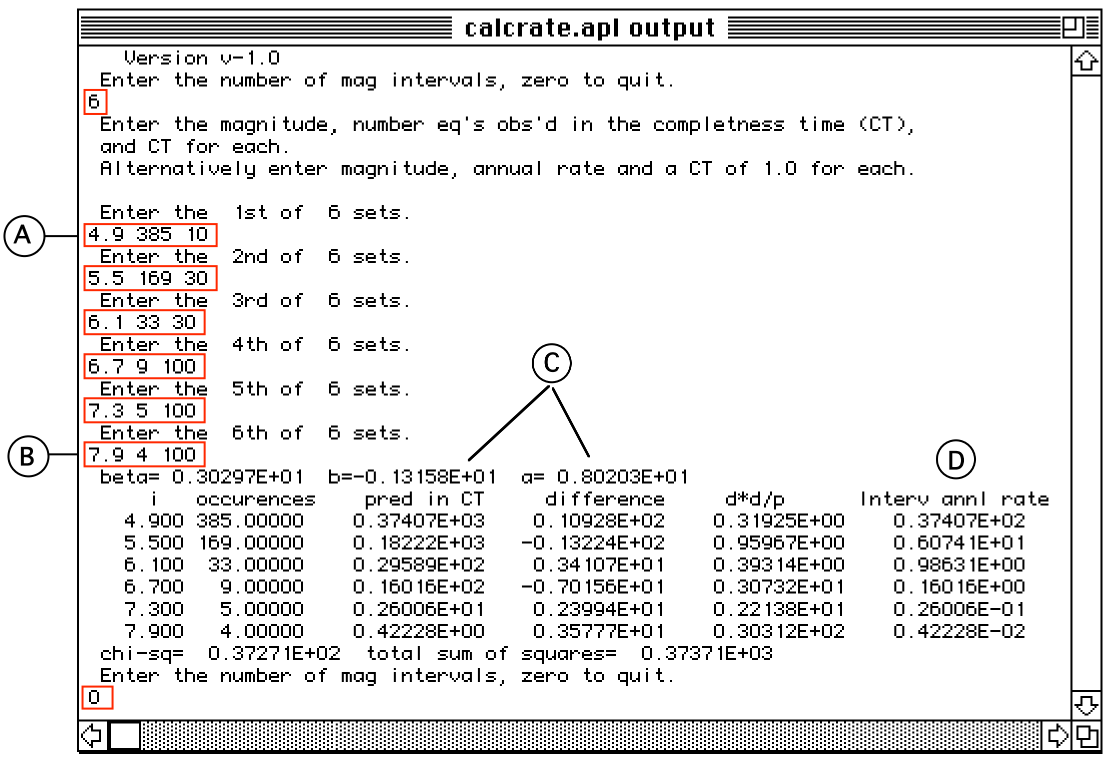


Figure-22 *User window showing the terminal input responses for* CALCRATE *in boxes, and the computed interval annual rates under* (**D**) *for a simple sample input data set. Maximum magnitude for this source zone is the category 7.9. If the maximum magnitude was judged to be 8.5, the 8.5 category would also be added in the input even though no magnitude 8.5 earthquakes occurred historically in the source zone (See Table 2).*

STEP 4b

Since not all source zones will have adequate numbers of earthquakes to provide robust statistical analyses, an ensemble of source zones may be necessary to collect enough earthquakes to properly compute the annual occurrence rates. Generally a minimum of about 40 events is the minimum needed to do a proper statistical analysis, although 100 or more is preferable (Bender, 1983). If the annual occurrence rates are determined from an ensemble of source zones, the ensemble rate must be distributed among the constituent zones. For this purpose, WTBACK7 accepts as input the ensemble rate and the decade table summary of each constituent zone and allocates the rate to each of the zones. This program accepts the input either from the terminal or from a prepared input file and produces up to 4 tables of allocated rates. The output tables represent 4 different methods of allocating the ensemble rate. (see Appendix A)

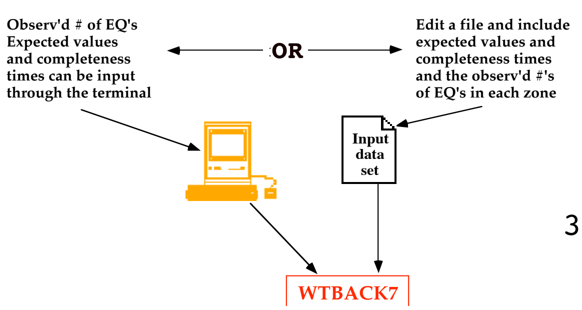
ALLOCATION METHODS

Before giving examples of the next set of computer programs, some discussion is given so the analyst can better understand the reasons behind their development.

In developing hazard maps of the United States we have found that we need at least forty 40 earthquakes in a zone to hope to fit a-values and b-values on a zone-by-zone basis. It is better to have on the order of 100 earthquakes to obtain b-values (Bender,1983) which are stable enough to categorize zones by their differing b-values. Zone totals of this size are rare in the United States and we have found it better to combine zones regionally in order to obtain more reliable a-values and b-values in the Gutenberg-Richter relation LogN=a+bM. CALCRATE provides the statistical fits to the regional earthquake data bases. Of course, they also provide the fits to individual seismic source zones that have sufficient seismicity for reliable a-values and b-values.

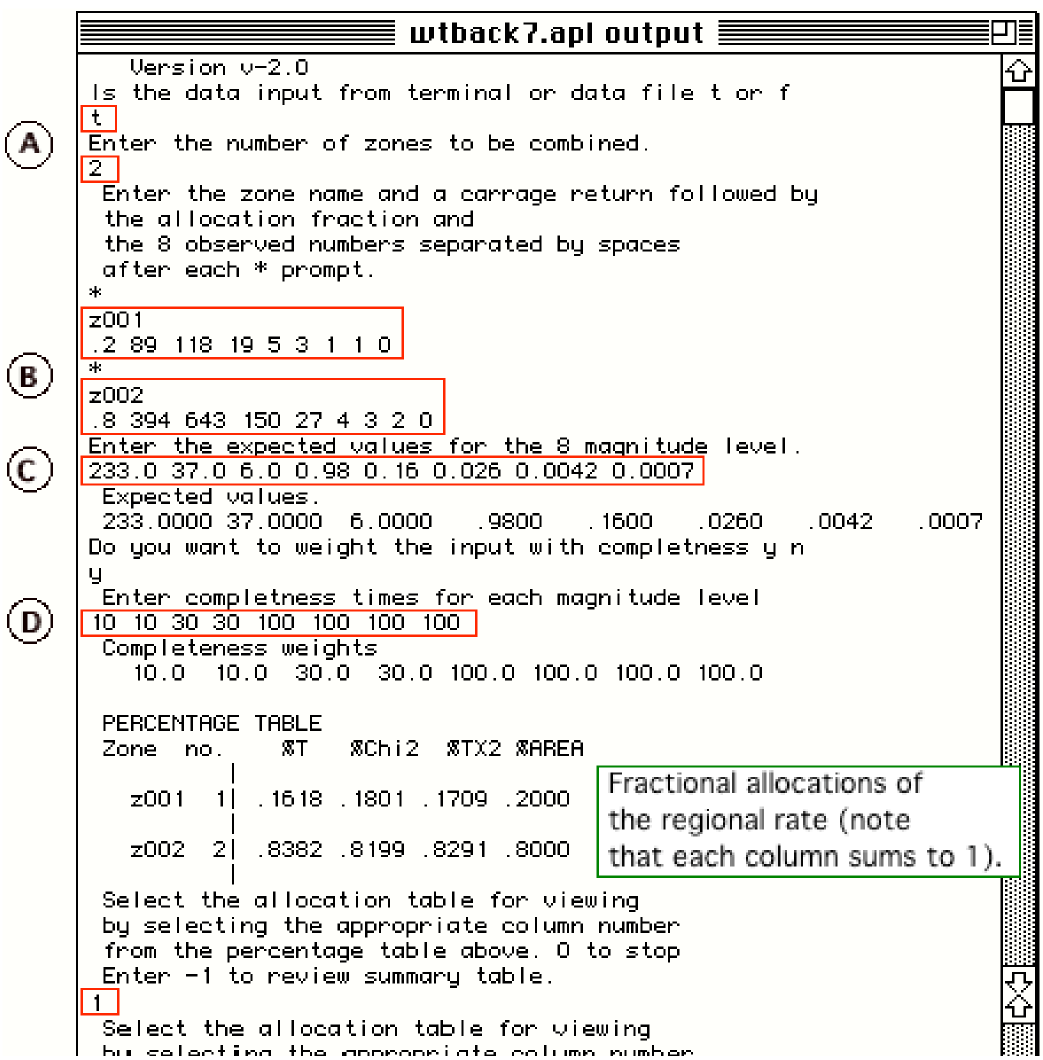
Once a fit of an ensemble of source zones has been made, it is necessary to divide that fit into parts, an appropriate part allocated to each zone having contributed historical observed earthquakes to the combined data base of earthquakes. In general, an allocation method calculates a contribution number for each zone, based upon some characteristic of the distribution of earthquakes observed in each magnitude range of that zone. The contribution number, or allocation fraction, is used to multiply the ensemble fit value for each magnitude category in order to obtain the number of earthquakes assigned to the given zone in that magnitude category.

The allocation methods that we use correspond to common statistical methods used to analyze log frequency vs. magnitude graphs, such as least squares, weighted least squares, maximum likelihood, minimum X^2, etc. (see Appendix A) Most of the allocation methods would give the same results for very large amounts of perfect data; in a statistical sense, this means they are "consistent" allocators.



WTBACK7 (TERMINAL INPUT EXAMPLE)

Notice WTBACK7 has two methods of input (figure 23), an interactive input from the terminal or input from a file. In the interactive window for WTBACK7 (figure 24) the required information is input at the terminal. Because this can be a tedious chore when a regional rate of seismic activity is being divided among a number of constituent seismic source zones, an input file can be built and input to WTBACK7. An example of such a file is given in next section. For the simple terminal input, a regional rate is being distributed into only two seismic source zones (**A**). Following the source zone identifier, an allocation fraction (% area in this example) and the observed number of earthquakes in each of the eight (8) magnitude categories are entered (**B**). The allocation fraction is a user defined percentage (we usually input area percentages) and may be of any normalization factor. The observed number is the total number of earthquakes in each magnitude column through all the decades of DECSUM.DAT (the output from INTY7). The expected values (**C**) are obtained from CALCRATE and are the fitted LogN=a+bM values. Estimates of completeness times (**D**) are required for each of the eight (8) magnitude categories, even if no earthquakes have historically been observed in some categories. Such completeness estimates can depend on a number of considerations (for example, history of settlement, intensity attenuation, paleoseismicity evidence, etc.) for a region. Selections of particular allocations are made by selecting the column number of the allocation. The allocated rates for each selection are output to "wtback.out".


wtback7.apl output

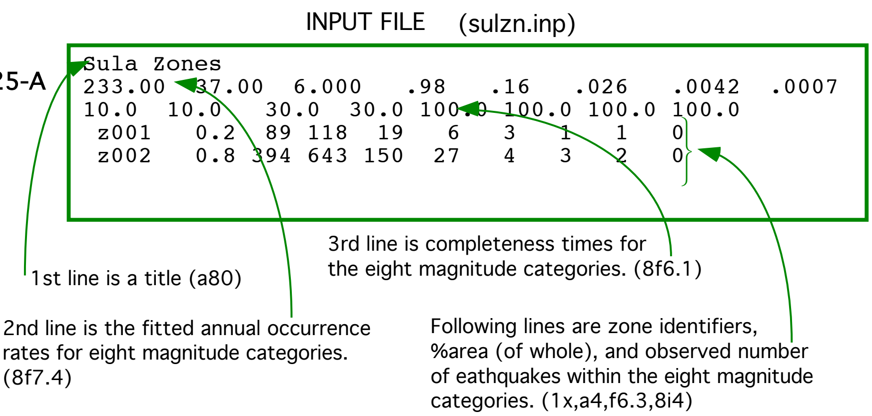
```
   Version v-2.0
 Is the data input from terminal or data file t or f
t
Enter the number of zones to be combined.
2
 Enter the zone name and a carrage return followed by
 the allocation fraction and
 the 8 observed numbers separated by spaces
 after each * prompt.
*
z001
.2 89 118 19 5 3 1 1 0
*
z002
.8 394 643 150 27 4 3 2 0
Enter the expected values for the 8 magnitude level.
233.0 37.0 6.0 0.98 0.16 0.026 0.0042 0.0007
 Expected values.
 233.0000 37.0000  6.0000   .9800   .1600   .0260   .0042   .0007
Do you want to weight the input with completness y n
y
 Enter completness times for each magnitude level
10 10 30 30 100 100 100 100
 Completeness weights
   10.0   10.0   30.0   30.0  100.0  100.0  100.0  100.0

 PERCENTAGE TABLE
 Zone  no.    %T    %Chi2  %TX2 %AREA
           |
   z001   1| .1618 .1801 .1709 .2000
           |
   z002   2| .8382 .8199 .8291 .8000
           |
 Select the allocation table for viewing
 by selecting the appropriate column number
 from the percentage table above. 0 to stop
 Enter -1 to review summary table.
1
 Select the allocation table for viewing
 by selecting the appropriate column number
```

WTBACK7 (FILE INPUT EXAMPLE)

Rather than entering all of the required information at the terminal, WTBACK7 will accept the information from a pre-constructed input file as shown below (figure 25A). It is important that the file be constructed exactly as shown or WTBACK7 will not read it properly. Figure 25B shows the WTBACK7 interactive window for entering the name of the input file .

NOTE: <u>NUMBER OF LINES AND SPACING MUST BE AS IN THIS EXAMPLE.</u>

25-A



25-B

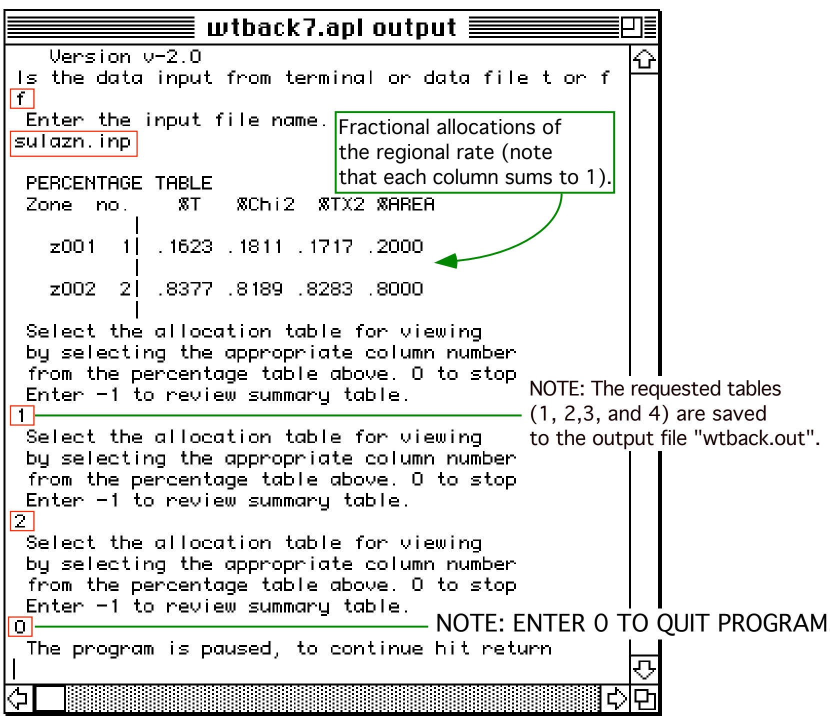


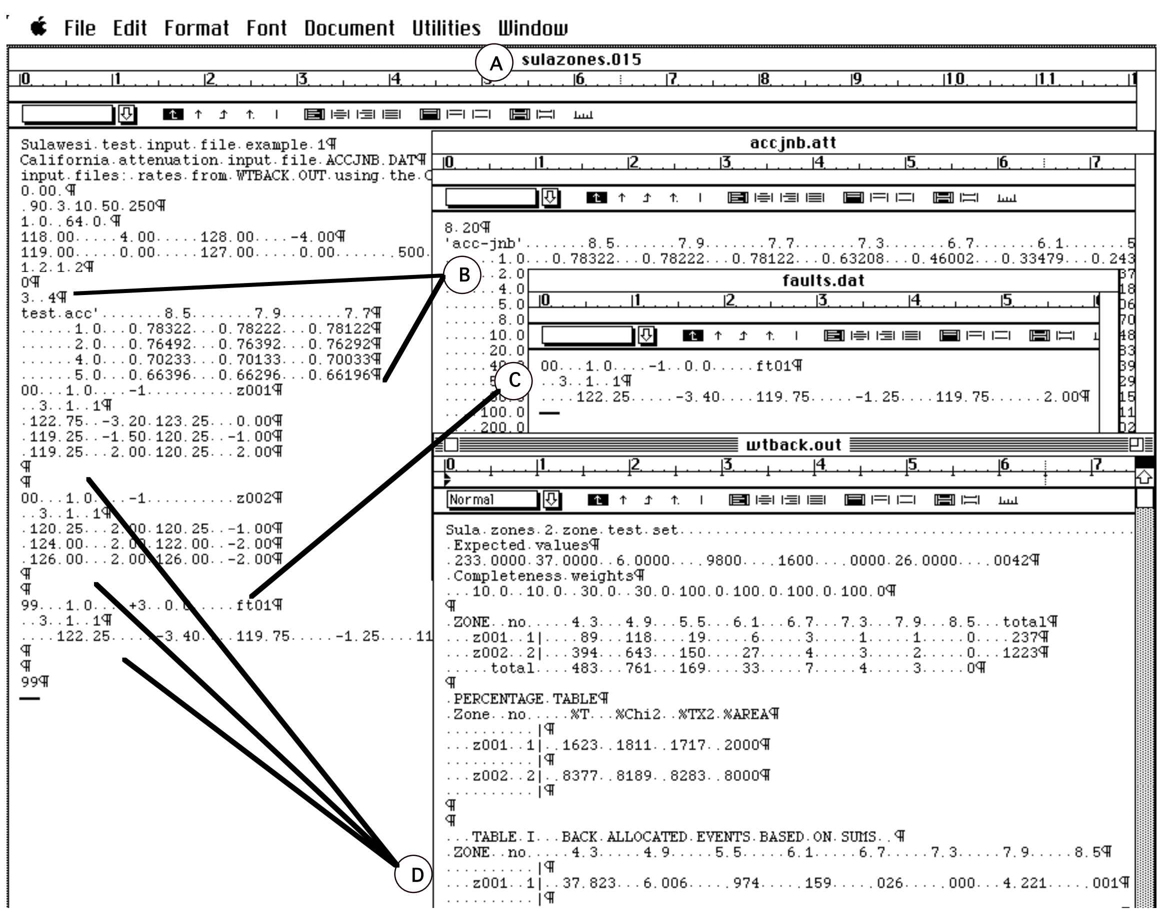
Figure-25 *User window showing the file input interactive input to the program* WTBACK7 . *The back allocated rates by their various schemes will be found in the data file* wtback.out.

STEP 5

From this point the analyst must assemble the Risk-Program input data file, using the data file containing the source zone coordinates and faults, if any, adding the appropriate attenuation table, and inserting the annual rates for each of the source zones. There are of course several other additional input parameters necessary to define the specific location of the site or sites to be computed, smoothing parameters, exposure times, etc. (see Bender and Perkins, 1987). Using this input data file in the Risk-Program, probabilistic ground motions can be computed.

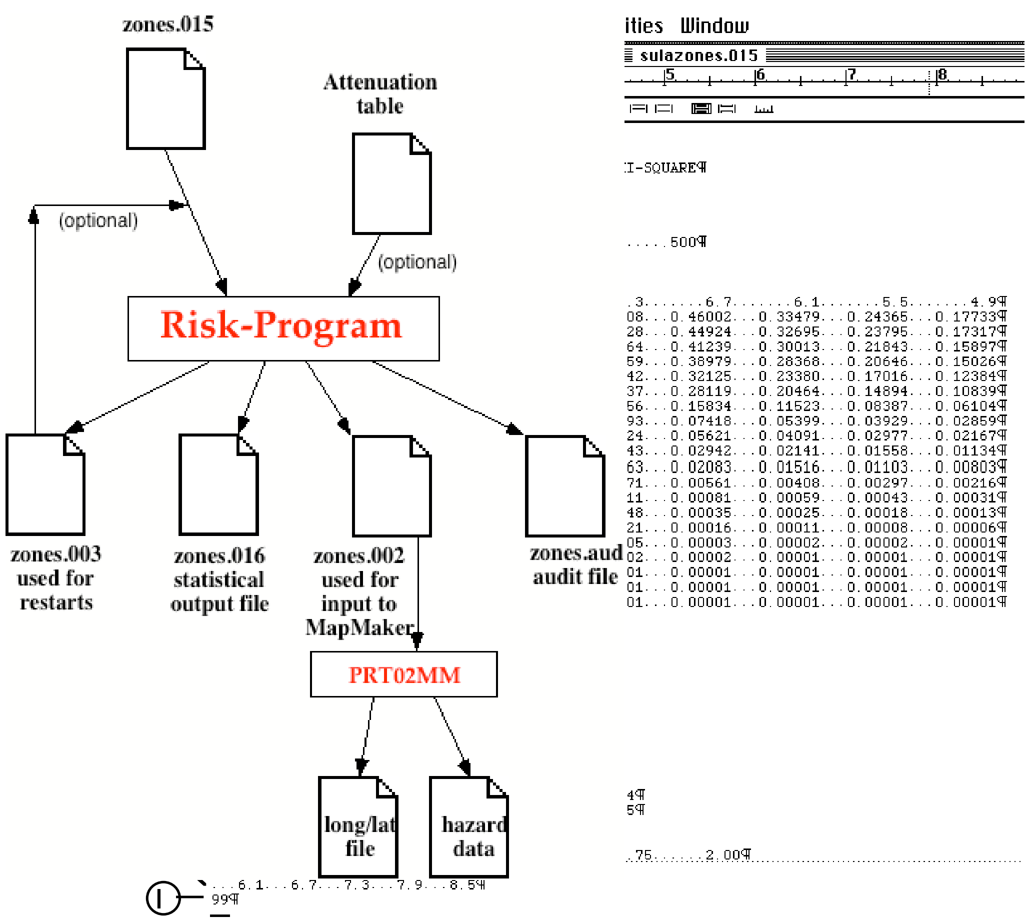
RISK-PROGRAM INPUT FORMAT

Having defined source zones and source faults if any, dipping planes if any, and determined seismic activity rates for the sources, the analyst is now ready to build the input file for the main seismic hazard program. Outputs from the various programs will be edited together in MICROSOFT WORD. Figure 26 shows the opened files that will need to be merged, (cut and paste) and edited to create the Risk-Program input file. (**A**) is sulazones.015, the file used as input to REGIONI (remember that initial Risk-Program input parameters have been provided but now **MUST** be changed to reflect the current mapping parameters). (**B**) is the complete attenuation table, here, a California-type attenuation for the United States has been selected. (**C**) is the fault from FAULTIN modeled within source area zone001. (**D**) is the output from WTBACK7 that contains annual earthquake-occurrence rates for the individual source zones. The leaders from file titles show the location of the respective pieces of information in the input (.015) file.



RISK-PROGRAM INPUT FILE

Below (figure 27) is the completed Risk-Program input data file named SULAZONES.015. The view is taken from the MICROSOFT-WORD editor with the entire document displayed in courier font. Notice that the input files in figure 26 are not in this font and columns of number and letter characters are not in alignment. This is the default font used by the editor when saving text files. When multiple files are being edited and merged into specific input formats, always select the entire document and apply the courier font so that all columns are aligned vertically. The input file is only briefly described here. Bender and Perkins (1987), and Appendix B, provide a detailed explanation of the input file format. **(A)** is three 3 lines of descriptive information concerning the file, (general location, type of attenuation, model description, etc.). **(B)**, line 5, is the probability level (.90), and, in this example, three (3) exposure times of 10, 50, and 250 years for which ground motions will be calculated. **(C)**,line 7, is the longitude-latitude points of the axis of the calculation area. **(D)**, line 9, is the upper-left and lower-right hand corner points that define the rectangular calculation area perpendicular to the axis, the last two numbers in this line define the grid spacing to be used, **(E)** is the attenuation table, in this case 8 columns by 20 rows. **(F)** is the source zone quadrilaterals from ZONEIN. **(G)** is the source zone seismicity rate and magnitude categories corresponding to the increment rates. **(H)** is the fault input sources and its corresponding rates and magnitudes, separated from the source area input by a "99". **(I)**, the second "99" at the end of the input file, is a data input termination indicator for the Risk-Program. Bender and Perkins (1987) describes the input parameters in detail.



The RISK-PROGRAM

The Risk-Program (figure 28) is now ready to be executed. The Risk-Program can have up to three separate input data files. The primary input file is the file with the ".015" file name extension, with two optional files, 1) an attenuation data file, and 2) a file containing some previously computed ground motions based upon some different modeling parameters. Notice that the primary input files' first name is applied to the first name of each of the four output files from the Risk-Program, only the file name extensions are different to distinguish the four files. The ".aud" file is simply an audit file containing a list of input modeling parameter changes from one run to the next run. This file is continuously appended with these changes and will grow in size with each execution of the Risk-Program. The file with the ".003" file name extension is a binary file containing the results of the previous computation of ground motions and can be used as input to the program for a successive execution of the Risk-Program (See Appendix C, Continuation Runs, for details on handling this file as input for a succeeding run). The output file with the ".002" file name extension is a binary file containing the results of the last computation of ground motions and is used as input to PRT02MM. The file with the ".016" file name extension is an ASCII output file containing the input parameters and, optionally, statistical information for every point for which ground motion values were computed (see Appendix D). The interactive window (figure 29) for the Risk-Program has for its primary input file, sulazones.015 (**A**), the file we have developed and edited throughout the preceding pages. At (**B**) the analyst may enter the name of a file containing any previously constructed attenuation table. Therefore, if the user wishes to make multiple hazard calculations at several sites, using the same input data but with different attenuation functions, the user may do so without having to re-edit the input data file to change the attenuation table. Simply answering the question at (**B**) with the file name of the file containing the new attenuation table will make it so. If the user wishes to use the attenuation data table that has previously been edited into the input file, just enter "default" as shown in this example. Bender and Perkins (1987) provide a detailed examination of the program operation and the input/output data and formats.

Figure-29 *User window showing input responses, in boxes, to the Risk-Program,* (**A**) *is the input file "sulazones.015" which contains all the location and execution parameters.* (**B**) *is the response for an attenuation table input file name. In this case, "default" indicates that the attenuation in the ".015" input file will be the used to compute ground motions.*

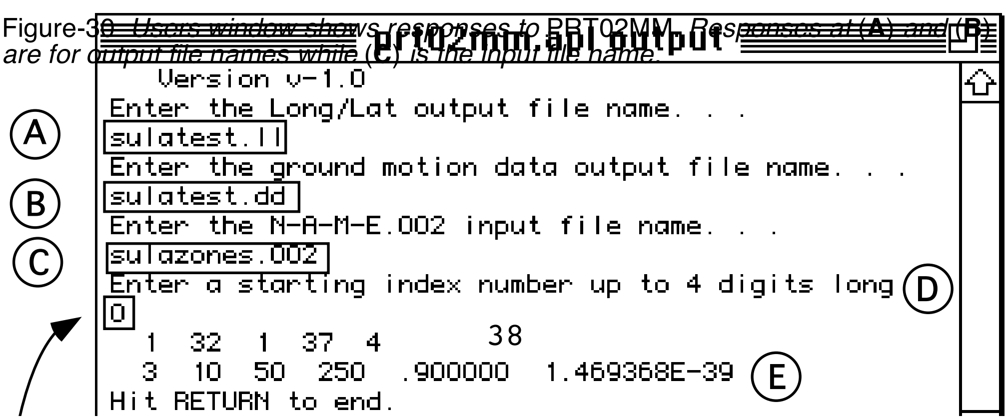
STEP 6

After computing the ground motions, the program PRT02MM is used to convert the binary output data from the Risk-Program into two ASCII files for input to MapMaker or Atlas-Pro so the data can be plotted.

PRT02MM

PRT02MM (figure 28) reads the binary output file from the Risk-Program (that is assigned a ".002" file name extension by the program) and creates two output files with user defined names needed by MapMaker or Atlas-Pro to plot the ground-motion values. (**A**) in figure 30 is a longitude-latitude file of the grid point at which the Risk-Program calculated ground-motion values. This file is assigned a ".ll" file name extension to show that it is a longitude-latitude file. (**B**) is a separate data file that contains the associated ground-motion values for each of the points in the ".ll" file in (**A**). The file (**B**) is assigned a ".dd" file name extension to indicate that it is the file containing only the ground-motion data values. The input file name (**C**) is the binary output file from the Risk-Program. This file will always have a ".002" file name extension. The command at (**D**), "Enter a starting index number up to 4 digits long" allows the analyst to set the starting index number for the consecutively ordered data points in the ".ll" file with the corresponding index number and ordered data points in the ".dd" file. Output ".ll" and ".dd" files from multiple runs of PRT02MM for the same mapping project should be assigned different first names, (such as AREA-1.ll, AREA-1.dd, AREA-2.ll, AREA2-.dd, etc.). The Risk-Program will compute approximately 1600 points in a single run before encountering problems with data dimension requirements. Some very large mapping projects (as the entire United States) could require as many as 25,000 data points for a $.25^{\circ}$X$.25^{\circ}$ grid spacing, so multiple runs of the Risk-Program would be required. The last two lines (**E**) are a reiteration of two lines of the input file (sulazones.002 in this case) showing the starting and ending rows and columns of the grid area and the number of exposure times, 3, what they are, 10, 50, and 250, and for what probability level the ground motions were calculated. The three exposure times are output to the ground motion data file as column headers. There are six columns of data output, the first three are the computed ground motions of each of the exposure times without attenuation variability, while the next three columns contain the ground motion data values computed with attenuation variability. Each of the column headings is labeled with the proper exposure time and **W/O** or **W** to indicate without and with attenuation variability.

Figure-30 *Users window shows responses to* PRT02MM. *Responses at* (**A**) *and* (**B**) *are for output file names while* (**C**) *is the input file name.*



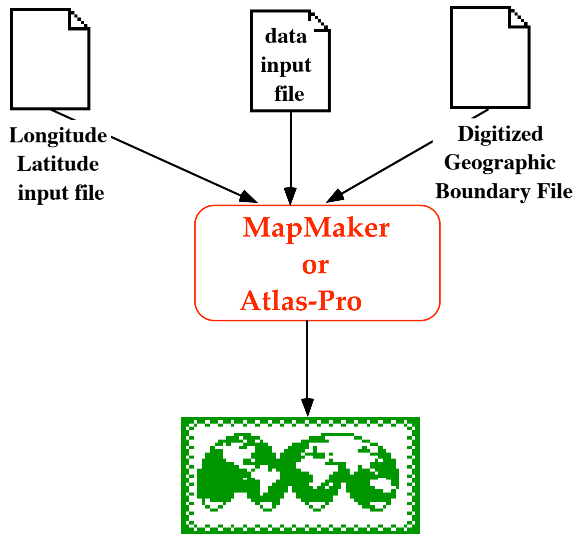


Figure-31 *Expanded view of the input and out files for the plotting software for step 6 of the overall system.*

Producing geographic plots of hazard data, epicenter data, etc., is achieved with the use of MapMaker or ATLAS-PRO (figure 31). Basically the inputs are: 1) a latitude, longitude location file, where each of the latitude-longitude pairs has associated with it an index number, 2) a data file containing the data to be plotted with a corresponding index number which relates to the latitude-longitude pairs in the location file, and 3) some geographical boundary file (optional). For a more detailed look at the inputs, outputs, and processing see Appendix C.

Appendix A

The allocation methods do not provide an allocation to zones which have had no historical earthquakes in the magnitude ranges being used. Although there is a statistical basis for such an allocation, there are problems in practice, which we will not go into here.

In the listing below, the manner in which the allocation fraction is calculated is given. Understand that the allocation fraction is given by the zone contribution divided by the total of all zone contributions. Next to the title of the method is the symbol that identifies the method in the program output.

1. Fractional total observed number of earthquakes (%T)

The zone contribution is simply the number of earthquakes observed within the magnitude category of a zone divided by total number of earthquakes observed within the ensemble set of zones. This allocation, suggested by Kalash Khattri in joint work with USGS staff on the probabilistic ground motion mapping in India, has been found by Bender (1983) to be the maximum likelihood allocation for perfect data. This method strikes many people familiar with Gutenberg-Richter relation curves as very counter-intuitive, there being no distinction made between the contributions from different magnitude categories. However, in our tests this method also appears optimal not only for perfect data but also for modeled imperfect data.

2. Minimum X^2 (%Chi2)

This method calculates a minimum X^2 a-value for the observed data, implicitly taking into account the uncertainty in the observed numbers. The a-value is used to obtain a number of earthquakes at magnitude 0, which is used as the contribution number. This method is nearly optimal, but is dominated by the maximum likelihood method, especially for sparse data.

3. Average of methods 1 and 2 (%TX2)

A compound method, averaging the allocation fractions of the total earthquake method, 1, and the minimum X^2 allocation method, 2.

4 Percent total area (%AREA)

An allocation method used only to find out the expected distribution of earthquakes if all zones had equal area-normalized rates of seismicity. This method is used to suggest whether an allocation seems to produce equal area-normalized rates.

Appendix B

SEISRISKIIIDP

A FORTRAN program for determining ground motions for use in seismic hazard mapping.

****
Allows locations of future earthquakes in seismic source zones to have a normal distribution
****

SEISRISKIIIDP is a revision of SEISRISK II, documented in Open File Report 82-293. The major change from SEISRISKIII is the additional capability of modeling dipping planes. See model description of SEISRISK III and additional documentation in USGS Bulletin 1772

Files:

file .015:	inputs
file .016:	outputs
file .002:	summary for plots--see text
file .003:	ground motions saved on file 03 for use in next run if next run is a continuation

Inputs:

Line #	Input
1.	**title**-up to 80 characters per line, **3 lines must** be used for documentation or left blank (free field)
4.	**isw, sigmax** (free field) isw = 0 new run (usual case) isw = 1 restart or continue from previous run sigmax = maximum standard deviation (km) for earthquake location variability in seismic source zones for this run.

5. **prob, ntims, jtim(1),jtim(2)....jtim(ntims)** (free field)
ground motion is sought for which there is probability 'prob' of not being exceeded in jtim(1), jtim(2), ...jtim(ntim) years

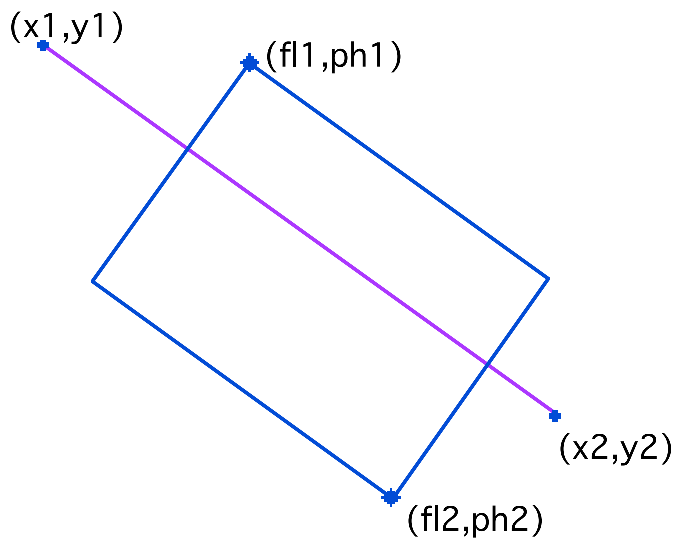
prob = extreme probability in <u>decimal</u>
ntims = number of times for which calculation is done
jtim(i) = duration (years) for which extreme motions are to be calculated at the prob probability level, $1 \leq i \leq$ ntims

6. **scale, dsw, sd, inos** (free field)

scale = scaling factor for ground motion boxes
= 1: for motions .02 to 1.0--scale accordingly
dsw = 1: if inputs are degrees and minutes
= 0 if inputs are decimal degrees
sd = standard deviation in log ground motion for ground motion variability around mean value
inos = 1: divide magnitude interval in half and do calculations at twice as many magnitudes (Assumes Gutenberg-Richter b-value is same for all intervals.)
= any number other than 1: do calculations for original magnitude intervals

7. **x1,y1, x2,y2** (long,lat) in decimal degrees (free field) transform great circle through (x1,y1), (x2,y2), to equator for new coordinate system

8. **fl1,ph1,fl2,ph2,phinc** (free field)
(fl1,ph1) upper left, (fl2,ph2) lower right (long, lat) corners of seismic felt region for risk computation. Rectangular region with sides parallel to arc of great circle through (x1,y1), (x2,y2) -- defined by 7. The other two sides are perpendicular and through given end points.



The area within rectangle represents the felt region.
Phinc (long,lat) is the increment in degrees (in new coordinate system) for which risk is to be computed and determines the size of the grid. For example if phinc = .25, ground motion will be computed at 16 sites per square degree.

9. **irow1, irow2, icol1, icol2** (free field)
Starting and ending rows and columns for this run. Ground motions computed for sites in these rows and columns--may be subset of seismic felt region defined in input 8.

10. **indv** (free field)
Number of line segments containing individual sites at which ground motion is to be computed; zero if only fixed grid is used. If indv > 0 read next inputs, otherwise skip to input 11.

nvs (free field) number of sites per line segment

xe1,ye1,xe2,ye2 (free field--indv lines, one pair per line) end points (long, lat) of line segment: sites will be evenly spaced on line in new coordinate system

NOTE: <u>SMOOTHING ONLY AVAILABLE FOR SITES ON A GRID, NO SMOOTHING OF GROUND MOTIONS AT SITES ON LINE FOR ACCELERATIONS FROM EARTHQUAKES WITHIN AERIAL SOURCE ZONES. CALCULATIONS FOR UNIFORM SEISMICITY ONLY AT THESE SITES.</u>

11. **jent,mdis** (free field)

jent	=	no of magnitudes for which ground motion is tabulated as a function of distance (maximum 8).
mdis	=	number of distances in attenuation table (maximum 20)

12. **nam, tm** (jent values of tm) (free field)

nam	=	identifier up to 10 characters-for example 'schn-seed' identifies attenuation curves used
tm	=	magnitude for which table of distance versus acceleration values follows (free field)

******<u>magnitudes must be in descending order</u>******

13. **rtab(i), (atab(i,j),j=1,jent)** (free field) (mdis lines, i=1,mdis)

rtab(i)	=	ith tabular distance in kilometers from earthquake source.
atab(i,j)	=	mean peak acceleration (or other ground motion parameter at i th distance for j th magnitude.

Source Area Inputs:

For each source deck :

1s. **num, yrnoc, iprint, totl, dumid, als, bls, sigls**

format(i2, f10.0, i2, f10.0, a4, 2f6.2, f5.2)

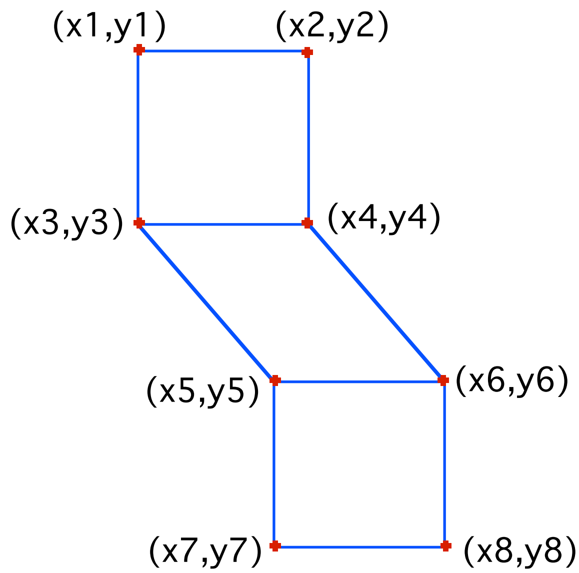
num	=	0 for source areas if no averaging for earthquake location uncertainty is to be done at end of ground motion computations for this source area
num	=	98 for source areas, if averaging for earthquake location uncertainty is to be done at end of computations for this source area
	=	99 first fault source and for first plane source, and after last plane source
	=	0 for all fault sets after 1st, and 0 for all planes after the 1st
yrnoc	=	number of years over which the earthquake occurrences take place
iprint	=	-1 no statistics for this (intermediate) set of occurrences
	=	+1 statistical calculations and printout (on output file - - - - .016)
	=	+2 same as +1 plus summary file for plot, etc. (on output file - - - - .002)
	=	+3 omit printout; do summary file for plot (on output file - - - - .002) totl ignored here but used for faults
dumid	=	four character identifier for source zone or fault
als	=	earthquake location uncertainty standard deviation in km; current value of als is ignored when num=0 bls, sigls ignored here but used for faults.

2s. **jseg,ifr,itot**

jseg	=	num of pairs of quadrilateral corner points in this source set (jseg-1 quads). seismicity to be apportioned by fractional area among itot sources.
ifr	=	set number (ifr =1,2...itot in sequence)
itot	=	total quad pairs for itot sources maximum 50

3s. **jseg** quadrilateral end-point (two points per line):

quad corner points (left long, left lat), (right long, right lat), in decimal degrees (if dsw=0) degrees, minutes (if dsw=1)



jseg = 4 in this example: quad end-point pairs are
(x1,y1)---(x2,y2)
(x3,y3)---(x4,y4)
(x5,y5)---(x6,y6)
(x7,y7)---(x8,y8)

Sub regions of a set are defined as shown. Sub regions of one set are separate from those of other sets

Repeat 2s, 3s for itot sources.

4s. **noc(l)** l=1,lev where lev is the number of siesmisity levels (lev=12f6.2) (lev=12 maximum)
Numbers of events expected in yrnoc years in each magnitude interval for earthquake occurrences.

5s. **fm(l)**, l=1,lev (12f6.2)
fm(l) = center of magnitude interval for which noc(l) occur

Repeat 1s. through 5s. for remaining sources.

Fault Inputs:

1f. **num, yrnoc, iprint, totl, dumid, als, bls, sigls**

Parameters defined as in 1s. above.

****Note****

num	=	99 for first fault,
	=	0 thereafter for successive faults als,bls,sigls are the rupture length parameters. If als, bls are non zero then:
length	=	10**(als +bls*m +fr*sigl)
where:		
m	=	magnitude;
sigl	=	standard deviation (in log length)
fr	=	(normally) 5 for values in range (-2,+2)

If sigl is non zero then

fr	=	0 (1 value)--mean rupture length only if sigl=0

If als,bls,sigls=0 (or blank) previous values are used.

If no previous values input, default values are used:

als	=	-1.085
bls	=	.389
sigls	=	.52

totl	=	distance between faults if this set of faults is a set of "dummy" faults used to approximate a uniform field of faults.
	=	0 if individual fault or a number of well defined faults are used.

Totl determines whether ground motions for a site are to be smoothed in distance or smoothed in magnitude
(smoothed in magnitude if totl=0)
(smoothed in distance (totl nonzero).

2f. **jseg, ifr, itot** (free field)

jseg	=	num of fault segment end points to be connected into single fault (jseg-1 segments)

ifr, itot as defined in 2s

3f. **(xl(i,ifr),yl(i,ifr), i=1,jseg)** (free field)

xl	=	long (degrees)
yl	=	lat (degrees) (ifr=fault number)
jseg	=	24 max
itot	=	26 max

4f. **noc(l)** same as in 4s.

5f. **fm(l)** same as 5s.

Repeat 2f, 3f for itot faults

Repeat 1f. through 5f. for remaining faults

End with num=99 (omit other inputs on line)

Plane Inputs

1p. **num, yrnoc, iprint, totl, dumid, als, bls, sigls**
Parameters defined as in 1s. above.

****

Note If there are no area sources in the input file there must be a line with num = 99 to signify the beginning of the fault sources.

Example: 99 (THAT'S ALL)

Likewise if there are no fault sources there must still be a line with num=99 to signify that the next line will be a plane source.

****

2p. Coordinates of shallow corners of plane
X1 Y1 X1 Y2 depthA (free field)

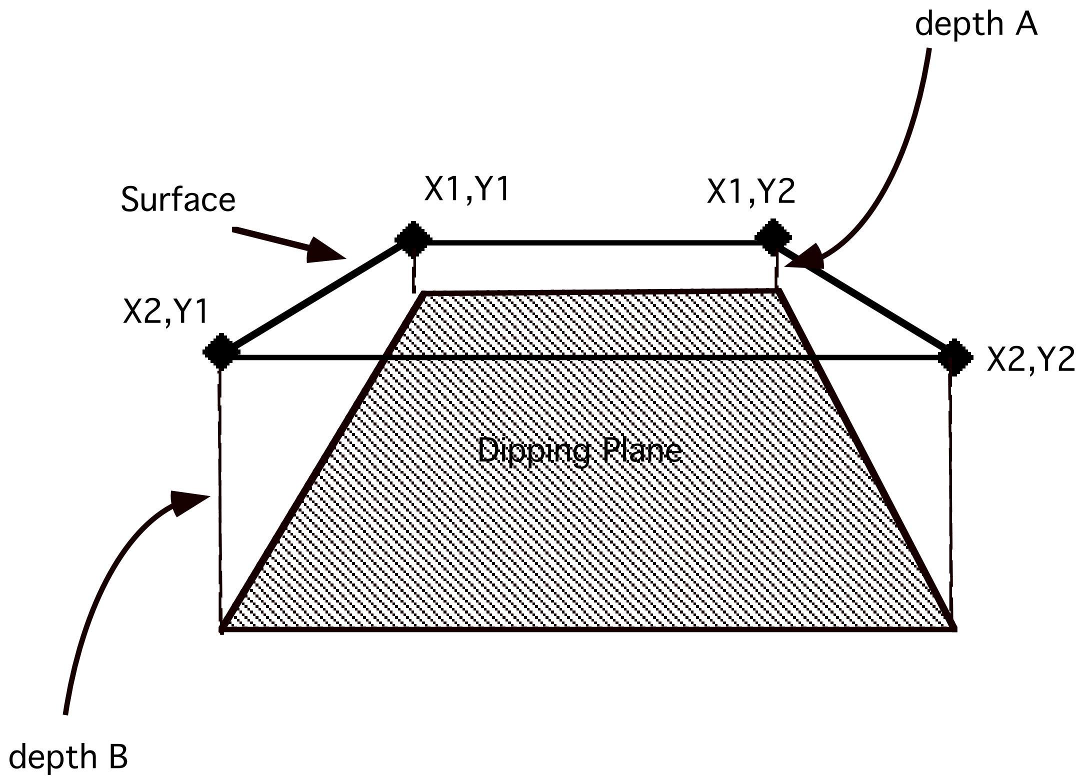
3p. Coordinates of deep corners of plane
X2 Y1 X2 Y2 depthB (free field)

4p. **noc(l)** same as in 4s.

5p. **fm(l)** same as 5s.

NOTE: ONLY ONE QUADRILATERAL IS USED TO DESCRIBE A DIPPING PLANE. SEISRISKIIIDP DOSE NOT SUPPORT LINKED QUADRILATERALS, AS WITH AREA SOURCES

.



ANATOMY OF A DIPPING PLANE
IN SEISRISKIIIDP

Appendix C

A Guide To Using SEISRISKIIIDP with MapMaker

__Selecting the Model Area__

The Equator

Using an Albers Equal Area Projection, draw a line connecting two identifiable points across the area for which you are computing ground motion. The ends must extend beyond the edge of the area.

- The data will be easier to read if the artificial equator is at some angle to the normal orientation of global latitudes and longitudes.

The Corner Points

Next you need to select the Upper Left and Lower Right corners of the model. SEISRISKIIIDP constructs a rectangular area with upper and lower sides parallel to the equator. (see below)

Computation Area

Once you have selected the ends of the Equator and the upper left and lower right corners of the grid, you will need to know exactly how many points there are. If you run the program for zero points (ie: 0 0 0 0 in line 9 of the input file) the .016 file will give you the number of rows and columns in the grid and also the area and earthquake rate per unit area for each source area.

SEISRISKIIIDP will compute ground motions for a maximum of 1600 points. If your grid is larger than that, you will need to do two or more runs to cover the area. For instance if there are 100 rows and 20 columns you might enter

1 20 1 50

in line 9 of the input file and save it as RUN1.015. Then you would change the first three documentation lines of the file and change line 9 to

1 20 51 100

and save the file as RUN2.015. In this way you would have a separate identifiable output file for each run. If you were to change only the starting and ending rows and columns and keep the same file name then the first output files would be overwritten by the second output files causing the data to be lost.

Text Files

Input files and Attenuation files must be in ASCII text file format! If you are using Microsoft Word save the file using the "**Save As...**" option. Click on the **File Format** button at the bottom of the File Manager dialog box. Then select **Text Only** in the File Format dialog box. Click "**Save**" to save the document with the current name or type in a new name to save the document as a copy of the original.

For other word processors, consult your users manual.

Inside/Outside Errors

The program tests each point on the grid to determine whether it is inside or outside a source area. If the position of the equator is such that a point is very close to the boundary of a source area, you may get an Inside or Outside error message at the bottom of your .016 file. Changing the coordinates for one end of the Equator one degree usually corrects the problem.

Running SEISRISKIIIDP

To run SEISRISKIIIDP on the Macintosh you just double click the mouse arrow on the SEISRISKIIIDP icon. The SEISRISKIIIDP Output screen will open and you will be prompted to select an input file. A typical Macintosh file menu will appear so that you may select from any folder or drive.

If you have the attenuation function within the input file (beginning on line 11), type "default" when prompted for an attenuation function file. Otherwise type in the name of the attenuation function located in the same folder as the input file. The first line of the attenuation file **MUST** contain the following information:

# of magnitudes, # of distances, scale, standard deviation, optional documentation.
Example:

8,20,.8,.64 Depth = 8.0 Kms for SOIL Boore&Joyner 1991

The format for the rest of the table is as follows:

line 2: (a10,m(6x,f4.1)

lines 1-d: (1x,f9.1,m(1x,f9.5))

Where:
(m = Number of Magnitudes, d = Number of Distances)

When the program comes to a normal completion, it asks if you would like to process another input file. Respond by answering "yes" or "no". If "yes", the program starts over prompting you for a new input file. If "no", the window closes and returns you to the Finder. The output files will be in the SEISRISKIIIDP program folder. The .016 output file is a text file which can be read with any word processing software. The program PRT02MM converts the .002 file to a text boundary file and data file for plotting ground motion data with MapMaker.

Continuation Runs

There are times when you may want to use different attenuation functions for some source areas affecting your computation grid. For these computations you will need to do continuation runs using the same equator, corner points, rows and columns, sigma, and scale factor. In short everything must be the same except the source areas and the attenuation functions. Pick a scale factor (scale on line 6) large enough to accommodate the largest ground motions and a standard deviation (sd on line 6) large enough to cover uncertainty in any of the attenuation functions that you are using. Remember to change isw on line 4 to "1" for the continuation run input files.

After running SEISRISKIIIDP for the initial input file (isw = 0) rename or copy the .003 file to match the prefix of the next continuation run. For example, if you start with a file called INITIAL.015 and the next set of inputs is called NEXTONE.015, you need to rename INITIAL.003 to NEXTONE.003 before running SEISRISKIIIDP with NEXTONE.015. That way the program will add to the ground motions from the first run.

PRT02MM

Before plotting data from SEISRISKIIIDP with MapMaker the .002 file must be reformatted and split into two text files: one containing identification numbers for each point and its coordinates, and a data file. The program Prt02MM creates these files according to the following format.

Coordinate File:

line 1: Feature ID#   Secondary Name   1(for point features)
line 2: Longitude   Latitude

The coordinates are in decimal degrees, negative for west longitudes and south latitudes. Each entry must be separated by a tab.

Data File format:

Feature ID #   Data   Data

Each line must begin with the feature identification number followed by the corresponding data for up to 30 categories. Again, all entries are separated by tabs.

Running Prt02MM

To launch the program, double click on its icon. A Prt02MM Output screen will open with a prompt for you to select an output file name for the latitudes and longitudes of the points that ground motion values have been computed. After supplying the file name the program prompts the user to supply a file name the ground motion data.
The next message is a prompt for a unique, up to a 5 digit, ID series number for this input data file. If you enter 10000 for instance, the first feature will be given the ID# 100001.

Some file statistics such as the beginning and ending rows and columns, sigma, the number of time intervals, the time intervals, and probability level will be printed on the screen. This gives you an indication of whether your inputs were correct or whether you have chosen the correct input file.

When the processing is completed successfully, you will be asked to enter a RETURN to exit the program.

<u>The Identification Number</u>

The ID series that you choose for a file does require some thought. How is this point file going to be used, by itself or in conjunction with other point sets? Are there multiple data sets that correspond to this same set of points? How large is this set of points? Once you have answers to all these questions you will be able to select a good ID series number.

Since MapMaker assigns data values to points according to the ID#, it must be unique to the ground motion model that you are creating. If you have two parts of a grid that you will plot on one map, they need to have a different ID# series <u>that will not overlap.</u> With two sets of 300 points you could give the first set an ID series of 100 and the second set an ID series of 400. However, if there were 301 in the first set you would overwrite the data on the last point of the first set when ever you made a map with both sets.

On the other hand, if you are using one set of points with different data sets, you <u>should</u> use the same ID# series each time you run Prt02MM for that set of points. Then you can create one boundary file for the set of points that can be used with any of the data sets. In which case you would throw out the extra longitude/latitude files that would be created with each data set.

<u>Plotting Data with MapMaker</u>

Creating a Boundary File

For convenience, you may want to move your longitude/latitude and .ground motion data files from the SEISRISKIIIDP folder to the MapMaker or Atlas-Pro folder. Holding down the "Shift" key will allow you to select several files. Then, with the shift key off and the mouse button down, drag any highlighted files onto the MapMaker folder. When the proper folder icon is highlighted, release the mouse button and the files that you had selected will be inside that folder.
The basic concepts of the two programs are the same, you first create boundary files for **MapMaker**, and geography files for **Atlas-Pro**. These files contain the geographical points to be plotted. If desired, these files may be placed in different layers, the geographic data in the base layer and other files into other layers as necessary. Next the actual data to be plotted is imported to the proper layer. Finally, select the category to be plotted, the symbols to show, latitude/longitude lines, etc. to polish the map.
The differences between **MapMaker** and **Atlas-Pro** are only in the location and in some cases the nomenclature of the pull down menu instructions. With the help of this manual and the plotting manual the user should have no trouble in designing and plotting the maps.

1. Open the MapMaker folder by double clicking on the folder icon. Then launch **MapMaker** by double clicking on the program icon. A white screen will open with a menu bar across the top and tool icons down the left side.

2. The first step is to convert your longitude/latitude file of points into a boundary file that MapMaker can use to plot points on the screen. Click on the **File** menu at the top left corner. While holding down the mouse button, drag the arrow down the menu till it highlights the words "**Convert Boundary Files**" then release the mouse button.

3. A dialog box will appear with options for converting boundary files. All of these options will be helpful at one time or another but right now we want to **convert text files to boundary files**. This is the default option so just click the "**OK**" box.

4. The coordinates from PRT02MM are in Lat/Long so in the next dialog box click "**OK**".

5. Now yet another dialog box opens asking you what projection you want. For smaller areas the default option, **None, just use Lat/Long**, is fine, but if you are mapping a large area, like the United States, you may want to choose your favorite projection. Keep in mind that you must use the same projection for the point features that you will be using for your base map. For now just click "**OK**" and we will use Lat/Long.

6. Finally you are finished with dialog boxes for awhile, now you have a file menu. MapMaker is asking you which file you want to convert to a

boundary file. Double click on the longitude/latitude file that you created in Prt02MM.

7. Now you have another file menu, only some of the names are grayed. **Type in a file name** for your boundary file. If you want it to be in a particular folder, open that folder by double clicking on the folder name then click on the "**Save**" box.

8. The screen will go white and you will be back in MapMaker, and you are ready to build a map.

Creating a Map

1. Under the "**Display**" menu, there is an item called "**Set Map Size**". Select this item to see what size your map is set for. MapMaker can create maps as large as 10 by 10 pages. Printing is another matter though. Printers will only print one page at a time, so you will have to paste the pages together if you want a larger map.

2. When you have made sure of the map size, choose "**New**" from the "**File**" menu. A dialog box will appear asking you whether you want to save the map you have created or discard it. If you have made a map already and want to save it, now is the time to do it. If you have not yet made a map do not worry, MapMaker always gives you this dialog box when you choose "New" after changing the page size or page setup. You can choose "discard" if you have done nothing more important. Your page setup and page size will still apply to your new map.

3. A dialog box will open giving you 4 options for selecting boundary files. Which you choose depends on how many boundary files you will use and whether you need to select portions of them or the whole thing. For instance if you wanted to make a map of Indonesia with a grid of points for which you have calculated ground motion, you would choose the fourth button: **Select a few areas from several boundary files**. That is what we want to do now. But do not click "OK" yet!

4. There is one more item in this dialog box that we need to think about. Under the "OK" button there is a little box that is automatically checked. It says "**Filter Points**". If you leave this box checked, the points that fall outside a rectangle enclosing your base map will be filtered out. You have to decide if this is what you want. If you want to see ground motion points outside your study area, you will want to un-check this box.

5. Now click "**OK**".

6. The file menu will reappear for you to **select the boundary file** you want to include first. It does not matter whether you select the base map or

point features first. If you want to go to a different folder than the one in the heading box, click on the heading box and hold the mouse button down. A hierarchy of folders ending with the name of your hard disk will appear. Drag the cursor to the name of the folder you want and let up the mouse button. The contents of that folder will appear in the file menu. **Double click on the boundary file name** you want.

7. MapMaker allows you to **assign boundary files to layers** so you can change line weight, text, color etc. to separate portions of your base map. Now is the time to decide if you want different layers. If you do not want layers, or if you are adding your base map boundary at this time, click "**Add Boundary**", since base map layer is already selected.

8. Now you are back to the file menu to make further boundary file selections. If you selected the first option in step 3, you would be finished but we still need our grid points. So **select your point feature boundary file** (or your base map file if you selected your point feature boundary file in step 6). **Repeat step 7**. Continue with steps 6 and 7 until you have selected all of the boundary files you want.

9. When you have selected the last boundary file choose **"Done"** when you get to the Boundary Layer dialog box.

10. Now you have a dialog box asking which features you want from the first boundary file that you selected. Use the shift key with the mouse button to select a range of features, and the command key (with the apple) with the mouse button to make multiple selections. When finished, click "**OK**".

11. The next window is very important. It allows you to size and position your map on the page, or pages. Since you can not move your map once it is on the screen, take care to get it right, or you will have to start all over again! When you have the rectangle the way you want it, click "**OK**".

12. Now MapMaker will go through all of the boundary files that you selected asking you which features you want. You can "**select all**" or only the ones you want. When MapMaker is finished with the last boundary file, your map will appear on the screen. You should have a regular grid of points somewhere and a legend with boxes and point symbols - all data divisions should be 0.00 - 0.00.

Importing Data

1. Now that we have a base map, we want to import our data. To do this go into the "**File**" menu and drag the cursor down to "**Import Data**" and release the mouse button. The dialog box will appear asking what sort of data you are going to import and if it will have category headings.

Prt02MM does not supply category headings, so choose "**data values only**" and click **"OK"**. You can add the headings later.

2. The File menu returns for you to show MapMaker where the data file is. **Double click on the name of your data file**. Remember you can go into different folders by holding the mouse button down on the heading folder name and dragging down to the folder you want.

3. That is it. MapMaker takes over. You know it is reading your data because you can see the feature numbers spinning by in the window. It does take some time to read large files. If you have files with more than 1000 features, you should break them up into smaller files. Keep in mind that **you can read in files as long as they are for different features**. If you have data files for the same set of features, save your map then read in the next set and save the map again with a different name (**save as** under the "File" menu).

Finishing the Map

1. Once you have read in data, you will notice the point features change, and the data divisions in the legend take on values. These will not be meaningful data divisions so you will want to change them later. First you need to label your categories. Select "**Data Values**" from the "**Assign**" menu. A dialog box will appear with the names of all the features of your map, select one of the point features and click on "**OK**". This will produce a data entry box. Under <u>**Category Names**</u> you may enter your category names. But what are they you may ask!

   You will have twice as many categories as time periods on line 5 of your SEISRISKIIIDP inputs. For example if on line 5 you have:

   .9 3 10 50 250

   there will be six categories in your MapMaker data file. The first three will be 10, 50, and 250 years <u>without variability</u>, and the last three will be 10, 50, and 250 years <u>with variability</u>. Type in these names here then click "**OK**" (not, "OK, Next").

2. Now, under the "**Categories**" menu you will have your 6 category names and 24 unnamed categories. To plot any of the categories you merely have to drag the cursor down to the category name and release the mouse button and MapMaker will re-plot the new category.

3. Select "**View Data Statistics**" under the "**Assign**" menu, a window will open with the vital statistics for the plotted category. With this information you can decide on some meaningful data divisions. If you are going to contour the map you will want to use your contour intervals. Next select "**Data Divisions**" from the "**Assign**" menu. The dialog box will ask how may divisions you want and how to divide the data up among them. There are three methods, you can try the first two to see what effect the have or you can choose "**manual entry**" to define your own divisions.

4. When "<u>**manual entry**</u>" is selected, another dialog box appears with windows for you to **enter your division limits for the lowest division**, and so on till you reach the number specified in step 3. Then the map will be re-plotted.

5. You can change many aspects of your map under the "**Assign**" menu. I suggest you try all of the items to see what they do.

6. You can get rid of the little boxes in your legend by selecting "**Select Area Features**" under the "**Display**" menu. A Dialog box with three different aspects will appear, the "<u>**Pattern Fill**</u>" box is automatically checked. Un-check it and the pattern fill boxes will disappear from the legend.

7. You can change the legend by selecting "**Edit Legend**" under the "**Edit**" menu.

8. If you want to display the data values for each point, select "**Global Text Change**" from the "**Display**" menu. In the dialog box that appears there is an item called "**Data Value Labels**", select this. Yet another dialog box appears with aspects of the data value labels that can be altered. Click the "**Show**" button to show them, the "**Hide**" button to hide them. The data values will be plotted above the point symbol. They cannot be moved so keep in mind that the <u>point symbol</u> is the location of the value.

9. Try all of the items in all of the menus and do read the manual as it has some helpful examples.

10. Do not worry. This is really simple once you get familiar with all of the dialog boxes. MapMaker is very useful for showing data for areas as well as points.

Appendix D

RISK-PROGRAM HARD-COPY OUTPUT

The following pages are actual hard-copy output from the Risk-Program for four points modeled off of the western coast of Sulawesi, Indonesia with the example inputs that we have been using throughout this manual and through all of the Macintosh II programs. Of course, the points are just tests and have not been generated using an appropriate ground-motion attenuation or carefully scrutinized earthquake occurrence rates. It can be seen on the first page of the listing that the ground-motion values were calculated at the .9 level extreme probability (90% nonexceedance probability) for exposure times of 10, 50, and 250 years and modeled both with and without statistical variability in the ground-motion attenuation function. These are the standard calculations performed at the USGS for national ground-motion hazard maps of the United States.

The ground motion values will be computed for a grid of points on a .5 degree grid (lines 19-20) oriented on an artificial equator that passes through the points 118.0 longitude, 4.0 latitude and 128.0 longitude, -4.0 latitude (line 16), and whose upper left hand corner point is at 119.0 longitude, 0.0 latitude and lower right hand corner point is at 127.0 longitude, 0.0 latitude (lines 17-18). Notice the output indicates the total number of rows and columns the grid area occupies. In this example we have asked to start at row 1 and end at row 2 and to start at column 1 and end at column 2 giving us the first four points of the grid in the upper left hand corner.

The top half of the next page is a reiteration of the input sources and their rates with some additional information the Risk-Program computes. The bottom half of this page and the remaining pages show the (optional) statistical information for each point the program was asked to compute.

The actual ground motions are given as a fraction of the acceleration of gravity (g). For example, for the first point, without attenuation variability, the ground motions are calculated to be .038 g, .260 g, and .694 g at a 90% probability of not being exceeded in 10, 50 and 250 years, respectively. Equivalently, the ground-motion values can be stated as 3.8% g, 26.0% g and 69.4% g for their respective exposure times. As referenced earlier in this manual, Bender and Perkins (1987) provide a detailed explanation of the output files from the Risk-Program.

```
 Attenuation is contained in input file (.015)
Run Started on: 03/11/1992
            at: 16:05:35

 Sulawesi test input file example 1
 California attenuation input file ACCJNB.DAT
 input files: rates from WTBACK.OUT using the CHI-SQUARE
 Maximum sigma for earthquake location smoothing=   .00
 isw=0: new run--no previous results included
 extreme probability   .900
   for exposure times (years)    10   50  250
 scale factor for ground motion "box" levels and  variability in attenuation sigma
 now on attenuation table (values read in here are ignored)
 coordinates input in decimal degrees
    coordinates are printed in decimal degrees
 grid oriented parallel to great circle throu ( 118.00,  4.00),( 128.00, -4.00)
 corners of gridded area-upper left= 119.00,    .00
                       lower right= 127.00,    .00
 longitude increment=  .5000 (decimal degrees)
 latitude increment =  .5000 (decimal degrees)
 gridded region contains  11 rows,   13 cols including border    0 rows and cols
 for this run begin at row   1 end row   2, begin col   1 end col   2
 new coordinates (km) gridded area
       upper left=  1059.95   364.90; lower right=   278.51  -278.51
 sites are also located on   0 line(s)
 Attenuation function: test        box scale factor=  1.00  ln-gm variability= .640
                              magnitude
```

	dist(km)	.00	8.50	7.90	7.70	7.30	6.70	6.10	5.50
,	1.00	.78322	.78222	.78122	.63208	.46002	.33479	.24365	.17733
,	2.00	.76492	.76392	.76292	.61728	.44924	.32695	.23795	.17317
,	4.00	.70233	.70133	.70033	.56664	.41239	.30013	.21843	.15897
,	5.00	.66396	.66296	.66196	.53559	.38979	.28368	.20646	.15026
,	8.00	.54757	.54657	.54557	.44142	.32125	.23380	.17016	.12384
,	10.00	.47953	.47853	.47753	.38637	.28119	.20464	.14894	.10839
,	20.00	.27089	.26989	.26889	.21756	.15834	.11523	.08387	.06104
,	40.00	.12798	.12698	.12598	.10193	.07418	.05399	.03929	.02859
,	50.00	.09746	.09646	.09546	.07724	.05621	.04091	.02977	.02167
,	80.00	.05197	.05097	.04997	.04043	.02942	.02141	.01558	.01134
,	100.00	.03738	.03638	.03538	.02863	.02083	.01516	.01103	.00803
,	200.00	.01153	.01053	.00953	.00771	.00561	.00408	.00297	.00216
,	400.00	.00338	.00238	.00138	.00111	.00081	.00059	.00043	.00031
,	500.00	.00059	.00059	.00059	.00048	.00035	.00025	.00018	.00013
,	600.00	.00026	.00026	.00026	.00021	.00016	.00011	.00008	.00006
,	800.00	.00006	.00006	.00006	.00005	.00003	.00002	.00002	.00001
,	900.00	.00003	.00003	.00003	.00002	.00002	.00001	.00001	.00001
,	1000.00	.00001	.00001	.00001	.00001	.00001	.00001	.00001	.00001
,	1500.00	.00001	.00001	.00001	.00001	.00001	.00001	.00001	.00001
,	3000.00	.00001	.00001	.00001	.00001	.00001	.00001	.00001	.00001

```
0yrnoc=     1. iprint=-1 for area z001
,   122.750    -3.200   123.250      .000
,   119.250    -1.500   120.250    -1.000
,   119.250     2.000   120.250     2.000
 nr of levels of seismicity =  3
 z001 beta= -3.0669
 earthquake rate/year
 occurrences= 42.202000  6.702000  1.087000
  magnitudes=      4.30      4.90      5.50
,z001 area=  118060. sq km, rate/sq km= 0.35746E-03 for mags  4.00- 4.60
0yrnoc=     1. iprint=-1 for area z002
,   120.250     2.000   120.250    -1.000
,   124.000     2.000   122.000    -2.000
,   126.000     2.000   126.000    -2.000
 nr of levels of seismicity =  8
 z002 beta= -3.0667
 earthquake rate/year
 occurrences=190.800000 30.300000  4.910000   .802000   .131000   .021000   .003000   .000400
  magnitudes=      4.30      4.90      5.50      6.10      6.70      7.30      7.90      8.50
,z002 area=  274158. sq km, rate/sq km= 0.69595E-03 for mags  4.00- 4.60
0yrnoc=     1. iprint= 2 for area ft01
 Distance between dummy faults=   .0
 fault  1 of  1
,    122.25   -3.40,    119.75   -1.25,    119.75    2.00,
 nr of levels of seismicity =  5
 ft01 beta= -3.0182
 earthquake rate/year
 occurrences=   .178000   .029000   .005000   .001000   .000200
  magnitudes=      6.10      6.70      7.30      7.90      8.50
 fault rupture length parameters al= -1.085 bl=   .389  sigl=   .52
 site at long  119.000, lat    0.000
 shortest dist to fault=   83.604 km
         zero attenuation variability                 variability in atten, sigma=  .64
    g.m.   occ/yr    exc/yr  r(events) r(yrs)     g.m.   occ/yr    exc/yr  r(events) r(yrs)
,     .02277.11270   .06824  4061.8    14.7         .02276.77444   .40645   681.9     2.5
,     .04   .05948   .00876 31643.8   114.2         .04   .33180   .07465  3713.0    13.4
,     .06   .00212   .00664 41758.0   150.7         .06   .05029   .02436 11376.3    41.0
,     .08   .00113   .00550 50356.5   181.7         .08   .01263   .01174 23618.2    85.2
,     .10   .00083   .00467 59291.1   213.9         .10   .00436   .00737 37590.4   135.6
,     .12   .00054   .00414 66995.1   241.7         .12   .00191   .00546 50746.3   183.1
,     .14   .00047   .00367 75558.3   272.6         .14   .00101   .00445 62301.7   224.8
,     .16   .00036   .00331 83660.2   301.8         .16   .00063   .00382 72554.2   261.8
,     .18   .00031   .00301 92168.6   332.5         .18   .00044   .00338 81910.0   295.5
,     .20   .00029   .00272 99999.9   367.9         .20   .00033   .00305 90795.0   327.6
,     .22   .00019   .00253 99999.9   395.8         .22   .00027   .00279 99459.1   358.8
,     .24   .00018   .00234 99999.9   426.8         .24   .00022   .00257 99999.9   389.8
   total yearly events  277.18093               total yearly events  277.18090

         zero attenuation variability                 variability in atten, sigma= .64
      .900 ext prob =   .038 for    10 years                    .085 for   10 years
      .900 ext prob =   .260 for    50 years                    .294 for   50 years
      .900 ext prob =   .694 for   250 years                    .933 for  250 years
   ratio  250 yr  .900 extreme value to   10 yr val=  18.18         11.03
  119.000    0.000    .0382    .2604    .6937    .0846    .2937    .9333
```

site at long 119.390, lat -.312
shortest dist to fault= 40.171 km

	zero attenuation variability					variability in atten, sigma= .64				
	g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
,	.02	275.92282	1.25805	220.3	.8	.02	275.49603	1.68484	164.5	.6
,	.04	.85457	.40348	687.0	2.5	.04	1.03998	.64485	429.8	1.6
,	.06	.25080	.15267	1815.5	6.5	.06	.32245	.32241	859.7	3.1
,	.08	.09504	.05763	4809.7	17.4	.08	.13909	.18332	1512.0	5.5
,	.10	.03926	.01837	15085.6	54.4	.10	.07028	.11304	2452.0	8.8
,	.12	.00797	.01040	26644.7	96.1	.12	.03914	.07390	3750.7	13.5
,	.14	.00346	.00694	39934.9	144.1	.14	.02333	.05057	5481.1	19.8
,	.16	.00126	.00568	48827.5	176.2	.16	.01464	.03593	7714.9	27.8
,	.18	.00096	.00472	58773.2	212.0	.18	.00957	.02636	10514.5	37.9
,	.20	.00044	.00428	64764.7	233.7	.20	.00647	.01990	13931.7	50.3
,	.22	.00039	.00389	71321.7	257.3	.22	.00450	.01540	18000.9	64.9
,	.24	.00034	.00355	78170.7	282.0	.24	.00321	.01219	22734.0	82.0
,	.26	.00032	.00322	86035.9	310.4	.26	.00234	.00985	28129.5	101.5
,	.28	.00021	.00301	92159.1	332.5	.28	.00174	.00811	34165.5	123.3
,	.30	.00022	.00278	99596.5	359.3	.30	.00132	.00679	40806.9	147.2
,	.32	.00025	.00253	99999.9	395.0	.32	.00102	.00577	48001.6	173.2
,	.34	.00018	.00235	99999.9	425.8	.34	.00080	.00498	55706.7	201.0
,	.36	.00013	.00221	99999.9	451.7	.36	.00064	.00434	63872.9	230.4
,	.38	.00017	.00204	99999.9	490.0	.38	.00051	.00383	72454.2	261.4
,	.40	.00014	.00190	99999.9	526.6	.40	.00042	.00340	81410.2	293.7
,	.42	.00010	.00179	99999.9	557.2	.42	.00035	.00306	90708.1	327.3
,	.44	.00015	.00164	99999.9	608.2	.44	.00029	.00276	99999.9	361.9

total yearly events 277.18090 total yearly events 277.18090

	zero attenuation variability	variability in atten, sigma= .64
.900 ext prob =	.119 for 10 years	.254 for 10 years
.900 ext prob =	.367 for 50 years	.501 for 50 years
.900 ext prob =	.757 for 250 years	1.112 for 250 years
ratio 250 yr .900 extreme value to 10 yr val=	6.34	4.38

119.390	-.312	.1194	.3670	.7569	.2537	.5013	1.1120

site at long 119.312, lat .390
shortest dist to fault= 48.799 km

	zero attenuation variability					variability in atten, sigma= .64				
	g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
,	.02	276.17830	1.00256	276.5	1.0	.02	275.76123	1.41957	195.3	.7
,	.04	.68086	.32170	861.6	3.1	.04	.89083	.52874	524.2	1.9
,	.06	.18375	.13796	2009.2	7.2	.06	.26438	.26436	1048.5	3.8
,	.08	.08370	.05426	5108.4	18.4	.08	.11276	.15161	1828.3	6.6
,	.10	.03754	.01672	16575.6	59.8	.10	.05713	.09448	2933.8	10.6
,	.12	.00749	.00923	30025.6	108.3	.12	.03208	.06240	4442.3	16.0
,	.14	.00320	.00603	45966.1	165.8	.14	.01931	.04308	6433.6	23.2
,	.16	.00115	.00488	56745.1	204.7	.16	.01224	.03084	8986.8	32.4
,	.18	.00089	.00399	69432.6	250.5	.18	.00807	.02277	12171.7	43.9
,	.20	.00038	.00362	76647.0	276.5	.20	.00550	.01727	16047.8	57.9
,	.22	.00032	.00330	84054.7	303.2	.22	.00385	.01342	20656.3	74.5
,	.24	.00031	.00299	92716.4	334.5	.24	.00276	.01065	26014.6	93.9
,	.26	.00022	.00277	99999.9	360.9	.26	.00203	.00863	32125.9	115.9
,	.28	.00019	.00258	99999.9	387.5	.28	.00152	.00711	38970.7	140.6
,	.30	.00018	.00240	99999.9	416.2	.30	.00115	.00596	46514.1	167.8
,	.32	.00019	.00221	99999.9	452.8	.32	.00089	.00507	54701.0	197.3
,	.34	.00016	.00204	99999.9	489.2	.34	.00070	.00437	63485.6	229.0
,	.36	.00014	.00190	99999.9	525.3	.36	.00056	.00381	72813.2	262.7
,	.38	.00010	.00180	99999.9	554.6	.38	.00045	.00335	82631.4	298.1
,	.40	.00015	.00165	99999.9	604.2	.40	.00037	.00298	92893.4	335.1
,	.42	.00009	.00156	99999.9	640.1	.42	.00031	.00268	99999.9	373.6
	total yearly events 277.18081					total yearly events 277.18081				

	zero attenuation variability		variability in atten, sigma= .64	
.900 ext prob =	.115	for 10 years	.241	for 10 years
.900 ext prob =	.327	for 50 years	.470	for 50 years
.900 ext prob =	.749	for 250 years	1.049	for 250 years
ratio 250 yr .900 extreme value to 10 yr val=	6.49		4.35	

119.312 .390 .1154 .3269 .7490 .2411 .4697 1.0485

site at long 119.702, lat .078
shortest dist to fault= 5.365 km

	zero attenuation variability					variability in atten, sigma= .64			
	g.m.	occ/yr	exc/yr	r(events)	r(yrs)	g.m.	occ/yr	exc/yr	r(events)	r(yrs)
,	.02	275.61651	1.56438	177.2	.6	.02	274.88830	2.29253	120.9	.4
,	.04	1.12986	.43451	637.9	2.3	.04	1.48114	.81139	341.6	1.2
,	.06	.26316	.17135	1617.6	5.8	.06	.42081	.39058	709.7	2.6
,	.08	.09770	.07365	3763.5	13.6	.08	.17067	.21992	1260.4	4.5
,	.10	.04067	.03298	8403.3	30.3	.10	.08286	.13706	2022.4	7.3
,	.12	.00893	.02406	11521.7	41.6	.12	.04507	.09199	3013.2	10.9
,	.14	.00436	.01969	14074.8	50.8	.14	.02656	.06543	4236.0	15.3
,	.16	.00211	.01759	15761.5	56.9	.16	.01664	.04879	5680.8	20.5
,	.18	.00180	.01579	17557.9	63.3	.18	.01095	.03784	7324.5	26.4
,	.20	.00191	.01388	19970.6	72.0	.20	.00751	.03033	9138.9	33.0
,	.22	.00074	.01314	21095.6	76.1	.22	.00534	.02499	11092.6	40.0
,	.24	.00035	.01279	21670.7	78.2	.24	.00392	.02107	13154.9	47.5
,	.26	.00107	.01172	23641.2	85.3	.26	.00296	.01811	15303.1	55.2
,	.28	.00110	.01063	26081.3	94.1	.28	.00229	.01582	17519.1	63.2
,	.30	.00076	.00987	28093.9	101.4	.30	.00182	.01401	19790.7	71.4
,	.32	.00070	.00917	30228.7	109.1	.32	.00147	.01254	22108.6	79.8
,	.34	.00074	.00843	32893.6	118.7	.34	.00121	.01133	24472.8	88.3
,	.36	.00074	.00768	36080.2	130.2	.36	.00102	.01031	26884.2	97.0
,	.38	.00055	.00713	38883.6	140.3	.38	.00086	.00945	29345.5	105.9
,	.40	.00064	.00649	42701.0	154.1	.40	.00075	.00870	31861.6	114.9
,	.42	.00045	.00604	45889.8	165.6	.42	.00065	.00805	34437.9	124.2
,	.44	.00051	.00553	50142.1	180.9	.44	.00057	.00748	37080.6	133.8
,	.46	.00039	.00513	54000.0	194.8	.46	.00051	.00697	39796.2	143.6
,	.48	.00037	.00476	58215.8	210.0	.48	.00046	.00651	42591.4	153.7
,	.50	.00033	.00443	62617.1	225.9	.50	.00041	.00610	45462.2	164.0
,	.52	.00039	.00404	68623.2	247.6	.52	.00037	.00572	48426.2	174.7
,	.54	.00038	.00366	75690.2	273.1	.54	.00034	.00538	51489.6	185.8
,	.56	.00026	.00340	81593.4	294.4	.56	.00031	.00507	54658.6	197.2
,	.58	.00031	.00308	89893.7	324.3	.58	.00029	.00478	57939.4	209.0
,	.60	.00023	.00286	97058.8	350.2	.60	.00027	.00452	61338.1	221.3
,	.62	.00023	.00263	99999.9	380.2	.62	.00025	.00427	64860.7	234.0
,	.64	.00026	.00237	99999.9	422.4	.64	.00023	.00405	68513.2	247.2
,	.66	.00022	.00215	99999.9	464.7	.66	.00021	.00383	72301.6	260.8
,	.68	.00020	.00195	99999.9	511.7	.68	.00020	.00364	76231.8	275.0
,	.70	.00020	.00175	99999.9	571.3	.70	.00018	.00345	80309.8	289.7
,	.72	.00017	.00158	99999.9	634.4	.72	.00017	.00328	84541.7	305.0
,	.74	.00018	.00140	99999.9	716.6	.74	.00016	.00312	88933.6	320.9
,	.76	.00011	.00128	99999.9	779.5	.76	.00015	.00296	93491.5	337.3
,	.78	.00015	.00114	99999.9	879.8	.78	.00014	.00282	98221.6	354.4
,	.80	.00016	.00098	99999.9	1021.7	.80	.00013	.00269	99999.9	372.1

total yearly events 277.18090 total yearly events 277.18084

	zero attenuation variability	variability in atten, sigma= .64
.900 ext prob =	.280 for 10 years	.355 for 10 years
.900 ext prob =	.655 for 50 years	.903 for 50 years
.900 ext prob =	.880 for 250 years	1.718 for 250 years
ratio 250 yr .900 extreme value to 10 yr val=	3.14	4.83

119.702 .078 .2799 .6552 .8800 .3554 .9033 1.7178

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