APPLICATION OF AN INTERNATIONAL DATA BASE FOR ANALYZING EARTHQUAKE STATISTICS

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ABSTRACT

This paper demonstrates some applications of an international data base for significant earthquakes. The prime focus is for determining statistics about earthquakes on an international level. Apparent trends which indicate some elements of periodicity in earthquakes are demonstrated. The value and limitations of the data base are also discussed.

INTRODUCTION

The National Geophysical Data Center (NGDC) has an impressive data base of earthquakes available at a nominal cost. The version discussed below was the most recent version at the time this paper was written (Dunbar 1992).

In this paper, the purpose of using this data base is to search for trends concerning earthquakes. This work is ongoing, and an update will be provided at the conference.

The version discussed below has data from 2150 B.C. to 1995 A.D., and has the most recent data available at the time this paper was written.

The data base is available in a printed form as well as in ASCII format on disk. The printed copy only provides information up to 1992, since it has not been updated in print, unlike the ASCII data, which is constantly being updated.

As point out on page 5 of (Dunbar 1992), it is misleading to compare data prior to 1962 to that after 1961, because of the number of recording sites and the type of equipment used prior to 1962. Also, to avoid comparing full years of data to that in 1995, which only has a small amount of data at this time, 1995 will not be used in the analyses that are discussed below. Thus, we will only consider data from 1962 to 1994 in this paper.

EARTHQUAKE INFORMATION CONTAINED IN THE DATA BASE

To be included in this data base, an earthquake must be "significant". NGDC defines "significant" as meeting at least one of the following four criteria:

1. Moderate damage (approximately US $1 million or more)

2. Ten or more deaths;

3. Magnitude 7.5 or greater;

4. Intensity X or greater (for events lacking magnitude data) on the Modified Mercali Intensity Scale of 1931; see pages 1-2 of (Dunbar 1992).

The data base includes such elements as: latitude and longitude of the earthquake epicenter; depth; year, month, day, hour, and minute of the quake; text description of the earthquake location; references to where the data was found in the literature; intensity of the quake; property damage in US dollars; and the number of people killed by the quake. Other useful items are also available in the data base.

SOME EXAMPLE APPLICATIONS AND ANALYSES

Figure 1 shows the number of earthquakes worldwide that meet this criteria as an annual average over three-year periods. In this figure, the 33 years covered have been divided into periods of 3 years. There are 11 such periods from 1962 to 1994. The number of earthquakes occurring in each period have been averaged, first on annual basis, and then as groups of three-year periods. The resulting number is an average number of earthquakes per year for each three year period.

There appears to be an increasing trend in the number of earthquakes per year. The number of earthquakes appears to have almost doubled over the 30 year period from 1962 through 1991. However, the last three years have had fewer earthquakes than one would expect had the trend from 1962 to 1991 continued. So another hypothesis would be that "significant" earthquakes are periodic in nature, and that we are now in a downward cycle. Observation of this apparent trend will continue.

It should be noted at this point that there are many duplicate records in this data base. Duplicate records exist because of different reports of the same earthquake. The duplicates are marked in the data base, and usually can also be determined by comparing dates and times for records which have locations (latitudes and longitudes) which are either identical or very close to one another. Where data conflict in the different "duplicate" reports, an average has been used in the analyses below.

It is also important to note that there are some incorrectly marked duplicate records in this data base. This data base has over 5,000 records (not just the portion from 1962 to 1994), and errors would seem inevitable in a data base of this size. The number of records concerning significant earthquakes that have occurred after 1961 exceeds 1,000 (including duplicate records).

These problems are mentioned in order to make the reader aware of some of the assumptions involved and problems encountered using this data. Special programs had to be written to recognize the duplicate records and to handle them in an appropriate manner. Duplicate records have occurred less frequently over the last 10 years, and hence, this may be an indication of more reliable earthquake reports.

Figure 2 displays the average intensity (using the Richter Scale) of significant earthquakes. Note that there appears to be a declining trend in the average magnitude of earthquakes from 1968 to 1991, but the last three years have shown a noticeable increase in the average intensity of significant earthquakes.

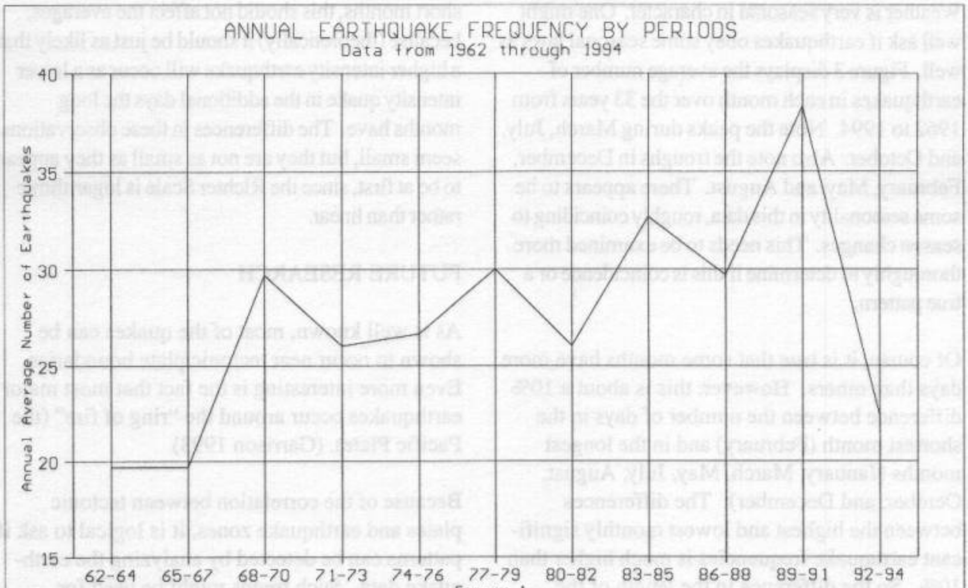

Figure 1.

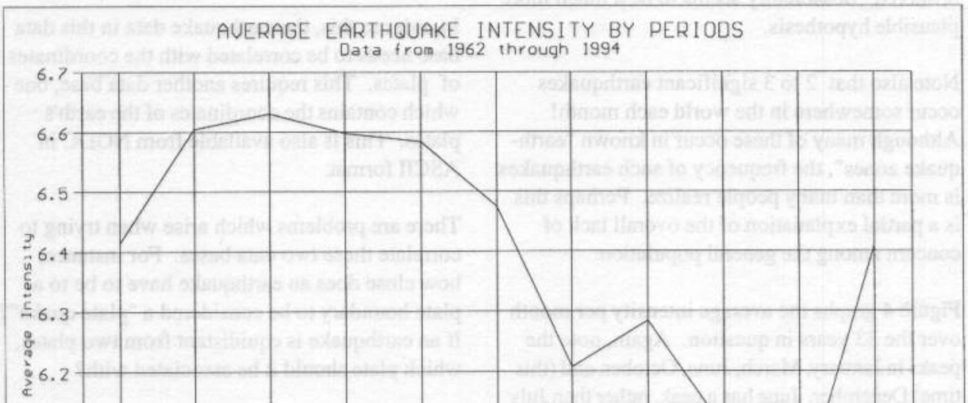

Figure 2.

Weather is very seasonal in character. One might well ask if earthquakes obey some seasonal laws as well. Figure 3 displays the average number of earthquakes in each month over the 33 years from 1962 to 1994. Note the peaks during March, July, and October. Also note the troughs in December, February, May, and August. There appears to be some seasonality in this data, roughly coinciding to season changes. This needs to be examined more thoroughly to determine if this is coincidence or a true pattern.

Of course, it is true that some months have more days than others. However, this is about a 10% difference between the number of days in the shortest month (February) and in the longest months (January, March, May, July, August, October, and December). The differences between the highest and lowest monthly significant earthquake frequencies is much higher than 10%. So the difference in the length of the months does not fully explain the differences observed. Seasonality seems to be a much more plausible hypothesis.

Note also that 2 to 3 significant earthquakes occur somewhere in the world each month! Although many of these occur in known "earthquake zones", the frequency of such earthquakes is more than many people realize. Perhaps this is a partial explanation of the overall lack of concern among the general population.

Figure 4 graphs the average intensity per month over the 33 years in question. Again, note the peaks in January, March, June, October, and (this time) December. June has a peak, rather than July (as with the frequency), but July is not far behind. The troughs occur in February, April, September, and November. Note that this is roughly the same times of the year as the frequency peaks and troughs, except for December. Although February, April, September, and November are short months, this should not affect the averages, because (theoretically) it should be just as likely that a higher intensity earthquake will occur as a lower intensity quake in the additional days the long months have. The differences in these observations seem small, but they are not as small as they appear to be at first, since the Richter Scale is logarithmic rather than linear.

FUTURE RESEARCH

As is well known, most of the quakes can be shown to occur near tectonic plate boundaries. Even more interesting is the fact that most major earthquakes occur around the "ring of fire" (the Pacific Plate). (Garrison 1993)

Because of the correlation between tectonic plates and earthquake zones, it is logical to ask if patterns can be detected by analyzing the earthquake data. Such trends might be used for predicting earthquakes.

In order to this, the earthquake data in this data base needs to be correlated with the coordinates of plates. This requires another data base, one which contains the coordinates of the earth's plates. This is also available from NGDC in ASCII format.

There are problems which arise when trying to correlate these two data bases. For instance, how close does an earthquake have to be to a plate boundary to be considered a "plate quake"? If an earthquake is equidistant from two plates, which plate should it be associated with?

There are also some problems which arise from the determination of the distance from an earthquake epicenter to a plate boundary. Efficiency is a primary concern in trying to automate such a correlation effort. The mathematics of dealing with spherical coordinates is also more complex

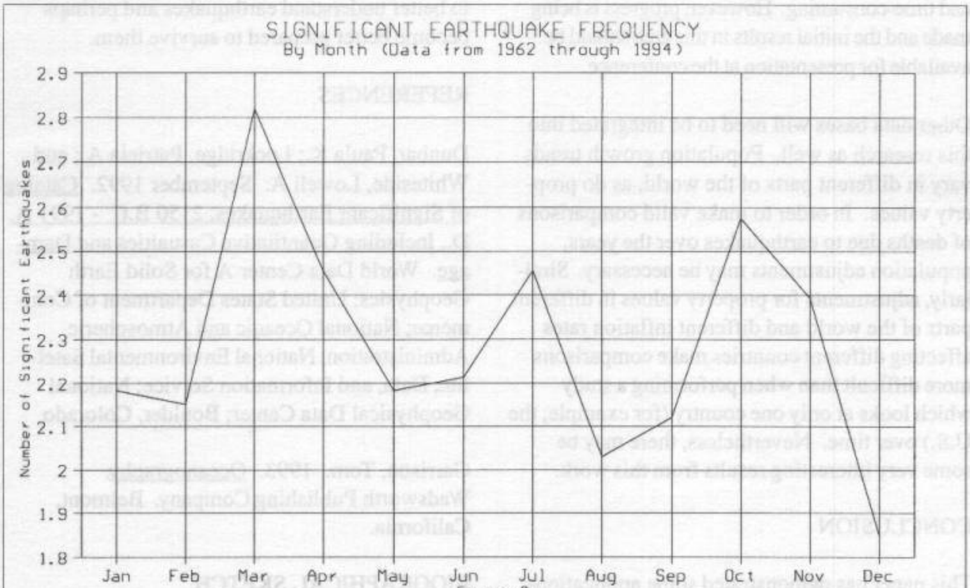

Figure 3.

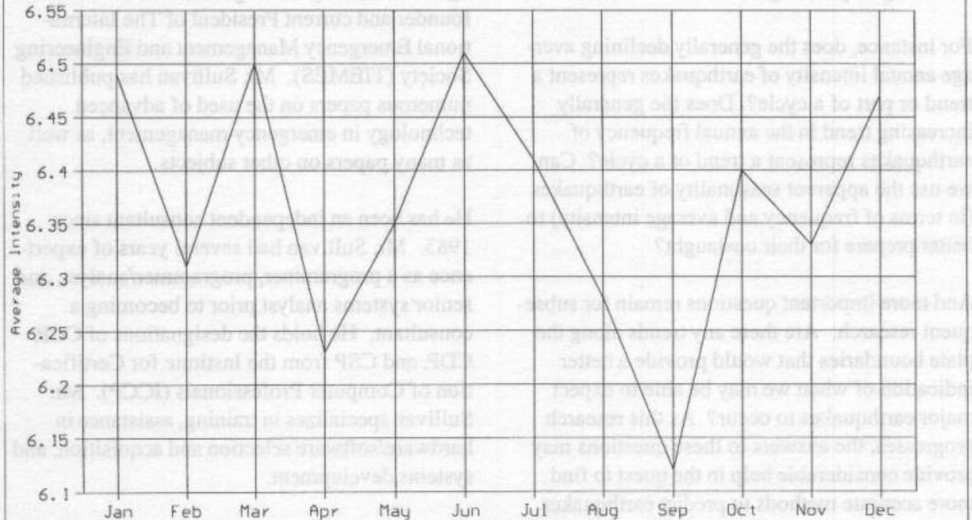

Figure 4.

and time-consuming. However, progress is being made and the initial results in this area should be available for presentation at the conference.

Other data bases will need to be integrated into this research as well. Population growth trends vary in different parts of the world, as do property values. In order to make valid comparisons of deaths due to earthquakes over the years, population adjustments may be necessary. Similarly, adjustments for property values in different parts of the world and different inflation rates affecting different countries make comparisons more difficult than when performing a study which looks at only one country (for example, the U.S.) over time. Nevertheless, there may be some very interesting results from this work.

CONCLUSION

This paper has demonstrated some applications of an international data base of significant earthquakes. Some interesting trends were observed, and may have important consequences for emergency management.

For instance, does the generally declining average annual intensity of earthquakes represent a trend or part of a cycle? Does the generally increasing trend in the annual frequency of earthquakes represent a trend or a cycle? Can we use the apparent seasonality of earthquakes (in terms of frequency and average intensity) to better prepare for their onslaught?

And more important questions remain for subsequent research: Are there any trends along the plate boundaries that would provide a better indication of when we may be able to expect major earthquakes to occur? As this research progresses, the answers to these questions may provide considerable help in the quest to find more accurate methods to predict earthquakes. Trend analysis may give us the answers we need to better understand earthquakes and perhaps become better prepared to survive them.

REFERENCES

Dunbar, Paula K.; Lockridge, Patricia A.; and Whiteside, Lowell A. September 1992. Catalog of Significant Earthquakes, 2150 B.C. - 1991 A. D., Including Quantitative Casualties and Damage. World Data Center A for Solid Earth Geophysics; United States Department of Commerce; National Oceanic and Atmospheric Administration; National Environmental Satellite, Data, and Information Service; National Geophysical Data Center; Boulder, Colorado.

Garrison, Tom. 1993. Oceanography. Wadsworth Publishing Company. Belmont, California.

BIOGRAPHICAL SKETCH

James D. (Jim) Sullivan has served as a leading organizer for six international emergency management and engineering conferences. He is the founder and current President of The International Emergency Management and Engineering Society (TIEMES). Mr. Sullivan has published numerous papers on the used of advanced technology in emergency management, as well as many papers on other subjects.

He has been an independent consultant since 1983. Mr. Sullivan had several years of experience as a programmer, programmer/analyst, and senior systems analyst prior to becoming a consultant. He holds the designations of CCP, CDP, and CSP from the Institute for Certification of Computer Professionals (ICCP). Mr. Sullivan specializes in training, assistance in hardware/software selection and acquisition, and systems development.