Significance of Caribbean and Regional Earthquake Events in the Determination of Seismic Attenuation and Hazard Assessments in Florida

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Abstract

More than seventy-five percent of seismic events recorded by the University of Florida Seismic network (UFL) originate in the circum-Caribbean tectonic region. The proximity of the Florida Plateau to the tectonic features in the circum-Caribbean region demands that earthquake events from this region be incorporated in assessments of seismic hazard for Florida. Data from the recently completed 6-station network, as well as that from an extensive review of record archives from station GAI, have yielded preliminary models of seismic attenuation for the Florida Plateau. Ground motion measurements from more than twenty events originating from the Caribbean, Central America and South America yield an attenuation coefficient approaching 0.22 deg^{-1}. This coefficient supports the idea that seismic attenuation in the Florida Plateau exceeds that of the Eastern United States. These results have further implications for the seismic hazard assessments in Florida and may be indicative of the unique lithospheric identity of the Florida basement as an exotic terrane. This study, in conjunction with a study of the tectonics of the circum-Caribbean region, contributes to an analysis of attenuation within the Caribbean. Seismic data obtained by the University of Florida Seismic Network characterizes the northern perimeter of this important region.

Introduction

The record of seismic activity in the Florida plateau is one of relatively few events and no known major earthquakes. Indeed, the distances from the peninsula to active plate margins or the prominent portions of the Appalachian Mountains are such as to justify an expectation of low seismicity. Lists of felt or reported events in Florida (Mott, 1983; Reagor et al., 1987) list some three dozen occurrences since 1727.

Although the largest event reported (1879) is assigned an intensity of MM VI and was felt throughout north Florida and south Georgia, the paucity of population and absence of instruments precludes the assignment of an epicentre. The best documented events occurred in 1973 (Long, 1974) and 1975 in Sanford and Daytona, respectively, but were assigned magnitudes of 3.5 m_b or less. Comprehensive reviews of the reported events and substantiating data (Smith and Randazzo, 1989; Smith, 1992) have reduced the number of plausible events over the past two centuries to five. All others are attributed to blasting, military activities, events from outside the state, or meteorological phenomena.

The same reassessments of reported events in Florida also documented the unique history of the Florida basement as an original part of the Paleozoic Afro-South American landmass which was sutured onto North America during a Pennsylvanian docking episode. Lord and Smith (1991) and Lord (1993) suggested a marked decrease in seismicity south of the Brunswick Magnetic Anomaly in south Georgia (the suture zone) as attributable to inherently different stresses within the Florida Plateau crustal block from those of the Appalachian system north of the suture.

The geological evidence for a separate origin of the Florida basement and the reassessed historical record of events collectively suggest a review of seismic hazard assigned to the peninsula. Previous efforts to assign seismic hazard were based on procedures given by Cornell (1968) or Reiter (1990) and were dependent on parameters generalized for much of the eastern United States.

A new model for seismic hazard in Florida (Lord, 1993) is based on the identification of seismotectonic provinces around the Florida Plateau (including one based on the Cayman Trough region) and on specific properties of attenuation for Florida. This paper reviews some of the investigations undertaken to determine seismic attenuation properties for the Florida Plateau.

University of Florida Seismograph Network

An initial University of Florida station was instituted at Gainesville, Florida (Station GAI) in 1977 with a single vertical component Sprengnether SS-80 short period analogue seismograph. This station, which continues to operate, was expanded in 1989 to include three Teledyne S-13 short period seismometers coupled to a Teledyne PDAS-100 digital recorder. Similar systems were also installed at remote stations in the Everglades and in Sarasota County. The Gainesville base station to the network was also equipped with three Teledyne BB-13 broadband instruments.

Since 1991, new remote stations have been added to the network near Tallahassee, Florida, and in Waycross, Georgia. Furthermore, the digital instruments of the base station have been relocated some 20 km outside Gainesville to create a network with six separate reporting locations.

The digital instruments are event-triggered, rather than being continuously recorded. If a specific amplitude threshold (determined by ratios to long-term background) is exceeded, the recorder is then triggered and records for a set period of time.

Attenuation

Seismic attenuation is the reduction in amplitude or energy of a transmitted wave with distance. It is dependent on the physical nature of the transmitting medium and, accordingly, varies by an order of magnitude from one geologic region to another (Nuttli, 1973). No independent calculations of attenuation have been presented for the Florida Plateau; previous hazard assessments have used generalized values assigned to the eastern United States.

Attenuation is usually expressed as a coefficient of absorption, γ, in the relationship

$$A(d) = A_o r^{-n} e^{-\gamma d}$$

where amplitude is expressed by A(d) at a distance, d, and A_o at the origin, and n is a coefficient of geometric spacing (usually 5/6 for Lg waves) for the radius, r, of the wave front. The maximum trace amplitude on short period seismograms in or just after the S phase is the Lg phase.

A total of fifty-one events with identifiable Lg phases were selected from archive records of the UF network for use in this project. Eighteen of the events originated in the Caribbean. All data were normalised to $m_b = 4.0$. Amplitudes were measured and peak ground velocities were plotted on log-log graphs with epicentral distances according to the method of Canas et al. (1988). A computer graphing program then derived best-fit values for the coefficient of absorption or attenuation.

Figure 1 shows the plot of all events used. The coefficient of attenuation yielding a curve which best fits the data distribution is $\gamma = 0.22$ degree^{-1} (Figure 2). The data are composed of events from dispersed, but surrounding, seismotectonic provinces. If one considers the attenuation (as recorded in Florida) of events which originated from Caribbean sources (Figure 3), a best fit curve has an attenuation coefficient of $\gamma = 0.54$ degree^{-1}. This value is significantly higher than the computer attenuation for data from all sources and could conceivably be attributed to uncertainties arising from the poor spatial distribution (Figure 3) of the Caribbean data. Nevertheless, attenuation values of $\gamma = 0.6$ degree^{-1} for Southern California and $\gamma = 1.11$ to 0.67 for western United States have been reported (Nuttli, 1973, 1980).

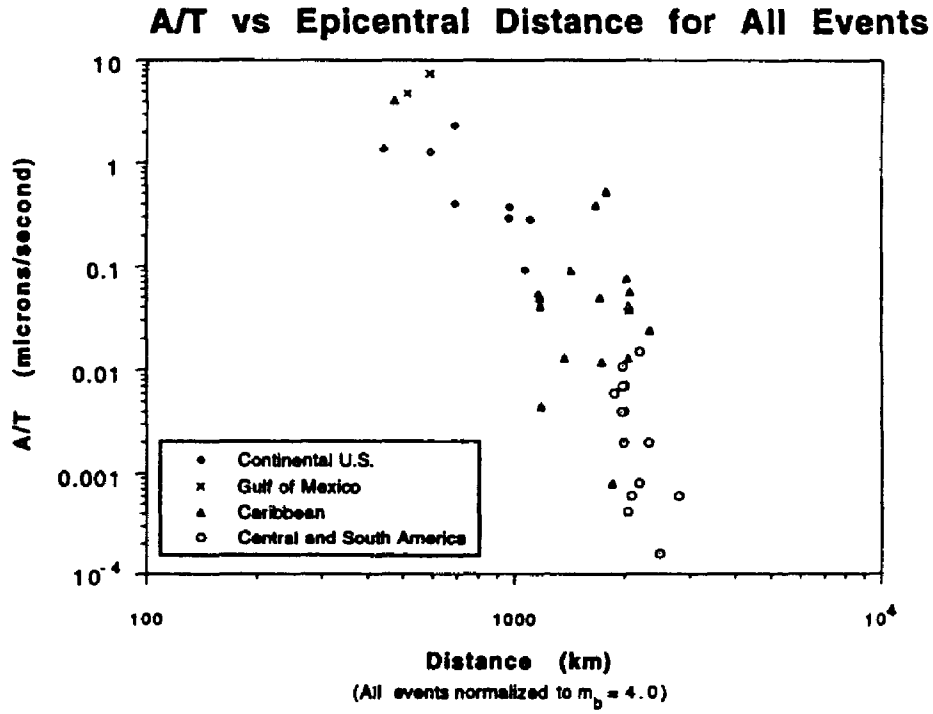

Figure 1. Plot of A/T versues epicentral distance for all events used in this study.

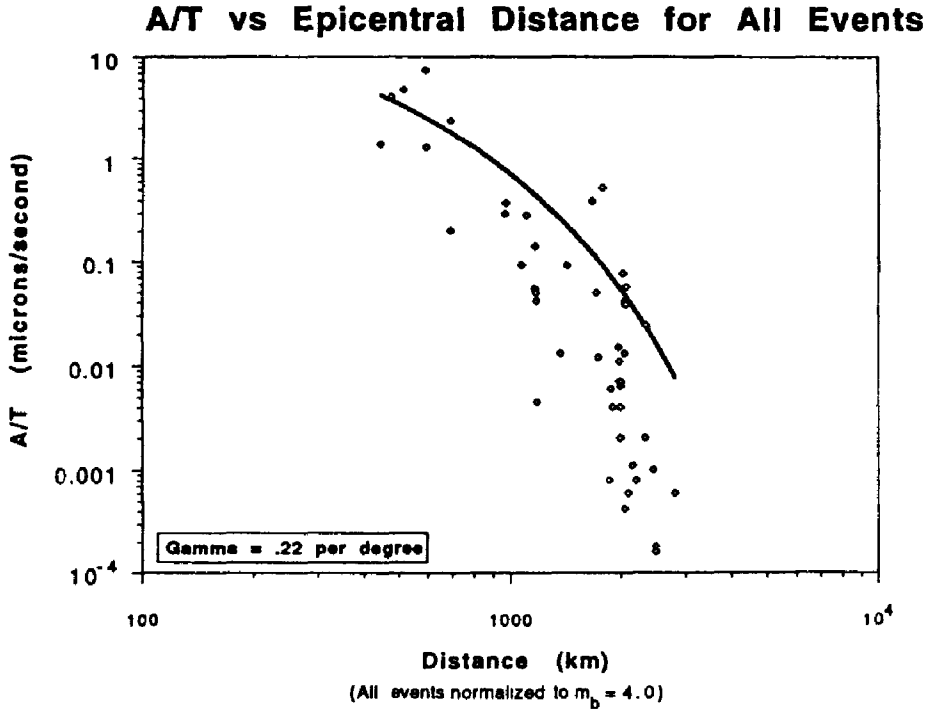

Figure 2. Computer generated curve yielding an attenuation coefficient (γ) of 0.22 degree^{-1} for all events used in this study.

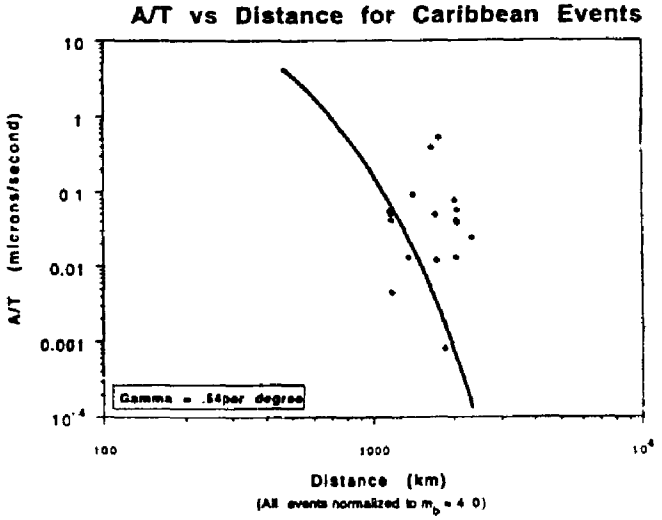

Figure 3. Computer generated curve yielding an attenuation coefficient (γ) of 0.54 degree^{-1} for Caribbean events.

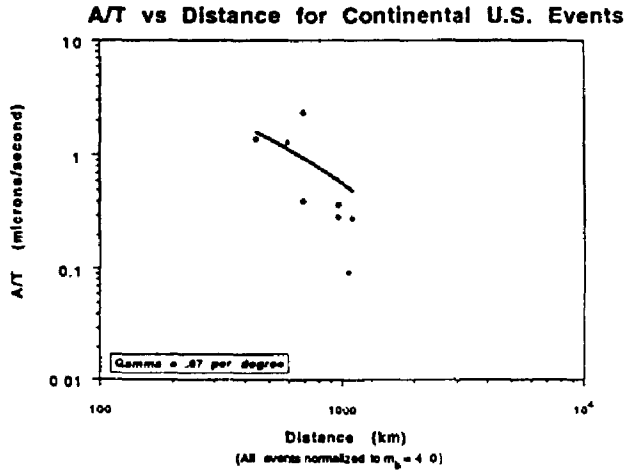

Figure 4 Events originating n the continental United States with a superimposed attenuation curve based on $\gamma = 0.07$ degree^{-1}

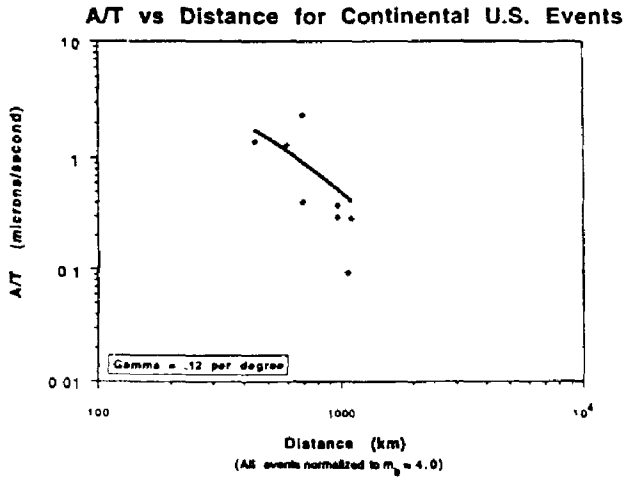

Figure 5. Computer generated curve yielding an attenuation coefficient (γ) of 0.12 degree^{-1} for events within the continental United States.

Typical values for the coefficient of attenuation for the eastern United States are $\gamma = 0.07$ degree^{-1} to $\gamma = 0.10$ degree^{-1} (Nuttli, 1973; Bollinger, 1979). Figure 4 depicts those events originating in the continental United States with a superimposed attenuation curve based on $\gamma = 0.07$ degree^{-1}. Using only those events originating in the continental United States, the Florida-based data yield a coefficient of attenuation of $\gamma = 0.12$ degree^{-1} (Figure 5).

Conclusions

Although only data from fifty-one events were available for use, an average value for the coefficient of attenuation for signals recorded in Florida is 0.22 degree^{-1}. This value is higher than that presently assigned to the eastern United States (0.07 degree^{-1}), but is lower than the value of 0.6 to 1.1 degree^{-1} computed for the western United States. This finding demonstrates:

1. additional evidence for a seismic uniqueness distinguishing the seismicity of Florida from the remainder of the eastern United States, and
2. the appropriateness of pursuing distinct seismic hazard analyses for Florida.

The attenuation values (0.54 degree^{-1}) computed for those events originating in the Caribbean is significantly higher than the overall average and suggests that hazard analyses should be segregated according to events originating in specific seismotectonic provinces. This research shows the need for additional reviews of data to compute attenuation values.

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