A STUDY ON HIGH FREQUENCY DECAY PARAMETER (KAPPA) FROM VARZAGHAN-AHAR DOUBLE EARTHQUAKES, NORTHWESTERN IRAN (M_W 6.5 & 6.3)

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In stochastic ground motion simulations, one of the most important issues is knowledge about the shape of Fourier acceleration spectra. Fourier acceleration spectra decay rapidly at high frequencies. In strong ground motion generation computer programs like SMSIM (Boore, 2005) or ESXIM (Motazedian and Atkinson, 2005), this high frequency decay is incorporated based on two models: first, the parameter f_{max} presented by Hanks (1982) and second, kappa developed by Anderson and Hough (1984). This study deals with the second model using strong motion recordings of Varzaghan-Ahar double earthquakes -two destructive events that occurred on August 11th, 11 minutes apart near two towns of Varzaghan and Ahar in Northwestern Iran (M_w 6.5 & 6.3). Our goal in this paper is to estimate the values of kappa for observed strong ground motions and their behavior in distance. We also evaluate issues in extrapolating the estimated kappa values to zero distance.

Anderson and Hough (1984) recognized that when Fourier acceleration spectrum plot is in log-normal units spectral amplitude at a specific frequency (well above the corner frequency) starts to decay linearly toward higher frequencies. They proposed that this "decay" has the following functional form:

$$A(f) = A_0 \exp(-\pi \kappa f), \qquad f > f_E \qquad (1)$$

where *A(f)* is observed spectrum, κ (kappa) is "spectral decay factor", A_0 is the constant term and f_E is the frequency that amplitude starts falling. This equation holds true to the frequency of f_X where the spectrum touches the noise floor. Anderson and Hough (1984) found a dependency between kappa and distance. They proposed a linear dependency but admitted that it is just an approximation not a definitive shape.

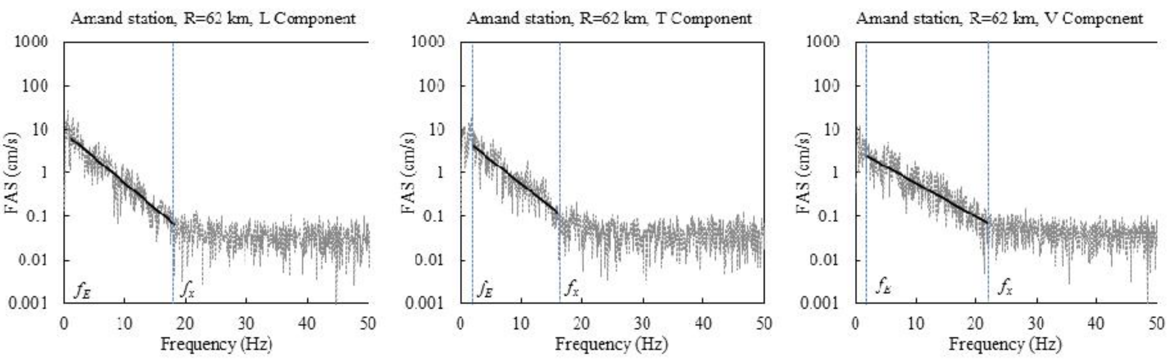

Figure 1. Examples of linear fit based on equation (1) to log-normal plot of Fourier amplitude spectra

Figure 1 shows some examples of the linear fit in log-linear plot to the acceleration spectra according to equation (1). For obtaining these fits, f_E and f_X are visually chosen for each record since there is a wide variability in these parameters. A distinct concavity was observed in estimated values of kappa versus distance. It is shown that if a linear dependency is assumed the least square regression leads to illogical values of κ_0 for both vertical and horizontal components. So as Gentili and Franceschina (2011) proposed, we fit the kappa values against distance with a piecewise bilinear function:

$$\kappa(R) = \begin{cases} \kappa_0 + c_1 R & R \le R_1 \\ \kappa_0 + c_1 R_1 + c_2 (R - R_1) & R > R_1 \end{cases} \qquad (2)$$

The hinge point for this bilinear shape is found by visually inspecting smoothed scatterplot. The data is smoothed using Lowess technique (Cleveland, 1979) and the hinge point is estimated to be at distance of 130 km.

Based on the hinge point of 130 km, a simple regression is done for finding the possible bilinear representative function. The results of this regression is shown in Table 1 and illustrated for vertical component in Figure 2. The extrapolated κ_0 values are in agreement with other researches in Iran.

Table 1. Results of regression based on piecewise bilinear shape of equation (2)

	κ_0	c_1	c_2	R_1
Horizontal	0.044	0.00048	0.00092	130
Vertical	0.023	0.0004	0.00125	130

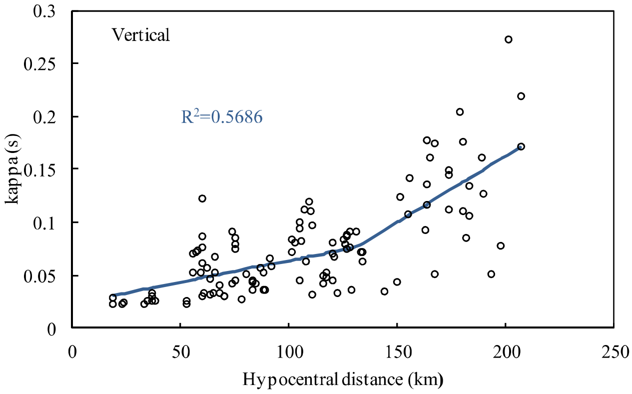

Figure 2. Illustration of piecewise bilinear regression for vertical component

REFERENCES

Anderson JG and Hough SE (1984) A model for the shape of the Fourier amplitude spectrum of acceleration at high frequencies, *Bulletin of the Seismological Society of America*, 74(5): 1969-1993

Boore DM (2005) SMSIM---Fortran programs for simulating ground motions from earthquakes: Version 2.3---A Revision of OFR 96-80-A, in US Geological Survey open-file report, 59

Cleveland WS (1979) Robust locally weighted regression and smoothing scatterplots, *Journal of the American Statistical Association*, 74: 368, 829-836

Gentili S and Franceschina G (2011) High frequency attenuation of shear waves in the southeastern Alps and northern Dinarides, *Geophysical Journal International*, 185(3): 1393-1416

Hanks TC (1982) fmax, *Bulletin of the Seismological Society of America*, 72(6A): 1867-1879

Motazedian D and Atkinson GM (2005) Stochastic Finite-Fault Modeling Based on a Dynamic Corner Frequency, *Bulletin of the Seismological Society of America*, 95(3): 995-1010