8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

SITE AMPLIFICATION EFFECTS ON INVERSION RESULTS (CASE STUDY: ZAGROS AND ALBORZ REGIONS)

Somayeh AHMADZADEH
Ph.D. in Seismology, IIEES, Tehran, Iran
s.ahmadzadeh@iiees.ac.ir
Gholam JAVAN-DOLOEI
Assistant Professor, IIEES, Tehran, Iran
javndoloei@iiees.ac.ir

Keywords: Alborz, Attenuation, Site effect, Inversion, Zagros

A widely used approach to separate simultaneously the source spectra, path attenuation characteristics and site responses from the observed amplitude spectra is the generalized inversion technique (GIT) originally proposed by Andrews (1986). This method can be performed adopting either the parametric approach with a particular shape for attenuation or nonparametric approach (Castro et al., 1990) without any predefined attenuation function. The logarithm of the Fourier amplitude spectra (FAS) of ground motion can be described as:

$$\log_{10} U_{ij}(f, M_i, R_{ij}) = \log_{10} S_i(f, M_i) + \log_{10} A(f, R_{ij}) + \log_{10} G_j(f) \quad (1)$$

where $U_{ij}(f, M_i, R_{ij})$ is the observed FAS at site j for an event i; $S_i(f, M_i)$ represents the source spectrum of the i^{th} event; $A(f, R_{ij})$ is the attenuation along the travel path, and $G_j(f)$ is the site amplification function.
Equation 1 represents a linear system of equations of the form **Ax=b** that can be resolved adopting appropriate inversion algorithms in a least square sense. The inversion can be performed in two steps or one step. According to Castro et al. (1990) in the first step of a two-step procedure the observed amplitude spectra are modeled by:

$$\log_{10} U_{ij}(f, M_i, R_{ij}) = \log_{10} \hat{S}_i(f, M_i) + \log_{10} A(f, R_{ij}) \quad (2)$$

where $\hat{S}_i(f, M_i)$ is a scaling factor for the source i. In the second step after correcting the observed spectra for attenuation, the residual amplitudes are separated into source and site function as fallows:

$$\log_{10} W_{ij}(f, M_i) = \log_{10} S_i(f, M_i) + \log_{10} G_j(f) \quad (3)$$

Considering the Equation 2 in the first step of this inversion scheme the site effects are included both in scaling factor $\hat{S}_i(f, M_i)$ and in the obtained attenuation function $A(f,R_{ij})$. As the average of site effects are included in $\hat{S}_i(f, M_i)$ and in determination of $A(f,R_{ij})$ if the site responses are similar for all stations one can expect that the estimated attenuation function will be unbiased. However, if stations are exposed to high amplification effects may lead to inaccurate estimates of $A(f,R_{ij})$ as described by Oth et al. (2011).

We performed the GIT for two datasets including the Silakhor aftershocks located in the Zagros region and also for 313 events occurred in the Alborz region using one-step and two-step procedure. The obtained attenuation functions are depicted in Figure 1. The estimated attenuation functions for the Alborz region using one step (by solving Equation 1 directly) and using the first step of the two-step GIT approach (as defined by Equation 2) are approximately the same. However, for the Silakhor aftershocks, the obtained functions show considerable differences. These results may reflect the fact that the permanent stations of Alborz were deployed on the typical rock sites without significant amplification effects with relatively similar site responses (Ahmadzadeh, 2018). On the other hand, the temporary seismic stations of the Zagros that were located on the surface of the ground with a few meters of clay have severe amplification effects with considerable differences between site responses as discussed by Ahmadzadeh et al. (2017). Hence, the amplification functions obtained from two-step inversion in the Zagros region are significantly biased while this is not the case for the Alborz region. Therefore, it is important to adopt an appropriate inversion approach to obtain robust inversion results and avoid inaccurate interpretations of the estimated path attenuation functions.

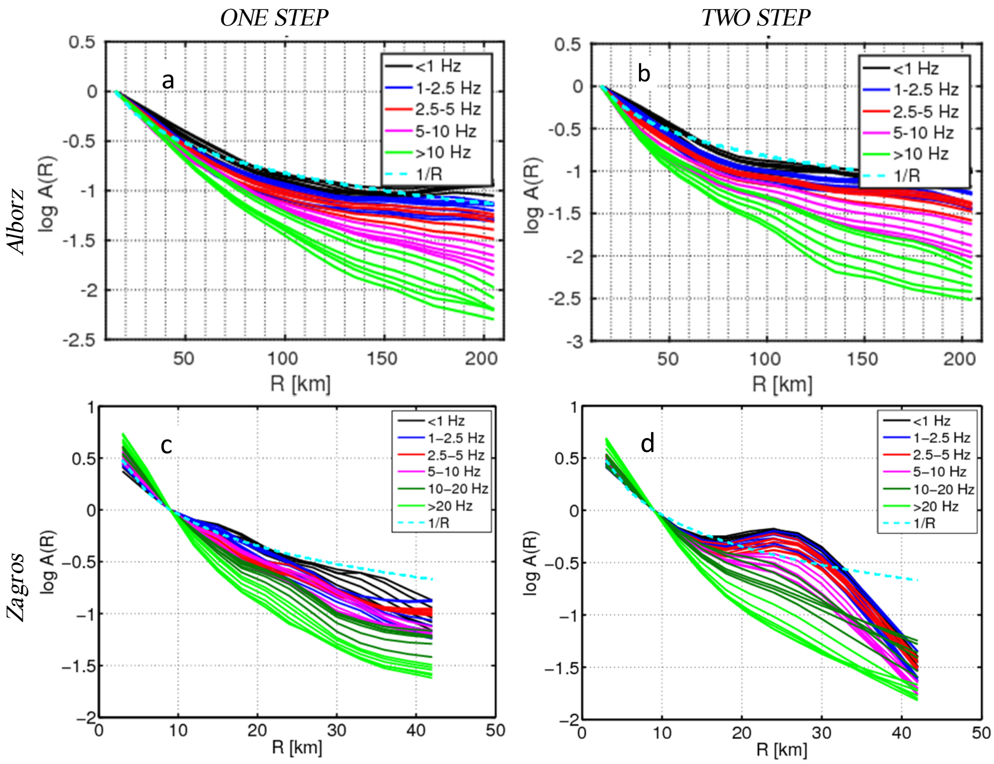

Figure 1. Comparison of nonparametric attenuation functions for the Alborz and Zagros regions using one step (left column) and two-step GIT approach (right column). (a),(b) Results for the Alborz region. (c),(d) Results for the Zagros region

REFERENCES

Ahmadzadeh, S. (2018). *Spectral Modeling of Stress Drop, Source Parameters and Path Attenuation of Earthquakes in Silakhor and Alborz Region*. Ph.D. Dissertation, International Institute of Earthquake Engineering and Seismology, 195P (in Persian).

Ahmadzadeh, S., Parolai, S., Javan-Doloei, G., and Oth, A. (2017). Attenuation characteristics, source parameters and site effects from inversion of S waves of the March 31, 2006 Silakhor earthquake. *Ann. Geophys.*, 60, 6 Sup., SE668, doi:10.4401/ag-7520.

Andrews, D.J. (1986). Objective determination of source parameters and similarity of earthquakes of different size. *Earthquake Source Mechanics*, edited by S. Das, J. Boatwright, and C.H. Scholz, 259-268, AGU, Washington, D. C.

Castro, R.R., Andersom, J.G., and Singh S.K. (1990). Site response, attenuation and source spectra of S waves along the Guerrero, México, subduction zone. *Bull. Seismol. Soc. Am.*, *80*(6), 1481-1503.

Oth, A., Bindi, D., Parolai, S., and Di Giacomo, D. (2011). Spectral analysis of K-NET and KiKnet data in Japan, Part II: On attenuation characteristics, source spectra, and site response of borehole and surface stations. *Bull. Seismol. Soc. Am.*, *101*, 667-687.