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Seismic Array Response in the Presence of Intra-Array Variations in Element Weights, Elevations, and Positions

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ABSTRACT

Seismic arrays are systematic arrangements of seismic receivers, sources or both. Seismic receiver array response is the sum of outputs of the geophones in the array. In reflection seismology, the purpose of using seismic geophone arrays is to enhance the signal-to-noise (S/N) ratio. Moreover, it will attenuate the undesired horizontally travelling surface waves (e.g., ground roll). The combined effect of variable element weights, positions, and elevations on the receiver seismic arrays response is addressed in this study. These variations are common especially in areas with rugged topography and obstacles such as trees. The objective of this research is to quantify the degradation in the wavelet response of a seismic array caused by the combination of these errors on a 12-element equally weighted geophone array. The array response is described here by calculating the trace energy of the wavelet response using element spacings ranging between 0 and 5 km and normalizing it by the maximum trace energy of the ideal array response at an element spacing of 0 m. In addition to variable element spacing, the incidence angle of a plane wave with a zero-phase 10-Hz Ricker wavelet was varied between 0° and 90°. The array responses are presented as a function of element spacing and incidence angle. The minimum array responses for the ideal case are 0 dB for 0° incidence angle and -45 dB for 45° and 90° incidence angles. Effects of errors were modeled using zero-mean Gaussian random errors in elements weights, positions, and elevations with 10% and 20% standard deviations. To get statistically meaningful results, every error response was repeated 32 times and their average response is used. Taking the 45° incidence angle as an example, the minimum array response of in the ideal case has a trace energy of -43 dB which occurs at a temporal element spacing of 0.064 s. The addition of 10% combined errors degrades the minimum array response by about 17%; while 20% combined errors degrades it by 30%. Therefore, we conclude that the effects of combined errors are considerable and care must be taken in planting arrays as close to the ideal case as possible.