Frequency-Independent Centroid Frequency Shift Method for Estimating Signal Attenuation

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Abstract

Objectives/Scope: Near-surface seismic attenuation estimation is a critical task in seismic processing and is essential for analyzing media characteristics and compensating. Current methods for estimating attenuation are based on assumptions of full-band analysis. In this paper, we propose a novel frequency-independent centroid frequency shift (FiCFS) method for signal attenuation estimation with higher adaptability. The frequency independence of the FiCFS method with the frequency-weighted exponential (FWE) spectrum assumption has been proved and applied to various seismic.

Methods, Procedures, Process: Most CFS methods are derived from the whole frequency band of the wavelet spectra. Here, we derive a frequency-independent CFS method to estimate the Q value of different frequency bands. We applied an arbitrary frequency band instead of the whole band, which is defined by the traditional CFS method, to calculate the centroid frequency. And then, the incomplete Gamma function is used to simplify and derive the new frequency-independent CFS method. We also simulate a complex synthetic wavelet and try to use the FWE wavelet to approximate it and analyze its accuracy and adaptability.

Results, Observations, Conclusions: The frequency independence of this method has been theoretically proven, and it can be extended to other signal attenuation estimation fields beyond seismic signals. The effectiveness of this method depends on the assumption of the FWE wavelet spectrum, which can match any wavelet spectrum in a narrow band. According to the field data example in this paper, there is an exponential relationship in the low-frequency bands, which however is gentle for some frequencies but indicates the uncertainty of attenuation changing with frequency. The FiCFS approach can be used to predict or estimate the attenuation sensitivity of a particular medium to different frequencies, facilitating the understanding of the physical attenuation properties of the medium. In conclusion, the proven frequency independence of the FiCFS method is promising for developing more complete and adaptive signal attenuation estimation methods in the future.

Novel/Additive Information: Although the method is based on certain assumptions (FWE wavelet spectrum assumption), the two-parameters controlled FWE spectrum can approximate most of the signal spectrum. Combined with the mathematically rigorous derivation of its frequency independence, this approach can be applied to most signal attenuation estimation scenarios with a narrow frequency band. Theoretical analysis indicates that FiCFS can obtain the true frequency-dependent Q value when the bandwidth is narrow to a certain extent.