Comparison of averaging techniques for F-K spectral analysis

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1.Introduction

Microtremores contain non-propagation waves(call 'noise' hereafter), such as regional waves by traffic or mechanical noise of seismometer. Noise contaminates FK power spectrum and causes estimation error of phase velocities of surface waves.

There are several techniques of reduction of the estimation error by noise, 1) Averaging phase velocities estimated from short sections [technique-1], 2) Calculate F-K spectrum from smoothed cross-correlation function [technique-2], 3) Calculate F-K spectrum from averaged cross-correlation function, [technique-3]. In this study, I investigated the characteristics and validities of these techniques using synthetic waves.

2. Synthetic Waves

First, I decide the average phase velocity V0 of surface wave. Next, I decide the location of the observation points. The observation points are on the vertex of three regular triangles whose centers are on the same point and size ratio is 1:2:4. Maximum distance between the observation points is 1/8 times maximum wavelength. Shape of the FK power spectrum is modeled to simulate observed FK power spectrum. The equation of modeled FK power spectrum is P(kx,ky,f)1/(2*Sa*Sk)exp(-1/2[((a-a0)/Sa)^2+((k-k0)/Sk)^2]). A0 and k0 are average of arrival azimuth (225deg.) and average of wave number (k0=2f/V0(f)) respectively. Sa and Sk are standard deviation of azimuth (30deg.) and wave number (10% of the k0). Synthetic waves are computed by 3D inverted Fourier transform of P(kx,ky,f). Finally I add random noise to the synthetic waves such that RMS ratio(noise/surface wave) is 0.25.

3. FK spectral analysis

FK spectral analysis is carried out for the synthetic waves whose duration are 204s, 409s, 614s, 819s, 1228s, 1638s . I compute 10 synthetic waves in each durations and compute average and standard deviation of estimated phase velocities.

4. Result

The standard deviation of estimated phase velocities are large in the case of technique-1 and the average does not converge into the true value. In the case of technique-2 and technique-3, average of estimated phase velocities converge into the true value. The standerd deviation of the estimated phase velocities by technique-3 is slightly smaller than technique-2. In this study, it is thought that technique-3 is the best among 3 averaging techniques.