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Attenuation-compensated reverse-time migration of waterborne GPR based on attenuation coefficient estimation

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To the waterborne ground-penetrating radar detection, reverse-time migration (RTM) method can image the structure of the bottom of the water and locate the buried bodies. However, the image quality is limited by the attenuation of electromagnetic waves. How to compensate the attenuation becomes a critical problem. Some RTM methods related to the attenuation-compensated have been developed in recent years. We use the attenuation-compensated RTM based on the minus conductivity. However, the method is limited by the estimation of the attenuation coefficient. Here, we propose an attenuation-coefficient estimation method based on the centroid frequency downshift method (CFDS). In EM attenuation tomography, the centroid frequency downshift method works for attenuation estimation. Compared with the CFDS method in tomography, our proposal is based on the centroid frequency of the bottom-interface of water instead of the source wavelet. Thus, we can avoid the problem of the unknown source wavelet. The method is based on two assumptions: 1) GPR data can be regarded as zero-offset records. 2) Reflections from underwater interfaces are independent of frequency. In addition, the formula about the attenuation coefficient shows when the ratio between the conductivity and the product of the dielectric constant and the angular frequency is greater than one, the attenuation coefficient tends to be a constant. This does not meet the assumption that the attenuation coefficient is linearly related to frequency. We will select a proper frequency range to meet the linear relation by the spectral ratio method. Because the ratio of the signal spectrum of the bottom interface to the spectrum of the underwater interface is consistent with the change of the attenuation coefficient with frequency. Then, the CFDS method will acquire a linear attenuation coefficient with the frequency. Finally, we choose half of the central frequency to acquire the estimated attenuation coefficient. We design a layered waterborne GPR detection model, the conductivity of the silt layer varies between 0.1 and 0.01. The error of the conductivity estimation is below 10%. After acquiring the attenuation coefficient, the attenuation-compensated RTM works correctly and effectively.