電磁波反射による媒質の複素比誘電率推定
The estimation of the complex relative permittivity using reflection of electromagnetic waves

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Ground Penetrating Rader (GPR) is a nondestructive testing method to visualize shallow subsurface using reflection of downgoing electromagnetic waves generated on the surface. Traveltime of reflection signals indicates the position and the depth of objects in the subsurface. Since we can survey wide area in an expeditious way, GPR has been widely used in many engineering fields.

On the other hand, great demand for quantitative estimations, i.e. physical properties of buried targets, has been increasing in recent years. Although the Cole plot has been proposed as a method to estimate the physical properties from the frequency response of the reflection both in reflection amplitude and phase, little attention has been drawn to its applicability in GPR survey. In GPR survey, the frequency of emitted electromagnetic waves depends on the shape and the size of antenna, we need to pay attention to optimal frequency range of the analysis if we try to apply the optimum frequencies to utilize the theory of Cole and Cole. Therefore, optimum frequency band for estimating physical properties of subsurface targets should be discussed.

In this study, we estimate physical properties of a target materials in the subsurface using reflected electromagnetic waves. The source frequencies would range from 10^7 Hz to 10^{12} Hz to draw Cole circles. Using a numerical model of two materials with an horizontal medium interface, we first simulate electromagnetic waves traveling vertically to estimate reflected waves. Then, the Cole circles are drawn with reflected signals to estimate complex relative permittivity for the interface of the two materials based on the amplitude and the phase difference between incident and reflected waves. Our numerical results indicate that the specific parameters of the target layer could be estimated with the accuracy sufficient to estimate the complex relative permittivity from the reflected electromagnetic waves. For avoiding any negative permittivity driven from the Cole circles, we would like to conclude the response in the high frequency band is of importance in the estimation of physical properties.

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