Geophysical Research Abstracts
Vol. 13, EGU2011-8658, 2011
EGU General Assembly 2011
© Author(s) 2011

Frequency dependence of soil permittivity and conductivity estimated by ground-penetrating radar full-waveform inversion

Phuong Tran (1), M. Mohammad Reza Mahmoudzadeh (1), Sébastien Lambot (1,2)

(1) Université catholique de Louvain, Earth and Life Institute, Environmental Science, Belgium (phuong.tran@uclouvain.be), (2) ICG-4 Agrosphere, Institute of Chemistry and Dynamicsof the Geosphere, Forschungszentrum J¨ulich GmbH, J¨ulich, Germany

Soil moisture is one of the most important parameters for hydrology, meteorology and agriculture. Amongst existing techniques, ground penetrating radar (GPR) has emerged as a noninvasive tool for mapping soil moisture at the field scale. Lambot et al. (2004) developed a full-waveform inversion approach which in particular applies to far-field, monostatic GPR. The radar-antenna-subsurface system is modeled by linear transfer functions and an exact solution of Maxwell's equations for wave propagation in planar layered media. The electrical properties of each layer are retrieved using a global optimization algorithm. The technique has been successfully validated in both laboratory and field conditions. In GPR applications, two key parameters are the permittivity and conductivity of the soil mixture, which are frequency dependent quantities. However, this dependence has not been investigated deeply, especially in the GPR field. Soil is a complex mixture of different components and there has been many electrical mixing models developed, including the model of Wang and Schmugge (1980) which is one of the most popular. This model not only accounts for the components in the soil but also includes the frequency dependence of its electrical properties. The purpose of this paper is to combine the full-waveform radar model of Lambot et al. (2004) with the mixing model of soil materials of Wang and Schmugge (1980) for soil property retrieval using inversion. In particular, instead of estimating soil water content from permittivity through empirical formulas as commonly adopted approach, we estimate it directly by optimization, which is expected to improve the water content estimates. We validated our approach in laboratory conditions with sand subject to eleven different water contents. Measurements were performed in the frequency range 1-4.5 GHz. The GPR data were very well reproduced in both the time and frequency domains. The estimated and measured volumetric water contents were in good agreement with average absolute error of 0.012 (cm3/cm3). The experimental results also showed that while the permittivity is nearly independent of the frequency in that frequency range, the apparent conductivity (including dielectric losses) increases exponentially with the frequency, especially for the high water content values. Further research will focus on the validation of the integrated approach for other soil textures, and in particular clay for which relaxation effects are more complex.