Geophysical Research Abstracts
Vol. 14, EGU2012-9857, 2012
EGU General Assembly 2012

Investigating the influence of clay and water content on GPR signals

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The amplitude and shape of GPR reflections are strongly dependent on water and clay content of the soil. To investigate this influence, laboratory measurements of GPR reflections on 23 soil samples of different clay contents (3-63 %) and saturated with different water contents (0-40 %) have been conducted. We observed a downshift of the center frequency of the reflection that can be explained by a simple theoretical model. From the spectral ratio between a reference wavelet and the reflection the quality factor Q can be determined that is a measure of the ratio between energy gained and energy lost. It is found to be constant between 0.6 and 1.6 GHz (for a 1.6 GHz antenna) and ranges between 5 and 15. Q can be described by an empirical multivariate function of clay and water content. Based on Q and independent measurements of DC electrical conductivity the imaginary part of permittivity can be determined. The relationship between the real and imaginary part of permittivity is found to be linear. Its slope is only dependent on clay content. Hence, it might be possible to determine the clay content in situ from electrical conductivity and GPR measurements that result in determination of the quality factor. This could be done e.g. by the frequency downshift calculated from the instantaneous frequency or for distinct reflections with the help of the spectral ratio method. A first test with field data showed that at least the order of magnitude of the clay content could be determined.

Acknowledgments:
iSOIL (Interactions between soil related sciences – Linking geophysics, soil science and digital soil mapping) is a Collaborative Project (Grant Agreement number 211386) co-funded by the Research DG of the European Commission within the RTD activities of the FP7 Thematic Priority Environment.