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Comparing spatial series of soil bulk electrical conductivity as obtained by Time Domain Reflectometry and Electrical Resistivity Tomography

Ali Saeed (1), Giovanna Dragonetti (2), Allessandro Comegna (1), Sarah Garre (3), Nicola Lamaddalena (2), and Antonio Coppola (1)

(1) School of Agricultural, Forestry, Food and Environmental Sciences (SAFE), Hydraulics Division, University of Basilicata, Potenza, Italy, (2) Mediterranean Agronomic Institute, Land and Water Division, IAMB, Bari, Italy , (3) Université de Liège, TERRA research center, Gembloux, Belgium

Conventional ground survey of soil root zone salinity by direct soil sampling are time consuming, costly and destructive. Alternatively, soil salinity can be evaluated by measuring the bulk electrical conductivity, σb, in the field. This approach is faster and cheaper, and allows a more intensive surveying. Measurements of σb can be made either in situ or with remote devices. Time domain reflectometry (TDR) sensors allow simultaneous measurements of water content, θ, and σb. They may be calibrated for estimating the electrical conductivity of the soil solution (σw). However, they have a relatively small observation window and thus they are thought to only provide local-scale measurements. The spatial range of the sensors is limited to tens of centimeters and extension of the information to a large area can be problematic. Also, information on the vertical distribution of the σb soil profile may only be obtained by installing sensors at different depths. In this sense, the TDR may be considered as an invasive technique.

Compared to the TDR, other geophysical methods based for example on the Electrical Resistivity Tomography (ERT) techniques represent an alternative in respect to those traditional for soil salinity characterization. In order to deduce the actual distribution of the bulk electrical conductivity, σb, in the soil profile, one needs to invert the signal coming from ERT sensors. The latter, in turn, depends on the specific depth distribution of the σb, as well as on the electrical configuration of the sensor used.

With these premises, the main aim of this study is to estimate the vertical σb distribution starting from resistivity data series measured using the ERT method under different salinity conditions and using TDR data as ground-truth data for calibration and validation of the ERT sensor.

This way, limited measured TDR data may be used for translating extensive ERT apparent electrical conductivity, σa, measurements to estimate depth-distributions of σb. These, in turn, may be translated to many σw values by applying the σw-σb-θ calibration relationship obtained in the laboratory by using the TDR probes.

A field experiment was conducted in the Mediterranean Agronomic Institute (MAI) of Valenzano (Bari - Italy). The experiment consisted of three transects 30 m long and 4.2 width, cultivated with green bean and irrigated with three different salinity levels (1 dS/m, 3 dS/m, and 6 dS/m). Each transect consisted of seven rows equipped by a dripper irrigation system, which supplied a water flux of 2 l/h. As for the salt application, CaCl2 were dissolved in tap water, and subsequently siphoned into the irrigation system. For each transect, 24 regularly spaced monitoring sites (1 m apart) were selected for soil measurements, using different equipments: i) a TDR100, ii) an ERT apparatus in the Wenner configuration array. Overall, 17 measurement campaigns were carried out. Monitoring along transects also allowed to evaluate the role of different smaller and larger scale heterogeneities on the electrical conductivity measured by the two different sensors.

Because of the different variability patterns and structure of the ERT and TDR data due to the different observation windows, a site-by-site comparison of the corresponding readings may not reveal the actual correlation between the σb values deduced by ERT measurements on one side and the TDR data on the other. In order to make TDR and ERT data actually comparable, we analyzed the effect of the different observation windows of the two sensors on the different spatial and temporal variability observed in the two data series.

Specifically, the study assessed the potential of applying a Fourier's analysis to filter the original data series to extract the predominant, high-variance signal after removing the small- scale (high frequency) variance observed in the TDR data series.