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Can we quantify the variability of soil moisture across scales using Electromagnetic Induction ?

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Soil moisture is a key variable in many natural processes. Therefore, technological and methodological advancements are of primary importance to provide accurate measurements of spatial and temporal variability of soil moisture. In that context, ElectroMagnetic Induction (EMI) instruments are often cited as a hydrogeophysical method with a large potential, through the measurement of the soil apparent electrical conductivity (ECa).

To our knowledge, no studies have evaluated the potential of EMI to characterize variability of soil moisture on both agricultural and forested land covers in a (sub-) tropical environment. These differences in land use could be critical as differences in temperature, transpiration and root water uptake can have significant effect, notably on the electrical conductivity of the pore water.

In this study, we used an EMI instrument to carry out a first assessment of the impact of deforestation and agriculture on soil moisture in a subtropical region in the south of Brazil. We selected slopes of different topographies (gentle vs. steep) and contrasting land uses (natural forest vs. agriculture) within two nearby catchments. At selected locations on the slopes, we measured simultaneously ECa using EMI and a depth-weighted average of the soil moisture using TDR probes installed within soil pits.

We found that the temporal variability of the soil moisture could not be measured accurately with EMI, probably because of important temporal variations of the pore water electrical conductivity and the relatively small temporal variations in soil moisture content. However, we found that its spatial variability could be effectively quantified using a non-linear relationship, for both intra- and inter-slopes variations. Within slopes, the ECa could explained between 67 and 90% of the variability of the soil moisture, while a single non-linear model for all the slopes could explain 55% of the soil moisture variability. We eventually showed that combining a specific relationship for the most degraded slope (steep slope under agriculture) and a single relationship for all the other slopes, both non-linear relations, yielded the best results with an overall explained variance of 90%.

We applied the latter model to measurements of the ECa along transects at the different slopes, which allowed us to highlight the strong control of topography on the soil moisture content. We also observed a significant impact of the land use with higher moisture content on the agricultural slopes, probably due to a reduced evapotranspiration.