Calibration of soil moisture sensors for a long-term field experiment

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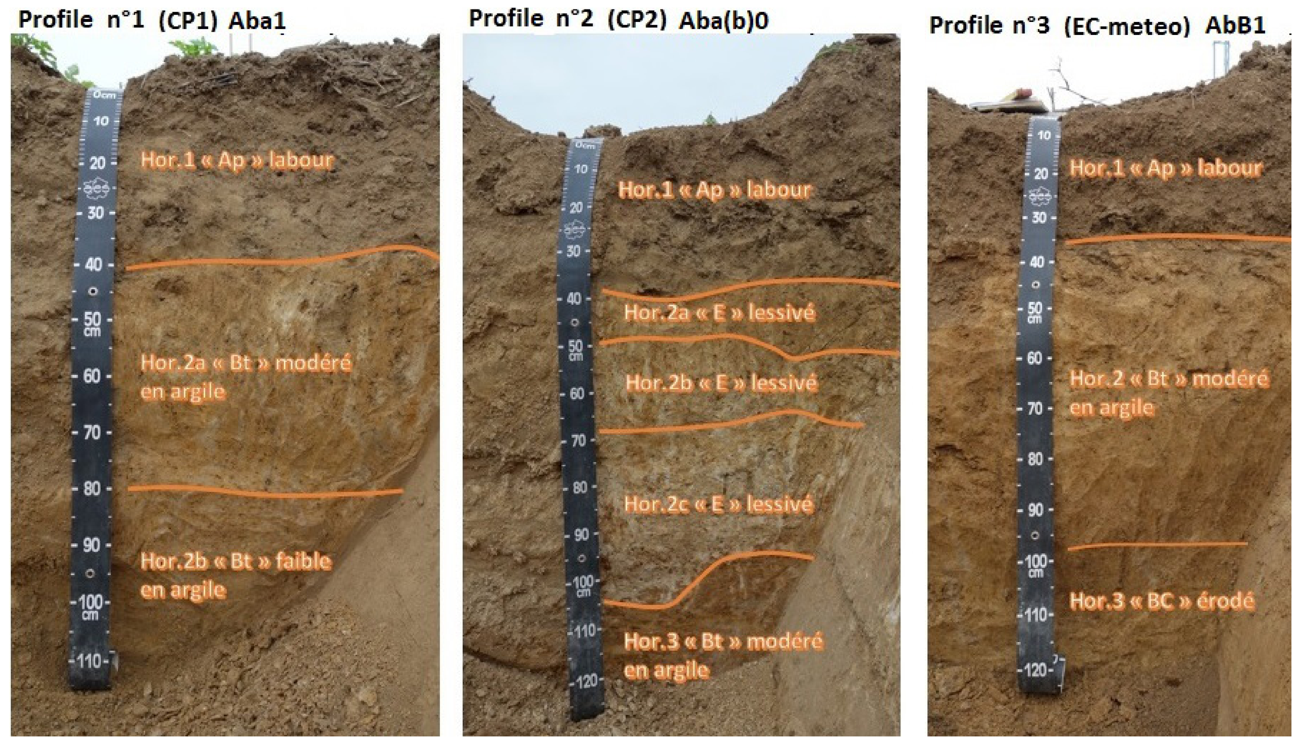
CONTEXT

In the framework of the ICOS RI network, a field site in Lonzée, Belgium, is equipped to provide long-term data on greenhouse gas emissions from an agricultural field and the associated environmental variables. To facilitate field installation in combination with agricultural practices, Sentek *Enviro*SCAN sensors, a collection of FDR sensors at different depths on a stick, were chosen to measure soil moisture. In order to ensure data quality standards equal to all field sites in the ICOS network, a lab calibration procedure is demanded and validation with an established capacitive sensor (ML3) is demanded.

CONTEXT

We calibrated the probes for different soil horizons at 3 different locations (15, 55, 85 cm below the surface) in the field using big reconstructed soil columns which were brought to defined soil moisture levels in the lab.



PROTOCOL

- Soil Preparation
- Column preparation
- Data Logger Installation
- Normalization Procedure (Air – Water) for each sensors of the *Enviro*SCAN
- ML3 ThetaProbe reading
- Repetition for increasing soil moisture contents

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OBJECTIVES

- Implementation and optimization of the caribration protocol for both *Enviro*SCAN and ML3 probes for a Luvisol
- Calibration curves etablishment for 15 *Enviro*SCAN probes and 5 ML3 probes
- Interpretation of the accuracy of these probes

CALIBRATION CURVES

*Enviro*SCAN

A Normalization Scale Frequency (SF) = $\frac{\text{(Air Frequency – Field Frequency)}}{\text{(Air Frequency – Water Frequency)}}$

B Power function : $y = A.x^B + C$

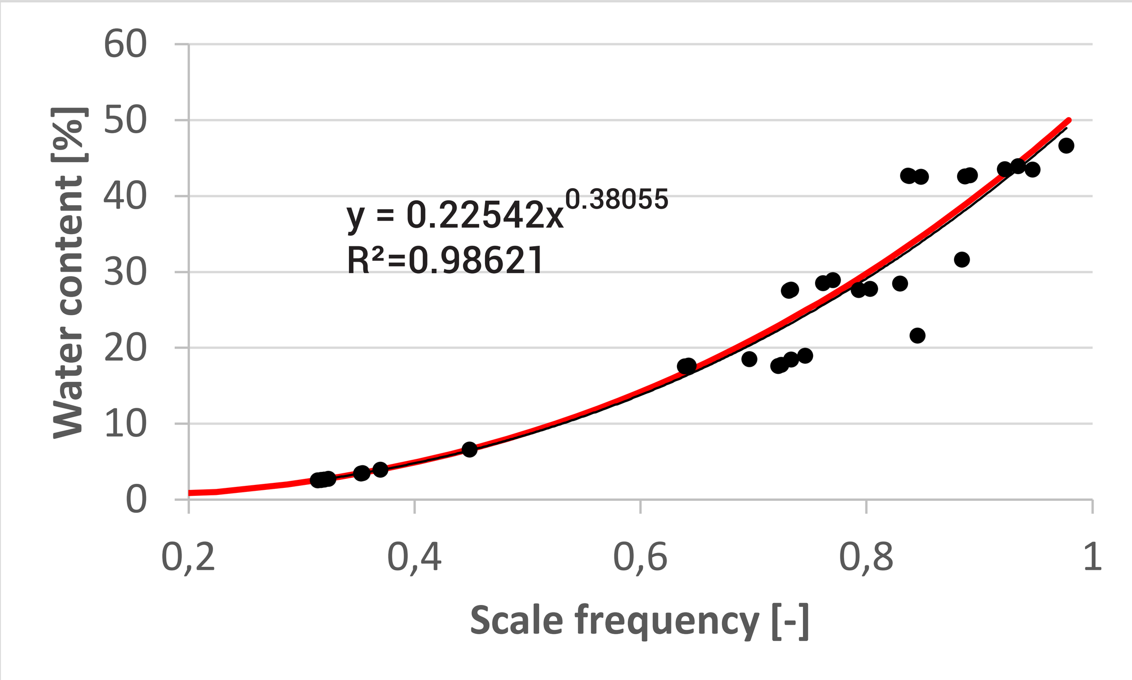
ML3 ThetaProbe

A Linear equation : determination of a0 and a1: $\sqrt{\varepsilon} = a_0 + a_1 . \theta$

B Polynomial transformation
$\sqrt{\varepsilon} = 1.0 = 6.175V + 6.303V^2 - 73.578V^3 + 183.44V^4 - 184.78V^5 + 68.017V^6$

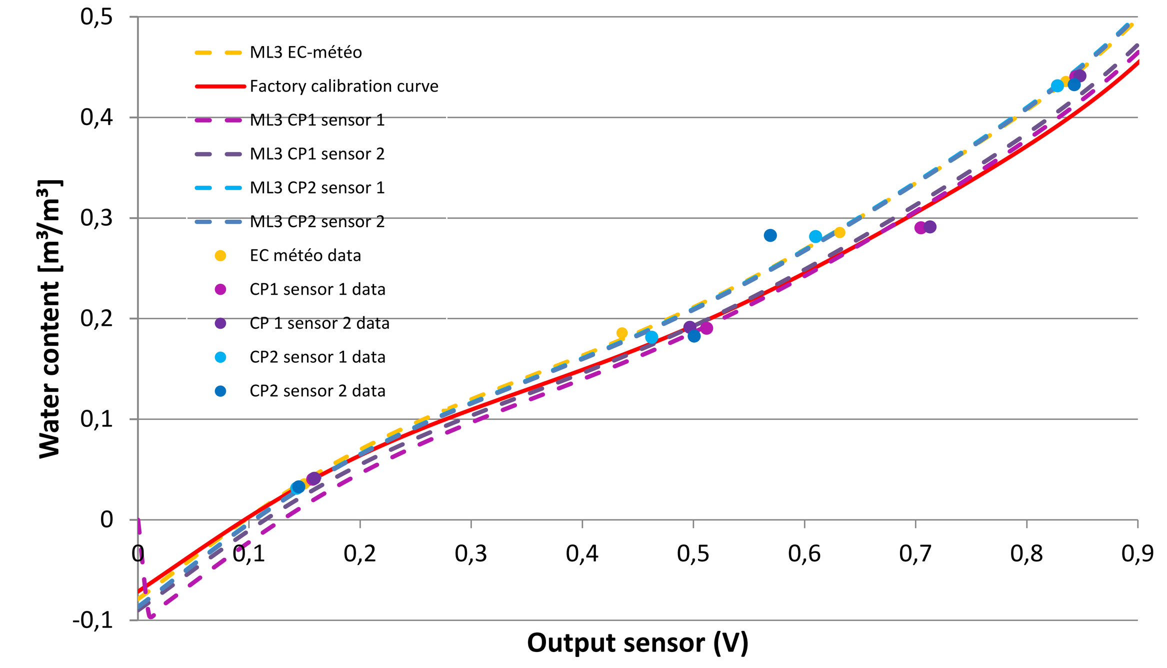
C Calibration curve : combination of (1) and (2)

Sentek sensor readings vs. universal factory calibration curve



There is some scatter of the readings arround the calibration curve, especially for WC=20%. Nevertheless, the calibration curve fitted to the data (black line) and the universal factory calibration curve (red line) are not very different.

ML3 sensor readings vs. universal factory calibration curve

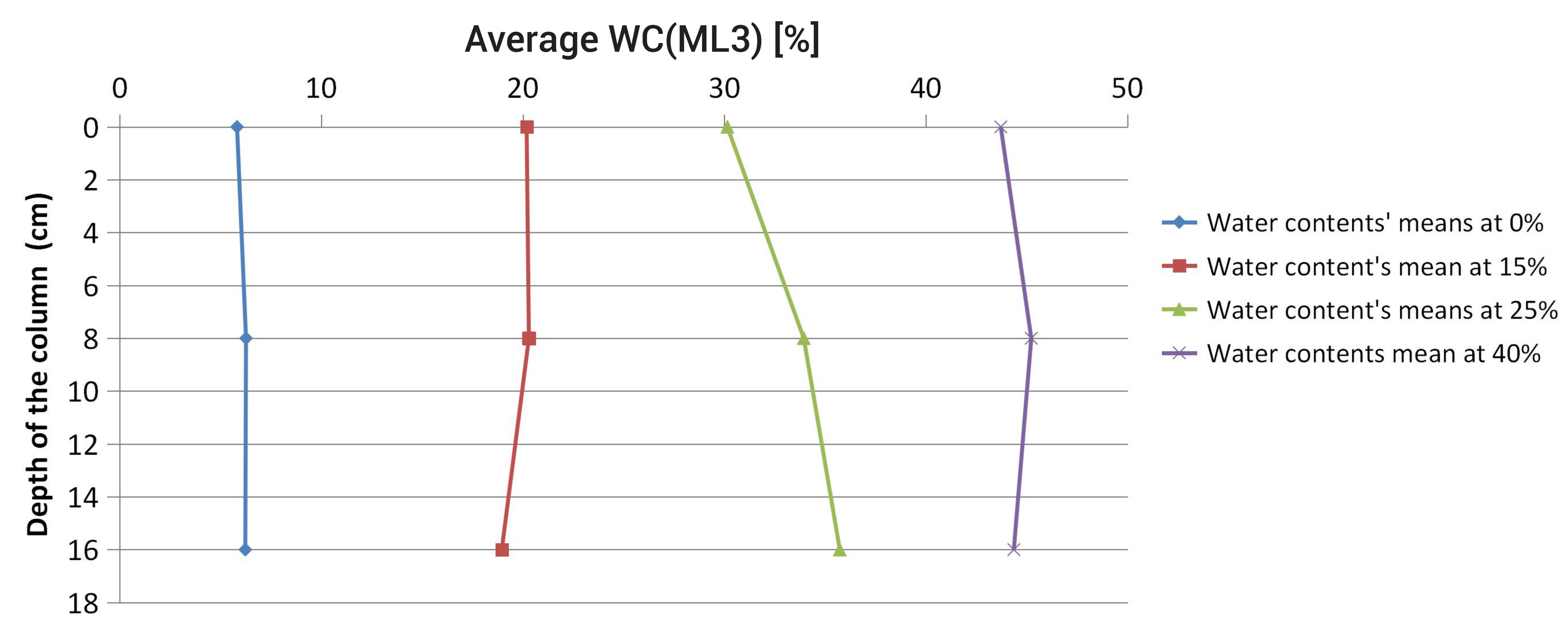


The data points are quite close to the calibration curve. Only at a soil moisture content around 30% the scatter is higher. The universal calibration curve of the ML3 sensors is very close to the functions fitted to the calibration data for each individual sensor.

CONCLUSION

- Increased scatter of calibration values is noticed for higher moisture contents for both sensor types. The additional examination of the homogeneity of water content in the column has shown that at higher water contents, the distribution is less homogeneous than at lower water contents. This heterogeneity in the column is probably responsible for higher scatter.
- The universal calibration relationship of the sensors gave similar results as the soil-specific calibration up till a moisture content of 40%. Given the high labor costs (time), we think ensor-specific calibration should only be performed for very specific soils or application where extremely high WC precision is necessary.
- Laboratory calibration methods where water is manually mixed with soil and then returned to the column are not error-free. At high water contents, it is difficult to obtain a homogenous water distribution.

Heterogeneity of soil moisture in the calibration columns



At higher soil moisture levels (>25%) the average water contents tend to vary with depth even though soil and water are manually mixed and then put in the column. Redistribution of water due to gravity is fast at these higher WC levels and results in more heterogeneity in the column.