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Monitoring carbon stocks in arable land: sources of errors, improvement of the one-layer equivalent soil mass method and minimum detectable change

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Reliable determination of the soil organic carbon (SOC) stock (SOCS) and its time trend at field scale is a key condition to monitor the agro-ecological transition, to evaluate the effectiveness of climate mitigation plans, or to value soil organic carbon (SOC) sequestration as a negative emission technology (NET) at farm level. Limiting the SOCS estimation to 30 cm depth is acceptable on the range of some decades (Balesdent et al., 2018). SOC stock, however, is not directly estimated from the SOC content. SOC content must be multiplied by the bulk density (BD) of the corresponding layer. BD determination is time consuming and tedious to determine. Moreover, it changes with time due to soil swelling with water, soil tillage, and changes in SOC. Therefore, the changes in SOCS must be monitored on an equivalent soil mass (ESM) basis, by referring to the sampled soil mass of the previous sampling rather than to a constant depth layer. Corrections of the mass, simplification of the soil mass determination overcoming the BD determination issue, as well as a simplified one-layer method have been proposed (Wendt and Hauser, 2013). However, this simplified ESM method requires the sampling and analysis of at least two layers for sampled mass correction and large unknowns remain on the sources of errors. For instance, the field volume percentage of the coarse (> 2 mm) fraction must be determined and removed from the sampled layer volume, which is not well documented. On the other hand, and to our best knowledge, private companies providing a SOCS certification use to sample the soils at constant depth using mechanical gauges that do not allow control of the quality of the extracted cores. The errors associated with these different technical options need to be clarified.

This study was performed by sampling 384 representative fields from different farms of the Swiss Leman-Lake region. It aimed at providing a full reliable methodology to determine SOCS at field scale, while solving the remaining issues, namely, to determine the errors associated to the different parameters estimated and to simplify the ESM one-layer method to decrease the sampling and analytical costs. Comparing mechanical and hand-held gauges showed that only the latter performed reasonably for SOCS stock evaluation. The minimum detectable change was then determined (i) for sampling performed at constant depth, (ii) for the ESM one-layer method as described in (Wendt and Hauser, 2013), (iii) the additional error introduced by coarse fraction estimation and gauge diameter and (iv) a simplification of the one-layer ESM method taking into account local average properties of the soil below the 0-30 cm sampled layer.

We conclude that the classical constant depth automatic sampling cannot be used for SOCS monitoring, while the proposed simplified one-layer ESM method yields acceptable minimum detectable changes allowing to detect most changes in a 5 to 10 year time lag in Swiss arable land at a much lower cost.

References

Balesdent, J., Basile-Doelsch, I., Chadoeuf, J., Cornu, S., Derrien, D., Fekiacova, Z., Hatté, C., 2018. Atmosphere–soil carbon transfer as a function of soil depth. Nature 559, 599–602. https://doi.org/10.1038/s41586-018-0328-3

Wendt, J.W., Hauser, S., 2013. An equivalent soil mass procedure for monitoring soil organic carbon in multiple soil layers. Eur. J. Soil Sci. 64, 58–65. https://doi.org/10.1111/ejss.12002