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

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Reliable determination of the soil organic carbon stock (SOCS) and its time trend at field scale is a key condition to value soil organic carbon (SOC) sequestration as a negative emission technology (NET) at farm level. Limiting the stock estimation to 30 cm depth is acceptable on the range of some decades (Balesdent et al., 2018). The carbon 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, and 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. Moreover, 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 SOCS certificates sample the soils at constant depth using mechanical gauges that do not allow to control the quality of the extracted core. Finally, the errors associated with these different technical options needs to be clarified.

This study was performed using samples collected in 60 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. The minimum detectable change was determine (i) for sampling performed using the mechanical gauges 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.