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Underestimation of soil carbon stocks by Yasso07, Q, and CENTURY models in boreal forest linked to overlooking site fertility

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The soil organic carbon stock (SOC) changes estimated by the most process based soil carbon models (e.g. Yasso07, Q and CENTURY), needed for reporting of changes in soil carbon amounts for the United Nations Framework Convention on Climate Change (UNFCCC) and for mitigation of anthropogenic CO_2 emissions by soil carbon management, can be biased if in a large mosaic of environments the models are missing a key factor driving SOC sequestration. To our knowledge soil nutrient status as a missing driver of these models was not tested in previous studies. Although, it's known that models fail to reconstruct the spatial variation and that soil nutrient status drives the ecosystem carbon use efficiency and soil carbon sequestration.
We evaluated SOC stock estimates of Yasso07, Q and CENTURY process based models against the field data from Swedish Forest Soil National Inventories (3230 samples) organized by recursive partitioning method (RPART) into distinct soil groups with underlying SOC stock development linked to physicochemical conditions. These models worked for most soils with approximately average SOC stocks, but could not reproduce higher measured SOC stocks in our application. The Yasso07 and Q models that used only climate and litterfall input data and ignored soil properties generally agreed with two third of measurements. However, in comparison with measurements grouped according to the gradient of soil nutrient status we found that the models underestimated for the Swedish boreal forest soils with higher site fertility. Accounting for soil texture (clay, silt, and sand content) and structure (bulk density) in CENTURY model showed no improvement on carbon stock estimates, as CENTURY deviated in similar manner.
We highlighted the mechanisms why models deviate from the measurements and the ways of considering soil nutrient status in further model development. Our analysis suggested that the models indeed lack other predominat drivers of SOC stabilization presumably the different role of microbes in carbon mineralization in relation to nitrogen availability and the organo – mineral carbon associations. Our results imply that the role of soil nutrient status as a regulator of carbon mineralization has to be re-evaluated, because we should have models that have their steady state SOC stocks at right level in order to predict future SOC change.