soil systems

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Comment

Current Estimates of Soil Organic Carbon Stocks Are Not Four to Six Times Underestimated. Comment on "Non-Flat Earth Recalibrated for Terrain and Topsoil. *Soil Syst.* 2018, *2*, 64"

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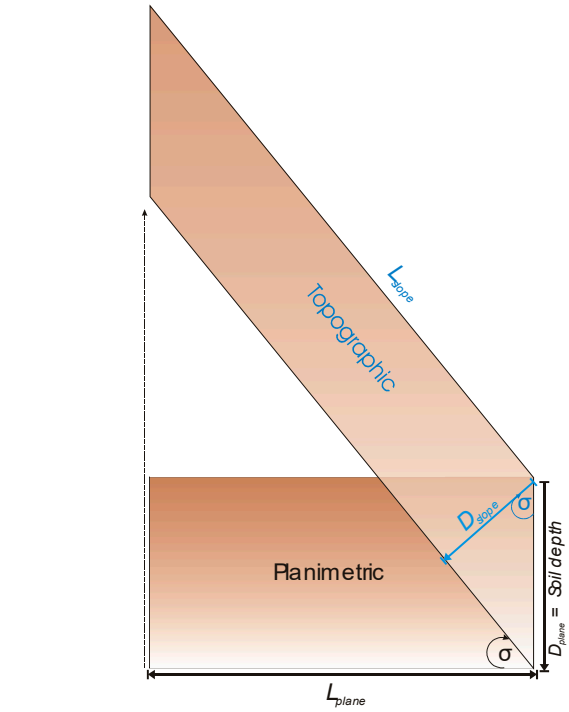
In the interesting paper "Non-Flat Earth Recalibrated for Terrain and Topsoil" published in Soil Systems [1], the author shows that taking into account hilly slope undulation and topsoil relief detail raises the Earth's land surface from the conventionally flat 15 Gha to >64 Gha. Among the conclusions, he states that "soil organic carbon (SOC) thereby grows to 8580 Gt mainly in SOM-humus". This striking result suggests that current estimates of global SOC are four to six times too low. We fully agree that the Earth is not flat, but we disagree with the conclusion of the paper that relief, although obviously increasing the surface area, increases the global SOC estimated down to a fixed depth. The main reason for this is that the observations used to calculate SOC are done vertically and not perpendicularly to the ground.

Actually, the hypothesis that volumetric SOC stock estimates are sensitive to the slope effect is conceptually flawed. It implicitly makes the hypothesis that soil is a kind of mantle characterized by a given thickness and that what we measure is this thickness. In practice, as shown in Figure 1, the observations contained in the databases are obtained vertically and the volume does not change at all.

In fact, a paper containing the same kind or error was published in Geoderma, and the authors decided to retract it [2].

Interestingly, this error raises another possible issue linked to how relief is accounted for. Indeed, the volume does not change, but the surface area does change. In the literature about mapping SOC stocks, we can find results expressing them in, for example, t ha^{-1}. The usual way of expressing surface areas is for a planimetric view. The over- or under-estimation of volumetric quantities arises when changing the surface but not adapting the depth, i.e., when mixing planimetric and topographic surfaces without adaptation. Applications that rely on slope length, such as studying soil erosion, have to use the topographic surface data. This may have some consequences if we want, for instance, to calculate or give practical advice on how many tons of external SOC we should add per hectare to increase SOC by a given percentile. Indeed, for many elements, the fact that the results found in the literature are often expressed as mass to area ratios may create some confusion, because these results may come from estimates realised on the surface area of a field and not a planimetric view.



$A_{slope} = L_{slope} * D_{slope}$

$A_{plane} = L_{plane} * D_{plane}$

$L_{slope} = L_{plane} / \cos(\sigma)$

$D_{slope} = D_{plane} * \cos(\sigma)$

$A_{slope} = L_{plane} / \cos(\sigma) * D_{plane} * \cos(\sigma)$
$\Rightarrow L_{plane} * D_{plane}$

$A_{slope} = A_{plane}$

Figure 1. Invariability of soil volume with slope, exemplified by the perpendicular height of a parallelogram area.

More generally, this error also raises questions about the definitions of soil depth and soil or horizon thickness. However, in practice, the observations used to establish soil depths and calculate global SOC stocks are based on vertical measurements.

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2. Chen, S.; Arrouays, D. RETRACTED: Soil carbon stocks are underestimated in mountainous regions. *Geoderma* **2018**, *320*, 146–148. [CrossRef]