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Interactive comment on "Ideas and perspectives: Can we use the soil carbon saturation deficit to quantitatively assess the soil carbon storage potential, or should we explore other strategies?" *by* Pierre Barré et al.

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We thank the reviewer for his/her stimulating comments. We believe that part of the comments come from misunderstanding and part from a difference in perception. Please find below some comments on the review to contribute to the debate.

In the context of the 4per1000 international initiative and at a national scale, policy makers ask a seemingly very simple question: how much extra organic carbon (OC) can be stored in the soil? Our understanding of this question is that we should under-

stand how much extra OC in total (considering the whole-soil OC stock and not only the mineral-associated OC) can be stored? This understanding is based on several considerations. First, the name of the initiative refers to a calculation based on total SOC stocks (http://4p1000.org/understand). Second, some of the farming methods mentioned in the initiative as promoting OC stock increases, such as agroforestry, have been shown to promote OC increase mostly in the particulate organic matter fraction (e.g. Cardinael et al., 2015). Third, the objectives of the initiative are to increase soil organic matter not only to attenuate climate change but also to contribute to food security (i.e. increase soil fertility) and to adaptation of agro-ecosystems to climate change. It is well known that the organic matter pools with long residence times are not the only ones contributing to soil fertility and soil water retention. Hence the initiative targets not only the mineral associated or the stabilized organic carbon. Fourth, it will be already very difficult to verify total soil OC stock changes, it will even be more difficult and extremely time and money-consuming to verify at large scale stock changes of OC associated to fine (<20 μm) particles. For these reasons, we do not believe that policy-makers had in mind something else that the whole-soil OC stocks when they pushed to launch the 4per1000 initiative.

As expressed in our draft and emphasized by Reviewer 1, the OC saturation deficit approach is not designed to estimate the whole-soil OC storage potential. We also want to make it clear that we did not pretend that Angers et al. (2011), Wiesmeier et al. (2014) or McNally et al. (2017) claimed that they provided estimates of the whole-soil C storage potential. However, the OC saturation deficit approach is an attempt to estimate the potential of a soil to store OC in a "stable" form, which is sometimes referred to as the soil OC sequestration potential (McNally et al., 2017). It may not be obvious to all (researchers and policymakers) that estimating the soil OC sequestration potential does not directly respond to the practical question "how much extra OC can be stored in the soil?" Consequently, we do not consider that our draft is only pushing open doors. At least, we had that feeling when discussing with colleagues from this area at the national and international levels.

Nonetheless, we consider that establishing how much extra OC can be stored in the soil in a "stable" form would be very useful for assessing the potential of soils to mitigate climate change. It is also more ambitious. We consider that the quantified estimates of OC sequestration potentials provided in the recent years do not provide clear results that can be directly used by policymakers on this. First, in such studies, the timescale of the storage is never defined (does "stable" mean 20 years? A century?). Second the fact that a soil with a large OC deficit can sequester more OC than a soil with a low OC deficit remains to be evidenced. Third, as properly recognized by the authors, it is "unrealistic" to consider that meeting the estimated soil C sequestration potential is achievable (Angers et al., 2011 or McNally et al., 2017). For these reasons, we agree that such estimates are "informative case studies" (McNally et al., 2017) but we consider that they should be considered as possible promising tracks towards sound estimates of the OC sequestration potential. For these reasons, we will follow with interest the development of such studies, but we consider that the results delivered by this approach are currently not operational. These are the reasons why we wrote in our draft that the Hassink approach "may inform on the long-term C sequestration potential" (page 4, line 24) or may allow to estimate the potential for OC storage at "a pluridecadal timescale".

We regret that the reviewer 1 was confused by our conclusion, which apparently was not clear enough. Our point was that if we want to deliver quantified estimates of the soil OC storage potential at various scales (from local to global scales) in the coming years, the most promising tracks are, to our opinion, the data- and model-driven approaches described in our draft. However, proper implementation of these approaches would need sustained effort in term of research, model development and data acquisition (i.e. "are not straightforward to implement"). Nonetheless, if we consider that such approaches are, at the moment, our best answers to practical questions raised by policy makers, we also acknowledge that they remain unsatisfying on several aspects. First, these approaches are mostly empirical (i.e. will only "allow little progress in understanding the mechanisms"). Second, they may not provide information on the

duration of SOC storage. For these reasons, we consider that a more process-based research targeting stable OC such as research using the Csat-def approaches can be relevant. As there is no need to oppose the research on SOC storage and SOC sequestration potentials, we suggest that they should be conducted in parallel.

We agree that for people well aware of the distinction between SOC storage and SOC sequestration and knowing exactly what are the risk of misuse of the published estimates of SOC sequestration potential, our draft may be of limited interest. However, we feel that such people represent a small minority of the community interested in the potential of soil in climate change mitigation.

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