Dear Reviewer:

Thank you for your comments on this manuscript. Your comments really help us to improve the manuscript. We tried to address each point and answer your questions one by one.

Answers:

The paper discusses the role of lithology and climate on the stabilization of organic matter. I like the choice of the sites on a clear precipitation transect. The approach is also straightforward, but I am not sure why the authors in contrast to the prevailing literature on the topic did not use wet sieving. After all, dry sieving does not result in water stable aggregates that occlude (to a certain extent) the organic matter. This choice for dry sieving needs to be justified and its implications discussed. Furthermore, details on the dry sieving method are lacking (line 159): agitation intensity and duration. Were the samples air-dried or field moist? The discussion section is speculative as many characteristics are mentioned in the discussion but neither the analytical methods nor the results are presented.

Answer in general: Thank you for the comments. In general, we used dry sieving instead of wet sieving because (1) density fraction (or wet-sieving plus ultrasound) can cause serve OM dispersion for acidic soils (ASs), and (2) using wet sieving to determine aggregate stability seems not to contribute to the topic of the manuscript. For detailed information, please check the answer to the question of **Lines 307-326** (isolating occluded OM) and that of **Line 144** (aggregate stability).

For other points, air-dried soils rather than moist soils were applied for the dry sieving. The sieving agitation intensity and duration were just the same as mentioned in the previous description of dry-sieving methods (Line 146-147). To make this part more clear, we will add the intensity and the duration in Line 159 (30 Hz for 20 s).

Line 103 Could you please explain the land use of the sites in somewhat more detail. As it stands, the land use is grassland, but you also mention cultivation and tree plantations. These activities would belong to cropland or forest land use classes.

Answer: The sampling rules were mentioned in **Line 121-123.** All sampling sites had the land use types of grassland, grassland with shrubs or fallow cropland. Tree plantation was avoided because tree litter can induce strong soil acidification. We will re-organize the sentences related to land use to make them easy to understand.

The reason why we include three land use types is that a previous study in this area found that the spatial distribution of SOC stocks is not controlled by land use (Yang et al., 2018). The limited effects of land use on SOC stocks may be attributed to the special land use strategy in which a cycle of cultivation, land set-aside and grazing were repeated every 3-5 years. This suggests the SOC sequestration might be in a dynamical balance. Thus, it is reasonable to sample from these land use types.

Line 142 The stoniness is not expressed in % but in fraction. Please also state that you use the gravimetric fraction. See the discussion on the role of coarse fragments for SOC stocks in SOIL by Poeplau et al and Hobley et al (2017 if I am not mistaken). The Bulk density should include the coarse fragments. Was this the case? You mention in line 132 that the gravels were removed. Please revise carefully.

Answer: Thank you for the very good questions and the relevant references. We apologize for the unclear statement of bulk density. We agree that the bulk density should include the coarse fragments and we actually have included all coarse fragments for the bulk density determination. The weights of coarse fragments were used to revise the bulk density for the SOC stock calculation because the coarse fragments were considered free of organic carbon.

We will make changes in **line 132** to emphasize that bulk densities were measured with coarse fragments involved and SOC contents were measured without coarse fragments involved.

We will also make changes for the formula as follows:

$$SOC\ stock = \sum_{i=1}^{i=k} BD_i \times C_i \times (1 - S_i) \times D_i$$

In which, BD_i = bulk density (g cm^{-3}) of the layer i (including gravels), C_i = SOC content (%) of the layer i (excluding gravels), S_i = stoniness of layer i, D_i= thickness (cm) of layer i.

Line 144 In general wet sieving is used to determine aggregate stability. Why did you choose dry sieving?

Answer: We agree that wet sieving is more suitable to determine aggregate stability than dry sieving. We also have the dataset of aggregates stability, macroaggreagte stability determined using wet sieving and microaggregate stability determined using sonication and sedimentation, respectively (details in Fig. R1). However, the objectives of this paper were to have insights into aggregate-size distribution and the stability of SOC distributed in different-sized aggregates. For these objectives, we considered that wet sieving is less suitable than dry sieving for two reasons.

The first reason is that we need to apply incubation to estimate SOC stability in different-sized aggregates. Compared to wet sieving, dry sieving is less destructive and keep the aggregates more similar to the original statues. The second reason is that aggregate stability determined by wet sieving seem not significantly contribute to the paper's topic. Literature showed that aggregate stability is not very useful to estimate SOC stability or OM occluded in aggregates (e.g. Heckman et al., 2014). This is also indicated by our data that neither macroaggregate stability nor microaggregate stability significantly predicted SOC mineralization (Fig. R1). After evaluation, we believe that the aggregate stability determined by wet sieving did not contribute to the topic of this manuscript. Thus, aggregate stability determined by wet sieving was not included.

Line 147 Please specify that these are gravimetric gravel contents.

Answer: We agree to do that.

Lines 307-326 I miss a discussion on the difference between wet and dry sieving. After all, the authors you cite all used wet sieving. It is possible that occlusion does not play an important role, because your aggregates are not water stable and therefore, there is no real occlusion of OM in stable aggregates. This possibility should at least be mentioned in a note of caution (see also general remark).

Answer: Thank you for this question. We will include this point in the paragraph if we have a chance to revise the manuscript.

First, we have to explain why we chose dry sieving. We did not apply density fractionation (or wet-sieving plus sonication) to isolate OM occluded in stable aggregates because the application of ultrasound caused severe dispersion of organic materials into dense solution (NaPT) for the ASs. In addition, separating the dispersed organic materials from the solution was extremely difficult. A similar situation has been reported by Kaiser and Guggenberger (2007). As we could not find a solution for this problem, we chose an alternative method (dry sieving plus incubating intact versus crushed aggregates) applied by Goebel et al. (2009), Juarez et al. (2013) and Wang et al. (2014).

We understand the alternative method estimated OM occluded in both stable aggregates and unstable aggregates. However, our final conclusion supports that there is no real occluded OM because no significant difference in SOC mineralization was found after the incubation between intact and crushed aggregates. Thus, the conclusion was still convincing.

Section 4.3 It is not clear to what extent characteristics have been measured. For instance, **lines 328-330** I have not seen any analytical data on Fe and Al hydroxide or Ca bridges.

Answer: The data of Fe, Al and Ca has been used as the focus of another paper (*Yang et al. 2019 Revised version submitted to Environmental Earth Science*). Briefly, the OM in the ASs was stabilized by interacting with Fe- and Al-oxides, whereas the OM in the LSs was stabilized by Ca bridges in addition to Fe- and Al-oxides (Table R1). In addition, soil pH values were the key factor controlling OM stabilization mechanisms (Table R1). As the focus of this manuscript was aggregate size distribution and OM stability controlled by aggregates, it could be a better way that we proposed the OM stabilization mechanisms using the previous results (i.e. Fe, Al and Ca) and data from this manuscript (i.e. pH).

Lines 368-369 How were these fatty acids analysed?

Answer: Relative abundances of all mentioned compounds (including fatty acids) were measured using a pyrolysis-GC/MS system. As the data was used for another publication paper (*Yang et al. 2019, under review Geoderma*), we just gave a brief description for the analysis in the subtitle of Fig. S2 as follows:

"Pyrolysis-gas chromatography / mass spectrometry (GC/MS) was applied to estimate the molecular composition of the soil organic matter. Briefly, milled soil samples were hydrolyzed and methylated

using tetra-methyl-ammonium hydroxide (25 % in water). Afterward, a Curie-point pyrolyzer was used for sample pyrolysis. Helium was used as the carrier gas. Initial temperature was kept at 40 °C for 1 min, followed by heating at the rate of 7 °C min^{-1} until 320 °C sustaining for 15 min. The products of the pyrolysis were analyzed by the GC/MS system. Relative abundance of each compound was calculated as the peak area of the compound divided by the sum of peak areas of all identified compounds."

Figures and Tables:
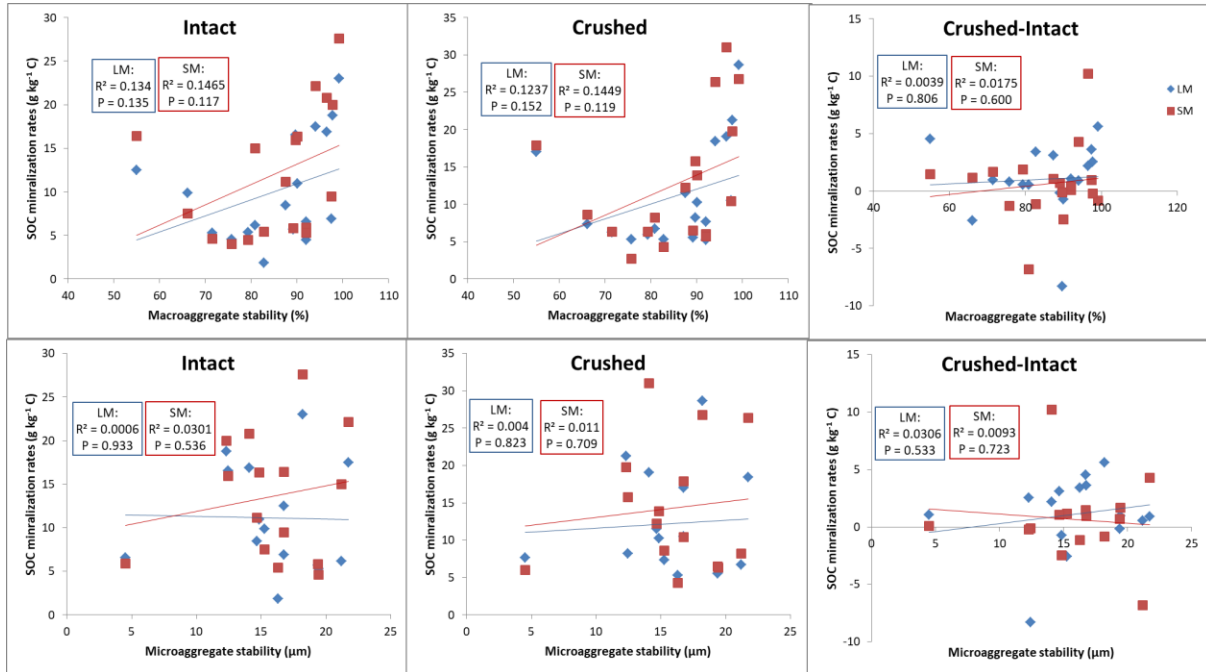
Fig. R1 SOC mineralization rates predicted by macroaggregate stability and microaggregate stability. Macroaggregate stability was measured by wet-sieving (20 Hz, 5 min) large macroaggreagtes (>2 mm) and determining the mass of remaining materials >2 mm. Microaggregate stability was determined by comparing the differences in mean weight diameters (MWD, μm) of microaggregates (<0.25 mm) between ultrasonic dispersion (20 W, 10 s) and non-dispersion applied.

Table R1 Correlations between SOC contents and selective extracted fractions, and between pH values and selective extracted fractions. The table shows the Fe, Al and Ca fractions contribution to SOC stabilization and the controls of soil pH on the Al and Ca fractions.

	Fe (pyrophosphate extracted)		Al (pyrophosphate extracted)		Ca (BaCl$_2$ extracted)	
	Correlation	P	Correlation	P	Correlation	P
Wet-LS (n=11)						
SOC content	**0.932**	**<0.001**	**0.816**	**0.002**	**0.750**	**0.008**
Wet-AS (n=7)						
SOC content	**0.687**	**0.088**	**0.736**	**0.059**	0.185	0.691
All (n=18)						
pH	0.063	0.805	**-0.704**	**0.001**	**0.532**	**0.023**

References:

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