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Reply on RC2

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Author comment on "Impact of freeze–thaw cycles on soil structure and soil hydraulic properties" by Frederic Leuther and Steffen Schlüter, SOIL Discuss., https://doi.org/10.5194/soil-2021-13-AC2, 2021

Answer: We thank the reviewer for the positive feedback, comments and suggestions.

This study was to analyze the cumulative effects of multiple FTC on soil structure and soil hydraulic properties for two different textures and two different initial structures.

I have decided to minor revision for Soil due to the following reasons:

The description of freeze-thaw experiment is not clear enough. It is unrecognizable from Fig. 1B that how long a specific freeze-thaw cycle is. It seems that the temperature in each cycle is not strictly controlled to reach the same temperature.

What is the reason and practical significance author select this freeze-thaw temperature?*Answer: In preliminary tests, we investigated the status of the sample at different measured temperatures. It was found that the samples and freezer packs were thawed at 0.5°C (measured inside the sample) and that the sample was frozen when temperature was below -2.0°C. Therefore, these temperatures were our thresholds for one cycle. That is, the measured temperatures had to reach at least this values, but were allowed to proceed beyond it. Every third cycle the sample reached a maximum of 4°C, the temperature of the control stored in the refrigerator, due to the weekends. The duration for one cycle was two to three days, as described in the manuscript (Lines 120 -122). In general, the freeze-thaw temperature was selected based on the recommendations of Henry (2007) as described in Lines 85-87. To clarify the experimental setup, we will rephrase the section about the temperature control and marked the temperature thresholds in Figure 1b.*

In this study, the author proposed a concept of pore distance. However, it seems that the pore distance shown in Fig.1d is not consistent with the actual situation.

Answer: The measurements of pore distances is done for every voxel in all directions in the 3-dimensional image. The calculated pore distance contains also the information based on the segmented pores and the soil matrix of the slices above and below the shown slice of the aggregates. Hence, the pore distance in Fig.1d shows the actual situation in 3D while the segmented slice in 2D can only provide information about the specific height. This will be clarified in the revised manuscript.

Line 26: What is the definition of a meso-pore system?

Answer: We changed the term to "a well-connected pore system of narrow macro-por", which we measured by X-ray CT and defined by the resolution. In this way, we are in agreement with the official terminology derived from hydraulic properties (micro-pores <0.2µm, meso-pores 0.2-10µm, small macro-pores 10-50µm, macro-pores >50µm). This will be clarified in the revised manuscript.

Lines 113-116: The effect of freeze-thaw cycles on soil structure would be controlled by soil moisture. The author changed the original soil water content before the experiment, but did not present relevant data.

Answer: Many studies showed that the water content is one of the controlling factors of soil vulnerability towards freezing and thawing (Lines 55-60). In addition, the potential of water can influence the freezing temperature and the redistribution of water due to its dependence on the hydraulic conductivity. Our intention was to rule out soil moisture a controlling factor and focus on texture and antecedent structure instead. Therefore, a uniform water potential (-10 hPa) was therefore chosen as a reference value. This was also within the water content range of the field-fresh samples taken. Small differences in water content between treatments cannot be avoided by adjusting the water potential in soils with different pF curves. The treatment in the sand bed therefore only led to a small increase in water content of: silt clay undisturbed +0.8 vol.-% (±0.1 vol.-%) / repacked +4.6 vol.-% (±0.4 vol.-%), silty loam undisturbed +6.2 vol.-% (±0.3 vol.-%) / repacked +3.7 vol.-% (±0.8 vol.-%). We have added this information to the revised manuscript.

Figure 3 and 4: I'm confused about the unit of frequency.

Answer: The image analysis provides the number of voxels which were assigned to the calculated pore sizes/the pore distances. The absolute number depends on image dimensions, which can vary among different samples. In order to make the frequencies comparable, we divide absolute frequencies by number of voxels in the region of interest and show these relative frequencies as volume percentages instead (vol.-%).

"3.2 Soil structure of subsamples after 19 FTCs", I think it should be "3.3".

Beyond that, the "4 Conclusion" should be "5 Conclusion".

Answer: Thanks a lot for spotting the mistake. It will be corrected in the revised version.