

SOIL Discuss., author comment AC1
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Reply on RC1

Frederic Leuther and Steffen Schlüter

Author comment on "Impact of freeze–thaw cycles on soil structure and soil hydraulic properties" by Frederic Leuther and Steffen Schlüter, SOIL Discuss.,
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The manuscript experimentally investigated the effect of freeze-thaw cycles on the pore structure and hydraulic conductivity of two different soils. The manuscript is well-written, and easy to follow. The experimental materials and setup are clearly described, and the testing results are reasonably analyzed and discussed.

A minor revision is suggested. Several comments are given below.

Answer: We thank the reviewer for the positive feedback.

Line 6: The abstract is relatively long, and some minor details may be deleted to make it concise.

Answer: We will shorten the abstract by deleting some minor details.

Line 119: Only one thermometer was inserted into one sample, and the measured temperature value was used as a representative for all the samples. Is this reasonable enough?

Answer: Yes, there was only one dummy sample with a thermometer per experiment. However, the large number of replicates required that the experiment was carried out in two runs and the temperature curve in the second run measured within a new repacked sample was comparable. We have chosen to show only one temperature curve, as the figure is more comprehensible for the reader this way. The condition (frozen or thawed) of the freezer packs at the end of the cycle also served as a control for thawing. We will mention in the manuscript, that a second temperature time series was comparable.

Line 122&Figure 1(b): When the measured soil temperature was just above 0.5 deg C, frozen part may still exist inside the soil sample (which means the sample was not fully thawed). As a result, this may not represent a full freeze-thaw cycle.

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 completely frozen when temperature was below -2.0°C. Therefore, these temperatures were our thresholds for one cycle. In addition, the sensor of the thermometer integrates the temperature over a depth of 1.0 cm (20 % of the maximum sample height) and was installed in the centre of the sample. So it should be representative for the locations that freeze and thaw last. 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 have rephrased the section about the temperature control and marked the temperature thresholds in Figure 1b.

Line 128-129: The subsamples were air dried at room temperature. During this process, the soil structure and pore structure should have changed. Did the authors distinguish this from the soil structure change due to effect of freeze-thaw cycles?

Answer: To avoid changes in pore and soil structure due to drying and clay mineral shrinkage, the subsamples were only dried until narrow macropores >10 were drained (-300 hPa), not completely air dried. To do so, we calculated the water loss based on the measured water retention curves and carefully observed the water loss throughout the drying process on a sensitive precision balance. We have added an explanation to the new manuscript.

Line 130-131: This sentence is unclear.

Answer: We will rephrase both sentences (Lines 128 -131) to make the drying process of the subsamples more clear.

Line 210: Was the structure change uniform along the sample's profile? Was the effect of freeze-thaw cycle monotonic with the increasing FTC number? Or, did the measure soil properties show variations (rather than monotonically decrease/increase) with the increasing number of FTC? What are the reasons?

Answer: Settling and compaction were the main drivers for changes along the profiles. When comparing the visible pore volume as a function of the sample height in Figure 3 (a), it is shown that the effect was dependent on the soil texture and initial structure. For the repacked silt clay, the first 2 FTC already increased the visible porosity at the upper sample boundary (30-45 mm) drastically, after which the settlement per FTC decreased. For the repacked silt clay, the largest effect per FTC was measured between 2 to 5 FTC, after which the measured differences became smaller but more monotonous (when comparing 10 and 19 FTC). For the undisturbed samples, changes occurred at the lower resolution boundary and settling was prevented by the higher bulk density. Here, a statement on the monotonic behaviour of settlement and compaction was not possible. We will describe the effect of settlement and compaction on the changes along the profile in more detail in the new manuscript. In addition, the effect of all measured structural soil properties as a function of FTC number are presented and discussed in the manuscript. Table 2 and Figure 3 provides the results of a statistic analysis: "The comparisons of means for each soil property as a function of FTC were done using a one-way ANOVA for repeated measures (Line 178 in previous version)" to determine significant changes after certain numbers of FTC. For example: Line 214: The measured visible porosity decreased

sharply at the beginning of the experiment while compaction in subsequent FTCs was less pronounced. Line 305: The reduction occurred gradually with increasing number of FTCs, so that already 2 to 5 FTCs had a significant influence on the investigated structural parameters.

The size and clearness of the figures may be increased for better presentation.

Answer: Thank you for the hint. For the final version we will upload the figures in vector format.

In the discussion part, the detailed description of other researchers' work should be limited. While the analysis and discussion on the authors own findings should be strengthened/highlighted.

Answer: We tried to implement the different approaches/methods which described the impact of FTC on soil structure of different textures and management practices, which are not consistent. Therefore the proportion of other studies might be slightly larger as usual. In the new manuscript we will shorten the content of other studies and highlighted some of our own results.