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Interactive comment on "Synchrotron microtomographic quantification of geometrical soil pore characteristics affected by compaction" *by* R. P. Udawatta et al.

Anonymous Referee #2

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Overview:

Synchrotron-based X-ray tomography study enables detailed insights into the pore space architecture at μm resolution. The authors used this technique to analyze the changes in pore space features during compaction. The main finding is that soil compaction leads to a significant reduction in macroporosity and that the reduction is pore size specific. More involved morphological features like coordination numbers and mean path lengths also exhibit characteristic differences. The analysis has no technical flaws. However, the findings are not supported by accompanying laboratory measurements, so the implications for functional properties are not backed by data and

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the conclusions are a bit weak. The manuscript can be improved quite a bit (see my comments below).

General comments:

1. The method description can be shortened considerably. Both the imaging & reconstruction (GSECARS and IDL) as well as the image processing methods (3DMA) have been published in detail elsewhere. It's sufficient to refer to them and state the important facts (energy, spatial resolution, filtering and segmentation method and network extraction).

2. The main message gets lost in too many details. Too often you just repeat in the main text what has already been presented in Table 1 or the figures.

3. The stated objective of your study (p4l25-27) is a bit vague. One could interpret it as if you used X-ray tomography in combination with 3DMA just because it was available to you and you want to demonstrate its capabilities now by detecting soil compaction at the pore scale. This may sound a bit unfair and I'm sure this is not true, but you need to put more effort into convincing the reader that from your findings one can learn something about the processes that act on the pore space during compaction.

4. Figures with 3D renderings or 2D sections of the pore space are required to get an idea about the expected differences

5. The whole concept of coordination numbers and mean path length between adjacent nodes is well defined for rocks with distinct granular structure and clearly separable pore bodies and throats. For a soil with coherent structure and anisotropic macropores it might be somewhat ill-defined. I have to assume this, because you do not show images of the pore space. This may be the reason why you got unrealistically high coordination numbers, because it is not intuitive what a directly connected pore node is supposed to be in those cases (see comment below). It is therefore hard to judge for the reader how much the results for mean path lengths and coordination numbers

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depend on the parameters that you've set during network extraction.

6. In some occasions you refer to changes in functional properties due to soil compaction. However, you didn't measure those functional properties like water retention, air permeability, penetration resistance etc. with accompanying laboratory measurements to support your findings. Therefore all implications are a bit speculative. The paper could be strengthened a lot, if you did this for the updated version of the draft (using the same sample preparation steps).

Specific comments:

p4l1: missing comma before connectivity

p5l5-7: What was the motivation to chose different size classes?

p5l22-25: Irrelevant information. It's better to cite an appropriate reference for the GSECARS beamline here.

p6l1-4: So you used a white beam setup with an energy range of 7-70keV and a spot size of 10-30μm. All other information is too complicated to understand for anyone who is not an expert in synchrotron X-ray tomography.

p6l10-13: irrelevant information

p6l24-25: unclear what the Riemann function does - better write: ... filtered back-projection with the IDL programming language (Rivers, 1998).

p7l19-21: These statements are hard to understand for someone who hasn't used IK before. Two threshold have to be set a priori; one for dark voxels that definitively belong to pores and one for bright voxels that definitively belong to solid space. The remaining voxels are assigned by the IK algorithm according to neighborhood statistics. These two thresholds were set manually at the histogram peaks for pores and the aluminium wall.

p8l3: ' ... pass so-called pore throats'

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p9l18-l25: This paragraph can be omitted (or should be placed somewhere else.)

Table 1: Total volume is hard to interpret. You should use porosities instead. There seems to be a footnote for Aggregate* compaction, but I couldn't find it. What are the units in the ANOVA lines? Sizes and volumes or probabilities

p10l1: Geometrically

p11l6-7: That's only the case, if the largest pore has connection to the surface.

p11l7-8: Do you present the results of the Assouline model somewhere in you paper and compare them to measures values? Otherwise this statement is a bit speculative and should be changed accordingly.

Figure 1: The differences between the sub-figures are hard to see. Also, why did you use selected replicates and not the the average pore size distribution of all three replicates. I suggest to plot treatment averages with for different line styles in one figure on a reduced x-range up to 400μm.

Figure 2: Same problem like Fig. 1. Why did you pick specific replicates and not treatment averages? All replicates seem to have virtually identical size distributions, which is in contrast to what you state in the text.

p11l27-p8l3: 'Masked' might be the wrong word here. Compaction is just less severe in a sand as compared to a silt loam with macropores.

p12l3-11: Your statements in this paragraph are not justified by your results, because you did not conduct a REV analysis. To do so you need to start with a small sub-volume, increase it in steps and look how porosity or any other property changes with sample volume. Only if the value stabilizes before you've reached the total sample size, is an REV truly reached. Also, your samples are very different from those in Wildenschild et al. Please do a correct REV analysis or omit this paragraph altogether.

p12l14: omit 'i.e. a good pore network.'

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p12l15: How can a pore node be directly connected to so many neighbouring nodes? Do up to 40 pores meet in one singular bond of the network? Even more than ten is hard to imagine. So what does the algorithm consider to be directly connected? The explanation in on page 9, l8-9 is not helpful.

Fig 3: Same problem like figures before: Why not treatment averages and plotting all in one figure with different symbols? Otherwise the impact of different treatments is difficult to evaluate.

p12l16-18: Leave out this sentence. It's just trivial that the probability has to decrease with increasing CN.

p12l24-29: That information is explained in too much detail and dilutes the main message, which is that different initial aggregate sizes had no significant effect on CN (or Co).

p13l14: 'imply' is a to strong word here, because CN is a local property whereas air continuity is a global percolation property. They don't necessarily need to be correlated. Independent laboratory measurements with the same aggregate packing would be helpful.

p13l29-p14l1: This information is irrelevant.

p14l11-23: The whole discussion would be easier to follow if you showed 2D section or 3D renderings of the pore space architecture for different treatments. After reading the draft the greater path lengths for smaller aggregates don't make much sense too me and the presented explanation is not convincing.

p15l16-17: Be more specific. How do they agree with your results? Values like 1.20-1.21 are quite different from 1.46-1.74.

p16l14-15: 'These results provide a picture ...' - To put it in a bit exaggerated terms, this study merely collected all results that 3DMA is able to compute and presented them in every detail. However, a general picture of what happens in the pore space

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during compaction is not given. It is somwhat obvious that macroporosity decreases and that big pores are more likely to be closed during compaction. Any further insights into pore-scale processes during compaction are not really obvious from the text, or at least not well discussed. They might be somewhere, but it's just too many results and unrelated discussions which distract from that important message. You could shorten the result section and provide this discussion as the separate section in between the results and the conclusions.

Interactive comment on SOIL Discuss., 2, 825, 2015.