Solid Earth Discuss., 7, C1546–C1552, 2015
www.solid-earth-discuss.net/7/C1546/2015/

Solid Earth Discussions
Open Access

SED
7, C1546–C1552, 2015

Interactive comment on "X-ray microtomography analysis of soil structure deformation caused by centrifugation" *by* S. Schlüter et al.

S. Schlüter et al.

steffen.schlueter@ufz.de

Received and published: 11 December 2015

We thank referee 2 for his additional comments and reply to them in the following:

In 2808 (5): "While volume changes due to swelling clay minerals are immanent to any drying process, the compaction of soil is a specific drawback of the centrifugation method." It is true, but I would like to see some references, where this drawback is highlighted and have significant effects to the water retention curves data determining by centrifugation.

We added some more references in the discussion section that show different water

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

retention functions for the same soil depending on whether they where obtained with a pressure plate or a centrifuge.

2810 (5): "The objective of this paper is to measure local deformations ..." I think this is the main objective and should be more clear in the abstract.

Done.

2814 (15) "X-ray microtomography" Here, it would be useful to get some more details about the CT scanning. 150 keV with beam current of 425 μA sounds strong. Is the number of power 63.8 W really correct? For this tube settings, what is the main attenuation of the scanned sample (I0/Iatt)? 1mm copper filter is really strong filtering photons and reduce significant beam hardening effects but you will loss photon flux during transmission through the sample. Would be 0.1 or 0.5 mm Al filter not enough for reducing beam hardening effects? Why do you use exactly 2749 projections (rotation of 360 ?). What kind of detector the X-TEk XCT 225 use (sure, the exposure time depends from specifications of scintillator material and CCD detektors, e.g. dead time etc.). Do you use one projection of 708 ms exposure time or collect averaging projections (if so, how many?) with this given exp. time? By the way: averaging projections reduce the noise significant of course its increase the scan time. What are the dimension of the projections (2k?, what datatype 12 or 16 bits?) and what are the dimension of the reconstructed image? What kind of reconstruction method the CT Pro-3D software use? I think, this software is an in-house product within the X-TEk Nikon CT scanner or not?

Yes, the power of 63.8W is correct. We cannot make a statement about the mean attenuation in our projections, but we made sure that the photon count in the darkest areas of the projection is high enough for a sufficent signal-to-noise ratio. The choice of the filter material and thickness is often a matter of experience rather than of strict rules and we did not test other combinations. The motivation for choosing these energy settings and filter type was to prevent overexposure at the margins of the detector panel and at the same have enough photon counts on the parts of the detector that capture the center of the sample. Yes, we used one frame per projection only and did not apply averaging over multiple frames to reduce scan time. We are aware that this causes more noise, but with the non-local means filter, we remove it efficiently afterwards. We will provide more information about the detector panel (Perkin Elmer 1620, 16bit with 1750x2000 pixels) and the reconstruction software (filtered back projection) in the updated draft.

2814 (20): I think you use the reconstructed raw images, right? Which scaling/resampling method do you use to get the resolution of 180μm (what dimension delivers)?

Since we downsized with an integer factor, we applied simple averaging.

2815 (10-25): I think the rescaling of the image histogram to get only all the rigid rocks is also part of image analyses and should be described in 3.5, because you segmented three features (pores, matrix and rocks) by fuzzy c-means clustering to get optimal thresholds for these phases. Doing this, why do you need to rescale the histogram to get out the rocks described in 2815 (10)? Do you use 3D NLM filter? Do you use this image processing/segmentation on the rescaled images? Maybe you should combine 3.4 and 3.5

We updated the image processing section considerably and provide more details on the workflow. Filtering and segmentation are only used for the pore space analysis.

Image registration is typically applied to grayscale data and not to segmented data. This is why we prefered contrast adjustment for rocks instead of segmentation of rocks because the outcome is still 8-bit (256 gray values) and not 1-bit (black or white) and therefore contains more information.

2817 (25): The change of porosity from 0 kPa to -500 kPa (lost of volume) corresponds with the volume increase of compaction?

The change in porosity that we capture with μCT only refers to macropores ($> 61\mu$m), whereas the change in soil volume is due to changes of the entire pore spectrum. Hence, they are correlated, but cannot be used interchangably.

2818 (5): Do you quantify and segment the data on the original image resolution of 60 μm or the resampled images?

Segmentation is done at the original resolution. This will be more clear in the updated draft.

2818 (20): "However, if the same rock does not have a spatial overlap to begin with, then a first-order optimization algorithm like adaptive stochastic gradient descent cannot find a useful displacement vector." Please described a bit more why it is so.

After adding the second soil sample with a lower rock content and redoing all the analysis, the focus of discussion section about methodological limititations of our approach has shifted entirely. So we dropped that statement in the updated draft.

2818 (25): Is that possible to get out a displacement tensor for the deformation from the displacement vector field? If so, please add the tensor to the results, so it becomes comparable with the second sample to be in the revision.

The displacement tensor would show the individual components (x,y,z) of the displacement vector. The 3D renderings would look too crowded then. We will also show deformation vector fields for the second sample in the updated draft.

2820 (5): Isn't it possible to simulate a kind of water retention curve on a segmented pore structure (e.g. with SatuDict module in the GeoDict software package? Maybe this can help to understand the influence of deformation (porosity changes) during compaction in comparison with an experiment.

Yes, but only for visibility porosity, which only covers a small range of the water retention curve.

2820 (20-25): There is no information about the computational cost, accuracy and efficiency, so you can't figure out this statement. What are the influence of resolution of the images in computational cost, because you reduced the resolution to 160μm? For the small rock registration problem, maybe it helps to try it with higher resolution, but this increase the computational cost. To optimize or test that, you can try to exclude classes of small rigid rocks as a kind of iteration process to find optimal settings for elastic registration in respect to the structure.

We have added some statement about computation time and memory consumption to the updated draft. We resampled the images mainly to reduce memory consumption, but the computation time decreases then as well of course.

Fig. 1: Please add the curve of a second sample

Figure 1 is removed.

Maybe add a small distance bar to demonstration the compaction of the soil from A to C (found the numbers in 2817 (25)).

The scale bar existed, but was too thin. It's thicker in the updated figure.

Fig. 3: Maybe add cumsum curves and get the numbers of d10, d50, d90 pore sizes. Are these numbers change during compaction?

We replaced the frequency plots with cumulative curves as suggested. We don't highlight d10, d50, d90 pore sizes in the figure, but these can be imagined as straight lines in the cumulative plots.

Fig. 4: If you profile the rocks (same way of porosity), it corresponds and how? Maybe add this "rock curve" to the diagram.

The position of rocks is more or less erratic. Plotting the rock profiles would certainly demonstrate the settlement of the rock matrix, just like we described it in the main text for a reference rock in the top part of the sample. However, we feel that the figures would look too crowded with six curves in one plot. Moreover, the displacement of rocks is depicted in more detail when discussing the results of digital volume correlation.

Fig. 5: Is that the complete ROI and contains all registered rocks?

Each image (red and green) covers a slightly different physical volume. So missing counterpart at the very bottom of figure B can be due to slightly different ROIs.

Fig. 6: A: from 0 to -100 kPa and B from -100 to -500 kPa? I am not sure.

No. figure B depicts the deformation from 0kPa to -500kPa. This is now clarified also in the figure caption.

Interactive comment on Solid Earth Discuss., 7, 2807, 2015.