Solid Earth Discuss., 7, C1525–C1529, 2015
www.solid-earth-discuss.net/7/C1525/2015/

Solid Earth
Discussions
Open Access

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

Anonymous Referee #2

Received and published: 9 December 2015

This manuscript addressed relevant scientific questions within the scope of SE, especially of special issue with the scope of pore-scale tomography and imaging – applications, techniques and recommended practice. It demonstrates an application of x-ray tomography analysis to quantify the spatial deformation of a soil structure caused by a standard method to determine soil retention curves by centrifugation. As I understood, the authors using centrifugation to demonstrate soil deformation under controlled experimental conditions (angular velocity and frequency) and apply a novel method to quantify this deformation with help of 3D imaging x-ray tomography techniques (exactly the scope of the SI), image registration and calculation of the deformation field. As I started the review, two comments in the interactive discussion were available. Many thanks to the annotator #1 and the answer of the author. I am fully agree with the comments of annotator #1 and thanks the authors for the answer. They will add some additional data and information addressed to the comments within the next version of the paper. Specially also I think, demonstration of the results of a second sample (with rock content 0.2%) would be essential to show how the new protocol works with more or less ideal conditions (for registration, the given one sample in this paper with 3% rock content) and not so ideal conditions with low rock content. This in generally would be the major revision work of this paper. In the following I have some questions/remarks in detail in addition the annotator #1: 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. (I am not a specialist in that, so I cannot give an example, but in this paper this method is one of the objectives and should be more addressed in p. 2810 (20).

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.

2813 (10):

Would be useful to have the information about the soil classification.

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)? 1 mm 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?

2814 (20):

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

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

2817 (25):

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

2818 (5): “The range of pore diameters that can be depicted with X-ray microtomography is rather small (> 60 μm) and limited by image resolution. Information about sub-voxel changes in porosity is lost.”

Do you quantify and segment the data on the original image resolution of 60 μm or and the resampled images?

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 gradient25 descent cannot find a useful displacement vector.”

Please described a bit more why it is so.

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.

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.

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 160 μm? 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.

2821 (5): I am absolutely agree!

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

SED

7, C1525–C1529, 2015

Fig. 2: Maybe add a small distance bar to demonstration the compaction of the soil from A to C (found the numbers in 2817 (25)).

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

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

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

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

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