Geophysical Research Abstracts
Vol. 18, EGU2016-8051, 2016
EGU General Assembly 2016

X-ray microtomography analysis of soil structure deformation caused by centrifugation

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Centrifugation provides a fast method to measure soil water retention curves over a wide moisture range. However, deformation of soil structure may occur at high angular velocities in the centrifuge. The objective of this study was to capture these changes in soil structure with X-ray microtomography and to measure local deformations via digital volume correlation. Two samples were investigated that differ in texture and rock content. A detailed analysis of the pore space reveals an interplay between shrinkage due to drying and soil compaction due to compression. Macroporosity increases at moderate angular velocity because of crack formation due to moisture release. At higher angular velocities, corresponding to capillary pressure of <-100kPa, macroporosity decreases again because of structure deformation due to compression. 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. A new protocol for digital volume correlation was developed to analyze the spatial heterogeneity of deformation. In both samples the displacement of soil constituents is highest in the top part of the sample and exhibits high lateral variability explained by the spatial distribution of macropores in the sample. Centrifugation should therefore only be applied after the completion of all other hydraulic or thermal experiments, or any other analysis that depends on the integrity of soil structure.