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Quantification of post-tillage soil structure dynamics via dynamic micro-CT imaging

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Tillage aims at optimizing the soil environment for crop growth and involves alteration of the topsoil structure by mechanical agitation. However, freshly tilled soil is unstable. The tilled layer of soil therefore undergoes slumping, largely caused by climatic forces such as wetting-drying cycles. Slumping is associated with changes in soil structure and associated functions, e.g. fluid transport properties. Although the processes involved in post-tillage soil structure dynamics are generally well established, their quantitative and predictive representation remain limited. The current research project aims at advancing the quantitative description of post-tillage soil structure evolution. A novel small-scale experiment was set up inside an industrial microCT scanner device to study the effects of wetting and drying on soil structural changes within a seedbed. Air-dry soil aggregates were loosely packed up to 35 mm into an aluminium ring (inner diameter: 22 mm; height 59 mm) and placed on a sand bed inside the CT scanner. Next, the sample was wetted from below at a constant pressure head (-1 cm). After 6 hours when the supplied water had reached the top of the sample, the wetting phase was terminated, and air-drying from the top of the column was started and maintained for up to 17 hours. During the wetting-drying cycle, the sample was scanned multiple times (varying time steps). Here, we present results from one clay soil and one loam soil. The onset and termination of different slumping mechanisms (micro-cracking due to differential swelling and coalescence under plastic conditions) were quantified from the temporal images taken at the different time steps. We propose a method for quantification of the degree of coalescence and the initiation and termination of coalescence based on the contact area between aggregates. In addition micro-crack evolution due to swelling and shrinkage of aggregates will be analysed based on crack volume and distribution. During wetting, rheological flow was more prominent in the loam soil while micro-cracking played the major role in aggregate fragmentation in the clay soil.