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A novel approach to evaluate the spatial complexity of soil aggregates using NanoSIMS

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Soil aggregation is a key factor for a number of biogeochemical processes (e.g. soil organic matter stabilization and nutrient and pollutant sorption) in soils. Although there is a large number of studies on the factors controlling such soil processes, it is still challenging to study these processes in-situ. However it can be assumed that the spatial arrangement of biogenic and mineral soil constituents in soil aggregates and thus the aggregate structure determine the processes happening at the aggregate scale.

We used the nano-scale secondary ion mass spectrometry (NanoSIMS) technology to study a cross section of a single large aggregate from the top-soil of an agricultural cropland with a regular grid of 45 measurements (each with a size of 30x30 μm). Using Cs+ as primary ion, the negatively charged ions 12C-, 12C14N-, 12C15N-, 27Al16O-, 56Fe16O- and 28Si- were collected with a lateral resolution of up to 100 nm. We applied pre-processing algorithms and unsupervised classifications to separate and identify organic and inorganic compartments in the NanoSIMS measurements.

Our approach enabled us to explore the elemental and isotopic composition of organic and inorganic particles at a before unresolved lateral resolution for a complete soil aggregate and spatially explicitly map and quantify the different compartments.