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Soil aggregate formation model informed by oxygen and water patterns development around the growing roots

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Model of microbial growth and aggregate formation in rhizosphere (Baumert et al., 2018) was applied to the results of drought simulation experiment with maize plants, where detailed images of water content and oxygen concentration patterns around roots were taken at regular intervals. In the present study we develop our model to describe biochemical situation around the real growing maize root, which consumes water and oxygen. We fit the model to the experimentally obtained profiles of oxygen and water with the distance from the growing maize root taken at a time step of 1 day.

We used rhizoboxes (15 cm x 15 cm x 1.5 cm), which were filled with a sandy soil. Sensor foils for fluorescence imaging of O_2 were installed on the inner-side of the containers. A maize plant was grown in each container for two weeks. Then we took time series of fluorescence images for visualization of oxygen changes induced by root respiration. Changing water content was mapped in parallel by non-invasive neutron radiography, a method very sensitive to water and capable of high spatial resolution. It can also detect the root system of the maize plants. Moisture content in the vicinity of the roots became elevated with time on the background of overall soil drying due to root exudation. Oxygen formed a positive gradient with distance from the root.

We model soil aggregate development in the rhizosphere using the dynamics of gluing agents, fungi and moisture spatial patterns. The results show theoretical aggregate formation in different moisture conditions. The model can be used to suggest a new experimental design which includes measurements of waterstable aggregate size distribution dynamics and its factors such as moisture, oxygen, fungi and total bacteria, labile soil C.