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Simulation of crop yield variability by improved root-soil-interaction modelling

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Understanding the processes and factors that govern the within-field variability in crop yield has attached great importance due to applications in precision agriculture. Crop response to environment at field scale is a complex dynamic process involving the interactions of soil characteristics, weather conditions and crop management. The numerous static factors combined with temporal variations make it very difficult to identify and manage the variability pattern. Therefore, crop simulation models are considered to be useful tools in analyzing separately the effects of change in soil or weather conditions on the spatial variability, in order to identify the cause of yield variability and to quantify the spatial and temporal variation.
However, tests showed that usual crop models such as CERES-Wheat and CERES-Maize were not able to quantify the observed within-field yield variability, while their performance on crop growth simulation under more homogeneous and mainly non-limiting conditions was sufficent to simulate average yields at the field-scale. On a study site in South Germany, within-field variability in crop growth has been documented since years. After detailed analysis and classification of the soil patterns, two site specific factors, the plant-available-water and the O2 deficiency, were considered as the main causes of the crop growth variability in this field. Based on our measurement of root distribution in the soil profile, we hypothesize that in our case the insufficiency of the applied crop models to simulate the yield variability can be due to the oversimplification of the involved root models which fail to be sensitive to different soil conditions.

In this study, the root growth model described by Jones et al. (1991) was adapted by using data of root distributions in the field and linking the adapted root model to the CERES crop model. The ability of the new root model to increase the sensitivity of the CERES crop models to different enviromental conditions was then evaluated by means of comparison of the simualtion results with measured data and by scenario calculations.