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Developing a methodology for the inverse estimation of root architectural parameters from field based sampling schemes

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Root traits are increasingly important in breading of new crop varieties. E.g., longer and fewer lateral roots are suggested to improve drought resistance of wheat. Thus, detailed root architectural parameters are important. However, classical field sampling of roots only provides more aggregated information such as root length density (coring), root counts per area (trenches) or root arrival curves at certain depths (rhizotubes). We investigate the possibility of obtaining the information about root system architecture of plants using field based classical root sampling schemes, based on sensitivity analysis and inverse parameter estimation.

This methodology was developed based on a virtual experiment where a root architectural model was used to simulate root system development in a field, parameterized for winter wheat. This information provided the ground truth which is normally unknown in a real field experiment. The three sampling schemes coring, trenching, and rhizotubes where virtually applied to and aggregated information computed. Morris OAT global sensitivity analysis method was then performed to determine the most sensitive parameters of root architecture model for the three different sampling methods. The estimated means and the standard deviation of elementary effects of a total number of 37 parameters were evaluated. Upper and lower bounds of the parameters were obtained based on literature and published data of winter wheat root architectural parameters. Root length density profiles of coring, arrival curve characteristics observed in rhizotubes, and root counts in grids of trench profile method were evaluated statistically to investigate the influence of each parameter using five different error functions. Number of branches, insertion angle inter-nodal distance, and elongation rates are the most sensitive parameters and the parameter sensitivity varies slightly with the depth. Most parameters and their interaction with the other parameters show highly nonlinear effect to the model output.

The most sensitive parameters will be subject to inverse estimation from the virtual field sampling data using DREAMzs algorithm. The estimated parameters can then be compared with the ground truth in order to determine the suitability of the sampling schemes to identify specific traits or parameters of the root growth model.