Reconstructing the root system development of spring barley using minirhizotron data

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Increasing computer power favors the use of detailed mesoscopic models to predict root water uptake at field scale. These models explicitly consider the 3-D root architecture development of a plant. However, a lack of high-quality data to calibrate and validate these models remains, especially for plants in undisturbed, layered soils. Combination of root architecture simulations and minirhizotron measurements at several depths may offer a way out...

Objectives:
(i) explore the value of the information that can be extracted from minirhizotron images in horizontally installed rhizotubes at four depths;
(ii) assess the sensitivity of predictions of variables that can be observed in minirhizotrons by the RS model RootTyp to changes of its model parameters;
(iii) estimate RS model parameters and investigate their information content concerning the root architecture

Minirhizotron measurements
- two undisturbed soil monoliths S1 & S2
  - h=150 cm, ø=116 cm
  - orthic Luvisol: A1 (0-40 cm), B1 (41-70 cm), B2 (71-100 cm) and B3 (>100 cm)
- 4 rhizotubes T1-T4 per monolith:
  - -22.5, -47.5, -72.5 and -122.5 cm depth
  - 5x2 images per tube

For each rhizotube: characteristics of root breakthrough curve (rBTC) \( N_{\text{Max}_{\text{IBG}}} \) SLP and overall course of the rBTC

Root architecture simulations
- Insertion angle
- Distance between rhizotubes
- Growth velocity
- Reiteration

Sensitivity analysis
- the Morris One-at-a-time test
  - effect of \( <\alpha_{\text{INIT}}(\text{Type 0})> \), \( <\alpha_{\text{INIT}}(\text{Type 1})> \), \( \text{std}(\alpha_{\text{INIT}}) \), \( \text{std}(v_{\text{INIT}}) \)
  - 70 model evaluations

Minirhizotrons are the only way to retrieve dynamic information on root growth and root architecture (RA) in an undisturbed soil environment at the lysimeter or field scale without destroying parts of the root system. RA model parameters greatly influencing the root breakthrough curve at a certain depth are the root growth velocity of the primary roots and the number of primary roots emitted. The deviation between the model results and the observations indicated that other processes which were not considered in the simple simulations, such as reiteration and varying soil resistance, played an important role in the root development during this experiment. However, the minirhizotron technique does not provide enough information to restrain a RA model with reiteration and soil layering in a satisfying way without being combined with additional information.

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