FORSCHUNGSZENTRUM JÜLICH

DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCES
K.U.LEUVEN - BELGIUM

KATHOLIEKE UNIVERSITEIT LEUVEN

Reconstructing the root system development of spring barley using minirhizotron data

S. Garré[1,4] *(sarah.garre@ees.kuleuven.be)*, L. Pagès[2], M. Javaux[3, 1], J. Vanderborght[1] and H. Vereecken[1]

Background

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;

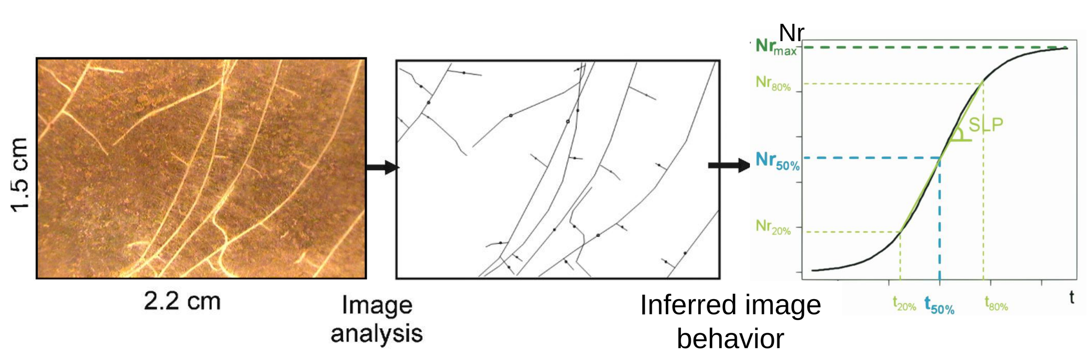
(ii) assess the sensitivity of predictions of variables that can be observed in minirhizotrons by the RS model RootTyp to changes of its model parameters;

(iii) estimate RS model parameters and investigate their information content concerning the root architecture

Methodology

Minirhizotron measurements

- two undisturbed soil monoliths S1& S2 h=150 cm, ø=116 cm
- orthic Luvisol: A_p *(0-40 cm)*, B_t *(41-70 cm)*, B_{v1} *(71-100 cm)* and B_{v2} *(>100 cm)*
- 4 rhizotubes T1-T4 per monolith: -22.5, -47.5, -72.5 and -122.5 cm depth
- 5x2 images per tube

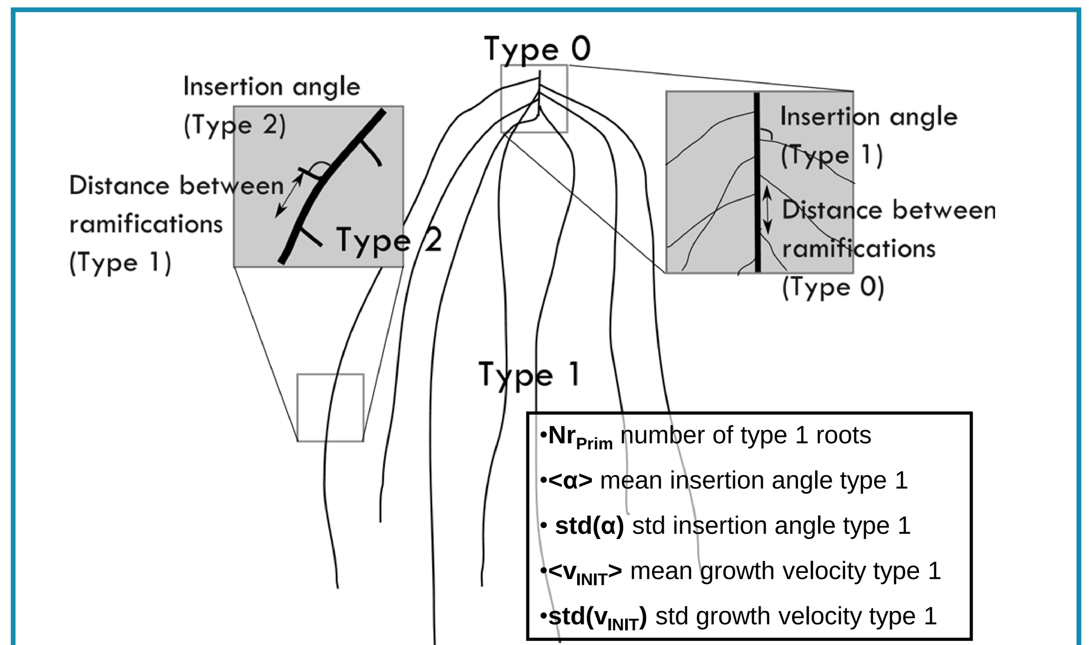


Nr_{norm}: normalized number of roots in tube T_i (cm^{-2})
$Nr_{im(i)}$: number of roots in image i (-)
$b_{im(i)}$: width of image i (cm)
N_{im}: number of images
r_{tube}: radius rhizotube (cm)

$$Nr_{norm}(T_i) = \frac{\sum_{N_{im}} Nr_{im(i)}}{\sum_{N_{im}} b_{im(i)}} \cdot \frac{1}{r_{tube}}$$

- For each rhizotube: characteristics of root breakthrough curve (**rBTC**)→ Nr_{Max}, $t_{50\%}$, SLP

Root architecture simulations

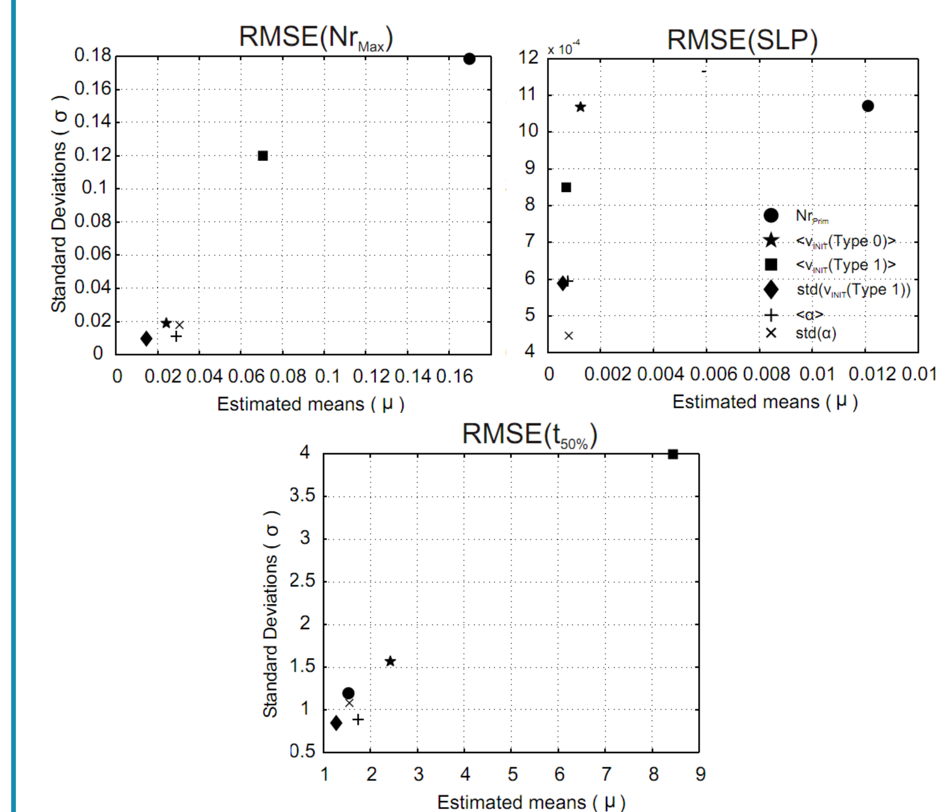


- **Simple model:** 5 ‚basic' parameters Nr_{Prim}, $\langle\alpha\rangle$, std(α), $\langle v_{INIT}\rangle$, std(v_{INIT})
- **Simulations**: 200 plants, 7 rows 24 cm apart, 2 cm between plants/row (≈ real lysimeter)

Model optimization:
comparison of minirhizotron data and simulations using rBTC characteristics Nr_{Max}, $t_{50\%}$, SLP and overall course of the rBTC

Sensitivity analysis

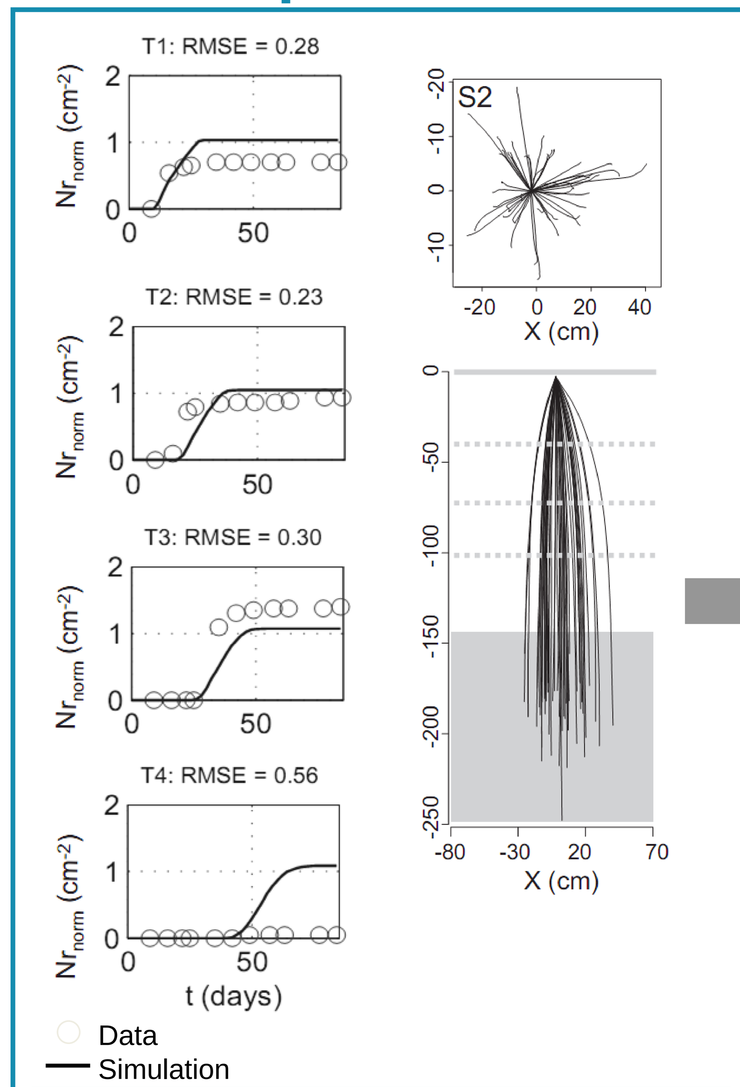
- the Morris One-at-a-time test
- effect of $\langle v_{INIT}(\text{Type } 0)\rangle$, $\langle v_{INIT}(\text{Type } 1)\rangle$, std($v_{INIT}$(Type 1)), $\langle\alpha\rangle$, std(α) and Nr_{Prim}
- 70 model evaluations



Results of Morris OAT-test: mean and standard deviation of the elementary effects of 6 model parameters on three curve characteristics

Results

Best simple model S2

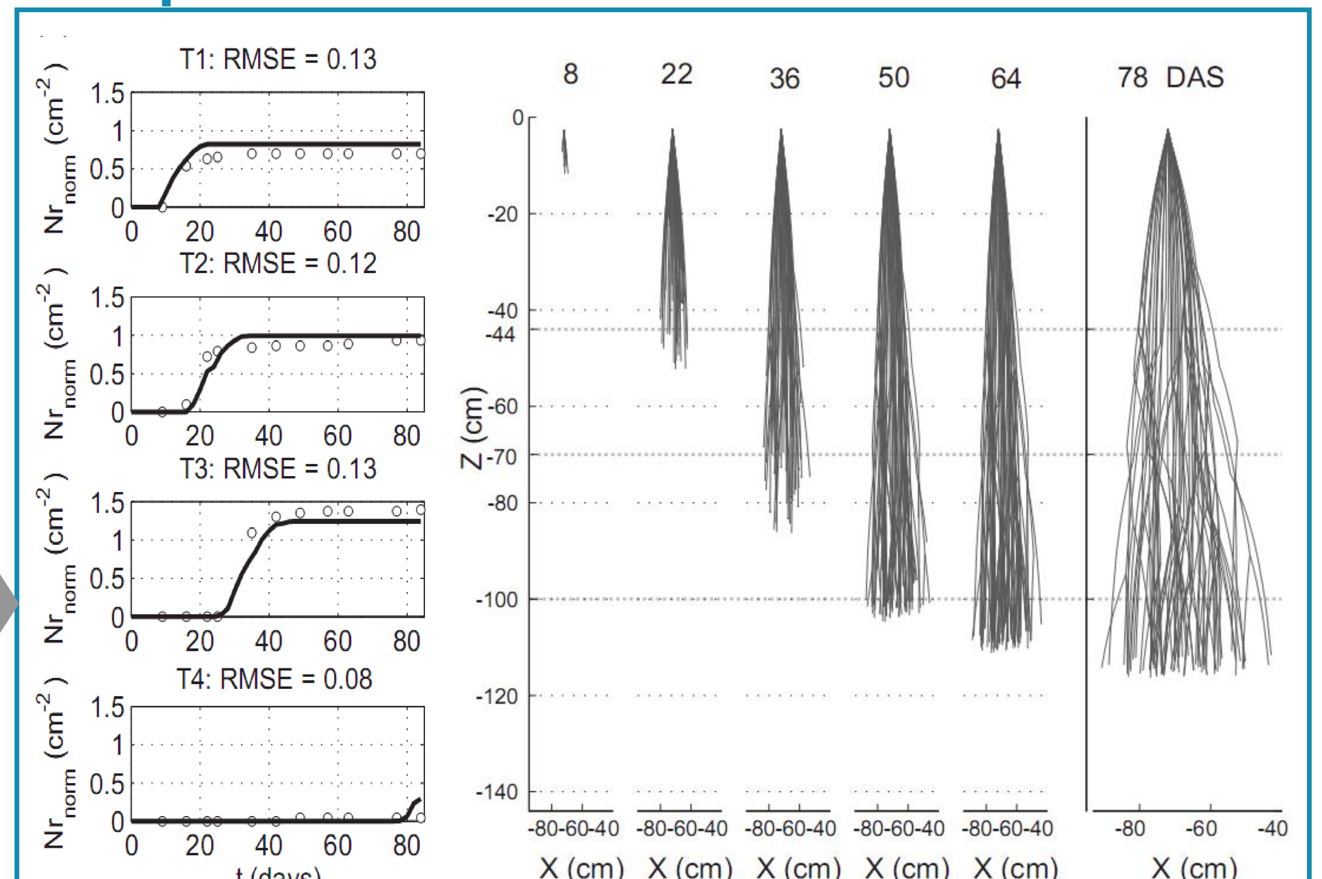


Nr_{Prim} 51; **$\langle\alpha\rangle$** 2.83 rad; **std(α)** 0.171 rad; **$\langle v_{INIT}\rangle$** 3 $cm.day^{-1}$; **std(v_{INIT})** 0.3 $cm.day^{-1}$

Observations

1. Highest number of roots is not observed at the tube nearest to the soil surface
   → new thick and long roots originating deeper in the soil profile?
2. Slope of the root breakthrough curves changes with depth
   → idem 1?
3. Effective growth velocity of the roots changes with depth
   → varying soil resistance may cause roots to change growth velocity or tortuosity of their paths within certain horizons?

Complex model S2



= simple model
\+ root reiteration → increasing number of roots with z
→ changing rBTC slope
\+ soil heterogeneity → root growth = f(soil resistance)

Conclusion

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.

1-IBG-3, Forschungszentrum Jülich GmbH, Jülich, Germany;
2-PSH, INRA PACA, Avignon, France;
3-ELI, Universite Catholique de Louvain, Louvain-la-Neuve, Belgium
4-EES, KULeuven, Leuven, Belgium