

Observations of root growth in stratified soils at the microscopic scale: Insights from micro-computed tomography

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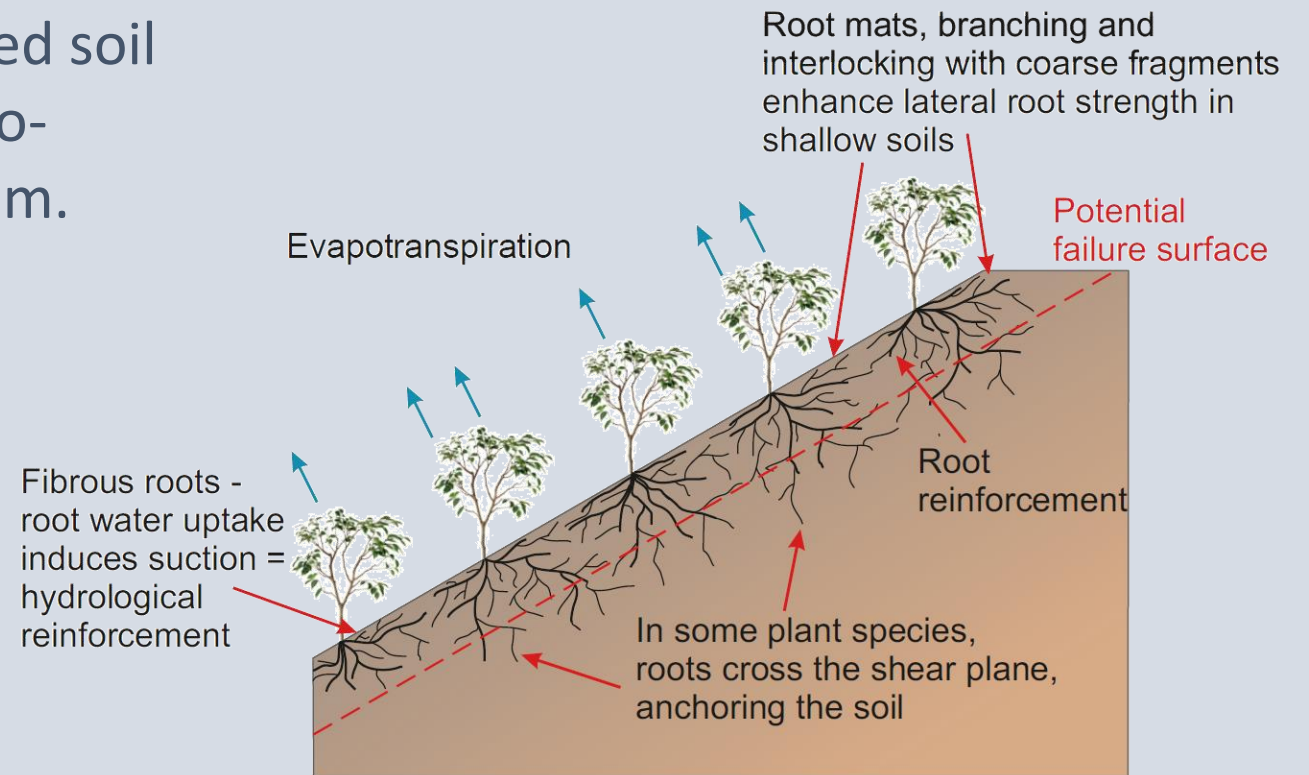
Sharing is
encouraged

Background

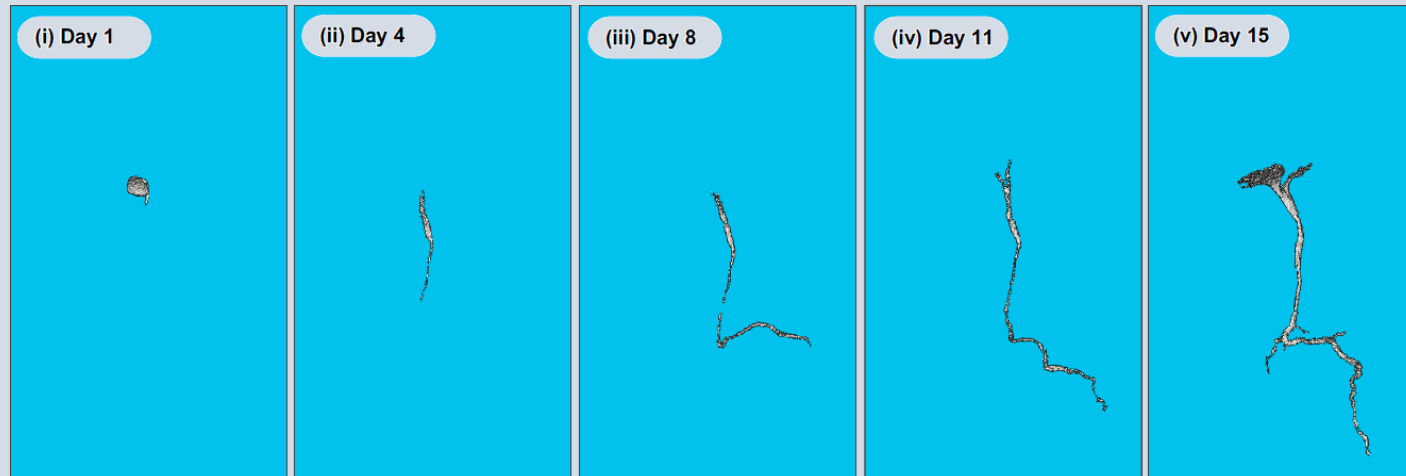
Vegetation is often used as a natural resistance mechanism against shallow mass movement.

Constitutive models to simulate vegetated soil at the macro scale typically require micro-mechanical parameters of the root system.

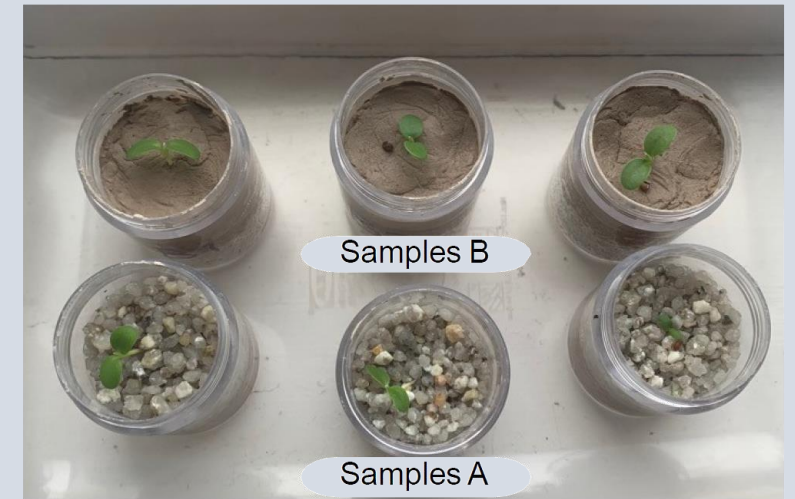
Standardised measurement of these parameters is currently non-existent, and thus typical ranges of their values or robust experimental techniques to measure them are still scarce.



Methodology

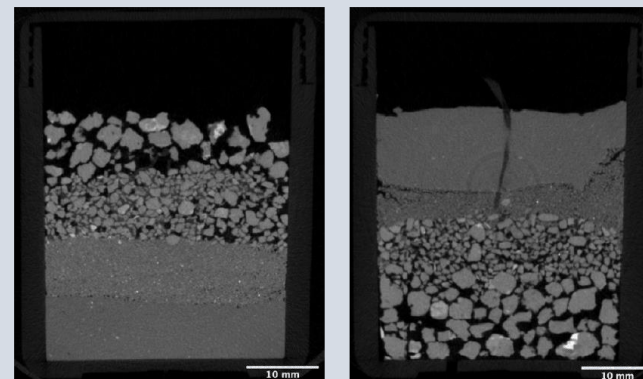


Monitoring root growth in 4-D, within 15 days of observation.

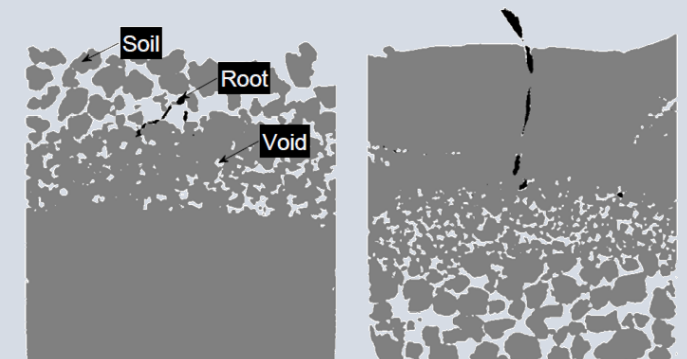


Samples at day 14 of the investigation

Two soil samples with distinct stratigraphy from top to bottom: (A) coarse-to-fine; (B) fine-to-coarse

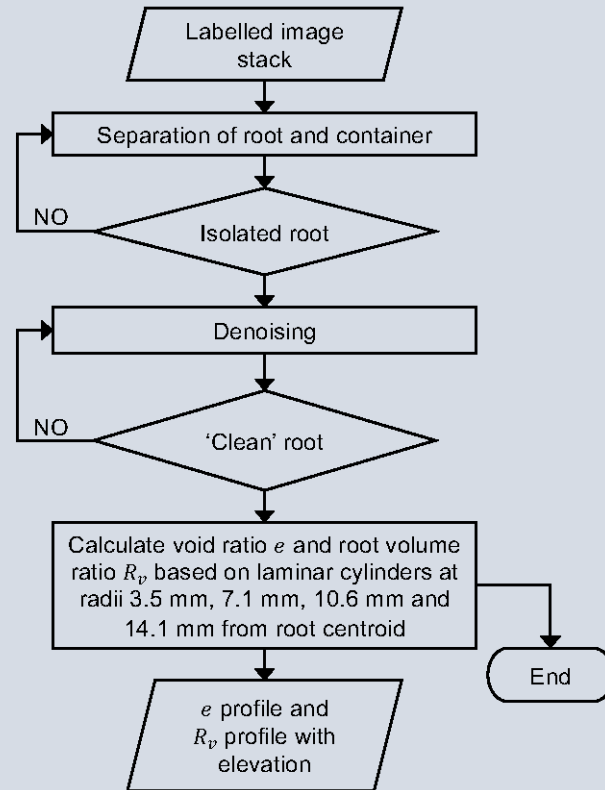


μCT image acquired on day 15

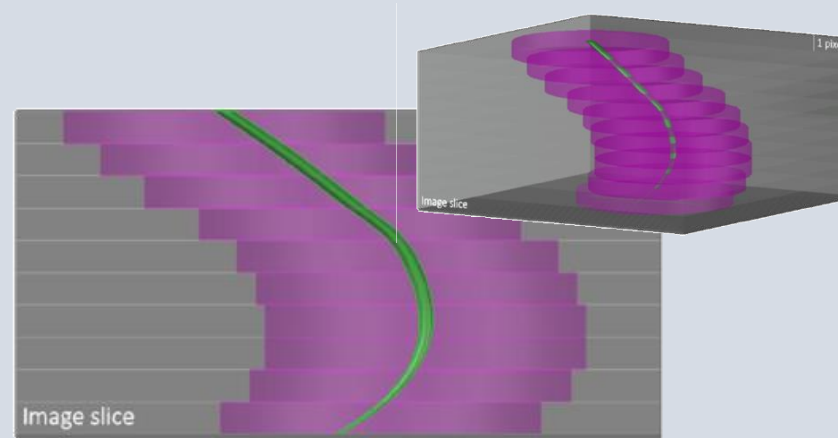


Labelled image

Methodology



In-house image-processing script to calculate soil-root characteristics automatically

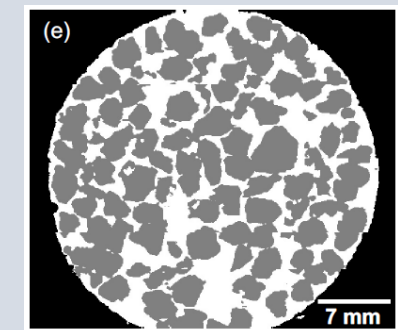
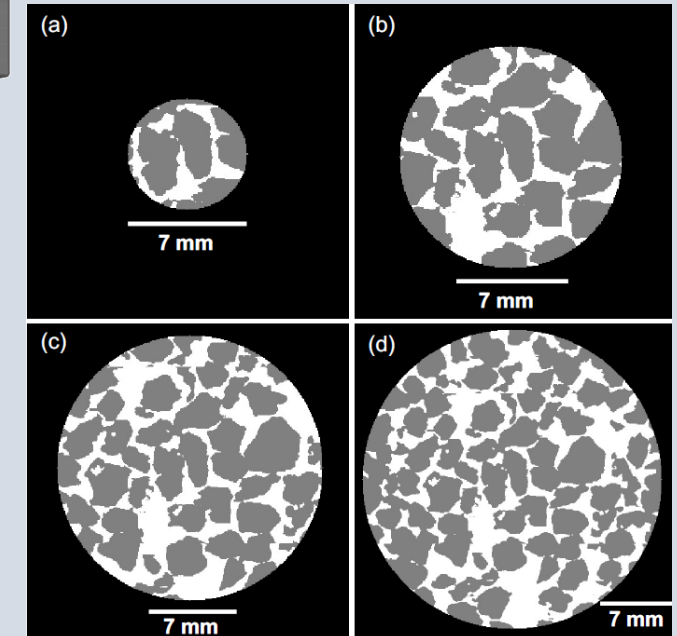


Laminar cylinder around root used as region of interest

Supervised training of Machine Learning Segmentation algorithm for different sizes of training datasets, i.e. 5%, 10% and 20% of all images.



Trainable Weka Segmentation



Sizes of the regions of interest

Results and Discussion

The Influence of Root Growth on Soil Fabric

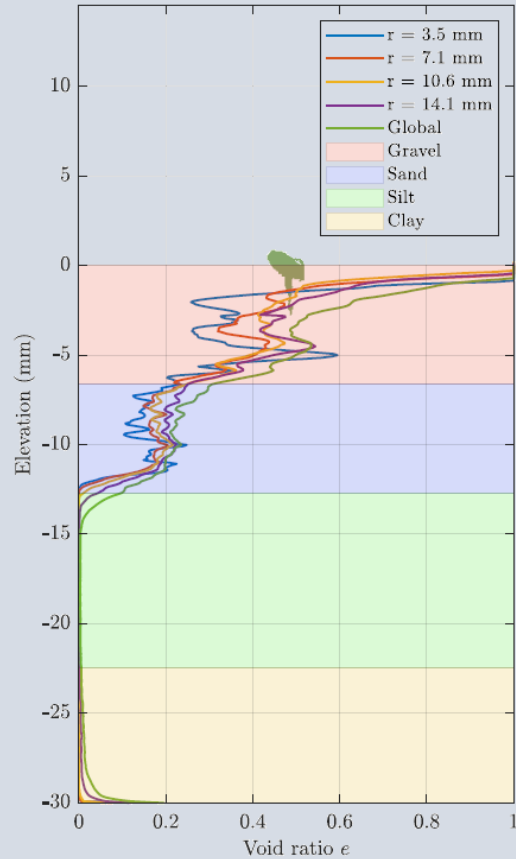
The Influence of Soil Fabric on Root Growth

Effectiveness of the Machine Learning Training Data Set Size

The Effect of ROI Size

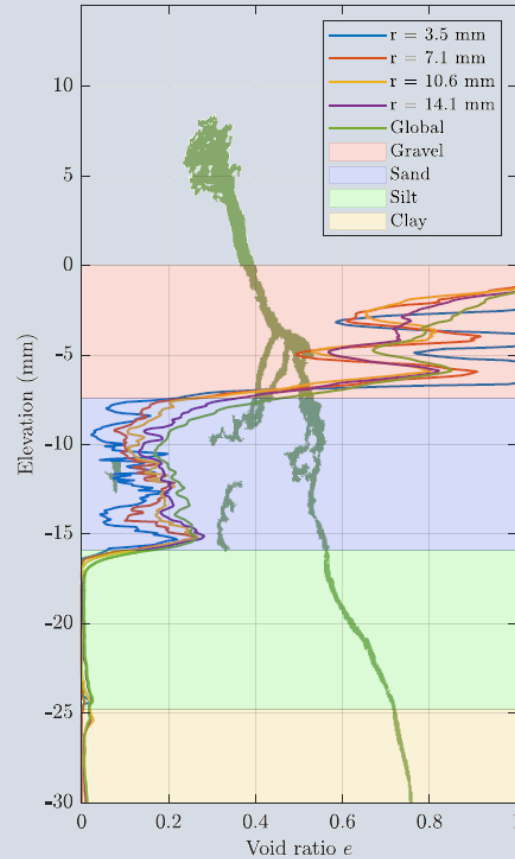
Results and Discussion

Void Ratio per depth $e = \frac{\text{Volume of voids}}{\text{Volume of solids}}$

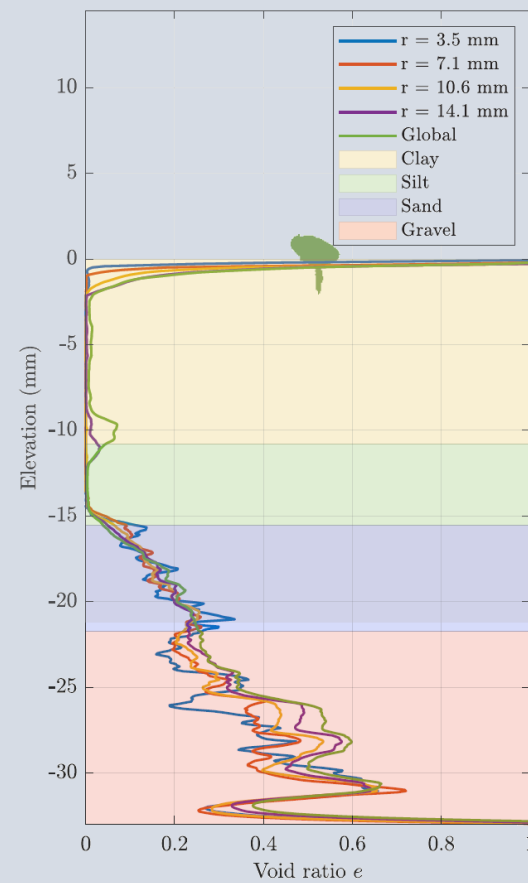


Day 1

Sample A - Coarse-to-fine

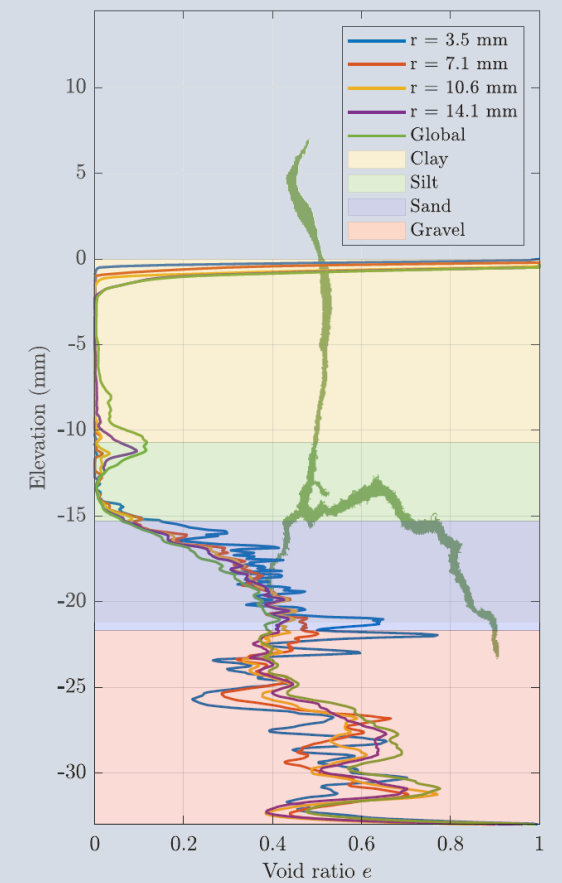


Day 15



Day 1

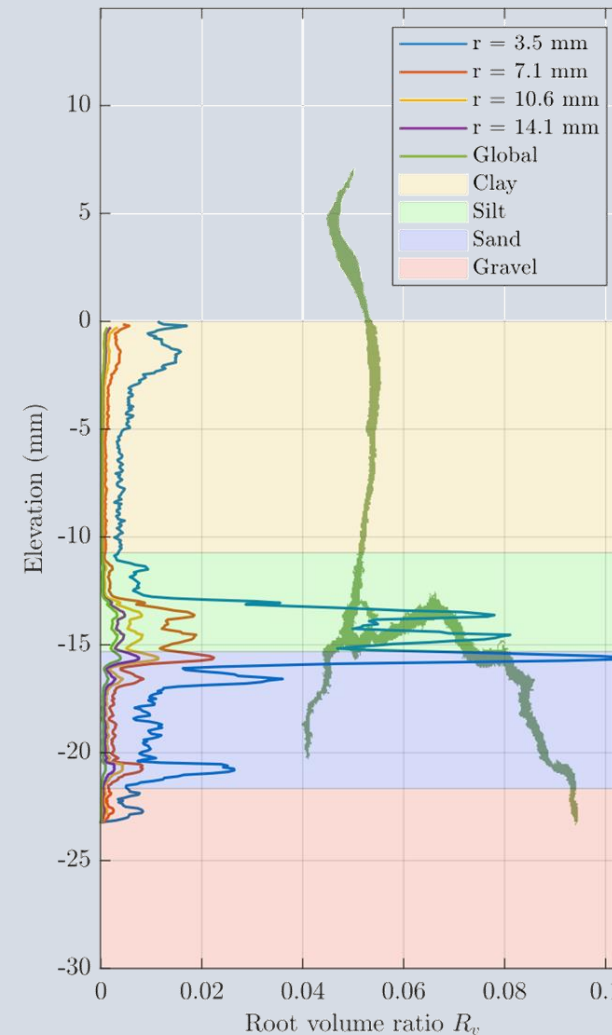
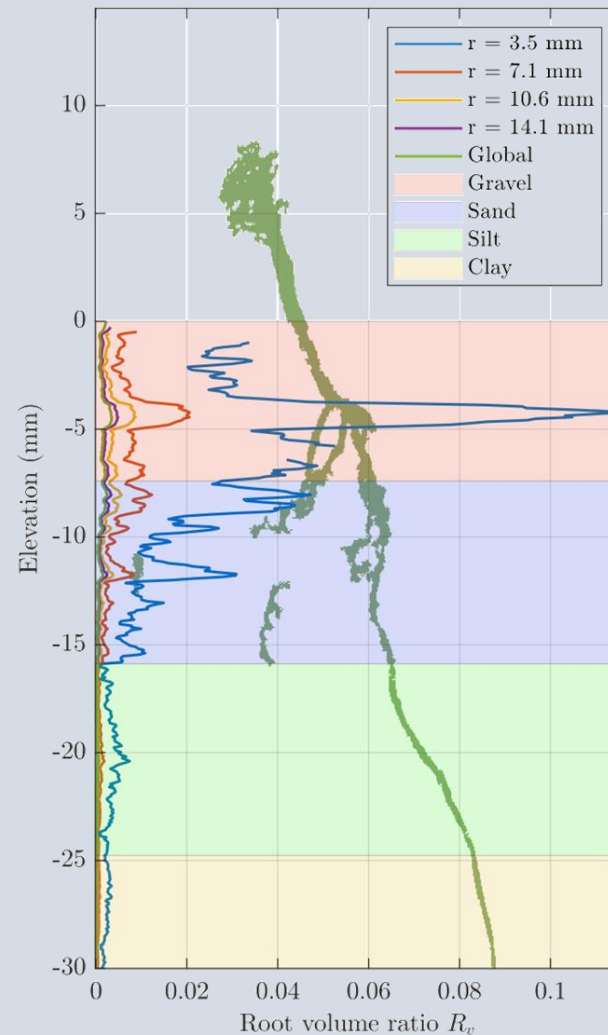
Sample B - Fine-to-coarse



Day 15

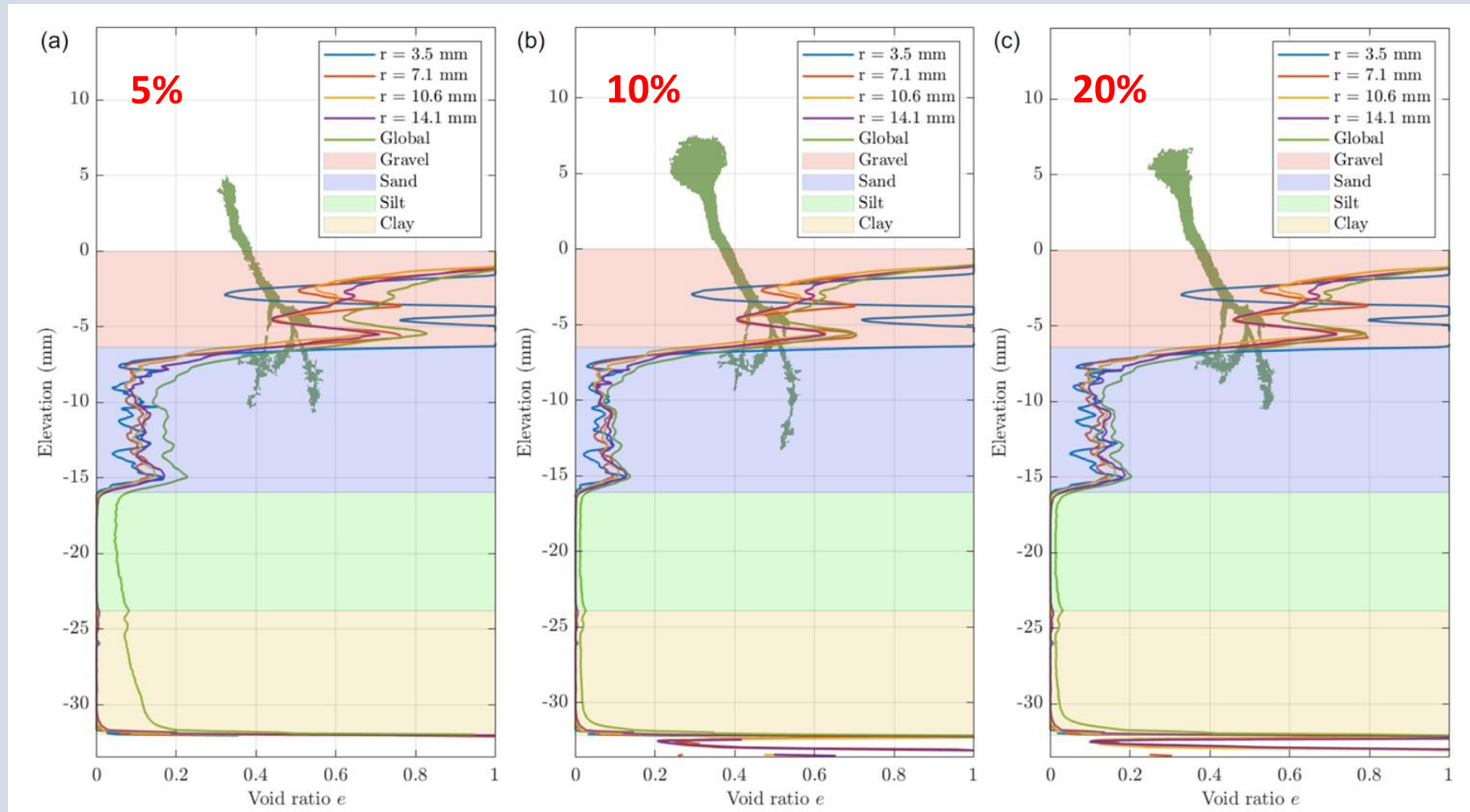
Results and Discussion

Root Volume Ratio



Results and Discussion

Training dataset size for Machine Learning-based segmentation



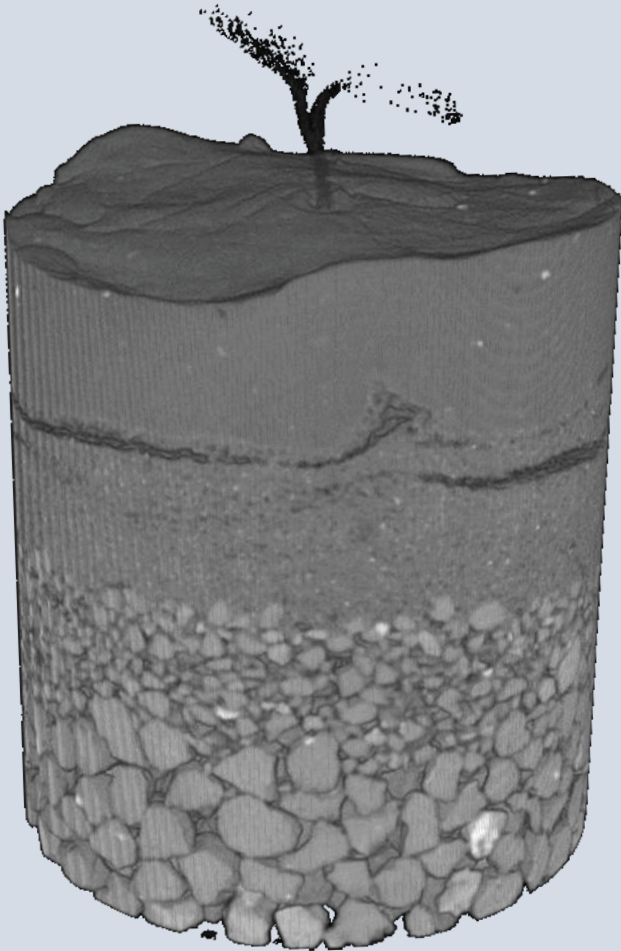
Conclusions

Roots in coarse soils (gravel) exhibited complex root growth patterns, because of increased mechanical resistance, and almost linear growth in fine soils (clay).

Roots growing from fine-to-coarse soils were observed to grow along the interface of the strata, until a point where they found sufficient voidage to keep growing downwards.

The size of the ROI is key in calculating representative values of void ratio and root volume ratio.

Experimentalists and constitutive modellers need to come together in deciding which ROI is representative of the rhizosphere.



Thanks for listening.

How Do Roots Interact with Layered Soils?

by Nina Kemp, Vasileios Angelidakis, Saimir Luli and Sadegh Nadimi
J. Imaging **2022**, 8(1), 5; <https://doi.org/10.3390/jimaging8010005>

Supplementary material

<https://doi.org/10.25405/data.ncl.16734565.v1>