How heterogeneous distributions of hydrophobicity affect capillary rise in soil
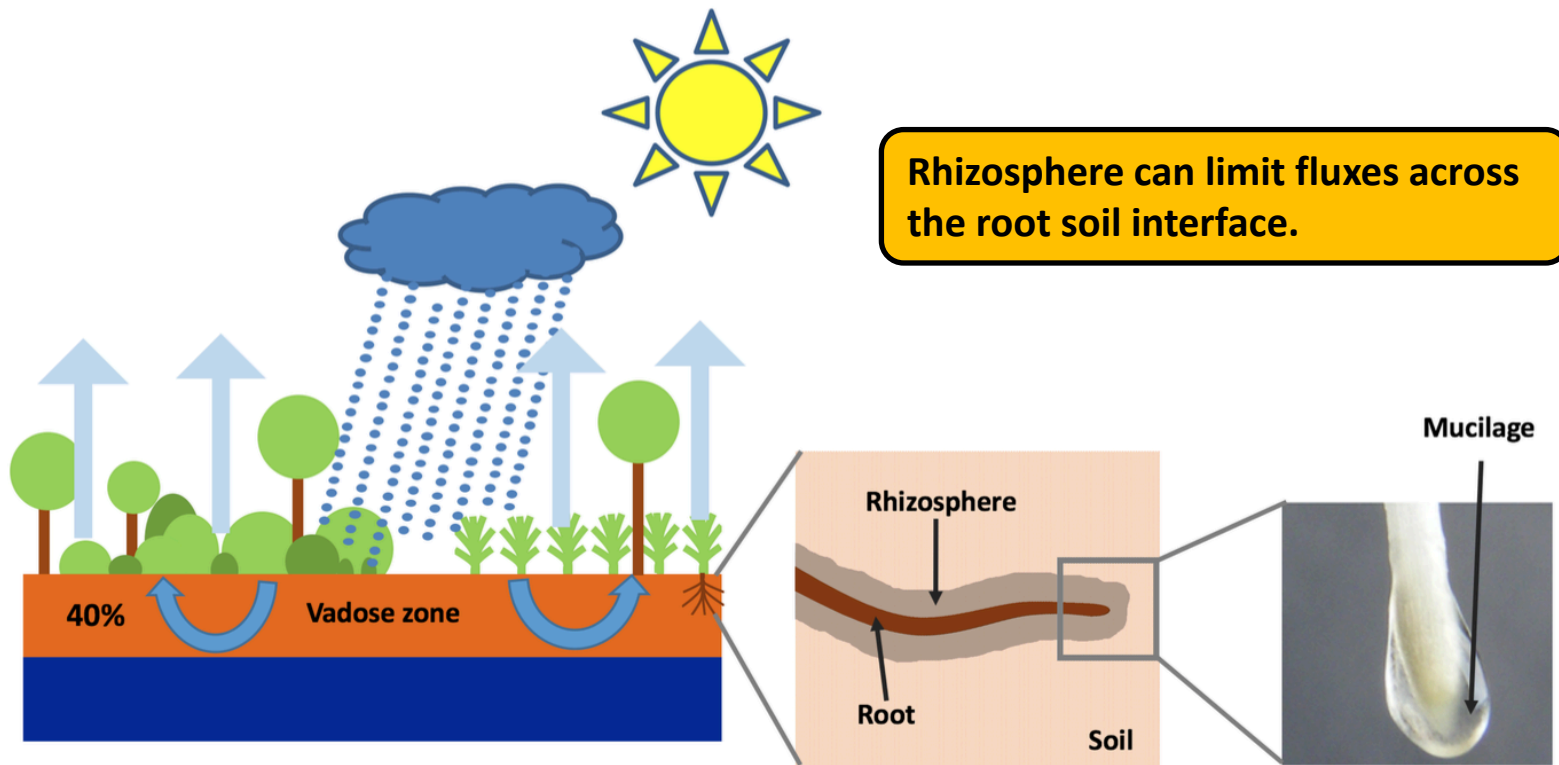
Jonas Bentz, Eva Kröner, Ravi Patel

Introduction

Motivation
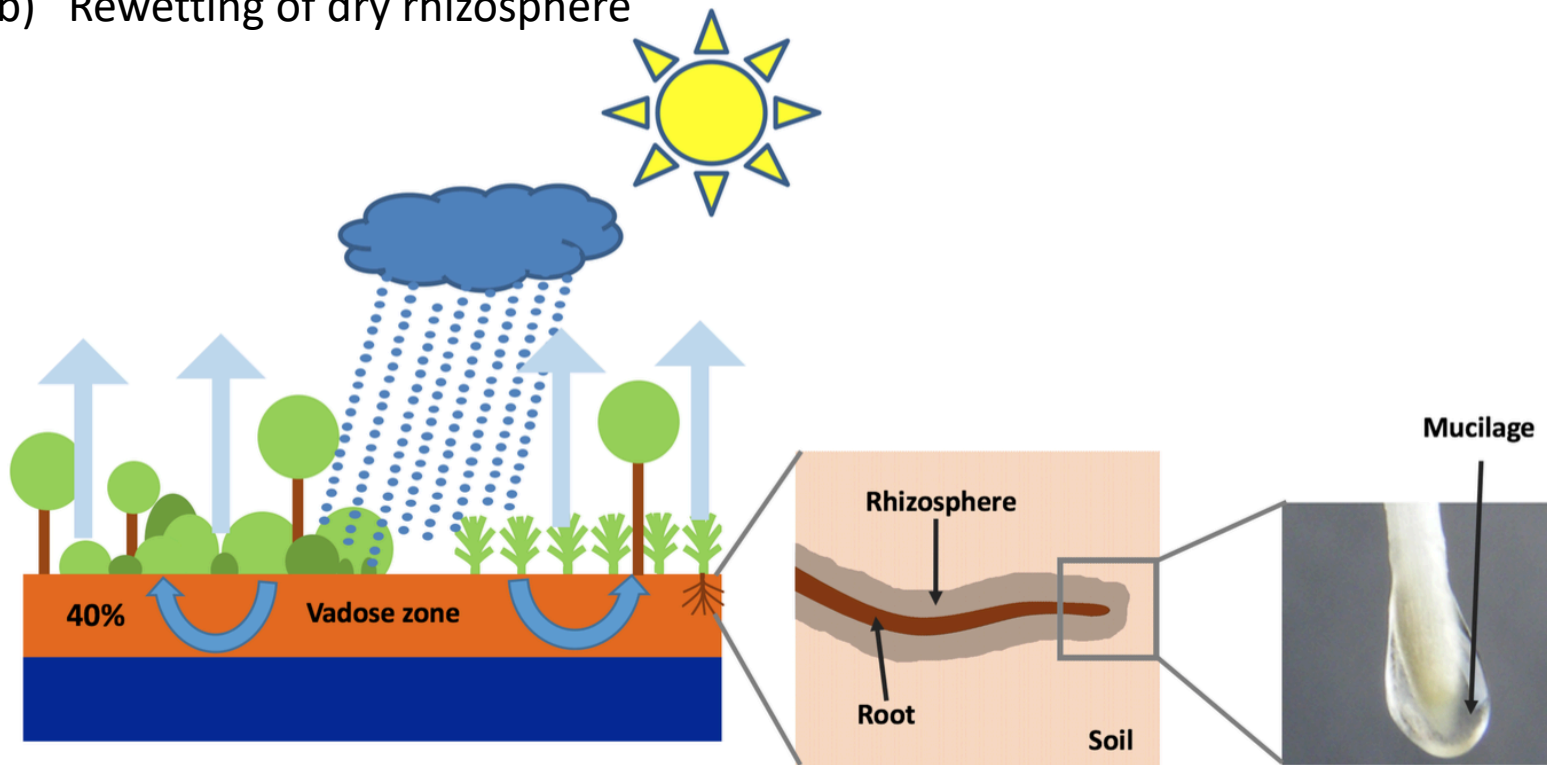
Plants are big water movers:
40% of the terrestrial precipitation flows through the root-soil interface

Rhizosphere can limit fluxes across the root soil interface.

Introduction

How can we upscale from pore scale processes to macroscale hydraulic properties?

a) Drying of rhizosphere
b) Rewetting of dry rhizosphere

Mucilage – a root exudate

❖ It makes soil water repellent when dry

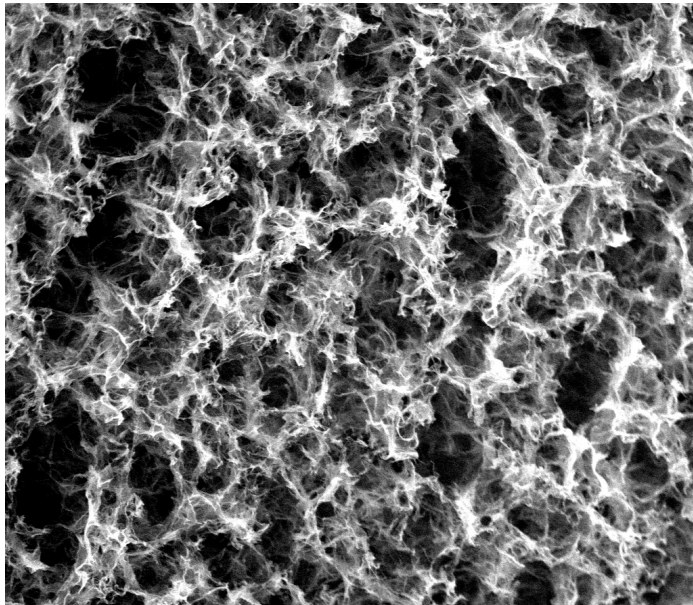⇒ **hydrophobic** when dry

[Moradi et al., VZJ, 2012]

❖ It can hold large volumes of water

⇒ **hydrophilic** when wet
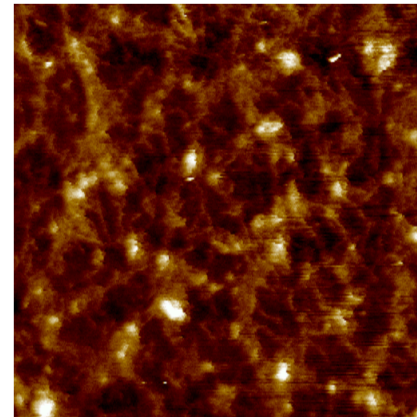
Heterogeneous structures in mucilage

ESEM picture of 3-D structure of freeze-dried **swollen chia seed mucilage**
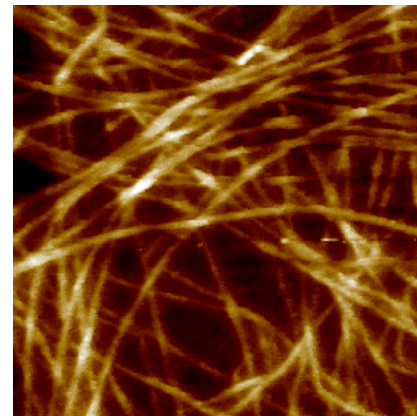

50 µm

[from soil chemistry group, Landau
Brax, Ani, Kaltenbach, Schaumann]

AFM images of filamentous structure of **dried mucilage** on glass
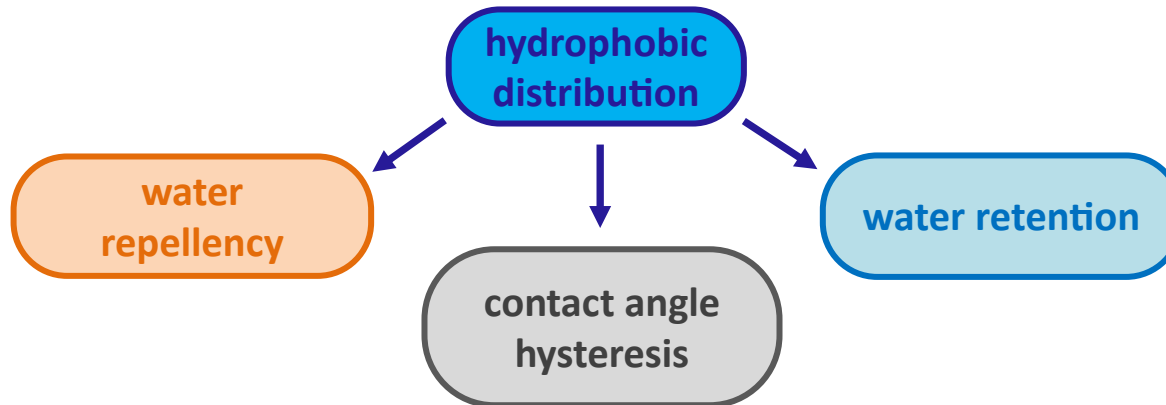

100 nm

cress root

cress seed

Capillary rise affected by spatial variations of hydrophobicity

Expectation:

hydrophobic distribution

water repellency

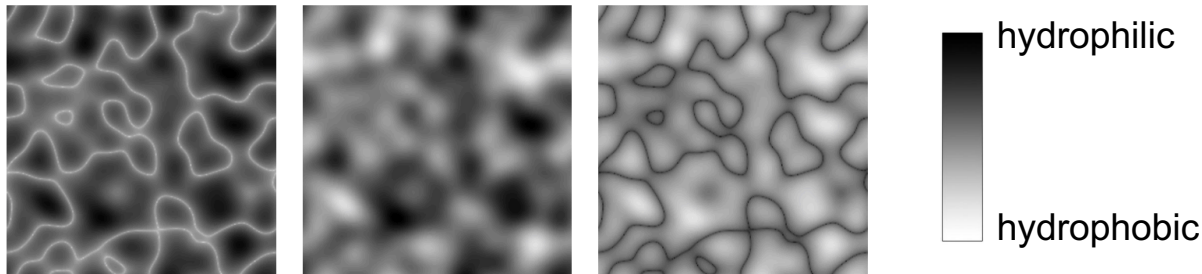contact angle hysteresis

water retention

How can we obtain effective parameters based on geostatistical information about local hydrophobicity?

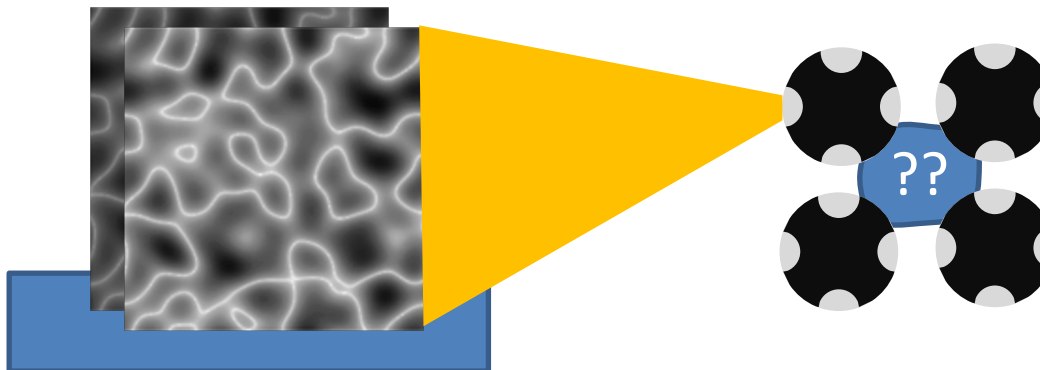# Capillary rise affected by spatial variations of hydrophobicity

Our approach:

input: fields of heterogeneous distribution of interfacial tension
(mean, standard deviation, correlation length, connectivity)

hydrophilic

hydrophobic

Simulations:

1. capillary rise **between two slides**
   => effective contact angle

2. capillary rise **within soil pore space**
   => effective water retention curve

??

Capillary rise affected by spatial variations of hydrophobicity

Simulations:

1. capillary rise **between two slides**
   => effective contact angle

2. capillary rise **within soil pore space**
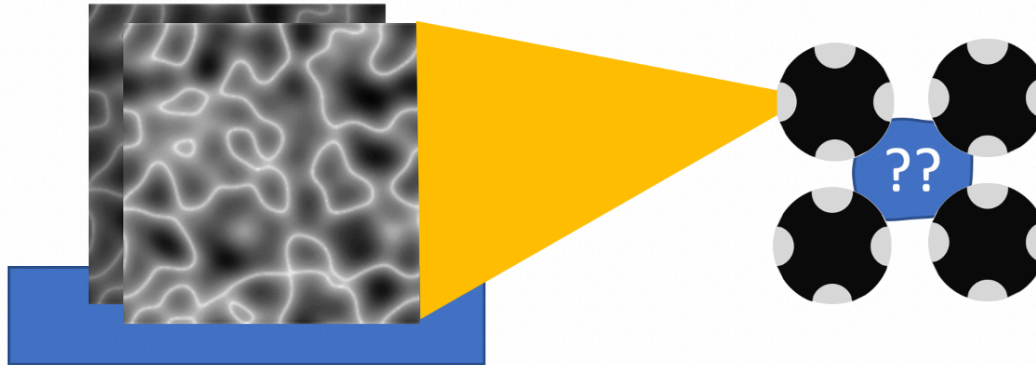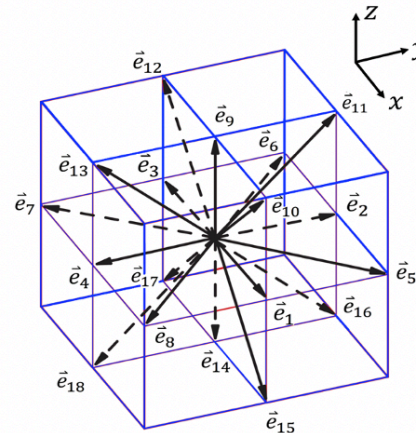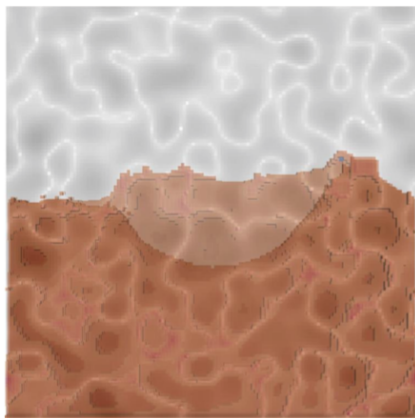   => effective water retention curve

Method:
➤ 3D two phase flow model based on Lattice-Boltzmann Modeling

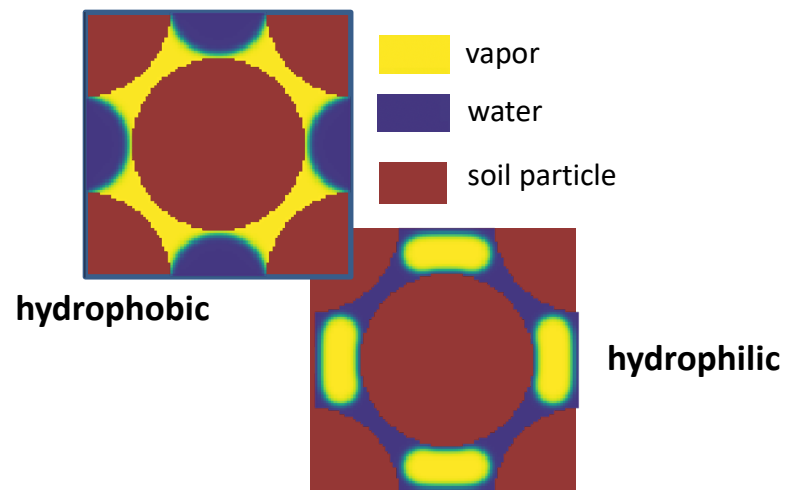# Capillary rise affected by spatial variations of hydrophobicity

First preliminary results:

1. capillary rise between two slides

drying   rewetting

2. capillary rise within pore space

hydrophobic

hydrophilic

- vapor
- water
- soil particle

Expected results (-> still to be validated):
- larger standard deviation of interfacial tension ➡ larger hysteresis
- larger characteristic length of patterns ➡ larger hysteresis
- connectivity of hydrophilic part is important
- location of deposition of mucilage is important

Thank you for your attention!