Plants and Soil Water

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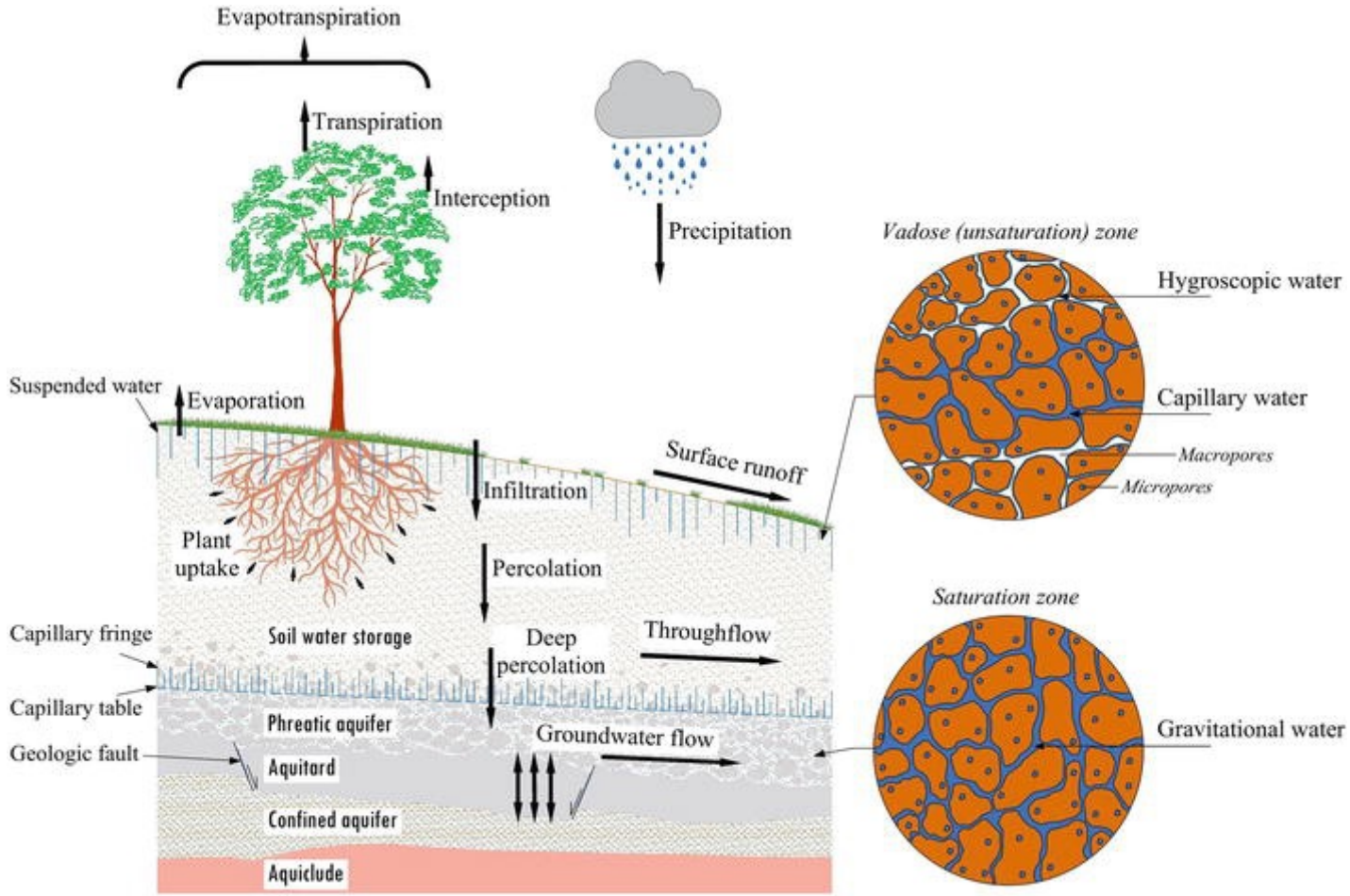
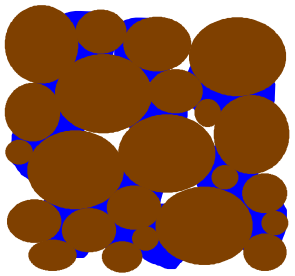


Kučera et al. 2020

Soil Water content



normal“ range

- ~10-30 vol%
- ~0.1…0.3 cm^3/cm^3
- ~ 0.1…0.3

…depending on soil type

Measurement methods

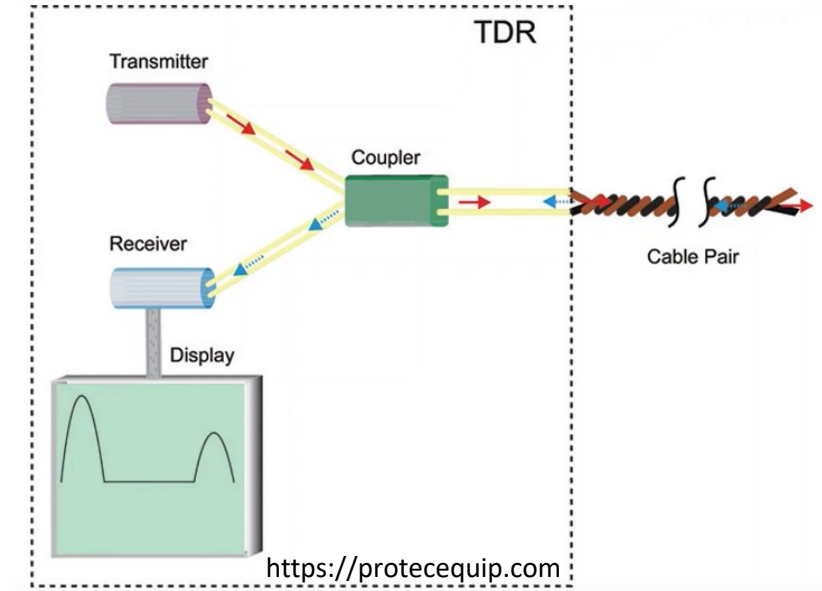
- Direct
  - Gravimetrical (weighing of samples with known volume) = gold standard
- Indirect
  - Electrically (tdr, fdr)
  - Neutron probe

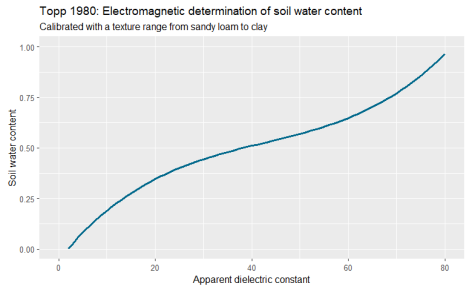
Time Domain Reflectometry (TDR)

How it works

- Original use: Cable fault finding
  - Send electrical wave signal along a cable pair
  - Reflected wave indicate where cable is damaged
  - Surrounding soil water disturbs measurement (electrical dipol H_2O)

- „Controlled misuse“ for soil water content determination
  - Probe of know length/reflection
  - Calibration with gravimetric measurements
  - Topp-Equation for many soil types
  - Problematic/inaccurate in
    - Fine textured soils Organic material (nonconform particles, elect
    - Volcanic soils





CS655 water content reflectometer
(Campbell Scientific, Logan, Utah, U.S.)

Soil matric potential

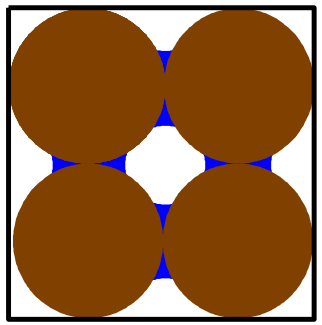
Water potential

$\Psi = \Psi_0 + \Psi_\pi + \Psi_p + \Psi_v + \Psi_m$

Dominant in soil:

Matric potential

- Adhesion to surfaces
- Cohesion between water molecules
- ->meniscus formation



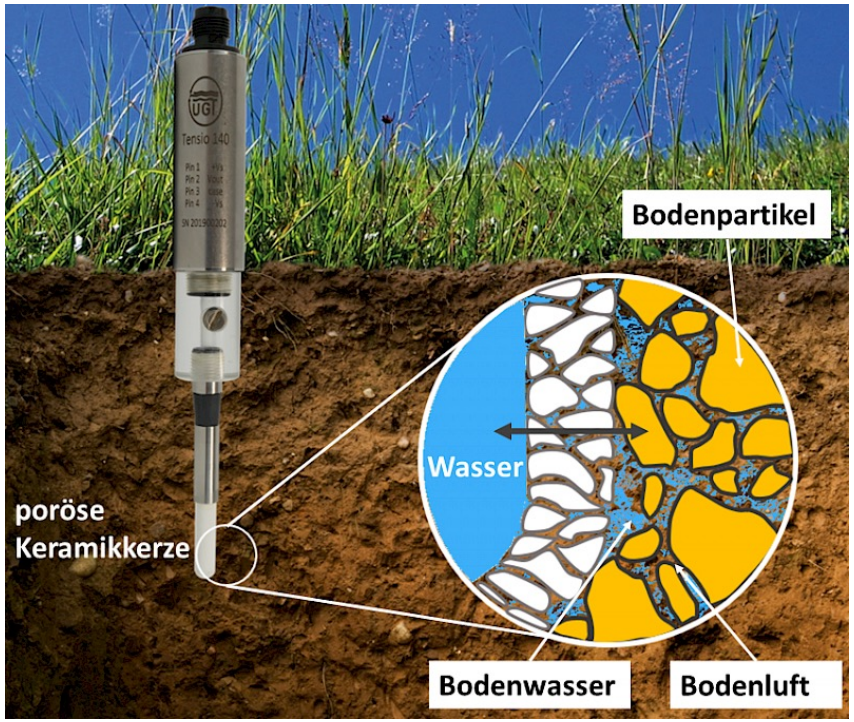
Measurement methods

- Direct
  - Water filled tensiometer
- Indirect (in gypsum, ceramic)
- (based on calibration)
  - Electrical conductivity
  - Thermal conductivity
  - Water content (known SWRC)

Tensiometers

Water filled tensiometer

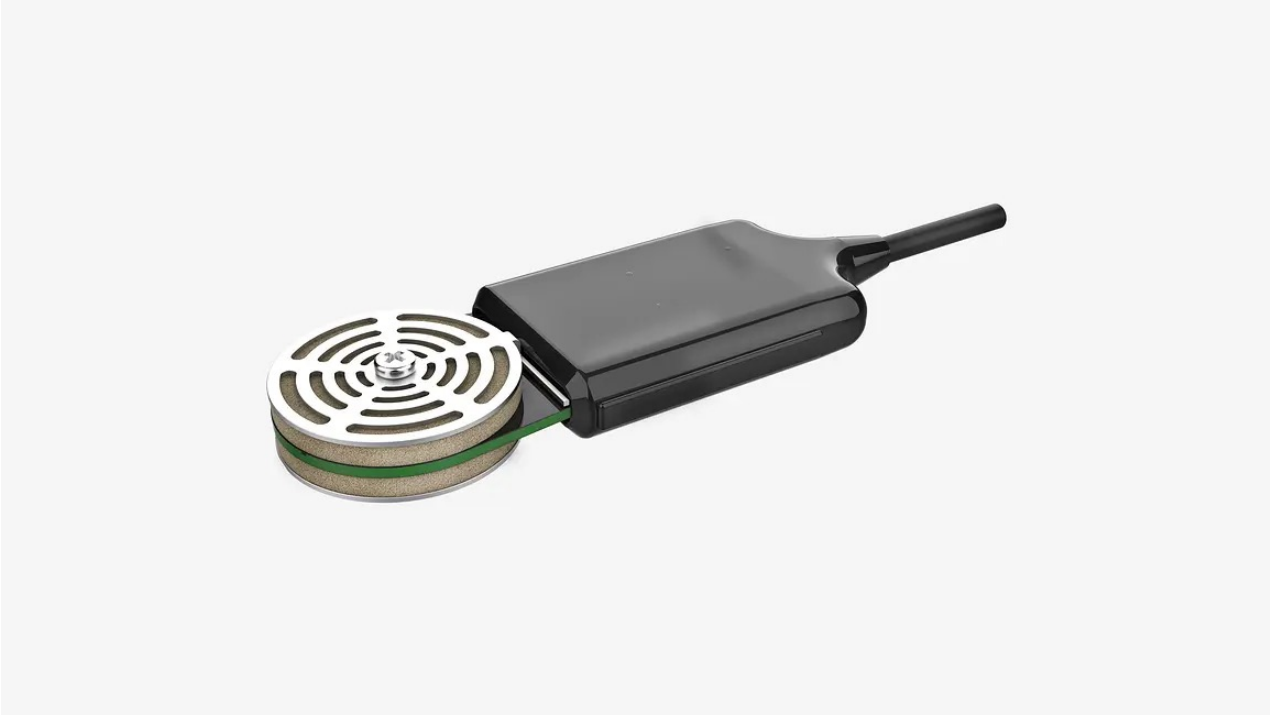
- Direct measurement
- Cavitation at ~80 kPa (refill)
- ->only for moist conditions



https://ugt-online.de/produkte/boden/sensoren/tensiometer/

Wide range water potential sensor

- Indirect measurement in ceramics (dielectric permitivity)
- Reduced precision <100 kPa
- Rubust results without maintenance



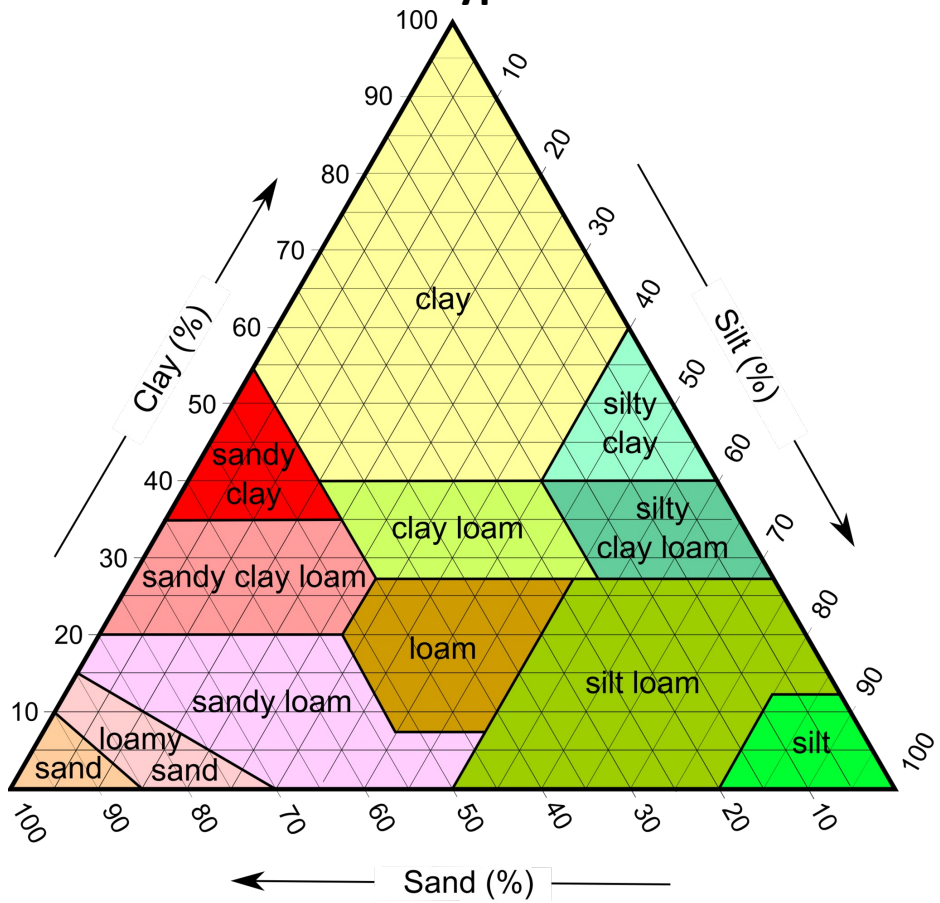
https://metergroup.com/products/teros-21/

Soil texture

Particle size classes

Class	Size (mm)	Evolution	Chemical
Rock/gravel	> 2		
Sand	0.063…2	Weathering of rock	Mostly hard minerals (Quartz, SiO_2)
Silt	0.002…0.063	Weatering of sand	Mostly hard minerals (Quartz, SiO_2)
Clay	< 0.002	Chemical (acid) weathering of silicate rocks	Clay minerals e.g Kaolinite $Al_2Si_2O_5(OH)_4$

Soil types

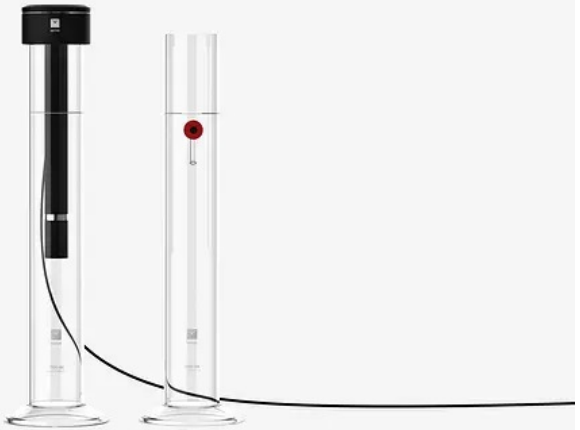


Particle size analysis

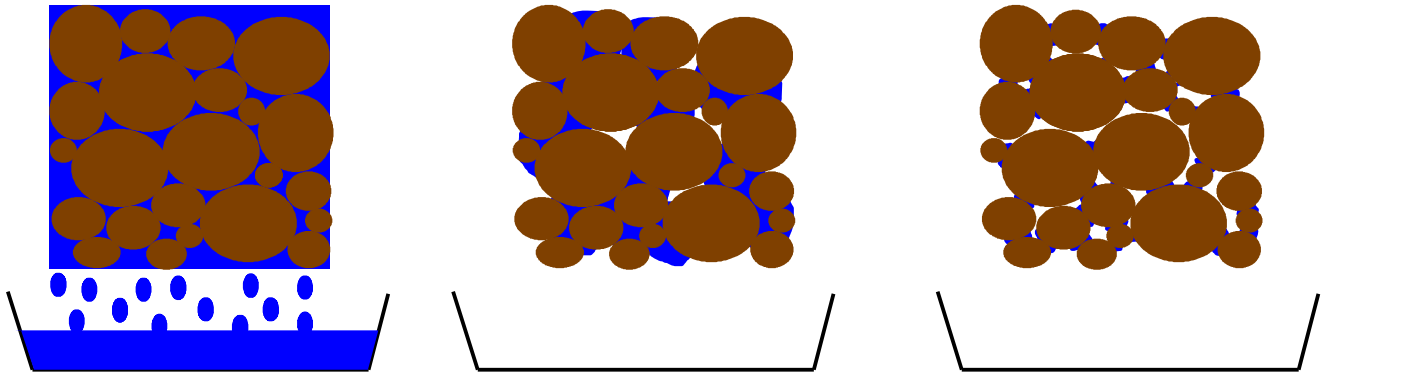
Sieve (sand diameter classes)

https://www.retsch.de/de/produkte/sieben/siebmaschinen/as-200-control/

Sedimentation (by density) (silt, clay)



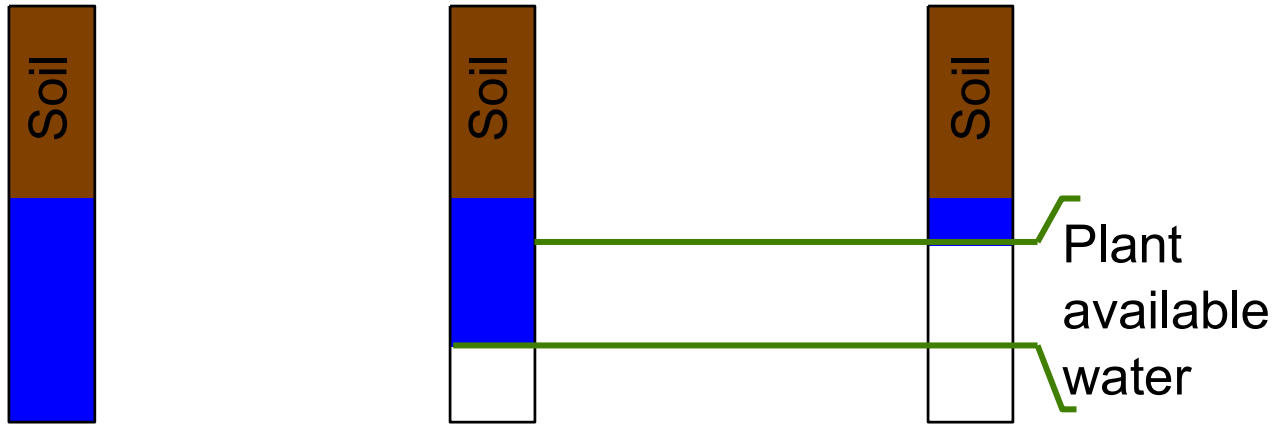
https://metergroup.com/products/pario/



Saturation

Field capacity

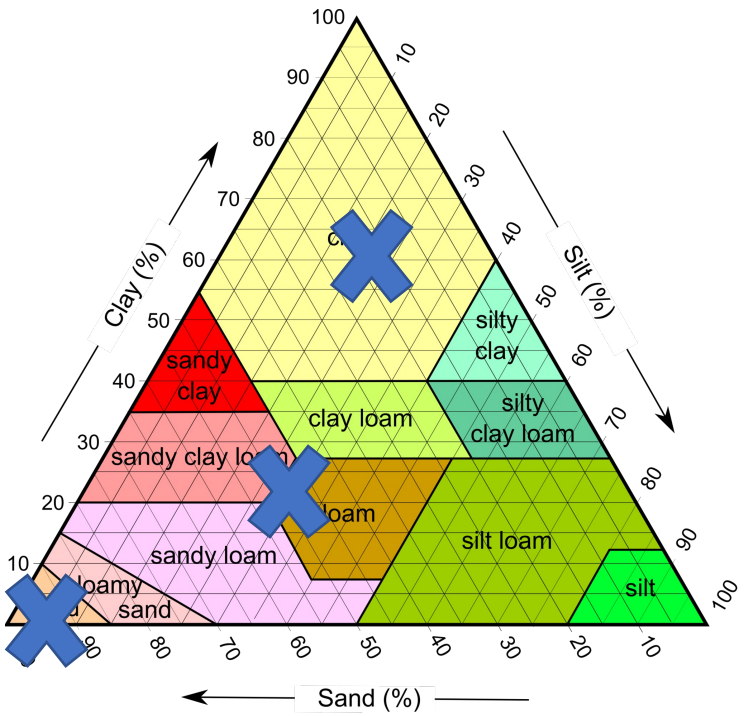
Permant wilting point



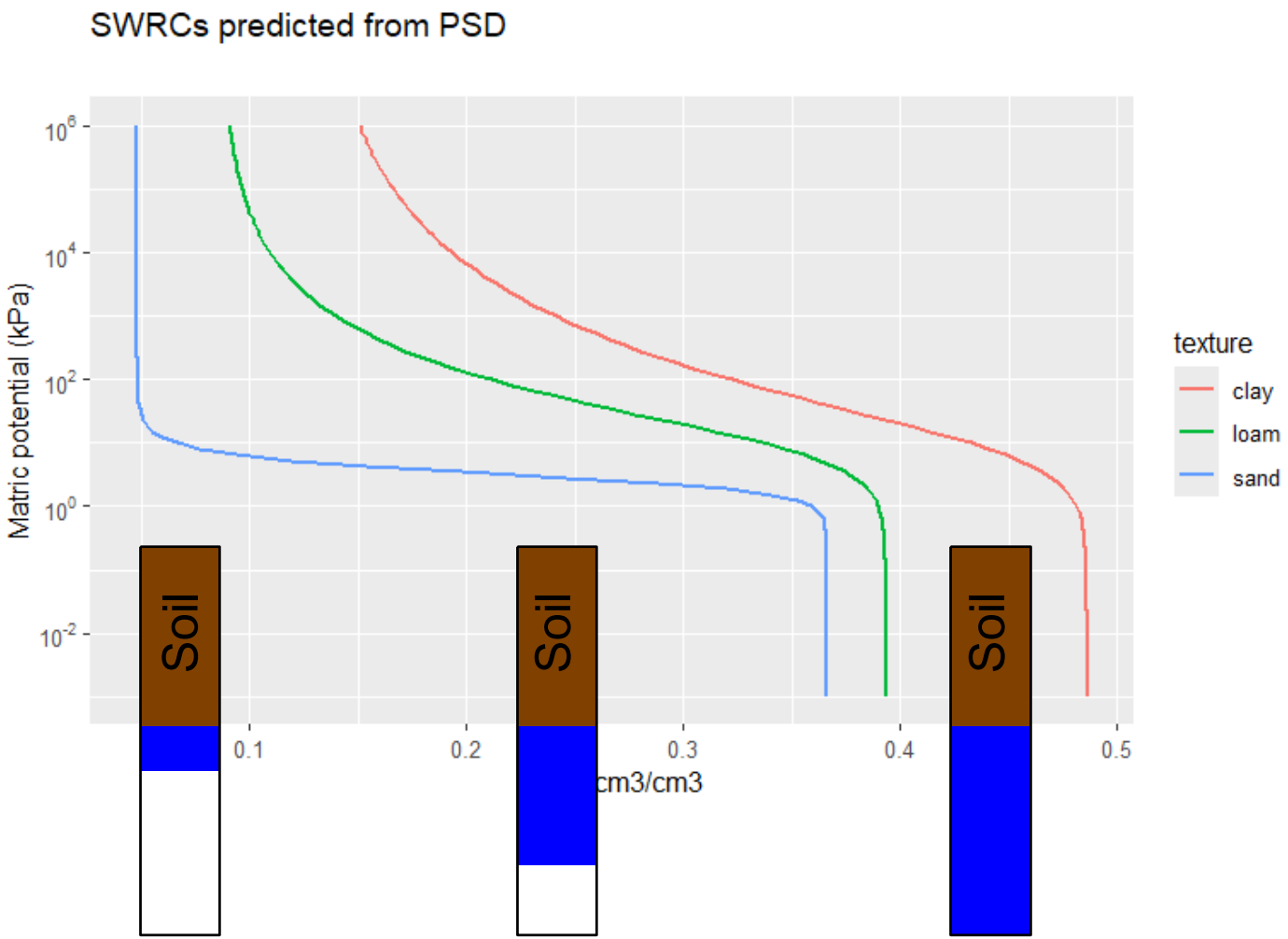
Soil Water Retention Curve (SWRC)

Van Genuchten 1980

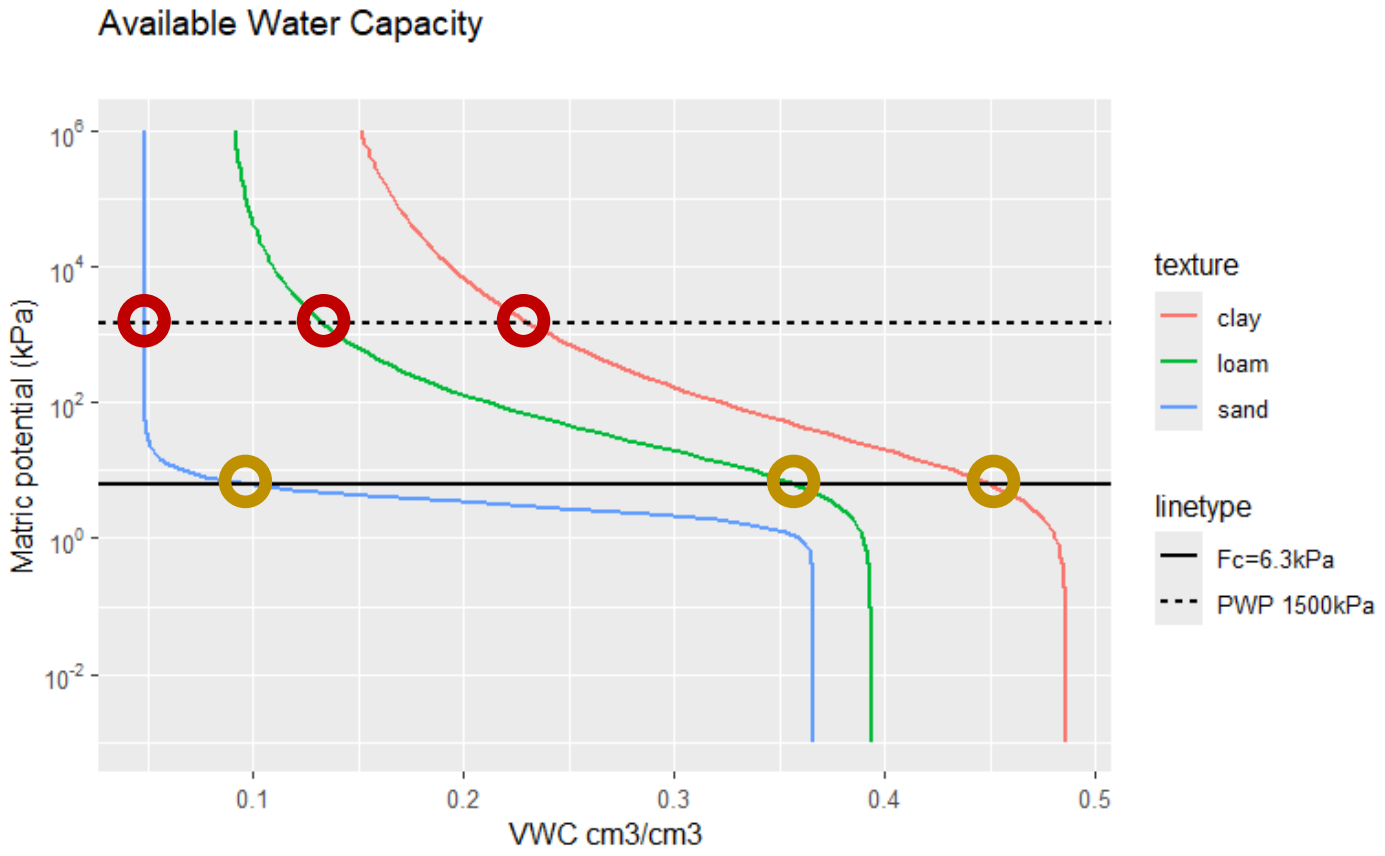
$$\theta(\Psi_m) = \theta_r + (\theta_s - \theta_r)[1 + (\alpha \cdot \Psi_m)^n]^{-m}$$

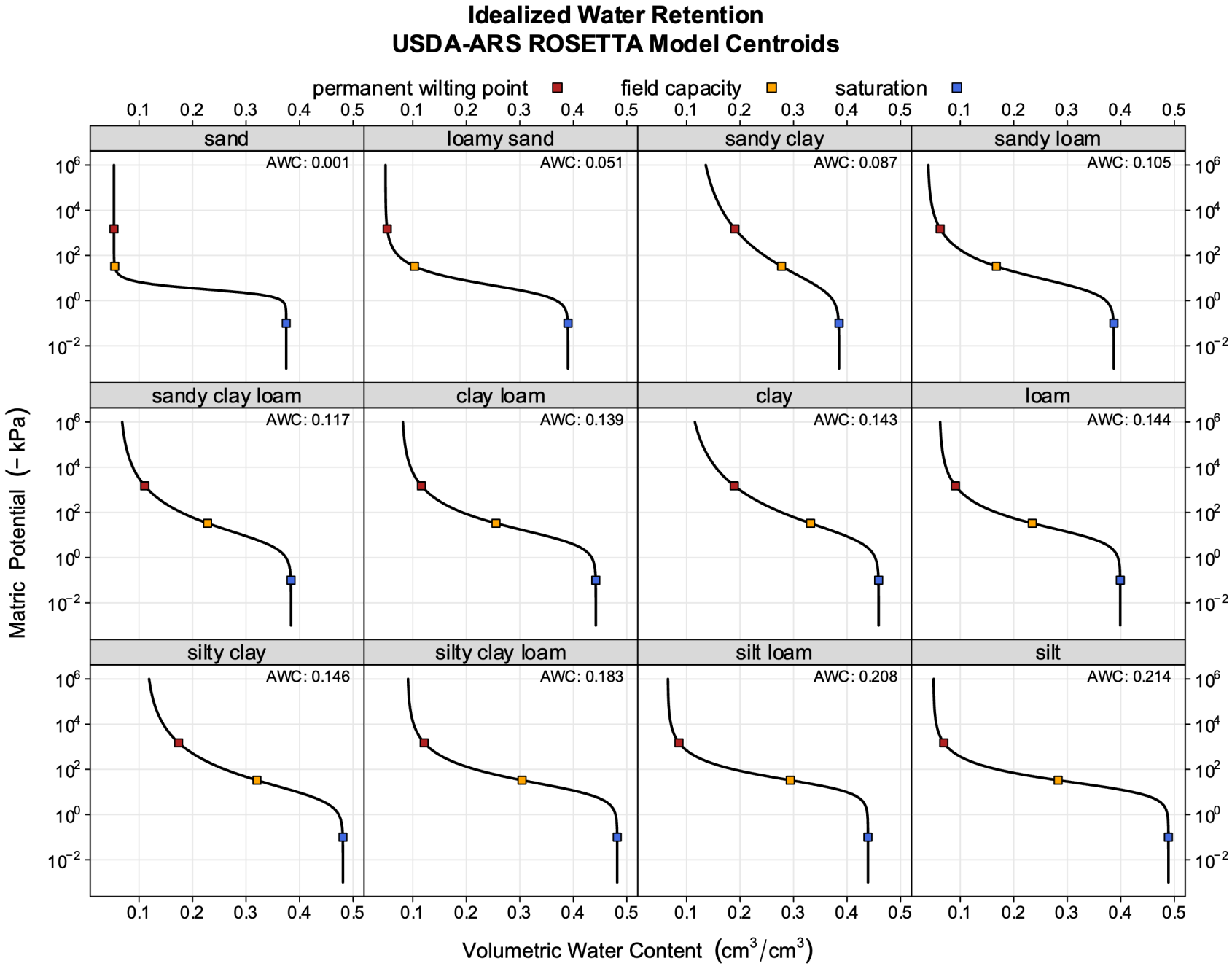


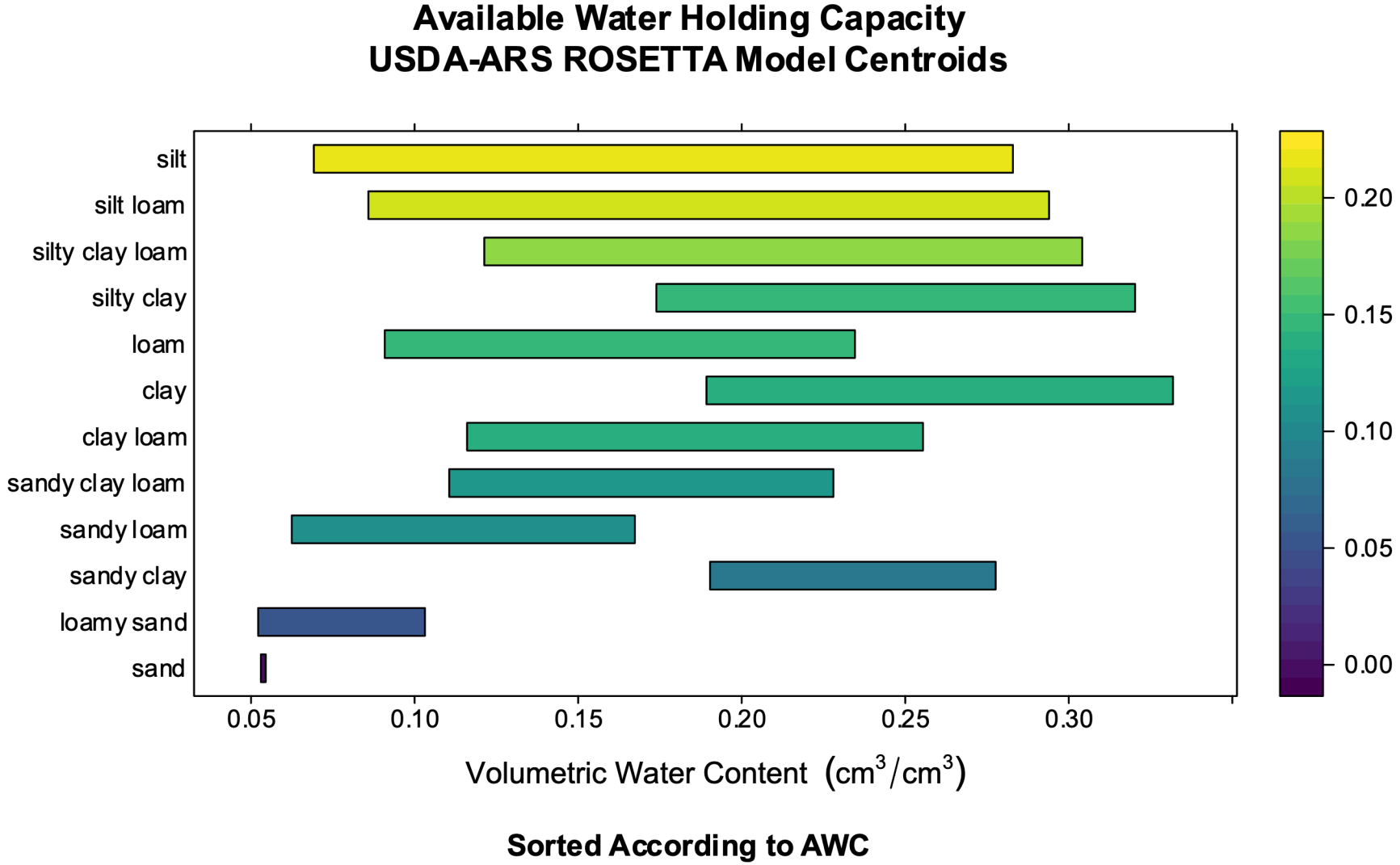
texture	sand	silt	clay
sand	95	5	0
loam	50	30	20
Clay	20	20	60



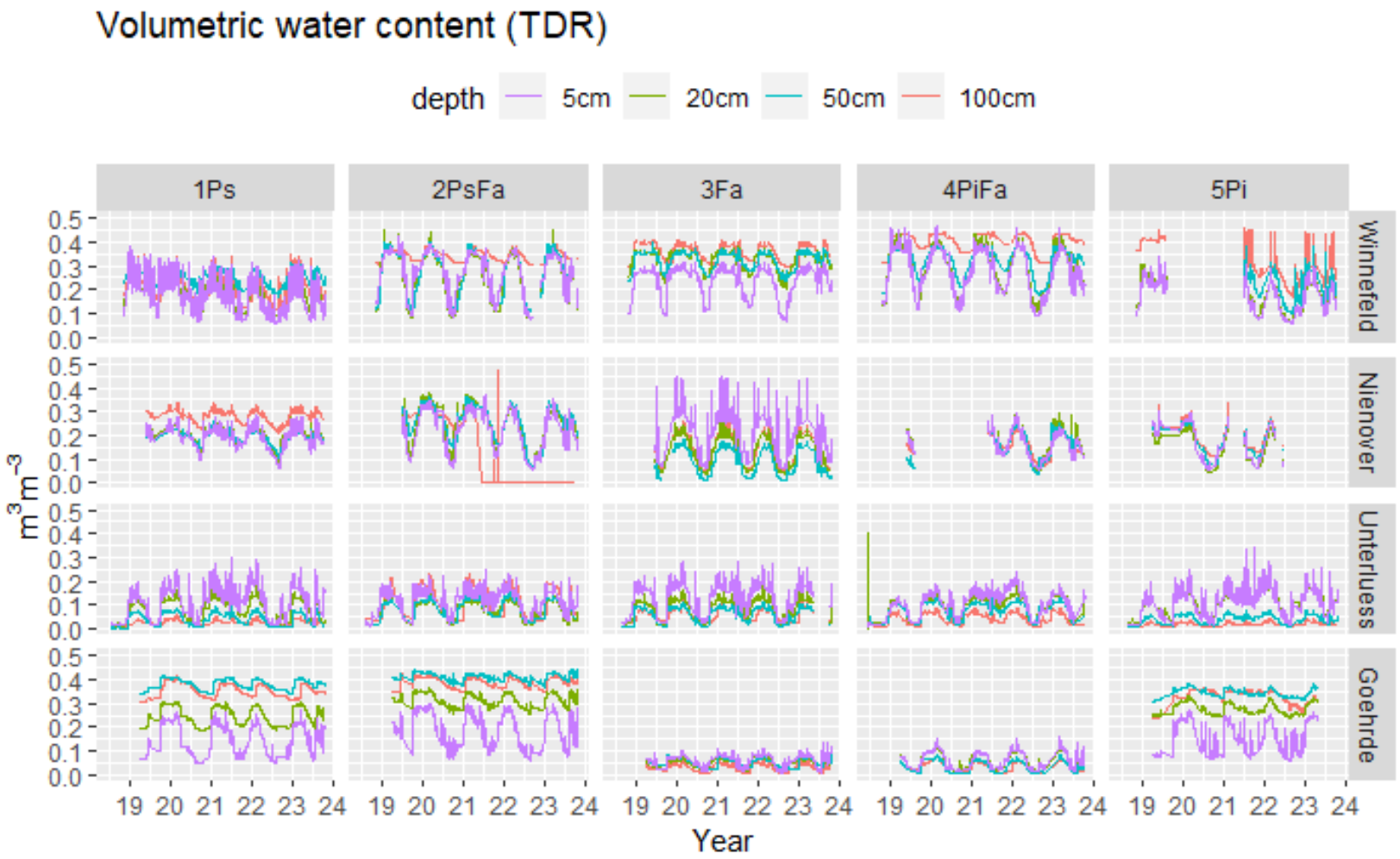
(Plant) Available Water Capacity




Idealized Water Retention
USDA-ARS ROSETTA Model Centroids
permanent wilting point
field capacity
saturation
sand
AWC: 0.001
loamy sand
AWC: 0.051
sandy clay
AWC: 0.087
sandy loam
AWC: 0.105
sandy clay loam
AWC: 0.117
clay loam
AWC: 0.139
clay
AWC: 0.143
loam
AWC: 0.144
silty clay
AWC: 0.146
silty clay loam
AWC: 0.183
silt loam
AWC: 0.208
silt
AWC: 0.214
Matric Potential (− kPa)
Volumetric Water Content (cm3/cm3)


Available Water Holding Capacity
USDA-ARS ROSETTA Model Centroids
silt
silt loam
silty clay loam
silty clay
loam
clay
clay loam
sandy clay loam
sandy loam
sandy clay
loamy sand
sand
0.05
0.10
0.15
0.20
0.25
0.30
Volumetric Water Content (cm3/cm3)
0.20
0.15
0.10
0.05
0.00
Sorted According to AWC

Some real-world data



Soil water experiment

- Two soil types (sand, loam)
- Starting with quite dry condition
- No grown soil, sensor installation not perfect
- Two irrigation regimes
- https://wwwuser.gwdguser.de/~logplanteco/LoggerDataViz/CwwCourseSoilWater2024.html