

#### Moisture measurements in soil and green roofs: lessons, data and challenges

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# Pilot Soil moisture

- 2020 10 sensors placed in Amersfoort
- Four depths
  - 10 cm
  - 40 cm
  - 80 cm
  - 120 cm
- Temperature & soil moisture (capacity)





### Resultaten

 Results first calibration: values >> 30% (maximum value expected in sand)



# Soil Moisture measurements

#### > 2021 A lot of experiments

- Improve DIY sensor
- Improve understanding





# Green Roof project

- 2021 4 Sensors placed in Amersfoort
- Measure capability of a green roof to perform
  - Water-bufferingInsulation



# Challenges

Applies to measuring water-content by a capacitive measurements in various media

#### <u>1. Soil-specific effects</u>

• Why measurements >> 30%

# Sensitive measurement Why measuring is not so easy

### Measurement principle (Andries)

- Capacity between two electrodes depends on the medium in between
- $\epsilon = relative permittivity$ 
  - Air = 1
  - Water = 80



# Soil specific effects

- Depend on measurement frequency
  - MW  $\approx$  ions
  - I  $\approx$  Clay, Silt



#### Do not occur in water

#### DIY sensor

- Measure at a higher frequency
- Measure at multiple frequencies
  - So we can correct later
- Test off-the-shelve capacitive sensors
  - PINOTECH SoilWatch (€25) ,
  - ∘ Catnip (€20),
  - DF–Robot (€3)





- Start with dry soil
- Add ..ml of water
- Mix & Measure

• ... Repeat

Add ...ml of water



0%

10%

20%

30%

40%

50%

0%

10%

20%

30%

40%

50%



- Frequentie
- 6kHz 60kHz 600kHz 1.6Mhz 10Mhz 20 Mhz 70Mhz



Frequency-effect



#### Effect of the soil on measurement



Multifrequency measurement allows to say something about soil properties as well !

# Conclusions

- 1. With our current measurement principle we can improve measurement frequency up to 13Mhz
- 2. Soil specific effects reduce at higher measurement frequencies, but a bit remains
- 3. Multi-frequency measurements may allow also to get data on soil properties
- 4. But we need to add more (costly and SMD) components to the DIY sensor to do this

# Challenges

- Applies to measuring water-content by a capacitive measurements in various media
- I. Soil-specific effects
  Why measurements >> 30%
- <u>2. Sensitive measurement</u>

• Why measuring is not so easy

### Field-tests

1. Multifrequency DIY sensor on Pilot location

2. Pinotech sensors in the soil

3. Pinotech sensors on green roofs







## Field-test Soil

#### Queekhoven (661)





## Field-test Soil

Capacity of components: 300 pF

16 pF

- Capacity in air:
- Capacity in water: 28 pF

Measurement range 12pF
 (!) 0.00000000012 F



# Field test – Soil

- Limnioveld (517)
  - Read-out is very stable for both sensors
  - Bottom sensor seems to respond opposite to rainfall initally

















## Conclusions

- Added components make multi-frequency measurement by DIY sensor less reliable
  - Needs some more attention

Pinotech sensors are relatively more stable, but also some side-effects can be seen

# Workshops 2022

- Start with the Pinotech sensors for workshops
  - Green roof,
    - one moisture sensor sideways in the mat
    - Sensor station V2 above the roof
  - Soil moisture:
    - Two moisture sensors buried in the soil
    - 5m cable to go from station to soil
    - Sensor station V2
- Interested? <u>meedoen@meetjestad.net</u>
- Questions? <u>paul@debaai.com</u>

