ACTIVE DISTRIBUTED TEMPERATURE SENSING FOR HIGH RESOLUTION MONITORING OF SOIL MOISTURE AT THE FIELD SCALE

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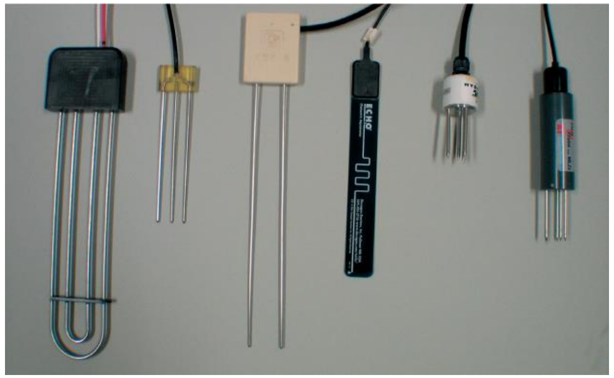
BACKGROUND

Examples of different soil types

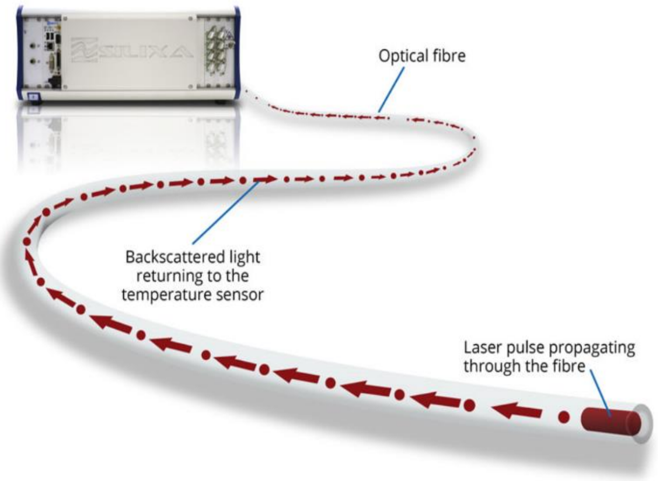
- ➢ Can we understand soil hydrological processes and soil variability at the field scale?

MONITORING SOIL MOISTURE



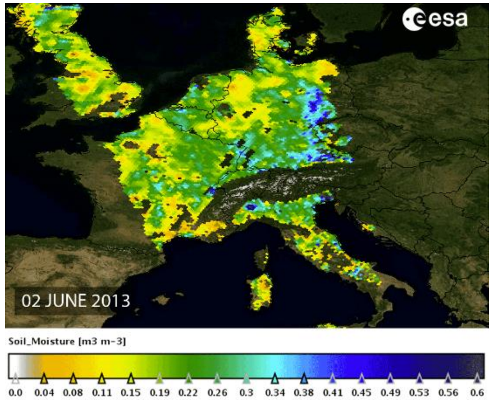
Dielectric sensors
(after Blonquist et al. 2005)

Volume of soil (< 1 L)



A-DTS

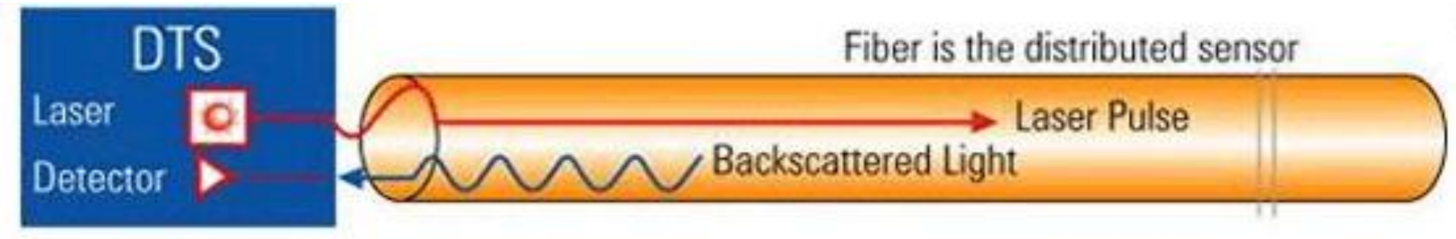
Lengths up to several km and high spatial resolution



COSMOS Remote Sensing

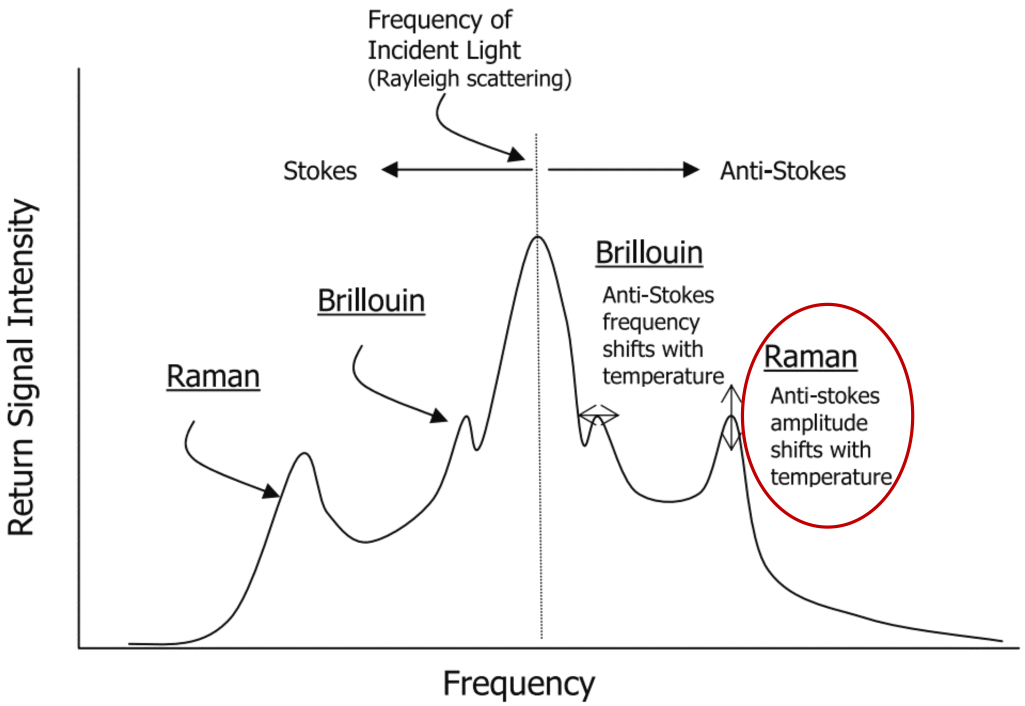
Large areas but low spatial resolution

ACTIVE DISTRIBUTED TEMPERATURE SENSING (A-DTS)



Courtesy of AP Sensing

A-DTS can be used to measure soil moisture at a sub-metre spatial resolution along a fibre-optic (FO) cable



From Selker et al., 2006

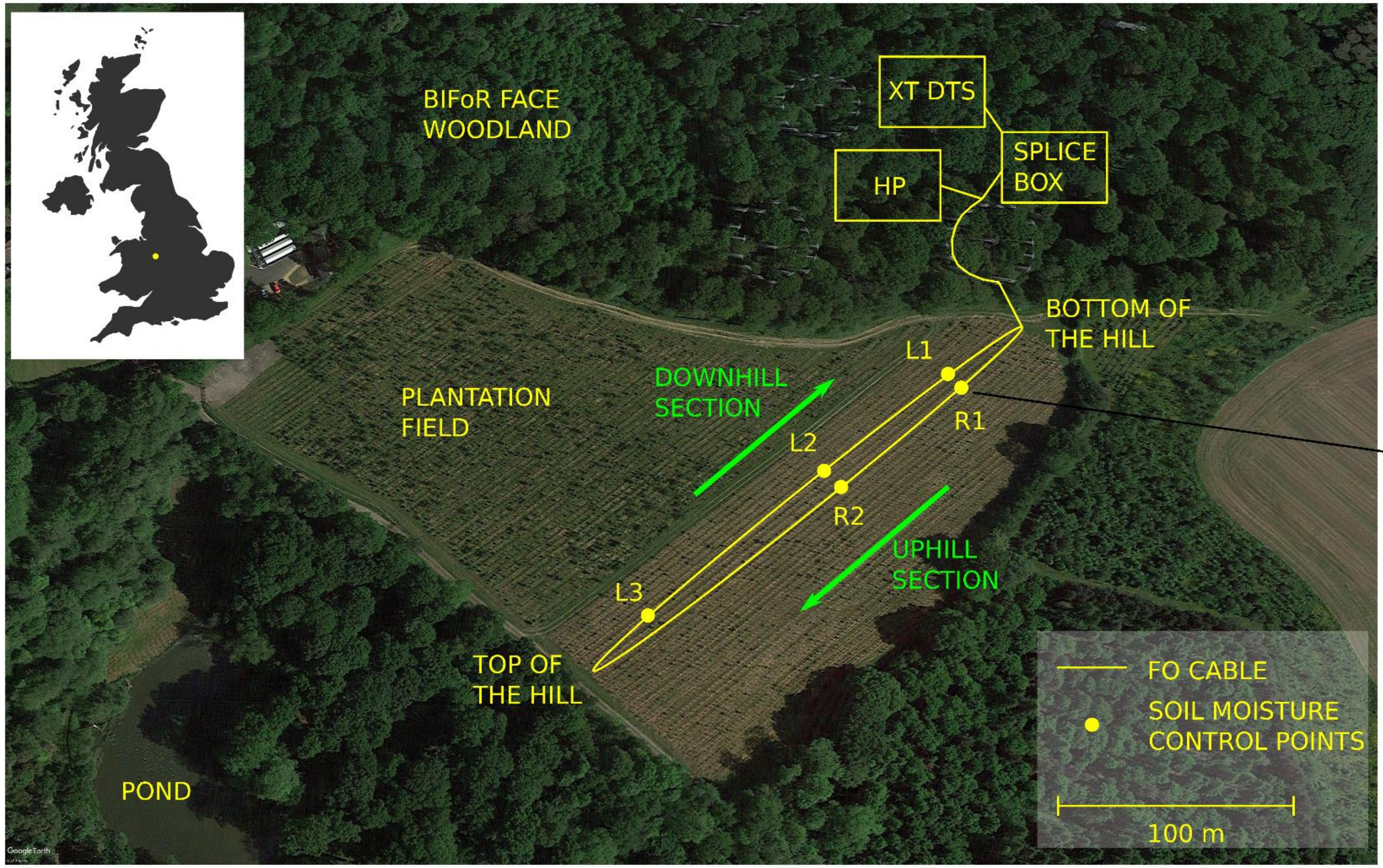
In active mode the FO cable is artificially heated and the cumulative temperature increase can be converted to soil moisture

$$T_{cum} = \int_0^{t_0} \Delta T \, dt \rightarrow \text{Soil moisture (VWC)}$$

FIELD TEST SITE

Plantation field (photo May 2017)

Plantation field (photo May 2019)



Soil moisture control point
(photo September 2018)

Field site next to the BIFoR FACE (Free-Air Carbon Dioxide Enrichment) experiment

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A-DTS EQUIPMENT

XT DTS (Silixa Ltd.) with sampling resolution of 0.25 m

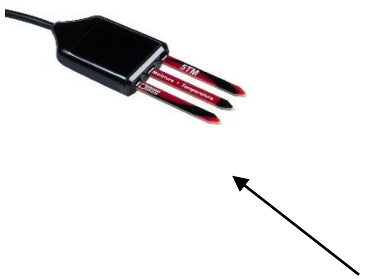
Heat Pulse System (Silixa Ltd.) providing constant power during heating (±1 % of the source)

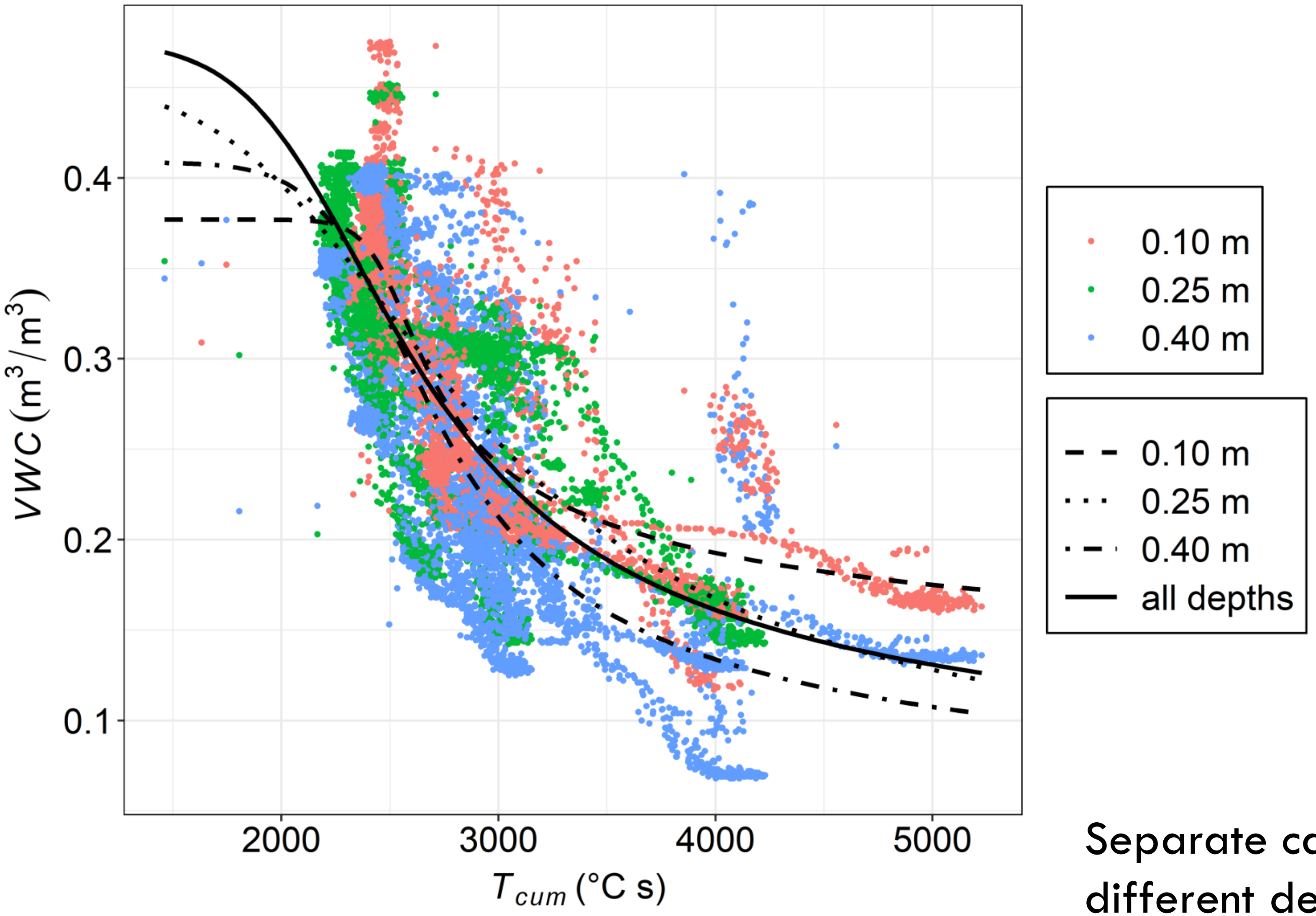
- One FO cable at 3 depths down to 0.40 m
- Temperature every 30 s
- Soil moisture every 6 h (15 min heat pulses, separate for each depth, power rates = 5.8 W/m)

SILIXA

A-DTS CALIBRATION

Reference VWC from 5-TE (METER Group) soil moisture sensors





Separate calibrations for the different depths (slightly lower RMSE)

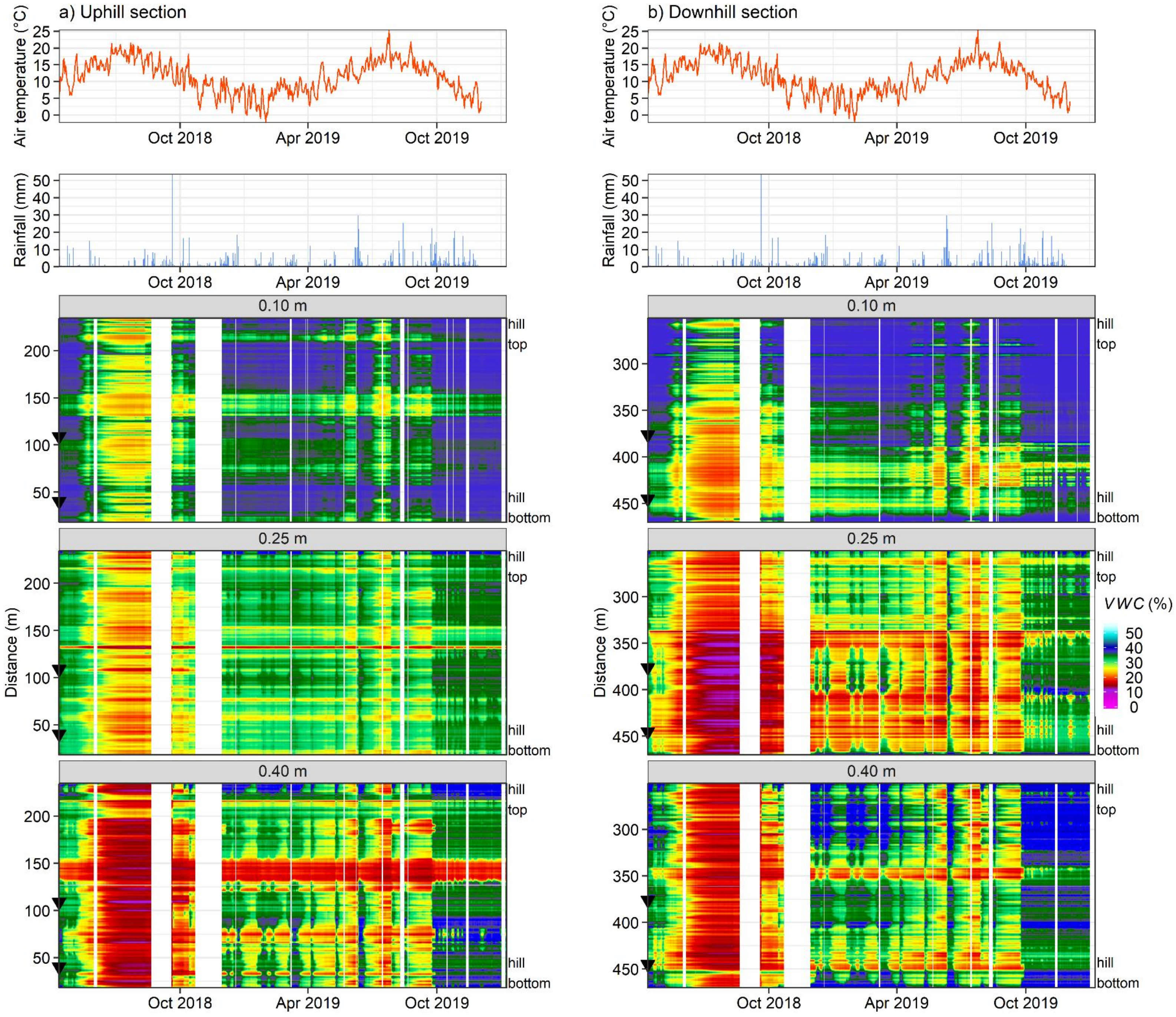
PRELIMINARY RESULTS

High temporal variability

- short-term strongly related to rainfall events
- long-term due to prolonged periods (i.e. weeks) of drying and wetting

High spatial variability

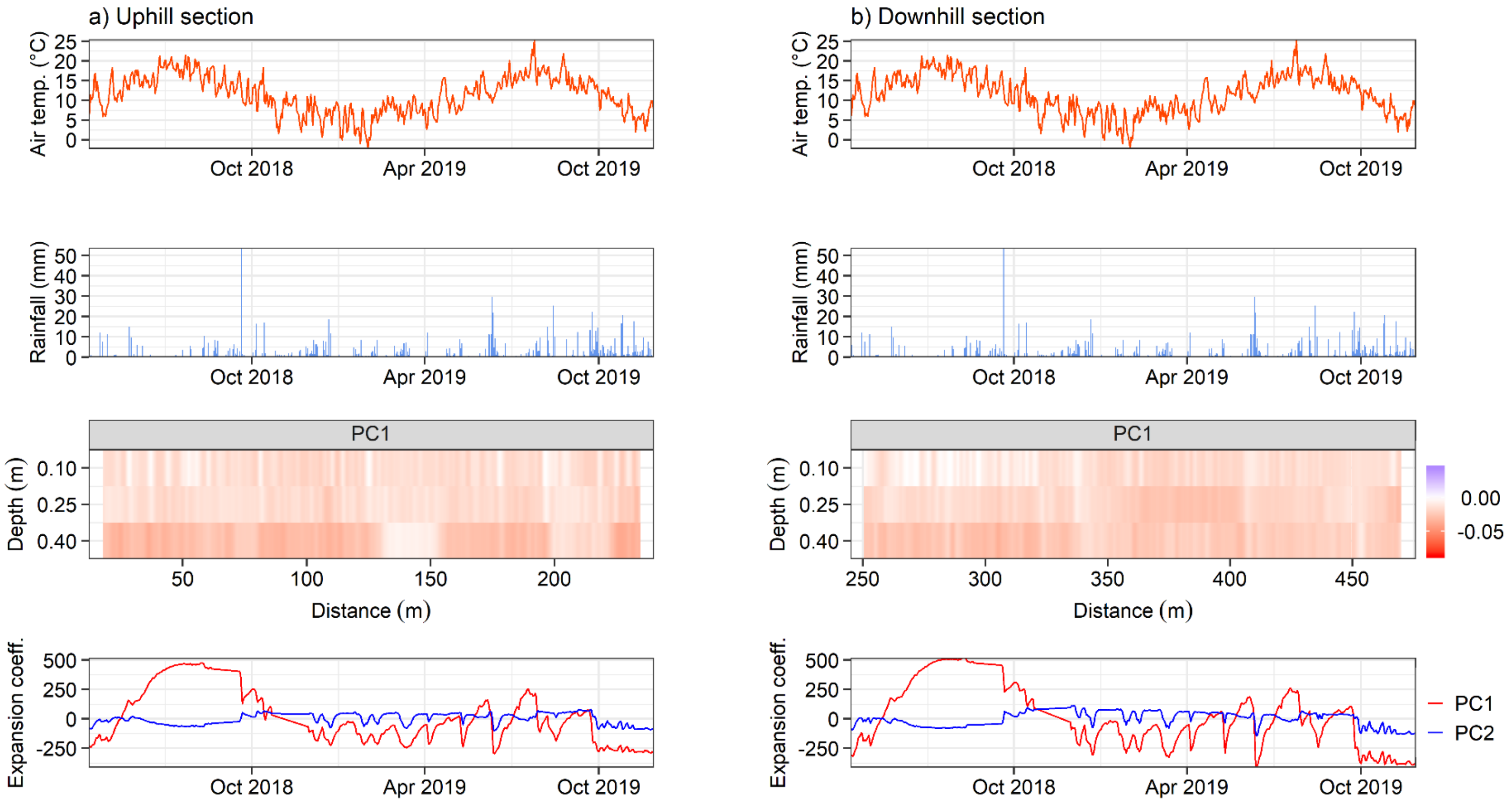
- Lateral across the same slope section and between the two sections
- Vertical among the different depths



PRELIMINARY RESULTS

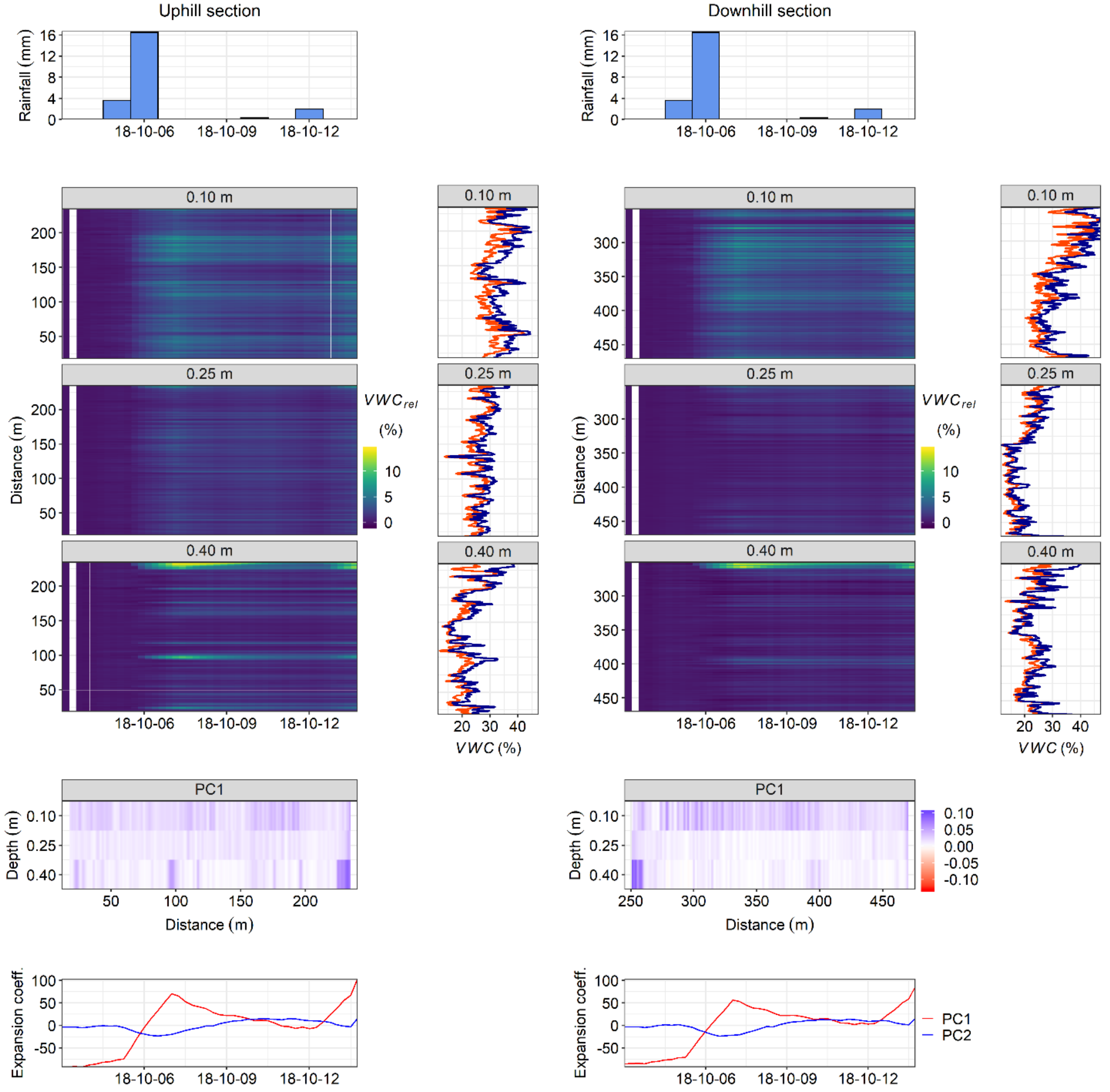
Empirical Orthogonal Function (EOF) analysis

- Higher small scale spatio-temporal variation at shallow depth
- More intense temporal change in the subsoil but more homogeneous spatially (except a few distinct anomalies)
- Rainfall is the main driver for change
- Prolonged periods of drying and wetting lead to relatively stable conditions

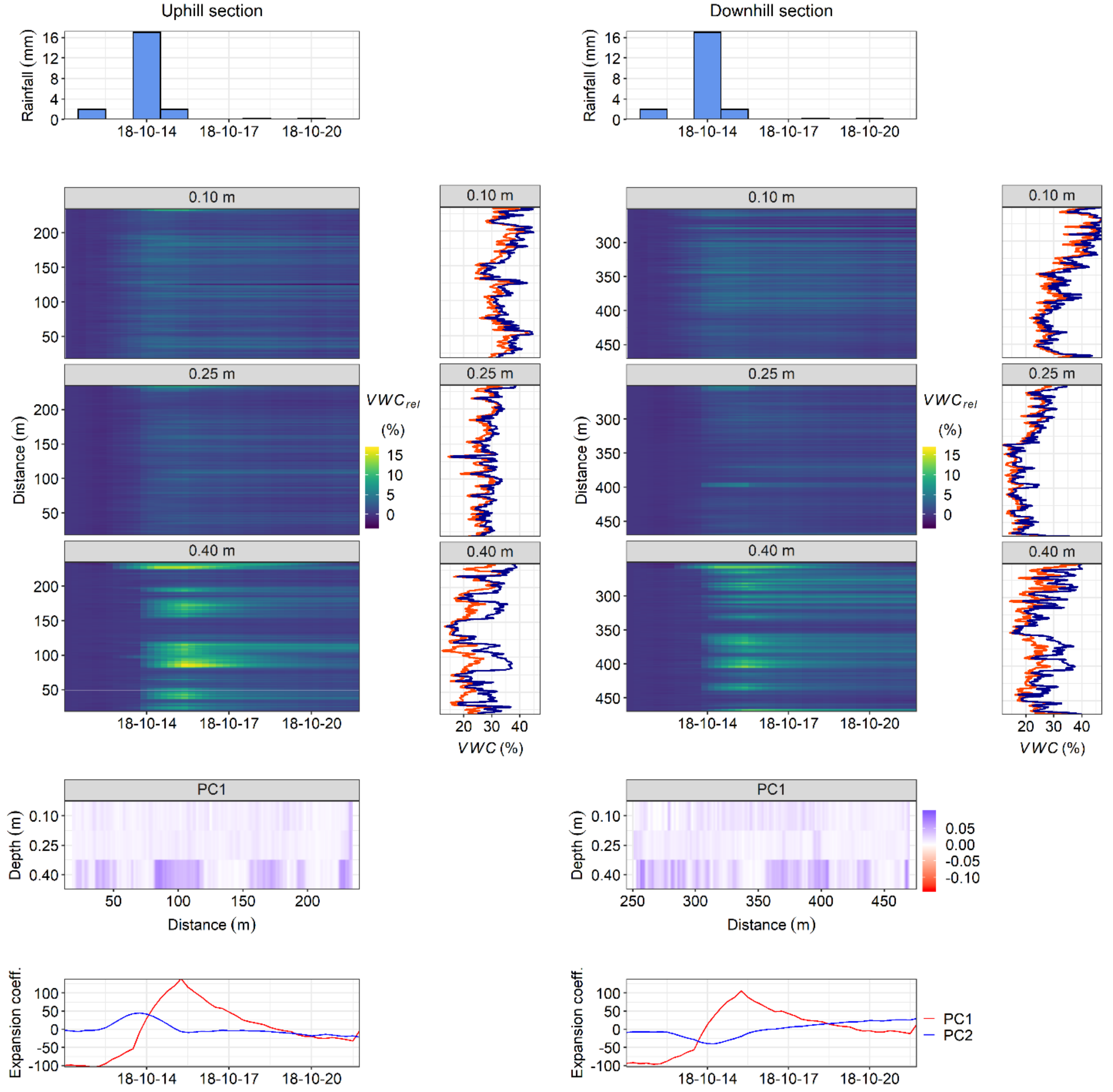


STORM-EVENT ANALYSIS

Event1 Oct 2018

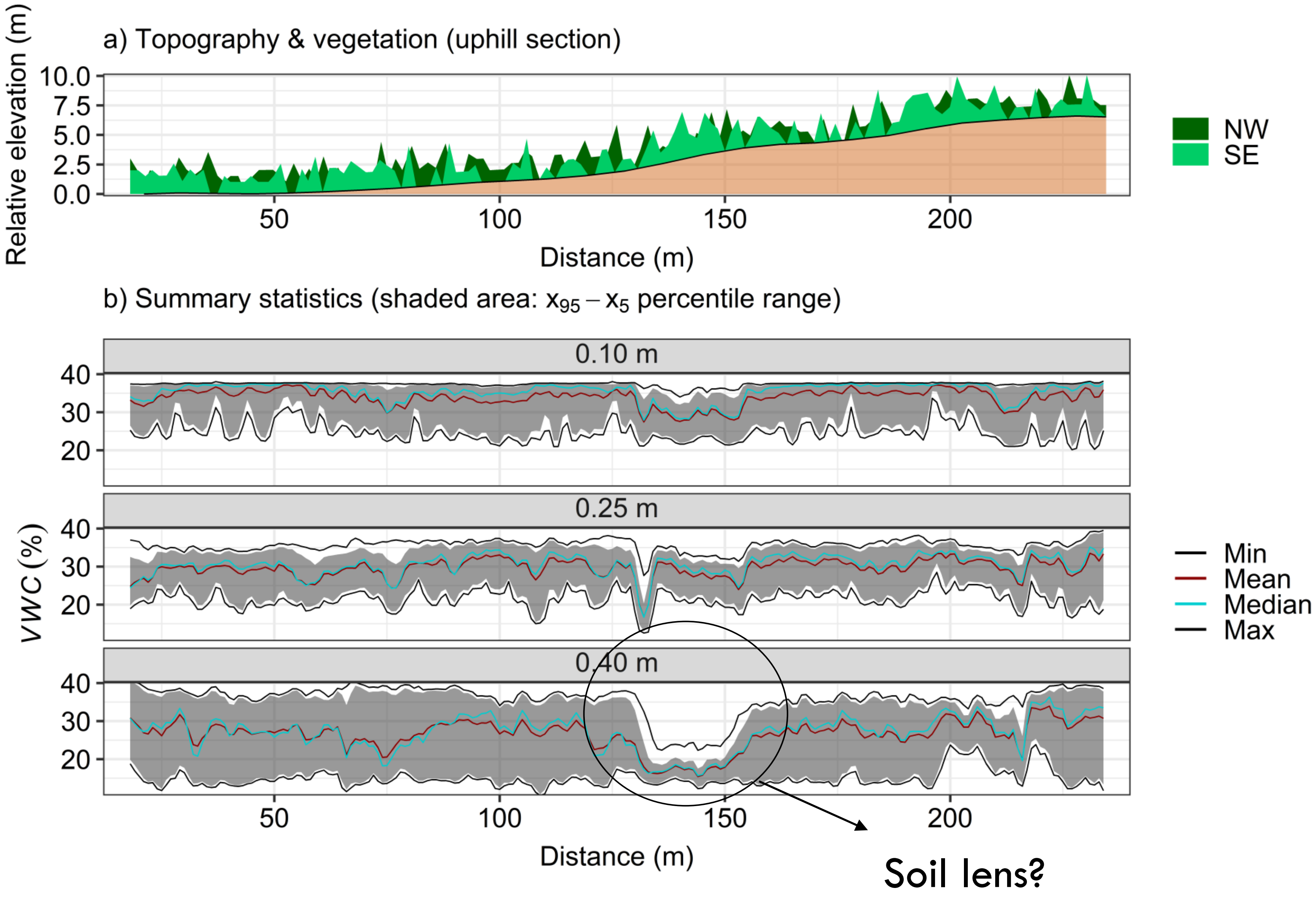


Event2 Oct 2018



PRELIMINARY RESULTS

- No clear relationship between soil moisture and vegetation (yet!) or topography



SUMMARY

- A-DTS can be used to measure soil moisture (and temperature) at an unprecedented spatial and temporal resolution at the field scale
- High spatio-temporal variation of the soil moisture was observed (>10% across the field at any time, and up to 25% within a matter of days or a few weeks)
- Rainfall (or lack of rainfall) is the main driver for change, and the spatio-temporal variation of soil moisture was little affected by topography and vegetation
- Infiltration is strongly dependent on previous soil conditions

Future goal:

- Long-term monitoring can help understanding changes in hydrology due to vegetation dynamics (plant-soil-water interactions)

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