Active DTS for spatio-temporal soil moisture monitoring

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1. Introduction

Active Distributed Temperature Sensing (A-DTS) is a relatively new technique that can potentially be used to monitor the soil moisture along a fibre optic (FO) cable [1,2].
Recent technological advances make it now possible to collect measurements at an unprecedented spatial resolution along cables over 1km long, making the A-DTS a promising tool for measuring the spatial variation of the soil moisture at the field scale.

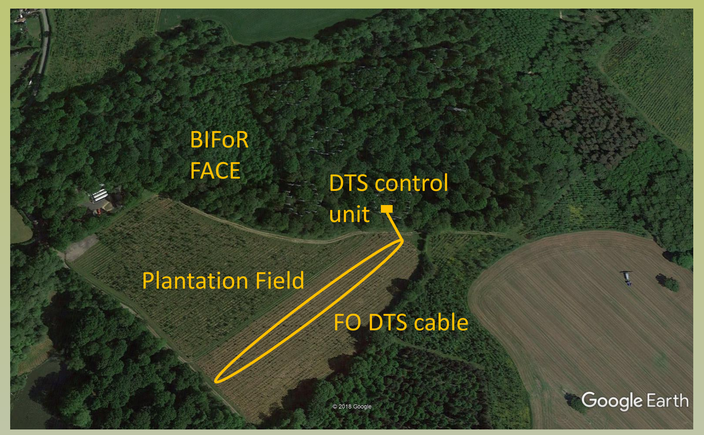

Fig.1 – Aerial view of the field site.

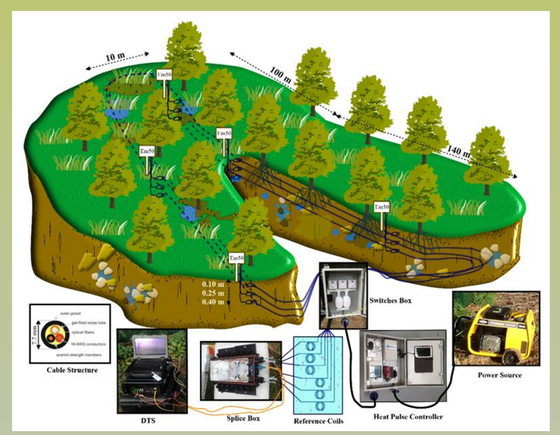

Fig.2 – A-DTS equipment and layout.

2. Field case-study

A field located adjacent to the BIFoR FACE forest (Norbury Junction, UK) has been selected as a field case study (Fig.1). The field is located on a gentle hill and has been recently planted with rows of deciduous saplings including English oak (*Quercus robur*) and sycamore (*Acer pseudoplatanus*).
A single FO cable, approximately 1500m long, was buried in a 400m loop configuration and at three different depths (i.e. 0.10m, 0.25m and 0.40m) in between two rows of trees (Fig.2).

3. Methodology

A XT DTS unit combined with a heat pulse system (both by Silixa Ltd.) have been programmed to measure temperature every 30s and at 0.25m spatial resolution.
The FO cable was heated 4 times per day and the temperature cumulative increase over a period of 15min (Eq.1) has been converted to soil moisture (i.e. volumetric water content) via an empirical relationship.

$$T_{cum} = \int_0^{t_0} \Delta T \, dt$$

Eq.1

Soil moisture (VWC)

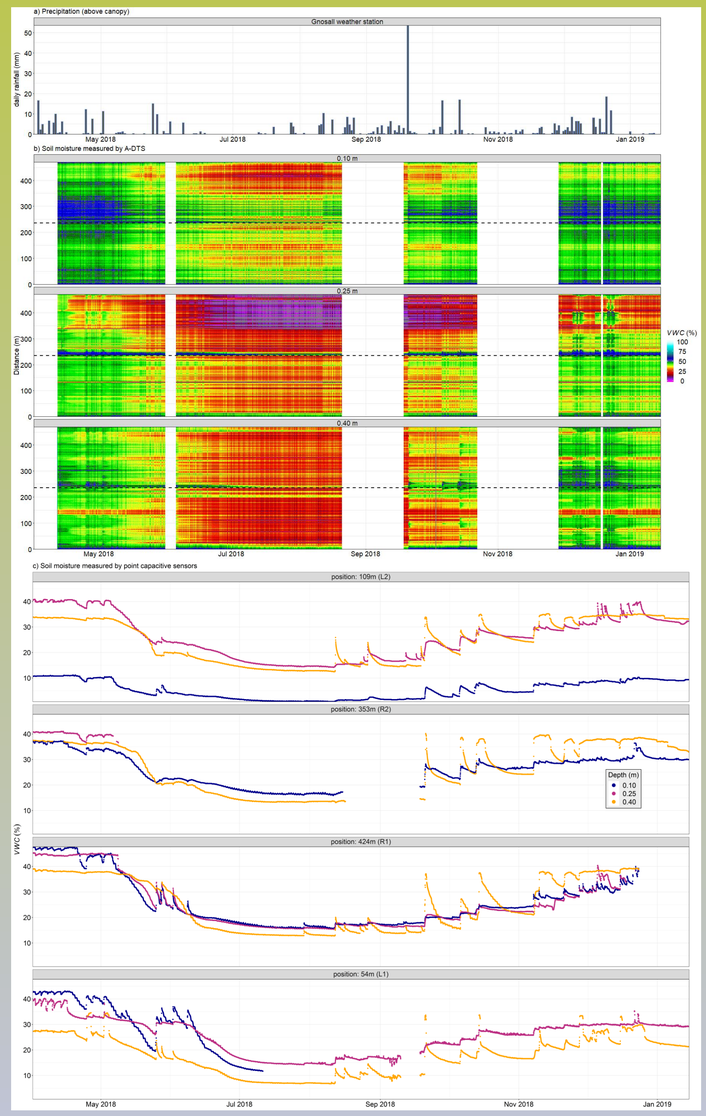

Fig.3 – a) Precipitation (mm), b) soil moisture measured by A-DTS over space and time, c) soil moisture measured by point probes along the FO cable.

4. Preliminary results

The spatio-temporal variation of the soil moisture measured by A-DTS on site is shown in Fig.3b. The measurements were taken continuously over several months in 2018 and 2019 with the exception of some gaps (two of several weeks) where the heat pulse system did not restart following a power cut at the FACE facility.

The results relate well with atmospheric precipitation (Fig.3a) and soil moisture measured with point sensors installed at different locations along the FO cable (Fig.3c) .

In Summer 2018 a strong drying event starting in June and lasting 3 months has been successfully captured by the A-DTS.

5. Conclusions

This study demonstrates that A-DTS is capable of monitoring soil moisture at a high spatial and temporal resolution at the field scale and for prolonged periods of times. This paves the way for monitoring soil dynamics with unprecedented detail allowing for both seasonal and event-based variations to be thoroughly investigated.

6. References

[1] Gamage, D.N.V., Biswas, A., Strachan, I.B., Adamchuk, V.I., 2018. Soil Water Measurement Using Actively Heated Fiber Optics at Field Scale. Sensors 18, 1116. https://doi.org/10.3390/s18041116
[2] Sayde, C., Gregory, C., Gil-Rodriguez, M., Tufillaro, N., Tyler, S., van de Giesen, N., English, M., Cuenca, R., Selker, J.S., 2010. Feasibility of soil moisture monitoring with heated fiber optics. Water Resour. Res. 46, W06201. https://doi.org/10.1029/2009WR007846