



**Scenario**  
DOCTORAL TRAINING PARTNERSHIP

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ENVIRONMENT

## Optimal Exploitation of GNSS Reflectometry Signals for Sensing Land Parameters

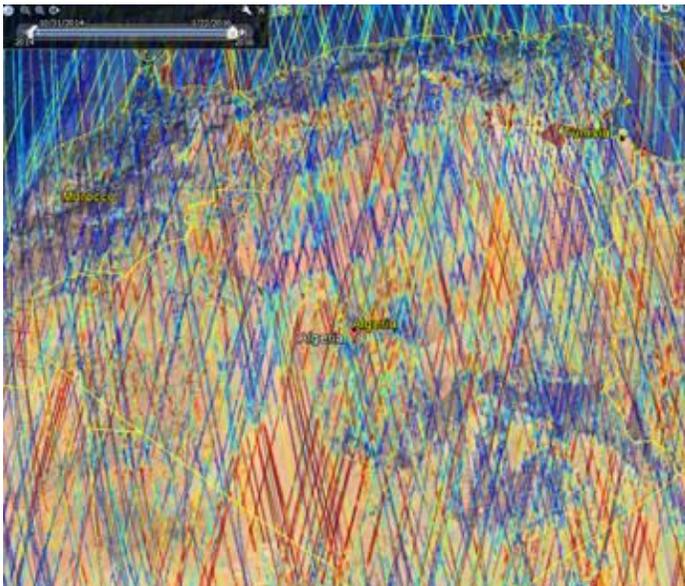
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Soil moisture is a key parameter closely associated with hydrology, weather, agriculture and climate change, and that has potential for improved measurement from space, and in particular flooding alerts could benefit from faster availability of such remotely sensed measurements.

GNSS reflectometry is showing tremendous promise for taking measurements of the sea state and ocean winds on missions such as on the UK's TechDemoSat-1 (TDS-1) and the NASA CYGNSS constellation, using Surrey's GNSS instrument. Signals are received and processed on-board into 1 second Delay Doppler Maps (DDMs), which are then sent to the ground, and inversion algorithms are applied to recover geophysical parameters such as wind speed and ocean roughness. Recent work has shown also that collections over land contain different geophysical information such as soil moisture and biomass, which is being investigated by scientists accessing the TDS-1 data.



*[GNSS reflection signal strength showing geophysical imprint over North Africa]*

Data used by scientists is generated on-board TDS-1 and the CYGNSS satellites, but the processing scheme currently used is not necessarily the optimal for soil moisture sensing. In collaboration with scientists, this PhD studentship will investigate the choices for on-board signal processing and calibration for emerging applications. In particular, while one of the limits of GPS open L1 signal is its bandwidth of 2 MHz, Galileo satellites have wider bandwidth signals (signals range from 4 MHz up to approx. 50 MHz) that will allow higher resolution measurements and weaker signal tracking, which could unlock new capabilities and applications in reflectometry. As well as bandwidth, another important parameter is

signal strength as this is closely related to the geophysical parameters. To achieve better inversion of parameters such as soil moisture, the signal strength must be radiometrically calibrated, requiring an understanding of the GPS system, the signal coding scheme and the instrument characteristics.

To verify the success, the student will interact with scientists who are users of soil moisture products to investigate cross-comparisons with existing models and measurements. The impact will increase with more measurements, e.g. from a small satellite GNSS-R constellation. A large volume of GPS measurements from TDS-1 and CYGNSS are now available for reference, but the new availability of Galileo signals, in combination with GPS, Glonass and Beidou, means that many more measurements can potentially be taken, increasing the coverage capability per satellite in orbit.

This PhD will look to investigate the new GNSS signals for reflectometry, the optimal processing scheme for soil moisture sensing to explore if the wider bandwidth and new processing will provide improved resolution and accuracy on the ground, opening the door for a new global measurements of soil moisture from low cost satellites.

**Training opportunities:**

The studentship will have access to the University of Surrey's space course lectures and materials. As a CASE studentship, the student will spend time embedded within SSTL exploring the use of Galileo signals for Reflectometry, collected from the UK TDS-1 satellite, and subsequent missions. The student will have access to make use of SSTL's laboratories and GNSS facilities.

**Student profile:**

The candidate must have a strong aptitude and preferably experience with signal processing theory and practice. Detailed knowledge of at least one of Earth Observation Radar, GNSS signals, FPGAs, C-programming will be essential. The student should hold a good first degree or Master's level degree in electronic engineering, spacecraft engineering or a physical science.

**Funding particulars:**

This is a CASE (Collaborative Awards in Science and Engineering) studentship with financial support from Surrey Satellite Technology Ltd.

**References:**

An overview of GNSS-Reflectometry and access to data from TechDemoSat-1 is available from:

[www.merrbys.org](http://www.merrbys.org)

Unwin et al., "Spaceborne GNSS-Reflectometry TechDemoSat-1: Early Mission Operations and Exploitation", 10.1109/JSTARS.2016.2603846.