Changes in soil hydraulic properties using long-term innovative monitoring to unveil process dynamics, improve numerical model parameterisation and support Nature-based Solutions

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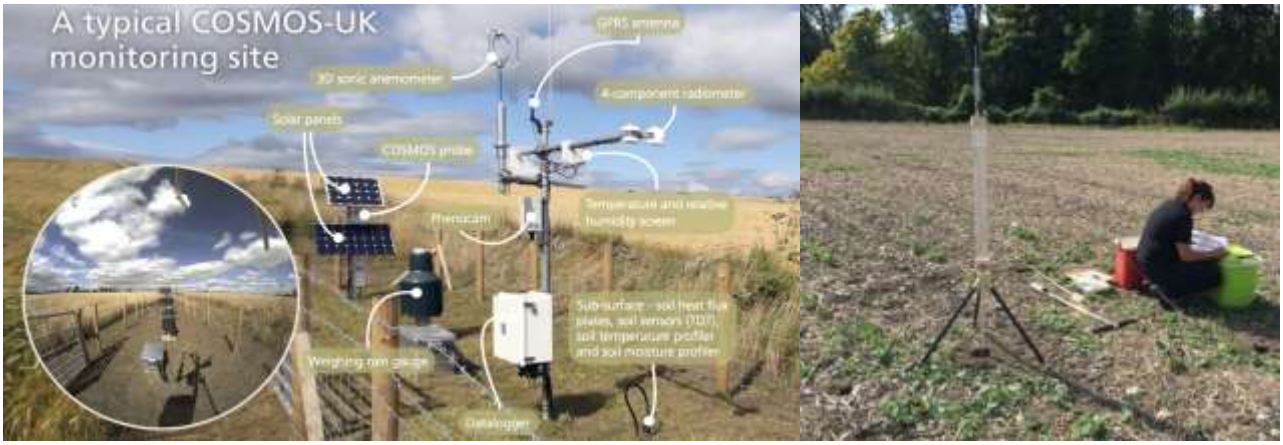
Changes in land use and land management can significantly alter the structure of soils and their hydraulic properties, which in turn impact their "sponge function" (water retention), critical for climate resilience against extremes (floods and droughts). However, we have scant information on dynamics of soil structure and hydraulic properties over time (annual-decadal). For example, how different crop covers or crop rotations affect infiltration, soil water retention and percolation. This knowledge gap prevents realistic parameterisation of models, including Land Surface Models, that usually assume constant soil structure and hydraulic properties. This in turn introduces higher uncertainty in predictions and hinders improved design of management options, such as Natural Flood Management (NFM), Natural Water Retention (NWR) or Nature-based Solutions (NbS).

This PhD project will benefit from detailed soil surveys done by LANDWISE NFM project (2019-2022), where a baseline of soil structure and hydraulic property data was gathered at several sites in the Upper Thames catchment; revisiting those sites at PhD year 0 and year 3, having thus three snapshots in time to characterise soil dynamics during a 5-year total time span. Additionally, water retention capacity will be measured at the plot scale using a COSMOS rover during dry seasons (estimating minimum soil moisture for a circa 300 m radius footprint). The project will benefit from a concurrent FLUXNET site, with eddy-flux tower data since 2017, to perform water and energy budgets. This will allow a longer-term look, albeit at point scale, of water retention capacity.

To assess the relevance of soil dynamics, the changes in soil structure and hydraulic properties will be parameterised in Land Surface Models, from simple screening (intended for crop productivity forecasting) to more complex (State-of-the-Art), and compared to data from eddy flux towers, as well as simulations assuming constant soil structure and hydraulic properties.

The research will be relevant to those involved in hydrologic extremes management and model development and, in particular, those with an interest in Working with Natural Processes (WwNP), NbS and NWR, who aim to mitigate the effects of changes in land use/management, climate extremes and water resources. The proposal builds on the current skills and experience of its applicants from UKCEH and UoR and will form the basis for partnerships in e.g., soil hydrology. The project will allow the student to work with and further develop innovative new surveying and modelling tools and techniques, as well as demonstrate advanced skills in analysing and presenting new spatio-temporal datasets.

The work will greatly improve understanding of the link between spatial and temporal aspects of soil water retention capacity, and related soil process dynamics. Ultimately, this can help deliver improved NFM/NbS measures for benefit of people and the environment.



Left: COSMOS-UK station (https://uk-scape.ceh.ac.uk/our-science/projects/COSMOS-UK). Right: Infiltration measurements

Training opportunities:

The PhD project provides comprehensive personal and professional development training alongside extensive opportunities for the student to expand their multi-disciplinary outlook through interactions with a wide network of academic, research and policy partners. The student will gain experience of both the detailed, specialised skills involved in the project and a strong understanding of how they fit into the wider context of water retention, soil environmental services and application to real world problems. The student will benefit from working alongside UKCEH and UoR scientists, and other PhD students. The student will also be encouraged and supported in engaging with stakeholders (e.g., environmental regulators and advisory bodies) to promote the potential of closer consideration of natural processes in catchment management. The student will be part of Verhoef's research group and interact with the other PhD students and PDRAs at group meetings as well as attending relevant wider UoR-based Research Group meetings (e.g., Soil Biogeochemistry Group, Water@Reading).

The training will be split between UKCEH and the UoR, giving the student ample exposure to research institute and HEI environments. Training will be given in field-based instrumentation deployment and maintenance (e.g., use of COSMOS rover), data analysis, and statistical and process-based modelling allowing development of numerical modelling skills and data visualization methods to view and disseminate the measurements. At UKCEH, the student will gain experience of working at the science-policy interface in a team that commissions, conducts and translates research for policy-makers and will have opportunities to be involved in meetings with catchment stakeholders. Ongoing UKCEH projects such as FDRI (https://www.ceh.ac.uk/our-science/projects/floods-and-droughts-research-infrastructure-fdri) will provide further opportunities including networking and expanded learning and development. The student will be embedded within a larger network of scientists working on hydrology, water quality and ecology at UKCEH and UoR, and will be exposed to the latest land surface water quantity monitoring and modelling techniques with access to national and catchment-scale datasets from long-term monitoring programmes and at high-resolution to support their own observations. The student will have access to advanced computer facilities, research seminars, general scientific training through the Reading Researcher Development Programme/UKCEH Postgraduate Training Scheme and opportunity to attend project meetings, and national and international conferences and workshops.

Student profile:

Candidates for this project should have a minimum of an Upper Second Class Honours degree or equivalent in environmental science, engineering, physics, geography, mathematics, ecology or a similar discipline, and ideally an interest in both soil hydrology and catchment hydrology. The candidate will have an interest in catchment water resource management, be willing to undertake field work and have good numerical and computing skills. Good communication skills will be essential to engage with stakeholders (potentially including citizen scientists). The student will be based at UKCEH Wallingford.

https://research.reading.ac.uk/scenario/