How do trees affect the hydrological cycle?

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One of the least constrained components of the hydrological cycle is the amount of rainfall that is captured by the vegetation and recycled back to the atmosphere – the Interception. Yet it has considerable impacts, both on the land-atmosphere feedbacks, and on the land-hydrology with related implications for Society. For example, Interception affects the water available for crop growth and ultimately the water in the rivers and the flooding potential of catchments.

In the UK, site studies and models of rainfall interception have shown it to be an important factor in determining the role of forestation on the water resources, because forests have a large leaf area and high aerodynamic roughness, and hence large values of Interception. However, there are aspects of the process that are not yet well understood such as how the spatial and temporal distribution of the rainfall affects the interception, the effect of forest design and age, and indeed how to represent that in our weather-prediction and hydrological models.

In the past, observational methods for interception were labour intensive and therefore there are data from only a few studies available. However, new sensor technology offers a chance to take this science forward. New sensors of the absorption of Cosmic Rays over field-scale areas (COSMOS*), and visible and radar wavelength satellite remote sensing (RS) retrievals are being used to diagnose surface water (soil moisture, ponding, snow and interception). These new data streams are usually interpreted to give surface soil moisture content, but a novel product would be to employ them to predict intercepted rainfall.

The new methods of observing interception could be compared to more traditional methods by establishing a blanket sheet interception gauge to directly measure within storm interception losses.

The aim of the PhD is to use the JULES land surface model, with improved Interception equations embedded, together with existing and new in-situ and RS data at a range of forest sites in the UK to quantify the interception of rainfall by trees and how it is changing with changing rainfall patterns, and what this would mean in terms of the UK Hydrological balance. It would also inform growing interest in woodland creation for natural flood management and the valuation of this service in natural capital accounts.

The PhD would combine several aspects of environmental physics: collating & interpreting data for model calibration and validation, using numerical models to predict key processes, and ultimately novel methods of bringing data and models together to increase the understanding of the physical

environment. An extensive network of COSMOS stations already exists in the UK, run by CEH including several in forested areas combined with rainfall, soil moisture and evaporation flux observations. In addition, experts in the use and development of the model used by the UK Met Office for their weather forecasting (JULES[**]) are based in Reading University and CEH. Data on rainfall distributions are available at both CEH and at Reading University. Forest Research can provide expertise in forest hydrology plus contribute flux data for forested areas.

Training opportunities:
The work on this PhD feeds directly into the Hydro-JULES programme based at CEH and would have strong links to the UK Met Office. Training would involve learning to use the Unified Model and the student would be part of a team delivering improved hydrological process modelling.

Student profile:
This project would be suitable for students with a degree in physics, mathematics or a closely related environmental or physical science.

References: (optional)
If required, put in any relevant recent publications.
*Zreda et al, 2012. COSMOS – the COsmic ray Soil Moisture Observing system. HESS
[**] Best et al, 2011. The Joint UK Land Environment Simulator (JULES) model description. Part 1 – energy and water fluxes. GMD

http://www.reading.ac.uk/nercdtp