RESEARCH CASE STUDY

UK Centre for Ecology & Hydrology

Combining data and models to improve soil moisture estimates

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Hydro-JULES

Why it matters

An important component of the terrestrial water cycle is the water stored in soil. As well as influencing river flow, soil moisture can also shape local weather and climate through evaporation. Accurate modelling of soil moisture is therefore vital for predicting river flow as well as drought and flood conditions. To do this, hydrologists must have information about local soil types and textures, as these strongly influence soil moisture. For example, sandy soils tend to drain rapidly, whereas water will move more slowly through soils containing a lot of clay.

Soil moisture can be modelled using the Joint UK Land Environment Simulator (JULES), a sophisticated mathematical model that can simulate the flow of water through soil based on soil type and texture. There are a number of freely available global databases of soil texture JULES can use for these simulations, as well as local measurements of soil texture in some parts of the world. However, uncertainties about soil texture, and the way that JULES uses them, mean that there are inevitably ambiguities and errors in soil moisture estimates when making predictions. This is where data assimilation can help.

Using data assimilation methods, we have significantly improved soil moisture estimates from the JULES model

Hydro-JULES, is a research programme funded by the UK's Natural Environment Research Council (NERC), in order to advance our ability to predict the future availability of water resources and the risk of water related disasters under a changing climate.

The Hydro-JULES programme is building a three-dimensional, open source, community model of the terrestrial water cycle to support and enable collaborative work across the research and academic communities in hydrology and land-surface science. This five-year programme is delivered by the UK Centre for Ecology & Hydrology (UKCEH) in partnership with the British Geological Survey (BGS) and National Centre for Atmospheric Science (NCAS).

w: hydro-jules.org
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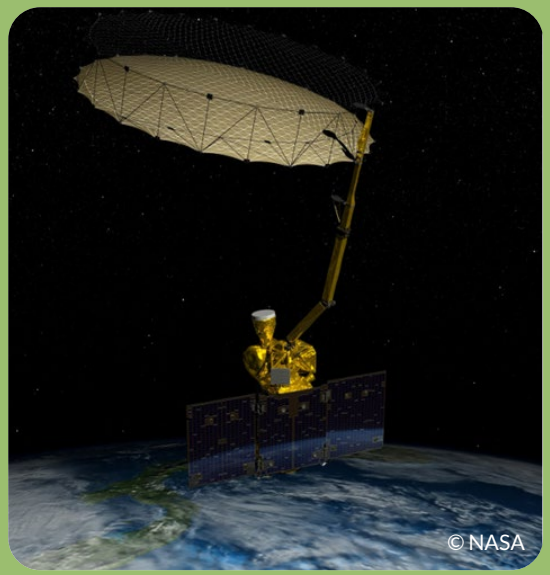
Two instruments for measuring soil moisture

Left: Cosmic-Ray Neutron Sensor (CRNS) at one of UKCEH's COSMOS-UK sites. From the COSMOS-UK User Guide: https://cosmos.ceh.ac.uk/

Below: Artist's rendering of the Soil Moisture Active Passive (SMAP) spacecraft (credit: NASA)



What we did

Data assimilation is a group of methods in which information from a physical model such as JULES is combined with observations; crucially, the uncertainties in both measurements and model output are each taken into account.

We used data assimilation techniques to combine JULES outputs with two different observational soil moisture datasets. In one study we used field scale soil moisture measurements from UKCEH's COSMOS-UK network, which provides in situ measurements of soil moisture using innovative cosmic ray neutron sensors at around 50 sites across the UK. In a separate study, we used soil moisture observations from the NASA Soil Moisture Active Passive (SMAP) satellite mission over an area of East Anglia. In both cases were able to improve the way in which JULES used soil texture information, resulting in significantly improved soil moisture estimates.

Impacts and benefits

Our work shows that there is great potential in using data assimilation techniques to improve soil moisture outputs from JULES. Better representation of soil moisture will in turn allow Hydro-JULES to make more accurate predictions of flood, drought and agricultural processes.

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BGS British Geological Survey
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