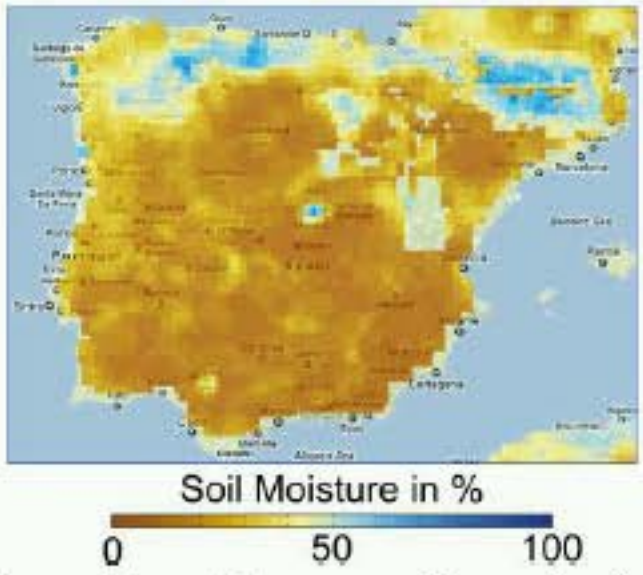
SATELLITE-BASED SOIL MOISTURE FOR DROUGHT AND FLOOD MONITORING AND FORECASTING

How relatives of your microwave oven help to monitor global soil water and why you benefit from these data

The challenge

Atmospheric processes like rainfall, evaporation and changes in temperature are crucial factors influencing weather, climate and water-related extreme events like floods or droughts. One variable that has attracted increasing scientific attention is the water stored in the pore space of soils. For decades it was only possible to measure this soil moisture on the ground via probes. A globe-covering probe-network is financially not feasible but satellite technologies now provide an opportunity to measure soil moisture from space, enabling quick and accurate measurements.



Dry soil moisture conditions in the profile of the Iberian Peninsula for late March 2012 as relative percentage (0 – 100%)

Benefits to citizens

The impact of extreme events is stronger in countries that already suffer from high levels of vulnerability. Nevertheless, industrialised countries are not immune to hydro-meteorological extreme events. Estimates for Europe indicate that 17% of Europe's territory and 11% of its population are affected by water scarcity, resulting in costs of €100 billion over the last 30 years. According to the newest Intergovernmental Panel on Climate Change (IPCC) report the frequency of extreme events is likely to increase in several parts of the world. Hence, it is important to estimate the water content in the root zone of plants for agricultural purposes or the degree of water saturation in the face of approaching flood events. Also weather forecasters have identified soil moisture as a valuable resource for improving predictions.

'The integration of satellite-based soil moisture information resulted in a positive impact in our operational forecasting system.'
Imtiaz Dharssi, MetOffice UK (HESS, 2011, Vol 8, pp. 4313-4354)

Soil Moisture

Of all natural disasters, droughts rank first regarding casualties, duration and economic loss (Image Source: Stock Free Images and Dreamstime Stock Photos)

The space-based solution

Modern active microwave systems (radars) used for soil moisture retrieval orbit planet earth close to the poles. They emit beams to 'see' so-called 'swaths', which change as the planet rotates. Each swath can be several hundred kilometres wide, while the resolution of one pixel is 25–50 kilometres.

One great advantage is that radars work independently of sunlight and weather. Additionally, active retrieval of soil moisture is based on backscatter characteristics as the only input. Auxiliary datasets are needed solely to correct, scale and classify the results.

Unfortunately, the penetration depth of microwaves into soil is restricted to a few centimetres. Therefore, a soil water index was developed at the Institute of Photogrammetry and Remote Sensing. It is based on a two-layer infiltration model that is applied to time series of surface soil moisture. This way the soil moisture content up to a depth of 1 m can be estimated. One of the first practical users was MetOffice UK, who successfully assimilated satellite-based soil moisture into a weather forecasting model. Within the GMES service GEOLAND 2 the soil water index is produced operationally.

Outlook for the future

Some regions (high elevation, dense vegetation, frozen or snow covered) still pose a challenge to active microwave remote sensing. Sophisticated research approaches are needed to minimise errors in the datasets. Cooperation between European and North American missions is required to produce data as practically oriented as possible to fulfil user needs.

The near real-time operational availability of soil moisture products has created wide-ranging scientific interest. This continues to lead to new applications, including the role of soil moisture in occurrence of water and vector borne diseases, such as malaria.

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