Multi-resource remote sensing data for soil moisture estimation.

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Soil moisture is a fundamental state variable of the soil three-phase system and has important implications for earth and environmental science applications. Soil moisture is an important characterization of soil water and an important part of determining soil parameters. Soil moisture plays an important role in the exchange of water between the soil, atmosphere and water bodies. Soil moisture affects soil respiration and the cycling of soil carbon and even global carbon. Therefore, soil moisture can affect global climate change and even global warming. In addition, surface and soil moisture is an important parameter in micrometeorological and hydrological studies. Soil moisture can also be an important indicator in drought monitoring. It has a leading importance in agricultural production and in the prevention and reduction of drought disasters. Therefore, the study of obtaining or predicting soil moisture with high accuracy has a certain ecological, economic and social value [1].

The methods used to determine or predict soil moisture can be divided into two types: the traditional method and the modern method. In general, the traditional methods are the thermogravimetric technique and the calcium carbide technique, which generally require field sampling and laboratory determination. In the thermogravimetric technique, soil samples are dried in an oven at 105 °C for 2 hours. Then, they are quickly weighed and their weight is recorded. Finally, the moisture content of the soil is obtained by calculating the ratio of oven dry weight. Accuracy is ± 1%. The most commonly used methods for measuring soil moisture are time domain reflectometry (TDR), neutron scattering sensor method, frequency domain reflectometry (FDR), heat flow technique and resistance method. Although traditional methods have many advantages, such as their high accuracy, short duration, simple principle, etc [2].

They also have disadvantages such as complex testing processes and a large number of repeated experiments, limitations of different soil samples for laboratory measurements, etc. TDR, neutron scattering method and FDR are expensive and complicated. Heat flow technology and the resistance method are easy to use and inexpensive, but require soil-specific adjustment and have high response times. Dielectric technology is only suitable for measuring the moisture content of individual soils. The aforementioned methods for measuring soil moisture are based on soil measurements and tests. At the same time, most of these methods can only monitor specific locations and are not sufficient for large-scale monitoring of the spatial distribution of soil moisture [3].

Compared to these traditional methods, remote sensing technology is one of the most important tools for large-scale monitoring and assessment of near-surface moisture. The remote sensing technique has a number of advantages and has been used to estimate soil moisture since the 1970s. Various remote sensing sensors are used to determine soil moisture. Currently, three main types of remote sensing sensors are used to obtain soil moisture: optical, thermal and microwave. The optical remote sensing method itself is divided into three types: remote sensing images based on spatial and spectral resolution, including high spatial resolution, hyperspectral bands (00-2500 nm) and multispectral bands (several narrow bands in visible space). band and near-infrared band) to analyze near-surface properties. In optical remote sensing, reflectance from 350 nm to 2500 nm was used to estimate soil moisture [4].

In addition, a linear or non-linear model was created to estimate soil moisture. However, the accuracy of soil moisture estimation varied depending on the data, with correlation coefficient R varying between 0.89 and 0.95 and RMSE (root mean square error) between 0.025 and 0.126 cm3/cm3. Optical remote sensing methods also have some disadvantages, such as the fact that optical remote sensing images are affected by weather conditions and the accuracy of soil moisture estimation is affected by vegetation on soil surfaces. In thermal infrared remote sensing, bands with wavelengths from about 3500 nm to 1000 nm were used to estimate soil moisture content. In addition, evaporative land surface temperature (LST) was commonly used to estimate soil moisture with reasonable accuracy (R2 = 0.79). In addition, soil moisture index and triangulation method are also widely used approaches for soil moisture estimation using thermal remote sensing images. Compared to optical remote sensing images, the use of thermal remote sensing in soil moisture estimation has been limited due to high acquisition costs. With the development of affordable remote sensing platforms such as unmanned aerial systems (UAVs), thermal images with high spatial and temporal resolution have become available at low cost and increased the ability to understand the variability of ground conditions [5].

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