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Estimation of Soil Moisture Using Remote Sensing and GIS

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SUMMARY

Remote sensing and GIS play a crucial role in agriculture, offering rapid and repetitive data collection for crop production estimation, irrigation scheduling, and water stress assessment. These technologies provide spatial and temporal distribution of soil moisture coverage, enabling efficient water resource management and optimizing irrigation practices. Various remote sensing methods, including visible, thermal infrared, and microwave, offer unique capabilities for soil moisture estimation by measuring electromagnetic radiation. In agriculture, these technologies facilitate precision agriculture, water resource management, irrigation planning, drought monitoring, and land use planning, allowing for informed decision-making and sustainable resource utilization.

INTRODUCTION

Soil moisture is a key variable in controlling the exchange of water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration. Changes in soil moisture have a severe impact on agricultural productivity, forestry and ecosystem health. Soil moisture (SM) influences water, energy and biogeochemical cycles and is a key parameter in meteorological, hydrological, ecological and agricultural systems. Soil moisture is a key state variable of the global energy and water cycle, as it controls the partitioning of incoming radiative energy into sensible and latent heat fluxes. Numerous studies have shown the influence of soil moisture on the feedbacks between land surface and climate, which, in turn, affect the dynamics of the atmosphere boundary layer and have a direct relationship to weather and global climate. It exhibits high temporal and spatial variability due to heterogeneous soil types and precipitation behaviour. The methods used to determine or predict soil moisture can be divided into two types: Conventional and Remote Sensing (RS). Compared to conventional methods, RS technology is one of the most important advanced tools for estimating

surface soil moisture. Different remote-sensing sensors are utilized to obtain the soil-moisture data. There are, three main types of sensors are used to obtain soil-moisture content, which can integrate different types of remote-sensing data with linear or nonlinear statistical methods such as optical, thermal and microwave RS. Most commonly used satellite images to estimate soil moisture are SAR (Synthetic Aperture Radar), SMOS (Soil Moisture and Ocean Salinity), SMAP (Soil Moisture Active Passive), LANDSAT and Sentinel data and non-linear approach using Artificial Neural Networks (ANN).

Importance of soil moisture

Crop production estimation and Irrigation scheduling/crop water stress assessment. Water resources inventory/water supply planning and it can also be used as an indicator for the prediction of natural disasters and environment changing, such as dust storms and erosions. Soil moisture exhibits high temporal and spatial variability due to heterogeneous soil properties and precipitation. Due to this accurate estimation of soil moisture at larger scales is difficult. In-situ methods can accurately estimate soil moisture throughout the profile but the information is point specific or localized. Soil moisture estimation by means of remote sensing depends upon the measurements of electromagnetic energy that has either been reflected (active) or emitted (passive) from the soil surface. Recent advances in remote sensing have shown that these techniques have the ability to measure soil moisture under a variety of topographic and vegetation cover conditions quantitatively.

Why remote sensing and GIS

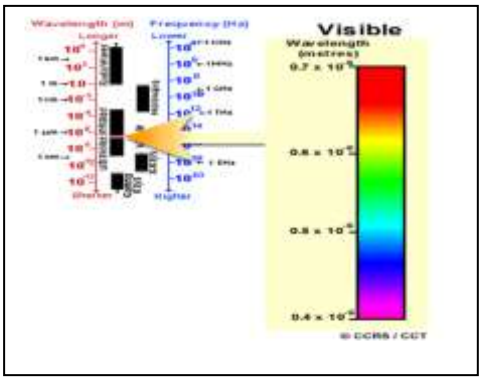
- Rapid data collection over large areas on a repetitive basis.
- They provide the spatial and temporal distribution of soil moisture coverage
- Easy data acquisition at different scales and resolutions.
- The images are analysed in the laboratory thus reducing the amount of field work.
- These methods do not disturb the object or area of interest.
- Map revision at medium to small scales is economical and faster.

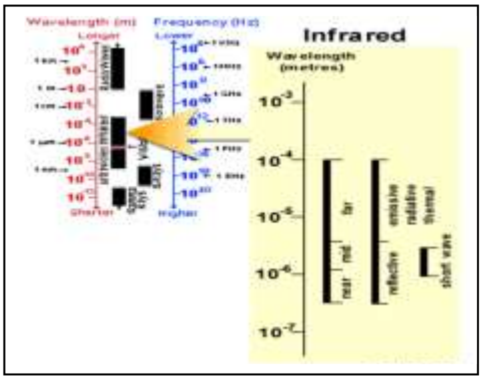
Remote sensing and GIS methods

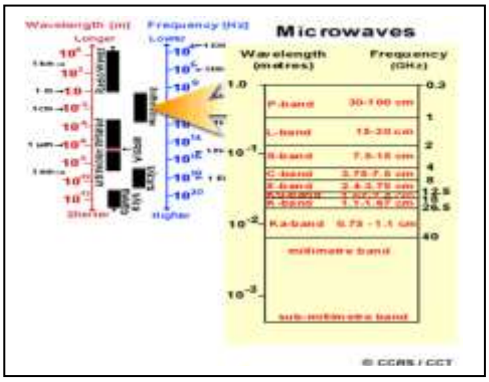
- Visible and near IR
- Thermal IR
- Active microwave
- Passive microwave

Visible method

Reflected solar energy is measured (400 to 700nm). Relationship between reflectance and SM depends on reflectance of Soil Roughness, Dry Soil, Soil Colour, Organic Matter and Soil Texture







Thermal infrared

Variations in soil moisture have a strong influence on the thermal properties of the soil, which is an intrinsic factor of soil surface temperature change. The amplitude of the diurnal range of soil surface temperature has been found to be highly correlated with the surface soil moisture content.

Microwave remote sensing

Microwave remote sensing provides a unique capability for soil moisture estimation by measuring the electromagnetic radiation in the microwave region between 1.0 mm and 1 m. The fundamental basis of microwave remote sensing for soil moisture is the large contrast between the dielectric properties of water and soil particles.

Visible and thermal inferred observations from the MODIS to parameterize parameters of the temperature vegetation/dryness index revealed the relationship between the TVDI and in-situ soil moisture is strong and significant, particularly during the period of sparse canopy cover (lower NDVI). Compared with the single-resource remote-sensing SMC-estimation model, the soil moisture- estimation model using multiple-resource remote-sensing data offered better accuracy with a correlation coefficient and low RMSE values. The non-linear neural network model can further improve the prediction accuracy of the SMC-estimation as compared with the single-resource remote-sensing SMC-estimation model.

Important key roles play in Agriculture:

Precision Agriculture: Remote sensing and GIS enable precision agriculture by providing detailed spatial information about soil moisture levels. Farmers can use this information to tailor their irrigation practices, optimizing water use and improving crop yield.

Water Resource Management: Efficient water resource management is essential in agriculture. By estimating soil moisture levels over large areas, authorities can make informed decisions about water allocation, drought preparedness, and irrigation scheduling.

Irrigation Planning and Optimization: Accurate soil moisture data helps farmers optimize irrigation schedules. By understanding the moisture content at different locations within a field, farmers can apply water where and when it is needed, reducing water wastage and energy costs associated with pumping.

Drought Monitoring and Early Alert: Remote sensing and GIS allow for the monitoring of soil moisture conditions over time. This information is vital for early detection of drought conditions, enabling timely interventions and adaptive strategies to mitigate the impact on crops and ecosystems.

Land Use Planning: GIS plays a crucial role in integrating soil moisture information with other spatial data, such as land use, topography, and climate. This integration helps in making informed decisions about land use planning, identifying suitable areas for different crops, and managing land resources more sustainably.

CONCLUSION

The integration of remote sensing and GIS in soil moisture estimation is a powerful tool for sustainable agriculture. It enhances decision-making processes, promotes resource efficiency, and contributes to the overall resilience of agricultural systems in the face of changing environmental conditions. It’s important to note that the remote sensing data and GIS techniques will help to find out the solutions to research problems and reduces the time in generating data base compared to conventional methods of soil moisture determination. These advanced technological interventions create more accurate and practically applicable research findings and more appropriate data interpretation for irrigation schedule.

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