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Potential Applications of Remote Sensing in Agrometeorology

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Introduction

Remote sensing is science and art of obtaining information about the objects without the making physical contact with them. The fundamental principle of remote sensing lies in discerning and characterizing objects by analysing the radiant energy reflected by their surfaces. Today's rapid advancements in remote sensing satellites, such as the Landsat series, Sentinel series, MODIS series, Resources at series and others, have revolutionized continuous land surface monitoring. These advanced satellites offer unprecedented capabilities, enabling us to observe and analysed the earth surface with greater detail (high spatial resolution), frequency (high temporal resolution), and accuracy than ever before. Remote sensing technology has revolutionized the field of agriculture, offering valuable tools for monitoring and managing crops, optimizing resource use, and ultimately increasing productivity. This article explores the significant applications of remote sensing technology within the domain of agricultural meteorology. This interdisciplinary field, bridging biophysics, weather, and climate, focuses on analysing how crop production is influenced by weather conditions.

Applications of Remote Sensing in Agrometeorology

1. Crop Yield Forecasting

Remote sensing plays crucial role in crop yield forecasting, providing valuable data and insights that enhance the accuracy and efficiency of predictions. After the creation of crop masks, statistical models are developed by calculating average values of various remote sensing-based vegetation indices (VIs) at specific time intervals. The VIs like NDVI (normalized difference vegetation index), GNDVI (green normalized difference vegetation index), SR (simple ratio), EVI (enhanced vegetation index), NDMI (normalized difference moisture index), LAI (leaf area index), FAPAR (fraction of absorbed photosynthetically active radiation) etc. are used for yield forecasting.

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2. **Drought Monitoring**

Droughts are natural disasters that can have devastating effects on agriculture, water resources, and ecosystems. Traditional methods for monitoring droughts often rely on ground-based measurements of rainfall, soil moisture, streamflow etc. However, these methods can be time-consuming, expensive, and may not provide a complete picture of the drought situation across large areas. Remote sensing technology has emerged as a powerful tool for monitoring droughts, offering several advantages over traditional methods in term of large-scale coverage, high temporal resolution, cost effective, offer diverse data sources (optical, infrared, and microwave sensors) and provide monitoring in adverse weather condition also (use microwave remote sensing). Here are some specific ways remote sensing is used in drought monitoring:

i. **Vegetation indices (VIs) / Drought indices**

- Enhanced Vegetation Index (EVI)
- Evaporative Stress Index (ESI)
- Normalized Difference Vegetation Index (NDVI)
- Temperature Condition Index (TCI)
- Vegetation Condition Index (VCI)
- Vegetation Drought Response Index (VegDRI)
- Vegetation Health Index (VHI)
- Water Requirement Satisfaction Index (WRSI)
- Normalized Difference Water Index (NDWI)
- Soil Adjusted Vegetation Index (SAVI)
- Land Surface Water Index (LSWI)

ii. **Land surface temperature:** Land surface temperature (LST) data can be used to identify areas where water is scarce and evapotranspiration is high, indicating potential drought conditions.

iii. **Soil moisture:** Microwave sensors can measure soil moisture levels, which are critical for plant growth and can help assess the severity of drought.

3. **Evapotranspiration Estimation**

The surface energy balance models like Surface Energy Balance Algorithm for Land (SEBAL), Mapping Evapotranspiration at High Resolution with Internalized Calibration (METRIC), Bowen Ratio Energy Balance (BREB) Model, Two-Source Energy Balance

(TSEB) Model, Simplified Surface Energy Balance (SSEB) Model etc. are use for estimate evapotranspiration over large and heterogenous area. These algorithms analyzed satellite data and extract valuable information, including evapotranspiration, crop coefficients, energy fluxes, albedo, LAI and solar radiation. The advantage of using surface energy models are large-scale coverage, non-intrusive, cost effective and effective specially where evapotranspiration measurement instruments are not available.

4. Surface Energy Balance Study

Using of satellites data, the surface energy balance models like SEBAL, TSEB, METRIC, SSEB etc. are use for study the energy fluxes i.e. sensible heat flux, latent heat flux, ground heat flux and net radiation at different time period during crops growth stages. Using this information, we can measure radiation use efficiency (ground level dry biomass measure required) of crops and also assess of intercepted solar radiation at different growth stages.

5. Integration of Remote Sensing Information to Crop Models

Traditional crop models often face limitations when applied to large-scale regions due to the need for numerous input parameters, which can be difficult and costly to collect. This often restricts their application to point-based simulations, limiting their effectiveness in representing the spatial variability of agricultural landscapes. Remote sensing technology offers a powerful solution to this challenge by providing data for key input parameters such as Leaf Area Index (LAI) over large areas. By integrating this data into crop models, we can overcome the limitations of point-based simulations and achieve more accurate and representative predictions of crop growth and yield across diverse landscapes.

This integration offers several significant advantages:

- **Reduced reliance on ground-based measurements:** Remote sensing data eliminates the need for extensive and expensive ground-based data collection, making crop modeling more efficient and cost-effective.
- **Improved spatial representation:** Remote sensing data provides spatially explicit information, enabling crop models to capture the variability of agricultural conditions and predict crop performance across large regions.

- **Enhanced model calibration:** Integrating remote sensing data allows for more accurate calibration of crop models to specific regions and environmental conditions, leading to more reliable predictions.
- **Dynamic adjustments:** By providing real-time data on crop and environmental conditions, remote sensing enables dynamic adjustments to crop models, improving their ability to adapt to changing circumstances.

Conclusion

Remote sensing plays a critical role in agrometeorology, offering valuable information for drought monitoring, evapotranspiration estimation, surface energy balance analysis, and yield prediction. Advancements in satellite technology with improved temporal resolution can provide more frequent and detailed data on crop conditions. However, challenges such as cloud cover, data analysis complexity, and the need for skilled personnel remain.