Utilizing GPS Signal Interference Patterns for Soil Moisture Analysis via Dielectric Constant

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Abstract :

This research focuses on using GPS signals to estimate soil moisture in a paddy field in Fuchu, Tokyo. By analyzing GPS signal interference patterns, we can measure changes in the soil's moisture content without invasive methods. The study aims to improve precision farming techniques by providing accurate moisture data that can be used to optimize agricultural practices.

Key words: GPS reflectometry, Soil moisture estimation, Dielectric constant, Fresnel's coefficient

1. Introduction

This research explores the use of GPS reflectometry to estimate soil moisture content in a paddy field in Fuchu. By utilizing signal reflections from GPS satellites and calculating the dielectric constant through Fresnel's reflection coefficients, we can assess soil moisture without the need for invasive methods.

This study aims to provide an efficient and non-invasive method for monitoring soil moisture, which is crucial for managing water in paddy fields. The ability to track moisture levels in real-time supports better water management and precision agriculture practices.

2. Methodology

(1) Setting Up Equipment

A Trimble GNSS Ti-V2 Choke Ring antenna was installed at a height of 305 cm in a paddy field in Fuchu. The antenna was positioned to capture GPS signals from satellites, focusing on signal reflections from the soil surface.

(2) Collecting GPS Signal Data

Data collection occurred daily, with the GPS receiver capturing both direct and reflected signals from specific satellites. Signal-to-Noise Ratio (SNR) data was recorded, with attention to changes in environmental conditions.

(3) Processing and Analyzing Data

Once the GPS signal data is collected, we calculate the Signal-to-Noise Ratio (SNR) in Volt/Volt (V/V). This SNR data helps identify the reflections from the ground. By focusing on the reflected waves, we can gather information related to soil moisture.

Next, we use a curve-fitting method to separate the reflected signals from the noise in the data. Then, an experimental constant 'a' is calculated by comparing the

SNR with the reflectivity of the soil. Using this constant, the dielectric constant (ε) of the soil is determined, which reflects the soil's moisture level. Finally, a graph is generated showing how the dielectric constant changes over time, helping us analyze how the soil moisture varies during the experiment.

3. Results

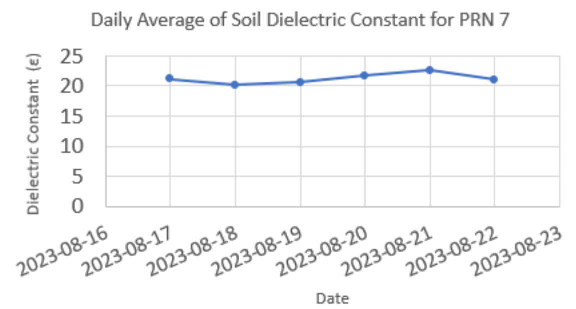

Fig 1: Daily average of Soil Dielectric Constant for PRN 7

The results show the daily variation in the soil's dielectric constant of the paddy field in Fuchu in August 2023, reflecting changes in soil moisture content. Overall, the dielectric constant remained fairly stable, indicating consistent moisture levels. Minor fluctuations suggest small changes in soil conditions, likely influenced by environmental factors such as weather or irrigation.

This method effectively tracks soil moisture using GPS-based reflectometry, providing daily insights without invasive procedures. The observed stability in the dielectric constant demonstrates the potential of this approach for monitoring soil conditions in agricultural settings, ensuring optimal moisture levels for crop growth.

4. Conclusion

The results demonstrate that the dielectric constant remained stable, reflecting consistent soil moisture levels in the paddy field during the observation period. This shows the reliability of using GPS-based methods for monitoring changes in soil moisture over time. The data collected is crucial for understanding moisture distribution, which can be useful for agricultural applications, especially in water management. However, adjustments may be needed in the future to consider variables like plant growth, which could affect the accuracy of the measurements.

Acknowledgement

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