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Proximal Gamma Ray Spectroscopy for monitoring Soil Water Content in vineyards

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Soil Water Content (SWC) is a key information in precision agriculture for obtaining high levels of efficiency and health of crops, while reducing water consumption. In particular, for the case of vineyards, due to the recent extreme temperature fluctuations, the knowledge of the SWC of the entire field becomes crucial to allow a timely intervention with emergency irrigation to preserve plant health and yield.

Unlike electromagnetic SWC measurements, that are punctual and gravimetric measurements, that are punctual and also time-consuming, the Proximal Gamma Ray Spectroscopy (PGRS) technique can provide field-scale, non-invasive, and real-time measurements of SWC. This is achievable through an in-situ NaI detector, continuously recording photons resulting from the radioactive decay of ^{40}K in the soil, which are attenuated proportionally based on the amount of stored water. Given the inverse proportionality between soil moisture and photons detected by the gamma ray sensor, the SWC value can be easily obtained.

In this study we investigate the performance of PGRS applied to the case of study of a vineyard at the farm “Il Poggione” located in Montalcino (Siena, Italy).

The effectiveness of the results obtained is supported by different tests: first the validation allowed to compare the PGRS measurement (5.8 ± 1.5)% with a gravimetric measurement (9.0 ±

2.5)%, highlighting a 1-σ agreement; then by the rainfall recognition capability indeed, in correspondence to the most significant rainfall event (18 mm) the SWC value before and after the rain increased of 7.8%.

Moreover, the integration of the in-situ system with an agrometeorological station resulted in a Web App, allowing for real time data storage and thus facilitating data management, spectrum analysis, and display for both gamma ray sensor and agrometeorological station results, enabling comprehensive studies of environmental parameters (e.g., temperature, air humidity).

This research underlines the potential of PGRS as a precise, real-time, and field scale SWC monitoring tool not only in vineyards but for cultivated fields in general. Further refinements concerning the gamma ray spectra analysis and broader applications in environmental monitoring are envisaged for improved agricultural practices.

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