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Discriminating biomass and soil water content with proximal gamma-ray spectroscopy

Fabio Mantovani[1,2], Matteo Albéri[1,3], Carlo Bottardi[1,2], Enrico Chiarelli[1,2], Kassandra Giulia Cristina Raptis[1,2], Andrea Serafini[1,2], and **Virginia Strati**[1,2]
[1]University of Ferrara, Physics and Earth Sciences Department, Ferrara, Italy
[2]INFN, Ferrara Section, Ferrara, Italy
[3]INFN, Legnaro National Laboratories, Legnaro, Padua, Italy

The exceptional capabilities of proximal radiometric measurements to estimate Soil Water Content (SWC) have recently been proven effective for precision farming applications. The water contained in the growing vegetation (i.e. Biomass Water Content, BWC) attenuates the terrestrial gamma signal acquired by a permanent station in a crop field and it represents the most relevant source of systematic bias. In the perspective of employing proximal gamma-ray spectroscopy for automatic irrigation scheduling, the Biomass Water Content (BWC) correction is mandatory for assessing crop water demand and for a sustainable use of water.

In this study we model the time dependent gamma signal attenuation due to BWC and we demonstrate that the SWC estimated through the corrected spectrometric data during a crop life-cycle agrees on average within 4% with the measurements obtained by gravimetric sampling campaigns. A reliable Monte Carlo simulation of the gamma photon generation, propagation and detection phenomena permits to evaluate the shielding effect due to the linear increase of BWC associated to stems, leaves and fruits of the tomatoes during their crop life-cycle. Compared to a SWC gamma estimation in the case of bare soil, the percentage overestimation δ is linearly correlated with the thickness of a biomass equivalent water layer (Tk) as $\delta\ (\%) = 9.7 \cdot Tk\ (mm)$, with a coefficient of determination $r^2 = 0.99$.

Generalizing this approach, we can conclude that the plant growth curve is a fundamental input for correcting the SWC estimates in proximal gamma-ray spectroscopy via Monte Carlo simulation, in the perspective of filling the gap between punctual and satellite soil moisture measurements using this technique.