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Sensitivity of the Cosmic Ray Neutron Sensor (CRNS) to Seasonal Biomass Dynamics in Cherry and Olive Orchards

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Biomass estimation is important in many applications, such as carbon sequestration and precision agriculture. Developing a reliable method for biomass estimation from satellite, airborne and near-surface remote sensing sensors is an ongoing task due to the large uncertainty in current methods, which are often related to sensor limitations. Indeed, signals from optical sensors and synthetic aperture radar at high and medium frequencies suffer from saturation issues at high biomass levels. The Cosmic-Ray Neutron Sensor (CRNS) is a new non-invasive near-surface sensor used primarily to estimate soil water content (SWC), but it has also shown potential for retrieving other hydrological and environmental parameters such as biomass water equivalent and snow depth. The CRNS detects and counts the number of neutrons controlled by hydrogen atoms in the soil, air just above the ground, and vegetation. Biomass attenuates the intensity of cosmic ray neutrons, hence the ability to estimate biomass from a CRNS. Recent studies have used CRNS measurements to estimate biomass changes in crop areas and forest stands, while the use of CRNSs in orchards is limited. The objective of this study is to explore the potential of two CRNSs to estimate the biomass variation in irrigated cherry and olive tree orchards. The olive tree orchard is located in an arid region in northern Saudi Arabia (plantation density of 1667 trees/hectare) with an average tree height of 3 m and canopy diameter of 2 m. The cherry field is located in southern France (plantation density of 260 trees/hectare) with an average tree height of 3.5 m and canopy diameter of 5.5 m. Several soil moisture probes recording soil water content (SWC) at 15-min intervals at both sites were installed at different depths within the CRNS footprint. SWC measurements were used to assess the variations in the sensitivity of CRNS to soil moisture with increasing biomass. Tree parameters (height, canopy width, canopy length, leaf area index, and diameter at breast height) were measured in situ to estimate biomass using allometric equations. In addition, repetitive Light Detection and Ranging (LiDAR) scanning was performed over the cherry field to detect canopy volume changes over time. The results showed that the CRNS is sensitive to SWC variation, and this sensitivity is controlled by biomass evolution, indicating that CNRS measurements can also be used to estimate biomass. The sensitivity of CRNS neutron counts to SWC in the early season (before blooming) was twice as high as that during the mid- and late growing seasons (maximum leaf cover). The Cornish Pasdy model, which models the

measured neutron counts as a function of SWC and biomass contribution, was calibrated and then inverted to estimate the biomass in the cherry and olive tree orchards.