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Cosmic-Ray Neutron Probe – A New Method to Monitor Soil Moisture Content

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Abstract

The measurement of soil moisture content at large scale involves either taking large soil samples for gravimetric analysis or installation of large number of sensors such as TDR. However, these methods are tedious, time taking and destructive. In this study a novel, non-invasive and non-destructive technique named as 'Cosmic-Ray Neutron' probe was applied which can measure the soil moisture content at large scale. The theoretical framework of Cosmic-Ray Neutron(CRN) probe is that in the atmosphere, secondary cosmic rays are generated and after colliding with the land surface, they randomly scatter and distribute both below- and above-ground. As a results, neutrons are generated which after reacting with hydrogen molecule moderate their intensity. Cosmic-ray neutron probes detect neutrons at two energies, but use “fast” Neutrons for soil moisture detection because calibration is less sensitive to the chemistry and texture of the soil. Thus, the intensity of neutrons above the ground surface strongly depends on the water mass present in soil. The measurement depth of CRN probe is 10—50 cm (depending on water content) thus, provide observations within the root zone and average soil water content over a footprint of large area of 34 hectares (a circle with a radius of 330 m).

In this study CRN probe was installed at Korla, Xinjiang Province, China. The region has an arid climate with extreme shortage of water having an annual rainfall less than 300mm while the yearly evaporative demand is more than 1500mm. However, one-third of the country's cotton is produced in this region, which relies heavily on irrigation. The objective of this study is to develop a calibration method which can be used for longer monitoring periods to estimate the average regional soil moisture content. To calibrate CRN probe, soil moisture measurements were made using profile TDR probes with cotton crop growing in the field. In addition, meteorological data and aboveground crop biomass were included in the evaluation. About 50 profile TDR probes were installed at eight different directions around the CRN probe.

Keywords: Calibration, China, COSMOS, cotton, soil water content