Infrared Spectroscopic Analysis on the Spatial Stability of Soil Water Content in Sloping Sandhills of Nebraska

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Soil water content (WC) is one of the main soil properties and is an important component in agriculture and water resources management. It is a crucial factor in the land surface designs in global climate models because it is linked to evaporation and the transport of moisture thus, to the distribution of heat fluxes from the land to the atmosphere. It has a critical role in the partitioning of available energy into latent and sensible heat fluxes, which in turn have a significant impact on atmospheric boundary layer growth, stability and under certain conditions can lead to significant mesoscale circulations affecting regional precipitation patterns (Avissar, 1995 and Bindlish et al., 2001). Grayson et al. (2002) and Lin et al. (2005) stated how soil moisture patterns can offer insight regarding the variability of structures and functions over an area, as well as the underlying process controlling hydrologic response.

Empirical models have been developed to predict the soil water content (Arya and Paris, 1981; Janik et al., 2005). The most widely used models for classifying soil water regime according to U.S. soil taxonomy are those of Billaux (Billaux, 1978) and Newhall (Newhall, 1972). Edoardo et al. (2002) made a comparison of the two methods. The Billaux method determines the water content of the moisture control section graphically, while the Newhall system represents the soil profile as a matrix of buckets with different water holding capacities. The only soil parameter taken into account is the available water capacity (AWC). The two methods provide the total amount of days when soil is moist, dry, or partially dry, but they do not calculate the soil water content at specific dates. Edoardo et al. (2002) asserted the need to work out a more reliable methodology for assessing the soil moisture regime.

The conventional method to determine water content by oven drying of soil samples collected from fields is a difficult, costly, and time-consuming procedure. The soil reflectance spectroscopy is a proven technique for the measurement of soil moisture content. It is fast, nondestructive, and cost effective, although the instrument is expensive.

The Infrared (IR) reflectance spectroscopy technique was developed more than three decades ago for rapid moisture analysis of soil grains (Ben-Gera and Norris, 1968). It is an analytical technique that is non-destructive and is widely used for studying interactions between electromagnetic radiation and the surface a material. Because of its simplicity and rapidness in implementation, IR spectroscopy is a dominant analytical technique for soil grain assessment.

Several studies have concentrated on analyzing soil properties using IR spectroscopy (OM and Particle Size: Bowers and Hanks, 1965; OM: Krishnan et al., 1980; Organic C, N, Moisture Content: Dalal and Henry, 1986; N and OM: Yong, 2005). Research studies that have applied soil reflectance spectroscopy to investigate relationships between soil reflectance and WC include those from Baumgardner et al. (1985), Twomey et al. (1986), and Ishida et al. (1991).

Water in soil greatly controls the reflection of shortwave radiation from soil surfaces in the VNIR (400–1100 nm) and SWIR (1100–2500 nm) regions of the electromagnetic spectrum.

Ben-Gera and Norris (1968) reported that water absorption bands were present at 760, 970, 1190, 1450 and 1940 nm of the soil reflectance curve.

Quantification of soil WC using these wavelengths remains tricky though, since other soil chemical and physical properties, such as organic matter and mineralogy have significant variability themselves. Even so, a quantitative knowledge of WC effects on IR reflectance is important for reasons such as (1) reflected solar radiation has the most persuasive passive signal obtainable to satellites; any method that uses the shortwave reflectance could provide very high spatial resolution (2) a variety of methods to infer surface properties such as vegetation cover and density are significantly affected by changes in background reflectance because of moisture (Pinty et al., 1998). It is therefore clever to examine soil water based on soil shortwave reflectance to help improve the detection of other soil properties.

Observations of soil WC can be done temporally and spatially. Temporal pattern of WC could present a clear visual impression of the dynamics of soil water. Spatial distribution of soil water gives aid in field monitoring and design of sampling strategies. Locations of high spatial variability of WC in soils provide insights regarding hydrological processes involved. Lobell and Asner (2002) stated that the stability of spatial variation in soil water status does not only depend on hydrologic processes. The spatial distributions of soil types and landforms are among the first controls of soil moisture dynamics and landscape hydrologic processes.

This study sought to quantify variations of the soil water content in soil reflectance by looking into the 1190, 1450 and 1940 nm absorption bands of the soil spectroscopic curve while water content is investigated in sloping transects. Soil WC dependency to terrain characteristics (slope, aspect, profile curvatures) and soil texture (sand, silt, clay) will be investigated to further knowledge on the spatial variability of the measured WC to terrain attribute changes. Which direction is active in draining more water? What is the dependence of the WC changes to soil type, landforms and IR wavelength? Can IR spectroscopic absorption bands able to detect varying soil WC from sloping transects and offer interesting possibilities for deriving information on soil water content? Further, which IR band is best for estimating soil WC?

Although considerable verifications have been offered in the scientific arena that the soil WC conditions are reliant on the spatial locations of soil samples, the relationships between the spatial stability of WC and the landform properties, specifically the slope, remains unclear. The potential of using IR spectroscopy as a qualifying method to identify and quantify relationships has to be further explored. This study may be a new quantification methodology that might provide useful information for future soil studies, not only for soil water content.

Finally, soil samples from transects running from the four cardinal directions will be taken for the near-surface and root zone soils from study plots in the Sandhills of Nebraska to enable further scrutiny to the changes of the WC at different depths.

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