Geophysical Research Abstracts
Vol. 16, EGU2014-6649-1, 2014
EGU General Assembly 2014

Potential of the Thermal Infrared Wavelength Region to predict semi-arid Soil Surface Properties for Remote Sensing Monitoring

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Digital soil mapping with the means of passive remote sensing basically relies on the soils' spectral characteristics and an appropriate atmospheric window, where electromagnetic radiation transmits without significant attenuation. Traditionally the atmospheric window in the solar-reflective wavelength region (visible, VIS: 0.4 – 0.7 μm; near infrared, NIR: 0.7 – 1.1 μm; shortwave infrared, SWIR: 1.1 – 2.5 μm) has been used to quantify soil surface properties. However, spectral characteristics of semi-arid soils, typically have a coarse quartz rich texture and iron coatings that can limit the prediction of soil surface properties.

In this study we investigated the potential of the atmospheric window in the thermal wavelength region (long wave infrared, LWIR: 8 – 14 μm) to predict soil surface properties such as the grain size distribution (texture) and the organic carbon content (SOC) for coarse-textured soils from the Australian wheat belt region. This region suffers soil loss due to wind erosion processes and large scale monitoring techniques, such as remote sensing, is urgently required to observe the dynamic changes of such soil properties. The coarse textured sandy soils of the investigated area require methods, which can measure the special spectral response of the quartz dominated mineralogy with iron oxide enriched grain coatings. By comparison, the spectroscopy using the solar-reflective region has limitations to discriminate such arid soil mineralogy and associated coatings. Such monitoring is important for observing potential desertification trends associated with coarsening of topsoil texture and reduction in SOC.

In this laboratory study we identified the relevant LWIR wavelengths to predict these soil surface properties. The results showed the ability of multivariate analyses methods (PLSR) to predict these soil properties from the soil's spectral signature, where the texture parameters (clay and sand content) could be predicted well in the models using the LWIR-window (sand content: R2 = 0.84 and RMSECV = 1.09 %, and for clay content: R2 = 0.77 and RMSECV = 1.0 %, both with 3 factor models). In comparison, the quantification from the solar-reflective window showed its limitations in its relative complex PLSR models and a lower prediction accuracy (sand content: R2 = 0.69 and RMSECV = 1.5 % with 7 factors, and for clay content: R2 = 0.64 and RMSECV = 1.26 % with 9 factors). The prediction of the SOC content, on the other hand, showed minor disparity between the two atmospheric windows (LWIR: R2 = 0.73 and RMSECV = 0.1 % with 6 factors, VNIR-SWIR: R2 = 0.69 and RMSECV = 0.11 %, with 9 factors). The prospect of the LWIR for determining soil texture was demonstrated to be even more impressive when reduced to the spectral band specifications of airborne (TASI-600) and spaceborne (ASTER) sensors. The results demonstrate the high potential of the LWIR to detect and quantify soil surface properties in the future for a monitoring via LWIR hyperspectral remote sensing.