Geophysical Research Abstracts
Vol. 16, EGU2014-14139, 2014
EGU General Assembly 2014

In situ soil clay content estimation using a VisNIR penetrometer fore optic

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Higher spatial resolution soil data is required for hydrologic modeling, environmental assessments, and site-specific land management. While there has been considerable progress in the development of lab-based VisNIR (400-2500 nm) and MIR soil spectroscopy for soil property estimation, in situ VisNIR has lagged behind. In this talk, we present the design of a VisNIR penetrometer foreoptic that can be used with any VisNIR spectrometer, including commonly used, field-portable, ASD instruments (Analytical Spectral Devices Inc., Boulder, CO, USA). Both the VisNIR penetrometer and an ASD Contact Probe, attached to an ASD AgriSpec spectrometer in the lab, were used to interrogate 389 milled and pressed surface and subsoil samples taken from two US continent-scale transects. The reflectance spectra obtained from these two foreoptics were highly correlated ($r > 0.95$ for most wavelengths) and the 1st derivatives of the spectra were well correlated for all but the detector splice points ($r > 0.9$ for most wavelengths).

Using the VisNIR penetrometer, we interrogated soil profiles at 11 fields and 248 sub-field locations throughout the US Pacific Northwest region to a depth of 80 cm, collecting intact cores at each location for spectral model development. Cores were scanned in the lab at field interrogation depths, then 3-cm depth increments were extracted at these depths for lab clay % determination, with dried and sieved samples also scanned using the VisNIR penetrometer. Using partial least squares regression and core-out cross-validation, in situ VisNIR spectra yielded better cross-validation results (standard error of prediction, SEP = 4.8%) than spectra obtained from dried/ground samples or intact core interrogations. Localizing predictions with either field-specific calibrations or including field as a predictor improved predictions (SEP = 4.0%). Our results suggest that for clay content determination, in situ VisNIR spectroscopy can be used to obtain predictions as good or better than lab-based VisNIR spectroscopy. Work is ongoing to use both penetrometer tip-resistance and in situ VisNIR spectra for improved soil clay content estimation.