



Vis-NIR spectroscopy for multivariate classification of soil samples throughout Denmark into Danish Soil Classification System

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Different spectroscopy methods such as visible near-infrared (Vis-NIR) spectroscopy have proven to provide useful information on soil physical and chemical properties. The majority of previous studies have focused on multivariate regression methods such as partial least squares regression (PLSR) to predict soil characteristic features from soil spectra. The objective of these efforts was to provide precision data for agricultural and land management practices where the knowledge about the soil differences in each part of the field can be used for variable-rate irrigation, seeding, liming, fertilising and pesticide application. Since the currently available machines can only apply few (less than 10) variable classes of seed, fertiliser, etc., using soil classification seems to be a more appropriate option compared to regression. As a part of Danish National Soil Survey in 1980s, 2460 soil samples were collected from 789 soil profiles in 4 depths (0-30, 30-60, 60-100 and 100-200cm) throughout Denmark (some profiles did not have samples from all 4 depths) and tested for several soil characteristics including complete soil texture, organic carbon content and calcium carbonate in the lab. Based on these soil characteristics, all soil samples were classified into 8 soil types or 12 soil classes in the Danish Soil Classification System (JB system). Later the Vis-NIR spectra of samples were measured using a FOSS DS2500 spectrometer in the range of 350-2500nm. Partial least squares and support vector machines discriminant analyses (PLS-DA and SVM-DA, respectively) were used to calibrate and cross-validate classification models where soil Vis-NIR spectra were used to classify each sample from each depths into its corresponding JB soil type and soil class. The cross-validated models on 70% of the samples were then used to classify the remaining 30%. The results show excellent classification accuracy ($\geq 80\%$) for samples from the same depths and when samples from all depths were combined. Since our models were calibrated and validated on soils from all over Denmark, the generated models can provide a rapid and reliable tool for soil classification in Denmark by a simple scan for the soil Vis-NIR spectra.