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Quantifying the effect of prediction uncertainty from soil spectroscopy on soil management

Alice Milne, Timo Breuer, Stephan Haefele, Jack Hannam, Richard Webster, and Ron Corstanje
Rothamsted, Harpenden, United Kingdom of Great Britain – England, Scotland, Wales (alice.milne@rothamsted.ac.uk)

Few studies to date have investigated the effect of uncertainty in soil property estimates from spectroscopy on soil management. In this study we considered the implications for variable rate application of phosphorus (P) and potassium (K) fertiliser. First, the uncertainty in soil available P and K estimates from spectroscopy was quantified as a function of the calibration set size at the field-scale.

Based on the observed variation in P and K in four experimental fields, we simulated 100 realisations per field for an in silico experiment. To simulate the process of sampling soil and predicting fertiliser requirement, we performed sampling on our simulated fields using a spatial coverage design. We added a calibration error to each sample value to simulate the error associated with spectroscopic prediction. Kriging was used to estimate the variation in the soil property of interest. We then computed the fertiliser requirement needed to minimise the expected loss associated with predictions. Here, the expected loss is defined as the difference in profit between applying fertiliser based on the estimated soil nutrient concentration accounting for uncertainty relative to the profit that would be gained from fertiliser application given the true soil nutrient concentration in known. We also accounted for data acquisition costs in computing the expected profit.

Results showed that calibration sample size outweighed the effect of total sample size on the uncertainty associated with predictions. Equally, for the same calibration set size, there were large differences in the kriging variance between total sample sizes. When data acquisition costs were disregarded, the expected loss for available P was particularly affected by the total sample size. For available K, the calibration sample size had a predominant effect on the expected loss. The expected loss showed diminishing returns on investment suggesting that there is an optimum sample size. However, the expected profit was dominated by the costs of sampling and spectroscopy, indicating that currently using spectral methods to inform fertiliser management is not cost effective. That is, no combination of the total- and calibration sample sizes considered would result in a financial gain and could thus be considered optimal. Should costs substantially reduce then spectral methods offer a promising method for informing variable rate management. We conclude that the loss function approach is an appropriate method to assess whether soil spectroscopy is a cost-effective means to inform soil management. We further suggest its application in different case-studies to gain more robust insight in the value of applied soil

spectroscopy.