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Airborne radiometric survey data and a DTM as covariates for regional scale mapping of soil organic carbon across Northern Ireland.

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A potential covariate for mapping of SOC (soil organic carbon) is airborne gamma-radiometric data. These are measurements of emission of gamma rays due to decay of radionuclides in the top 50 cm of the soil, including potassium (gamma-K). We might expect spatial correlation between gamma-K and SOC content for two reasons. First, the well-established spatial correlation between gamma-ray attenuation and soil moisture extends to SOC because the latter accumulates in soils which are wet for much of the year. Second, for soils with a wide range of SOC contents over the same parent material, the mineral content (and gamma emission) will be smaller when diluted by larger organic matter contents. We used data from the recent TELLUS survey of Northern Ireland including airborne radiometry and ground-based soil carbon measurements (n=6862; loss-on-ignition) to investigate the potential for improved regional-scale (13,360 square km) estimation of SOC.

We split the data at random into prediction (n=3000) and validation subsets. We fitted linear mixed models of the spatial variation of SOC to the prediction data and then used the empirical best linear unbiased predictor to predict the SOC concentration at the validation sites. We incorporated gamma-K and altitude (50 m resolution DTM) as fixed effects in these linear mixed models in order to test the effectiveness of these covariates for prediction, in terms of the root mean squared errors (RMSEs) of the

predictions at the validation sites. We also tested how these RMSEs varied with n (the number of SOC observations in the prediction set).

Exploratory analysis revealed that the frequency distribution of SOC was bi-modal. We attempted to analyze the two peaks of this distribution separately by applying a three-fold (organic, organo-mineral and mineral) classification to the samples (1:50,000 soil maps). Our tests confirmed that splitting the samples in this manner does improve the accuracy of the SOC predictions in the absence of covariates (RMSE reduced from 10.9 % to 8.9 %). However in all the tests a substantial proportion of sites appeared to be mis-classified at this local scale leading to larger prediction errors. Including altitude as a covariate reduced the RMSE to 8.5 %and including gamma-K reduced it to 6.1 %. On including both covariates the RMSE was 5.6 %. The accuracy decays very slowly as n is reduced; a result which will have implications for the costs of future SOC sampling exercises. Thus radiometric survey measurements can substantially improve the regional-scale estimation of SOC.