Spatial variation of subsoil organic carbon concentration and thermal fractions under agricultural landscapes

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Introduction and aims

- Previous research (Rawlins et al., 2009) estimated variance components of topsoil organic carbon concentration [by loss on ignition] across a substantial area of the UK.

- Variance increased by an order of magnitude in steps from i) analytical plus subsampling, to ii) short-scale (20 metre: paired samples), to iii) medium-scale (>1000m).

- There is little comparable information on subsoil (35 to 50 cm depth) organic carbon (SSOC) concentrations – and their biogeochemical fractions.

- We measured total SSOC concentration by combustion (elemental analysis) of soil samples from 64 grassland or arable locations across central England (Fig 1). At each site a pair of composite samples had been collected at separations of 21 metres and each composite sample was split into two fractions and analysed (Fig 2).

- We also measured other properties of soil from each site (total Ca, pH and dithionite iron (Fe(d)) concentrations, clay) to account – through various mechanisms – for preservation of SSOC. We recorded the Soil Group and Major Soil Groups for each site.

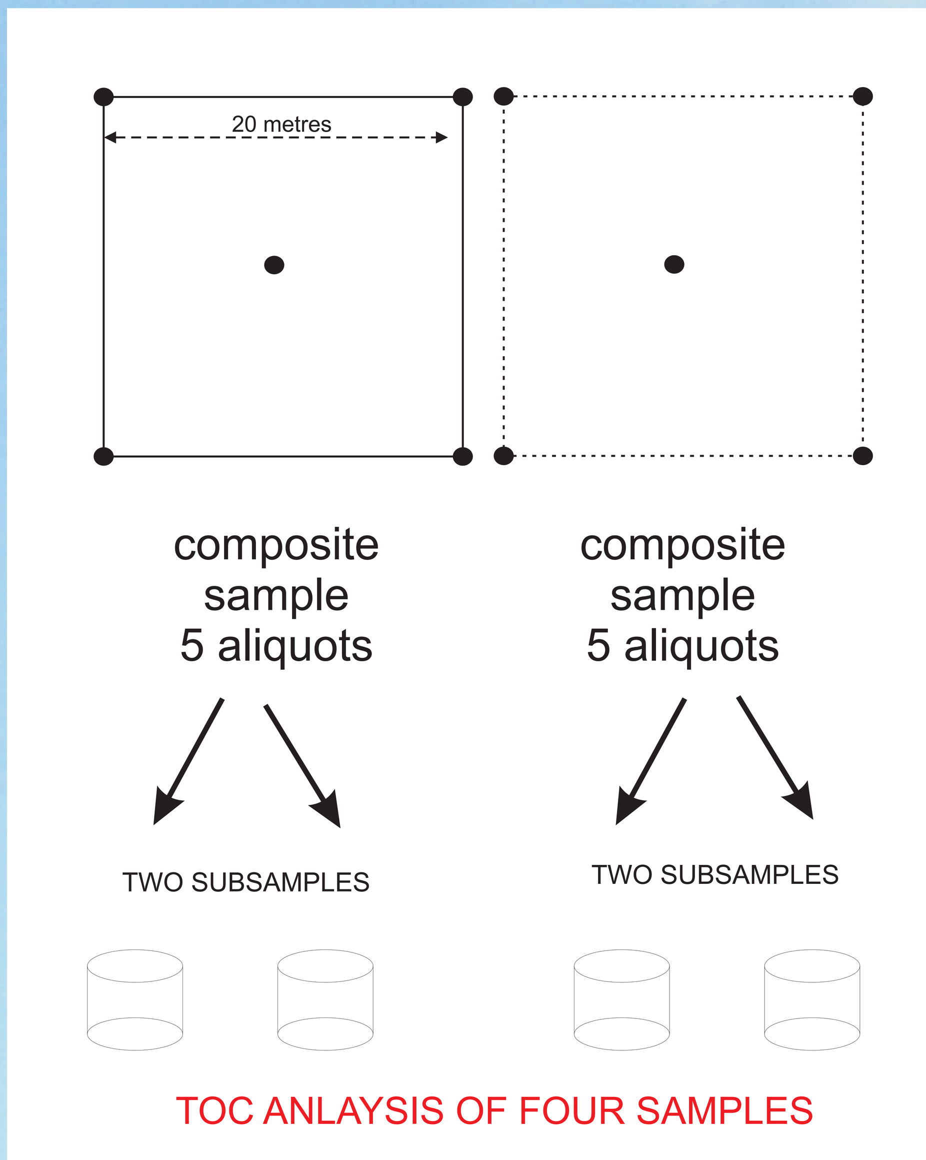


Figure 2 - Sampling configuration at each of 64 locations (32 grassland and 32 arable) where paired samples were collected at 21 metres separation and then subsampled to yield four aliquots.

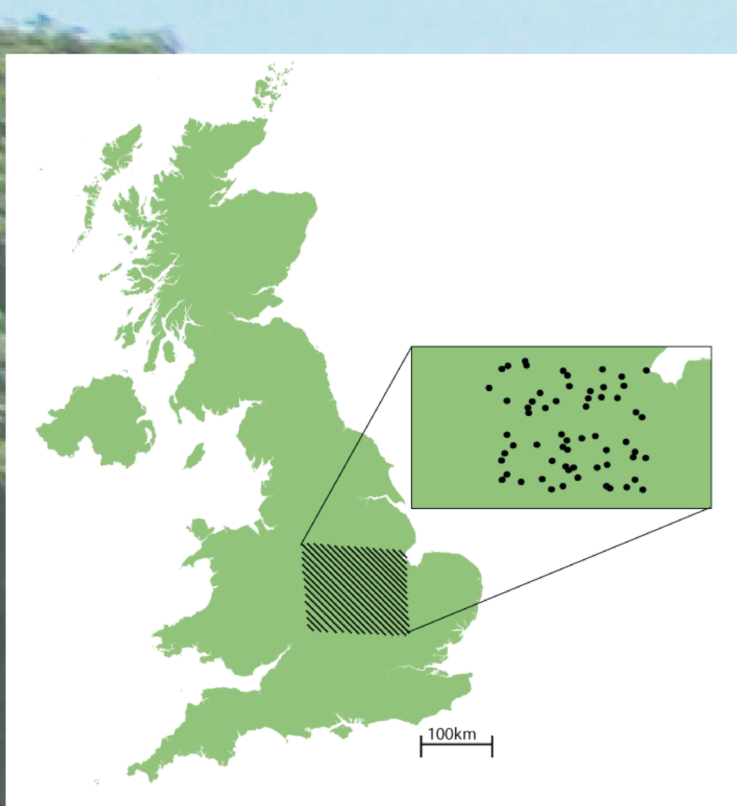


Figure 1 - Study region and sampling sites (grassland and arable sites)

- These data were used to determine whether associated soil chemical properties account for the variation in SSOC

- **We subjected half of the paired samples to thermal analysis to estimate the proportions of a more labile (Exo1; 210-410°C) and more recalcitrant (Exo2; 410-580°C) organic carbon fractions. We investigated the differences in the spatial variation of the total organic carbon and the thermal fractions**

Results and interpretation

- Variance of SSOC components i) and ii) were of the same magnitude – this was different to the results observed for topsoil (see Table 1)

- This difference is likely due to the quantity of subsample used in the two analytical methods (loss on ignition versus elemental analysis).

- As in the topsoil, variance in SSOC increased by an order of magnitude between components ii) and iii)- Table 1

- Soil Group accounted for a statistically significant component of the variance in SSOC, as did the measured properties other than clay (Table 2).

- The optimum linear regression model showed that 30% of the variance in SSOC could be accounted for by a combination of total Ca, soil pH and iron oxyhydroxide concentrations, implying that mechanisms associated with these properties in part account for its preservation at depth.

- The correlation of log SSOC concentration between paired sites was substantially weaker (r=0.39) than the correlation between the ratios of the two thermal fractions (r=0.62) at paired sites – see Figure 3.

- This finding has implications for understanding SSOC turnover and sequestration. It suggests that the thermal fractions are less spatially variable and so may reflect local soil conditions that influence SOC stabilization.

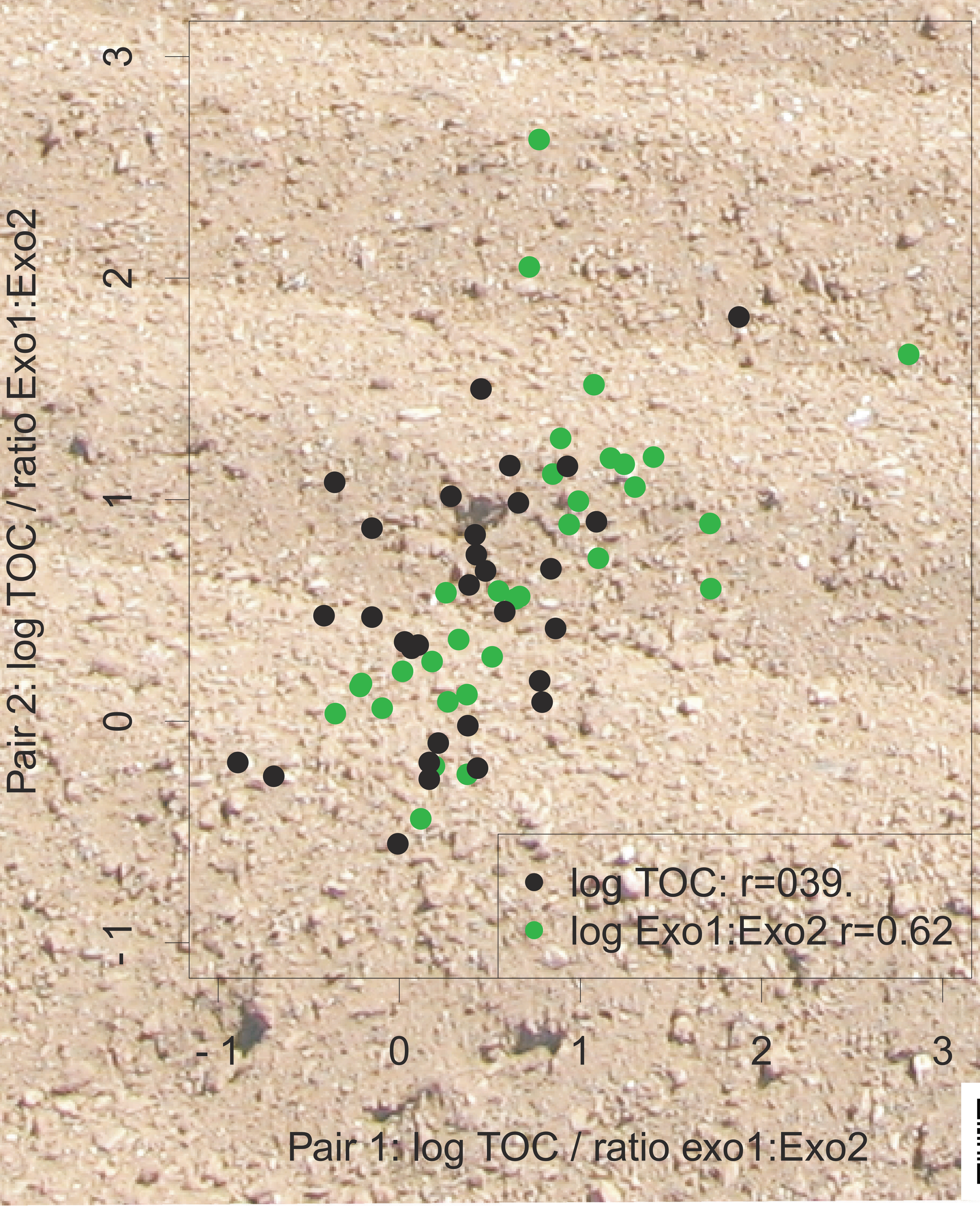
Table 1 - Variance components and standard errors (in parenthesis) for the three random effects for log transformed TOC. All 61 sets of samples (duplicate A, duplicate B, subsample A and subsample B), amounting to n=244 samples.

	Medium-scale	Short-scale	Analytical plus subsampling
Subsoil TOC	0.141 (0.032)	0.026 (0.008)	0.040 (0.0051)
Topsoil TOC from Rawlins et al. (2009)	0.181 (0.027)	0.024 (0.003)	0.002 (21×10^{-5})

Table 2 -Wald test results from sequential addition of three fixed effects to the model (soil class, land use and major soil class).

	Wald Statistic	*P*-value
Soil Group	9.30	0.035
Land use at time of sampling (cultivated / grass)	0.17	0.680
Major Soil Group	4.33	0.374

Figure 3- Scatterplot of log transformed values of properties at paired sites (pair 1 and pair 2) for both total organic carbon and the ratio of two thermal fractions (Exo1:Exo2)



References: Rawlins, B. G., Scheib, A., Lark, R. M., Lister, T. R. 2009. Sampling and analytical plus subsampling variance components for five soil indicators observed at regional scale. European Journal of Soil Science, 60, 740-747.