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Measuring and upscaling soil carbon dioxide efflux from different arable management practices and associated uncertainties

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The study of different agricultural management practices and their effect on soil carbon dynamics is a crucial factor in identifying suitable greenhouse gas (GHG) mitigation options. Soil CO_2 efflux is the main carbon output from the soil in comparison to losses through leaching and is the sum of heterotrophic and autotrophic respiration. Soil respiration varies with temperature, water availability and organic matter content, but also with vegetative productivity or gross primary production. Understanding the drivers of soil CO_2 emissions is important for producing accurate models for estimates of daily, seasonal or annual budgets and for making future predictions.

Usually, soil CO_2 efflux is measured by enclosing a portion of soil within a chamber (s) and the values assumed to represent the soil characteristics of the whole ecosystem. In reality, this assumption is rarely achieved. Due to limited spatial coverage soil heterogeneity is a major problem. However, to compare the impact of different arable management practices on soil CO_2 efflux and to evaluate their GHG mitigation potential, up scaling from point measurements to plot, ecosystem or national scale is necessary. Considering the up scaling required associated estimates of uncertainty are essential before we can draw any conclusions.

In this study, the effects of N fertiliser, straw incorporation and cover crop incorporation in conjunction with conventional or non-inversion tillage are being studied, resulting in eight different management practices. The experiment is being conducted in the Irish midlands (Carlow, Co. Carlow) and follows a random plot design, providing four replications per treatment. Random block designs with several replications are used to reduce the impact of soil heterogeneity. The plots were established in October 2009 on former non-inversion tillage treatments with a cover crop and straw incorporation. The main crop on all plots is barley (*Hordeum vulgare*) and mustard (*Brassica juncea*) is being used as the cover crop.

From March 2010 to October 2010, soil CO_2 efflux was measured weekly from three points per replication (point scale). The average of these was assumed to represent the soil CO_2 emission from the plot (plot scale). The treatment CO_2 emission was finally calculated as the average of all four replicate emissions (treatment scale).

Looking at the intra plot differences, the average coefficient of variation of all treatments and all measurement days was 31%. In comparison to this, the coefficient of variation between the four replications of one treatment was on average 26% over all treatments and all measurement days. Finally, the coefficient of variance between the treatments was 29% on average over all measurement days. These average results indicate that the differences inside one plot, between the replication and between the treatments are all in the same range.

Further, at all three scales the uncertainty varies with season. Considering the following three seasons: (1) just after sowing, when there is little or no vegetation cover (March/ April), (2) the growing season (Mai to July) and (3) the harvest and cover crop period (August to October), a clear pattern is recognisable. The coefficient of variation is highest during the time when there was little if any vegetation cover and lowest during the growing season. For the period covering harvest and cover crop growth the coefficient of variation increases, but it is lower than in March/April. This pattern reflects the dominance of root/ autotrophic respiration in the presence of vegetation which is less variable than heterotrophic respiration. These results show that a better understanding of the causes of variability in emissions is required in order to accurately quantify the impact of any GHG mitigation measures.