What can we learn from a ^{13}C and carbon soil inventory after 10 years of Swiss FACE experiment?

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Current scenarios predict an increase of atmospheric CO_2 concentrations to a level of 540-970 ppm until the year 2100 (Prentice et al. 2001). In order to study the effects of this enrichment on ecosystems, free air CO_2 enrichment (FACE) studies have been conducted on different types of vegetation worldwide during the last two decades. One of them was the Swiss FACE experiment carried out by the Institute of Plant Sciences (ETH Zürich) from 1993 to 2002 on a grassland site at Eschikon. During this time, 3 replicate plots with a diameter of 18 m were fumigated with ^{13}C-depleted CO_2 ($\delta^{13}C$ = -45 ‰) at an average concentration of 600 ppm, while 3 replicate control plots were exposed to ambient CO_2 levels (approx. 350 ppm). The plots were arranged in pairs of one control and one fumigated plot, with minimum distances of 100 m between plots to exclude any interference between them (van Kessel et al. 2000). During the experiment it was observed that variability of the results from replicate plots was higher than expected. Therefore, in order to improve the interpretation of the results of the fumigation experiment, a detailed soil survey was initiated after the experiment had been terminated. Its main objectives were to gain information on the heterogeneity of the site, the suitability of the plots' location, and to what extent the added CO_2 affected the surrounding area.

In total, 180 soil samples were collected over an area of 17 ha. 72 of the sampling sites were distributed regularly in a 50 x 50 m grid, 15 samples were taken within each of the 6 plots, and 6 samples were taken along a transect in main wind direction at distances of 11-42 m from the centre of each fumigated plot. Bulk density was recorded for each soil sample, and the samples were subsequently analysed for C_{org} and $\delta^{13}C$. The results show that the C_{org} content at the grid points close to the plots varies between 1.8 and 5.6 %, indicating quite substantial heterogeneity of the experimental area. This was especially striking at the plot C1, which is the same plot that often yielded abnormal results during the FACE studies.

Figure 1 shows $\delta^{13}C$ values of soil organic matter at various distances from the fumigated plots. Until a distance of 14 m from the centre (i.e. 5 m from the edge) of the plots, the label of the additional CO_2 could be detected in the soil. Beyond 18 m, isotope values of soil organic matter did not differ any more from the overall average of the area. This means that the minimum distance of 100 m was certainly large enough to exclude mutual disturbance between the plots, and even could have been reduced. This would have had the advantage that the plots could have been located closer to each other, thereby possibly reducing the effect of spatial variability and increasing the comparability of the paired plots.
In summary, the soil survey has shown that significant spatial heterogeneity exists in the experimental area, which might be responsible for the high variability of the results between replicates. Isotope data proved to be a useful tool to determine the extent of the fumigation effect outside the plots.

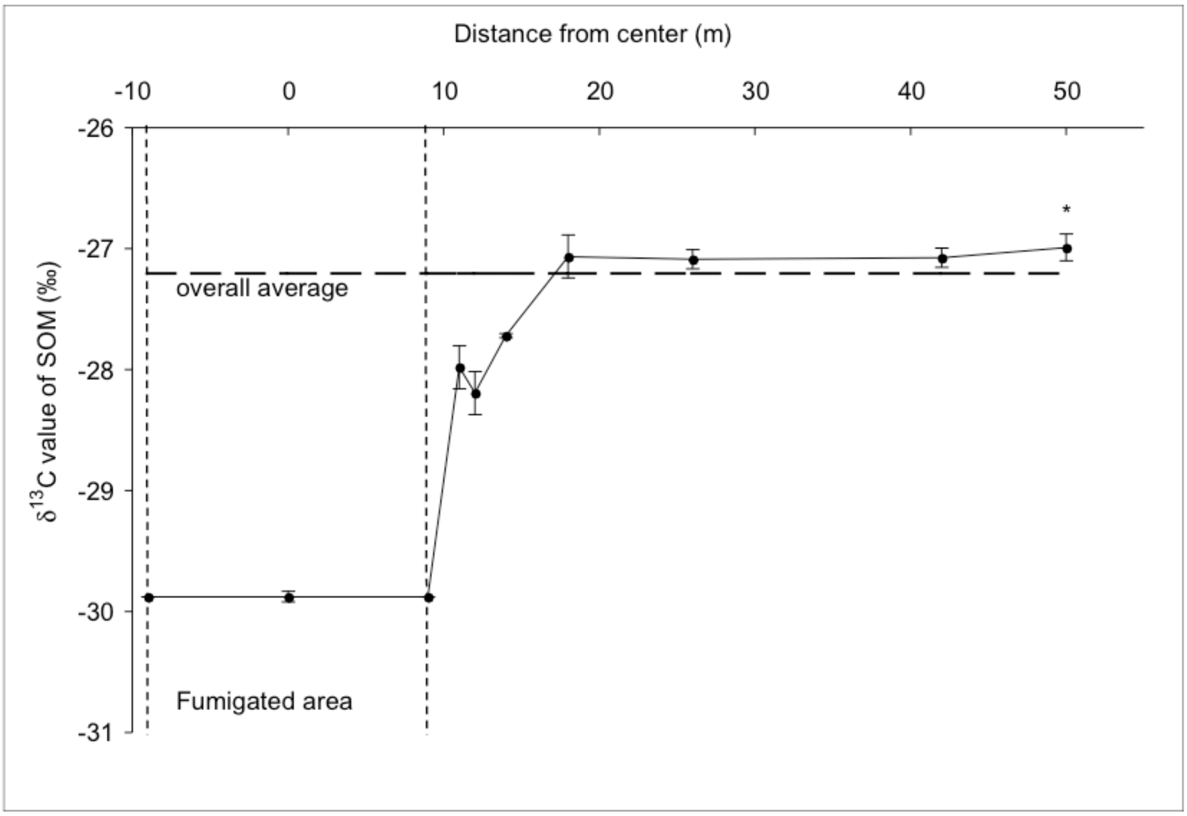

Figure 1. Isotopic label of soil organic matter as a function of distance from the fumigated plot. The value labelled with an asterisk (*) is the isotope value of the closest grid point from the field survey, while the horizontal dashed line indicates the average of all grid points of the field survey.

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