Response to Referee 2.

Thank you for your comments on our manuscript.

As with the calibration issue (point 1), it is important that the system have been checked for zero effluxes as is described in the first sentence in the results section (3.1). The performance of the device is primarily dependent upon the IRGA's precision and repeatability of the concentration measurement. The CO_2 concentration of the reference air and the sample is measured by the same IRGA and the IRGA is checked for its zero automatically and regularly. The detection limit is therefore dependent on the IRGA's response and 3 μmol.mol-1 CO_2 concentration difference, for example, results in 0.3 μmol.m-2.s-1 CO_2 efflux rate under the usually experienced field conditions (i.e. temperature and pressure ranges) and with the flow rates applied. Measuring high differentials at relatively small soil CO2 efflux rates requires small flow rates through the system, on the other hand, and the small flow rates could be achieved with properly sized (small) chambers. Further aspects of the design (dimensions of the chambers, area of vent holes, position and dimensions of the inner funnel, parallel application of two pumps) are also related to minimize the pressure differentials.

Spatial heterogeneity undoubtedly shows up during comparison of the gradient (between 5cm and the air above the soil) vs. chamber fluxes (point 2). We think, there are two points to consider here. One of them is the highly significant ($P<0.0001$) correlation between the effluxes as measured by the two independent systems. The other is the intercept of the regression between the chamber fluxes and the gradient fluxes (close to zero), showing that if the gradient system measures zero - the other (chambers of the open system) will as well (Fig 10). The graph comparing the two independent systems is also in support of the points regarding calibration (zero efflux from a real soil). The zero intercept also shows the concentration measurements are probably good enough and perhaps more importantly, it shows that the chamber flux system would measure zero efflux at concentration gradients approaching zero (as inferred from data of the gradient system). For these reasons we think the section is a necessary part of the ms. It is also to be noted that, while the gradient method was applied at three depths, the above (chamber vs gradient) comparison takes the gradient flux from between the upper sensor (5cm depth) and the air, only. In this case the CO_2 concentration gradient is significantly smaller than those within the soil. We acknowledge, on the other hand, the evidence provided in Koehler et al (2010) as empirical estimations of D can be in error, however, our point here was to compare the upper level flux from the gradient system to that measured by the chamber system, and to characterize the situation when the usual direction (upward decreasing) of CO_2 concentration gradient within the soil profile changes after rains.

The footprint area of the eddy and the chamber measurements differs by several orders of magnitude, of course (point 3.). Given the limitations by the number of the chambers, our approach in this case was to consider the fluxes in the trenched treatment (ch 3 and ch4) as a lower limit of soil CO2 efflux. The fluxes measured by chambers within the vegetation gaps were usually higher than those in the trenched plot. The spatial heterogeneity of soil respiration was addressed by a study utilizing the geostatistical approach of analyzing semivariograms from extended spatial sampling of soil CO2 efflux (Fóti et al. 2008). In that case it was possible to find the size (diameter) of a patch where one can encounter the variation of this process. On the other hand, these (manual) measurements can not be performed for extended periods, therefore the number of eddy flux - chamber flux data pairs would be few, and the data range would probably be also much too narrow for (pairwise) comparison. Soil respiration from vegetation gaps may indeed differ from that of the average of the whole source area of the eddy footprint. Similarly, soil respiration from below a grass tuft may differ from that measured within vegetation gaps. However, treating this problem in a quasi continuous measurement (for weeks, months) is rather difficult if not impossible. Our approach was to minimize the disturbance of soil CO2 efflux by avoiding use of collars and cutting the plants prior to measurements (e.g. disturbance of soil structure, cut roots, disrupted supply of assimilates, exposing the surface not exposed in otherwise, etc.). These disturbances much probably makes the measured data less reliable. On the other hand, CO2 efflux from below the grass tufts may indeed differ from that from vegetation gaps, but at the present we do not have a solution for that problem.

The Chebyshev function has really no theoretical background. The aim of using the calculation with exponential, Chebyshev or other function was to eliminate a noise of measured values. We think, we had to use a curve with best fitting of measured data. Chebyshev function is a kind of polynomial function. In our case the shape of used function is similar to exponential function but it had higher R2. Better tank efflux estimations could be achieved with minimizing noise caused by IRGA analyser.

Application of the approach of Koehler et al. (2010) and investigating those aspects clearly is a matter of another full study. While we plan to adopt the method and thereby improve the gradient estimates, that work is outside the scope of the present study. The separation of gas phase diffusion vs water phase transport and chemical partitioning (regarding the downward fluxes) is also a complex one, as CO_2 sources may be activated by the rain with different kinetics. For example, CO_2 concentration in the middle layer (12.5cm) seems to start to increase earlier than the one at 5cm depth (Fig. 6.). Whether it was caused by increased root respiration, downward water phase transport or both is surely an interesting question but can not be answered by using the data in the ms.

The soil CO2 efflux from the upper 5 cm soil layer was probably overestimated by the gradient method, as it is noted in the ms. Our proposition was - as also written in the abstract - that, the chamber fluxes might be used to constrain D, used in gradient flux calculation. However, given the spatial heterogeneity problem, this approach would require measurements from several replication chambers operated for a long enough period to have the necessary data range.

2011-04-06

In behalf of the authors
Nagy Zoltán

References

Fóti, Sz, J, Balogh, Z, Nagy, S, Bartha, Zs, Ürmös and Z, Tuba 2008. Temporal and spatial variability and pattern of soil respiration in loess grassland. Community Ecology. 9:57-64. IF: 0.898.