Geophysical Research Abstracts
Vol. 14, EGU2012-11987, 2012
EGU General Assembly 2012

Direct comparison of repeated soil inventory and carbon flux budget to detect soil carbon stock changes in grassland

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Experimental assessment of soil carbon (C) stock changes over time is typically based on the application of either one of two methods, namely (i) repeated soil inventory and (ii) determination of the ecosystem C budget or net biome productivity (NBP) by continuous measurement of CO_2 exchange in combination with quantification of other C imports and exports. However, there exist hardly any published study hitherto that directly compared the results of both methods. Here, we applied both methods in parallel to determine C stock changes of two temperate grassland fields previously converted from long-term cropland. The grasslands differed in management intensity with either intensive management (high fertilization, frequent cutting) or extensive management (no fertilization, less frequent cutting). Soil organic C stocks (0–45 cm depth) were quantified at the beginning (2001) and the end (2006) of a 5 year observational period using the equivalent soil mass approach. For the same period and in both fields, NBP was quantified from net CO_2 fluxes monitored using eddy covariance systems, and measured C import by organic fertilizer and C export by harvest. Both NBP and repeated soil inventories revealed a consistent and significant difference between management systems of 170 ± 48 and 253 ± 182 g C m^{-2} a^{-1}, respectively. For both fields, the inventory method showed a tendency towards higher C loss/smaller C gain than NBP. In the extensive field, a significant C loss was observed by the inventory but not by the NBP approach. Thus both, flux measurements and repeated soil sampling, seem to be adequate and equally suited for detecting relative management effects. However, the suitability for tracking absolute changes in SOC could not be proven for neither of the two methods. Overall, our findings stress the need for more direct comparisons to evaluate whether the observed difference in the outcome of the two approaches reflects a general methodological bias, which would have important implications for regional terrestrial C budgets.