Geophysical Research Abstracts
Vol. 14, EGU2012-2863-1, 2012
EGU General Assembly 2012

The$_{14}$C 'bomb' pulse in selected European stalagmites as a tracer of soil carbon cycling dynamics

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The decomposition of soil organic matter (SOM) is temperature dependant, but its response to a future warmer climate remains equivocal. Enhanced rates of decomposition of SOM under increased global temperatures might cause higher CO_2 emissions to the atmosphere, and could constitute a strong positive feedback. The magnitude of this feedback however remains poorly understood primarily because of the difficulty in quantifying the temperature sensitivity of stored, recalcitrant carbon that comprises the bulk (>90%) of SOM in most soils. In this study we investigated the effects of climate on soil carbon using the 'bomb' radiocarbon systematics of selected modern European speleothems. The 'bomb' ^{14}C spike was used as a tracer of the accumulation and decomposition of SOM under different climatic settings. New time-series radiocarbon measurements were carried out, and the attenuation of the 'bomb' ^{14}C spike was studied in three stalagmites and in one soda straw stalactite. The results were used to examine the quality of soil organic matter and carbon dynamics on decadal timescales under a range of soil conditions and different climatic regimes. These new data were combined with published results to further examine soil carbon transfer dynamics, and to explore the sensitivity of labile and recalcitrant organic matter decomposition to different climatic conditions. The initial radiocarbon activity from each speleothem was modelled using a three pool soil carbon inverse model (applying a Monte Carlo method) in order to investigate the soil carbon residence time and its turnover above the cave site. Sites that are characterised by high mean annual air temperatures (MAAT) and a high soil carbon storage capacity (e.g. overlain by thick soil cover with dense, well developed vegetation, such as La Garma, N. Spain and Sofular, Turkey) display the highest damping effect, and the oldest mean soil carbon ages (MSCA), with residence times of c. half a millennium. This suggests that carbon incorporated into these stalagmites originates predominantly from decomposition of old, recalcitrant organic matter. By contrast, the Grotta di Ernesto (N. Italy) site which is also overlain by a thick soil cover with dense vegetation, but with a low MAAT, does not show a strongly attenuated ^{14}C 'bomb' pulse, possibly reflecting higher inputs of young soil carbon and the preferential decomposition of young, labile carbon at low temperatures. New results from the Monte Carlo inverse modelling indicate young MSCA values (c. 40 years) consistent with a previously published forward model. Overall, these results are important because they suggest that decomposition processes in warmer conditions are dominated by old soil organic matter, implying greater temperature sensitivity of old, recalcitrant carbon. Modelled MSCA values from speleothems that exhibit low soil carbon storage capacity (sparse vegetation, thin soil cover) and high MAAT indicate that decomposition at these sites is dominated by young soil carbon.