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Estimation of storage and fluxes of recent and fossil organic carbon in an alpine catchment (Montmin, Haute-Savoie, France)

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Interest in the biogeochemical carbon cycle has increased since recognition of the essential role played by carbon in climate regulation. Constraining the carbon cycle requires knowledge of the different carbon stocks in reservoirs and the exchange between them. This study focuses on fossil organic carbon (FOC), a form of carbon largely omitted in the dynamics of the supergene carbon cycle, although it is ubiquitous in terrestrial pools such as soils and recent sediments.

Under the auspices of program CLIMASILAC 2, this study was carried out in a alpine catchment of the Petit Lac d'Annecy (Montmin, Haute-Savoie, France), where our objectives were to (i) asses the input of FOC to soils, (ii) present a first estimate of stocks of FOC and recent organic carbon (ROC) in different soil horizons and FOC / ROC erosional fluxes, (iii) propose how these fluxes might change with climate change. 19 soil profiles were sampled, representing a variety of vegetative cover and underlying rock types. Samples were analysed for palynofacies and geochemistry using optical methods and Rock-Eval 6 pyrolysis, respectively. After assessment of FOC and ROC stocks in the catchment, fluxes were estimated through the use of an erosion/deposition model (CAESAR) and were extrapolated to two climatic scenarios previously recorded in the sediments of the Petit Lac.

Results suggest that a substantial amount of FOC is delivered to soils from rocks, with the amount depending on the nature of the fossil organic matter (FOM) and the OC content of the parent rocks. The greatest stock of ROC is found in alpine grassland (44 $t.ha^{-1}$), followed by prairie (29 $t.ha^{-1}$) and forest (8 $t.ha^{-1}$). The amount of

FOC stored in soils depends mostly on the nature of the underlying parent rocks (i.e., the nature of the FOM) and varies between 0.7 $t.ha^{-1}$ (forest mostly underlain by shales) and 1.8 $t.ha^{-1}$ (alpine grasslands underlain by carbonates). The present day sediment fluxes calculated are in agreement with those in the literature, and reach 4.8 $t.ha^{-1}.yr^{-1}$, surprisingly close to that for a "full prairie" scenario (reflecting a colder climate), and about twice that for a "full forest" scenario (reflecting a warmer climate). The present day ROC flux is about 1.2 $t.ha^{-1}.yr^{-1}$, whereas it is estimated to be 0.6 and 0.7 $t.ha^{-1}.yr^{-1}$ for prairie and forest scenarios, respectively. The present day FOC flux is about 0.034 $t.ha^{-1}.yr^{-1}$, whereas it would be 0.015 $t.ha^{-1}.yr^{-1}$ and 0.026 $t.ha^{-1}.yr^{-1}$ for prairie and forest scenarios, respectively. ROC fluxes are a function of the OC content of the O and A1 soil horizons, whereas FOC fluxes are controlled by rainfall intensity. In forest cover, leaching of FOM into deeper horizons is expected, while in a prairie context FOM is preferentially stored.

This study is a first attempt to distinguish between FOC and ROC fluxes within a catchment, and reassesses the occurrence and transport of FOC in continental surfaces as a function of climate and the nature of the OM and OC content. The coupling of erosion modelling and OM characterisation should help in the understanding of the role of climate and human impact on OC export within a catchment. Despite uncertainties regarding the modelling, rainfall data, and OM quantification, the chemical denudation of rocks estimated here ($2\ \mu m.yr^{-1}$) is not far from that currently assumed for a mountain catchment in a temperate climate ($7\ \mu m.yr^{-1}$).