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Temporal and spatial variations of chemical weathering and CO_2 consumption in a multi-lithological karstic catchment (Baget, Pyrenees, France): a combined geochemical and isotopic approach

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Chemical weathering (CW) of rocks at Earth's surface plays a key role in the global carbon cycle along multiple pathways. The carbon budget depends largely on the nature and relevance of these pathways. It is therefore crucial to constrain them in order to estimate the impact of CW on the carbon cycle. To identify, quantify and constrain the CW rates and the CO_2 consumption associated (including their interannual, seasonal and spatial variations), the MEGA hydrogeochemical model and the mixing proportions based on isotope signature of $\delta^{13}C_{DIC}$ (-13.2 to -3.9‰$_{VPDB}$) and $\delta^{34}S_{SO4}$ (-8.1 to 13.3‰$_{CDT}$) were combined using a large database of a mountainous karstic catchment (Baget catchment, BC). The CW budget of BC between 1994 and 2019 showed that the (Ca^{2+} + Mg^{2+}) discharged is originated from carbonate dissolution (1.16 mol·m^{-2}·yr^{-1} equivalent to 74%) and silicate weathering (18%) by carbonic acid, while the gypsum dissolution contributes only 4% although it represents 66% of the dissolved sulphate. The sulfuric acid produced by sulfide oxidation drives only 7% of total carbonate weathering. This method was validated using $\delta^{13}C_{DIC}$ and $\delta^{34}S_{SO4}$ compositions issued from spatial sampling, whose findings allowed the identification of the main mineral sources in the basin. In addition, $\delta^{13}C_{DIC}$ values between 2016 and 2019 represented a similar mixture of DIC but with about 50% of calcite precipitation at the outlet. The inter-annual and inter-seasonal variations of the CW rates and CO_2 consumption associated were controlled by environmental factors such as discharge, temperature-vegetation, the epikarst and water dynamic that provoked inactivation of some water sources. The carbonate weathering rate was estimated to 117 t·Km^{-2}·yr^{-1}, which was 11 times higher than that of silicate weathering rate. Furthermore, the CO_2 fluxes consumed by carbonate dissolution (1.14 mol C·m^{-2}·yr^{-1}) represented 71% of total weathering CO_2 uptake in BC.