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Past Holocene detritism quantification and modeling from lacustrine archives in order to deconvoluate human-climate interactions on natural ecosystem over long time-scale

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Water budget is one of the main challenges to paleoclimate researchers in relation to present-day global warming and its consequences for human societies. Associated soil degradation and erosion are thereby becoming a major concern in many parts of the world and more particularly in the Alps. Moreover, humans are considered as geomorphologic agents since few thousand years and it is now recognized that such an impact on natural ecosystem profoundly modified soils properties as well as aquatic ecosystems dynamics over long-term periods. The quantification of such inference over long time-scale is therefore essential to establish new policies to reduce mechanic soil erosion, which is one of the dominant processes in Europe, and anticipate the potential consequences of future climate change on hydric erosion. The mechanical erosion of continental surfaces results from climatic forcing, but can be amplified by the anthropogenic one. We therefore suggest that quantifying and modelling soil erosion processes within comparable Holocene lacustrine archives, allows to estimate and date which and when past human activities have had an impact on soil fluxes over the last 10000 years. Based on the present-day geomorphology of the surrounding watershed and the evolution of the vegetation cover during the Holocene, we develop an interdisciplinary approach combining quantitative organic petrography (i.e. optical characterization and quantification of soil particles within lake sediments) with high-resolution seismic profiling, age-depth models on lacustrine sediment cores and soil erosional susceptibility modeling, in order to estimate the annual volume of soil eroded over the last 10000 years, and in fine to quantify the volume of human-induced soil erosion during the Holocene period. This method is applied to close but contrasted mountainous lacustrine environments from the western French Alps: lakes Blanc Huez and Paladru, sensitive to same climatic influences but where past human activities were different (mining versus agriculture, respectively). Lakes Blanc Huez and Paladru are defined by good Holocene chronologies and well detailed lithologies (1, 2). Both archaeological evidences and interdisciplinary characterizations of the two systems demonstrated that Lake Blanc Huez sedimentary infill is only sensitive to climate forcing and that soil fluxes are therefore only proportional to snow and/or water rainfalls (1), whereas the sedimentation recorded within Lake Paladru results both from climate and anthropogenic forcing. Results demonstrate that around Lake Paladru, human-induced soil erosion is effective since the Neolithic period and the beginning of agrarian activities (2). Following our quantification and modelling, human activities were able to explain up to 50% of soil fluxes in particular between the Bronze Age and the Middle Age suggesting that the actual geomorphology of the drainage basin is inherited from several millenary and not only from modern activities.

(1) Simonneau et al., accepted, Quaternary Science Reviews
(2) Simonneau et al., 2013, Journal of Archaeological Science, 40: 1636-1645.