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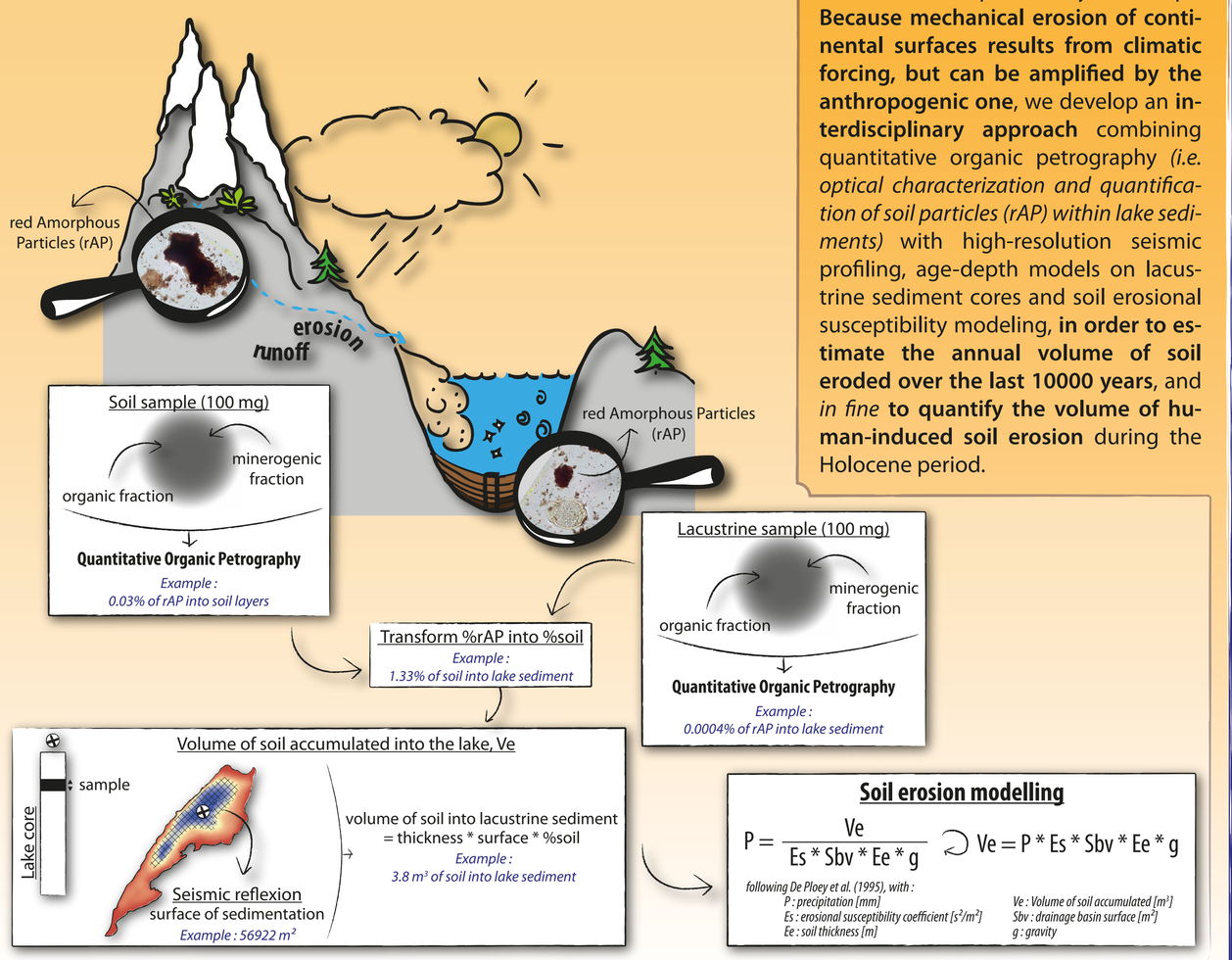
Strategy

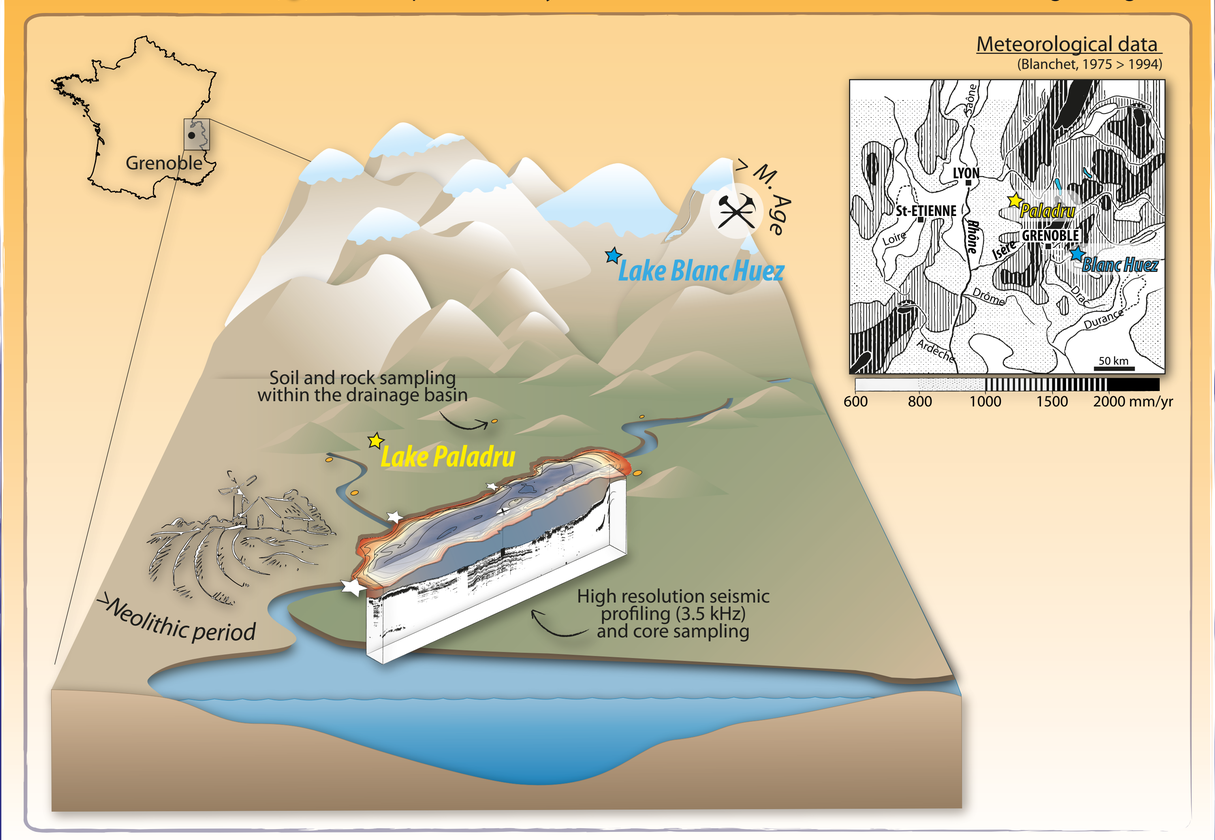
Water budget is one of the main challenges to paleo-climate researchers in relation to present-day global warming and its consequences for human societies. Associated soil degradation and erosion are thereby becoming a major concern in many parts of the world and more particularly in the Alps. **Because mechanical erosion of continental surfaces results from climatic forcing, but can be amplified by the anthropogenic one**, we develop an **interdisciplinary approach** combining quantitative organic petrography *(i.e. optical characterization and quantification of soil particles (rAP) 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.



Study site

Based on the present-day geomorphology of the surrounding watershed and the evolution of the vegetation cover during the Holocene, we quantified and modelled soil erosion processes within comparable Holocene lacustrine archives over the last 10000 years.

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 (Simonneau et al., 2013 - JAS, and in press - QSR). Soils, rocks (⬬) and lacustrine sediment (☢) were sampled and analysed for each site in order to calibrate clastic and organic signals.

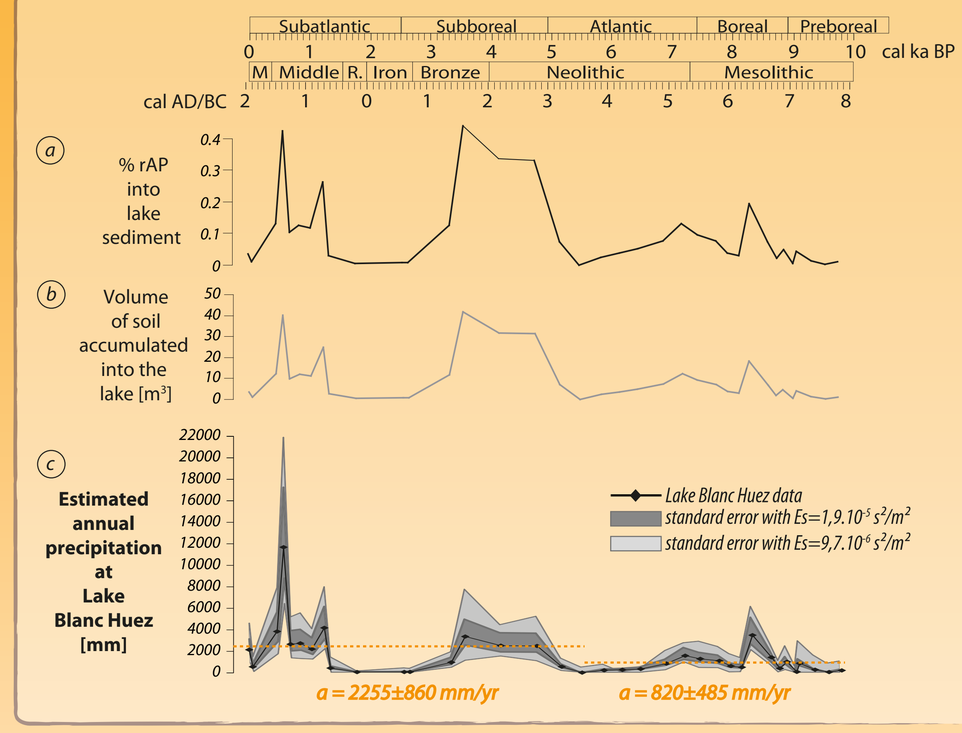


Results

Climate- *versus* human-driven soil erosion over the Holocene in French Alps

Based on AMS ^{14}C, ^{137}Cs, ^{210}Pb and historical events, Holocene alpine environmental changes in the vicinity of lakes Blanc Huez and Paladru were reflected by clastic and organic signals
(magnetic susceptibility, spectrocolorimetry, XRF core scanner, laser ICP-MS *versus* Rock-Eval pyrolysis, quantitative organic petrography, molecular compounds)
see Simonneau et al. (2013, JAS) and Simonneau et al. (in press, QSR) for more details

★ Lake Blanc Huez results

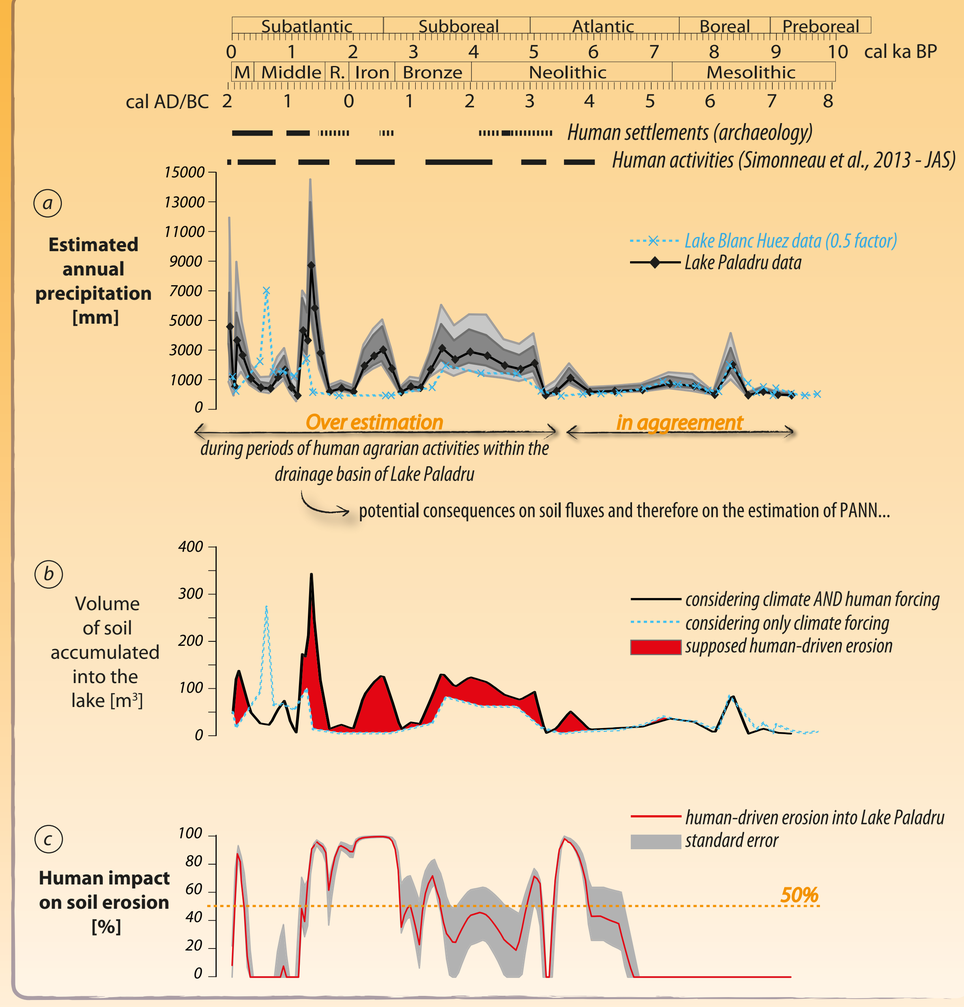


Both archaeological evidences and interdisciplinary characterizations of Lake Blanc Huez sedimentary infill demonstrated that, over the Holocene period, the system is only sensitive to climate forcing and that soil fluxes are therefore only related to runoff processes and not in relation to mining activities close to the lake (Simonneau et al., in press - QSR).

Holocene soil fluxes (a) were therefore considered as being proportional to snow and/or water rainfalls and the volume of soil accumulated into the lake (b) was used to estimate annual precipitation in the vicinity of Lake Blanc Huez for the last 10000 years (c).

Results show that **rainfall has been threefold between the Holocene Climatic Optimum and the Late Holocene.** Modern estimation is in agreement with meteorological data (see «*Study site*»). However, our model need to be improved notably during both the Little Ice Age or the Dark Age during which snow accumulation could exagerate soil fluxes, and the Roman period and the Iron Age when Lake Blanc Huez infill was disturbed by mass wasting deposits.

★ Lake Paladru results



The same framework was applied on Lake Paladru data. Estimations of annual precipitation (a) are consistent with the estimations from Lake Blanc Huez during the Early Holocene but are over-estimated after 6000 cal BP.

Moreover, both archaeological and sedimentological proxies indicate the development of human agrarian activities in the vicinity of Lake Paladru after around 6000 cal BP. We therefore assumed that, after 6000 cal BP, the volume of soil accumulated into Lake Paladru (b) could resulted both from climate and anthropogenic forcing and evaluate the contribution of human activities on soil erosion over this period.

Using the estimations of annual precipitation from Lake Blanc Huez and precluding periods of none conformity, such as during the Little Ice Age or the Dark Age, results suggest that human-driven soil erosion around Lake Paladru is effective since the Neolithic period and the beginning of agrarian activities. Following our quantification and modelling, **human activities, in this part of the Alps, were able to explain up to 50% of soil fluxes** in particular at the end of the Neolithic period, during 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.**

Conclusions

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. For the first time, we develop an **integrative approach combining the multiparameter characterization of natural lacustrine archives with soil erosion modelling over long time-scale**. Such approach is not only r**elevant to reconstitute past hydrological changes** but also promising since it allows to **objectively quantify and date which and when past human activities have had an impact on soil fluxes** over the last 10000 years. The quantification of such inference over long time-scale is 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.

References & Aknowlegments

Blanchet, 1974 - *Revue de Géographie de Lyon*, 50: 387-398.
Blanchet, 1994 - *Revue de Géographie de Lyon*, 69: 89-103.
Simonneau et al., 2013 - *Journal of Archaeological Science*, 40: 1636-1645.
Simonneau et al., in press - *Quaternary Science Reviews*.

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