

EGU2020-20333

<https://doi.org/10.5194/egusphere-egu2020-20333>

EGU General Assembly 2020

© Author(s) 2021. This work is distributed under the Creative Commons Attribution 4.0 License.



Combining hyperspectral and XRF analyses to reconstruct high-resolution past flood frequency from lake sediments

Kévin Jacq^{1,2}, William Rapuc¹, Anne-Lise Develle¹, Pierre Sabatier¹, Bernard Fanget¹, Didier Coquin², Maxime Debret³, Bruno Wilhelm⁴, and Fabien Arnaud¹

¹Univ. Savoie Mont Blanc, CNRS, EDYTEM, 73000 Chambéry, France

²Univ. Savoie Mont Blanc, LISTIC, 74944 Annecy Le Vieux, France

³Univ. De Rouen, CNRS, M2C, 76821 Mont-Saint-Aignan, France

⁴Institute for Geosciences and Environmental research (IGE), UGA, CNRS, IRD, INPG, Saint-Martin d'Hères, France

Due to global climate changes, an intensification of extreme events such as floods is expected in many regions, affecting an increasing number of people. An assessment of the flood frequencies is then a public concern. For several years now, numerous studies are undertaken on geological paleoclimate records and especially on lake sediments to understand the fluctuations of the flood activities in contrasting climatic contexts and over long time periods. Flood events produce turbidity currents in lake basins that will usually lead to a normal graded detrital layer that differs remarkably from the continuous sedimentation. Currently, in an overwhelming majority of studies, once identified, the layers with the same characteristics (e.g. texture, geochemical composition, grain-size) are usually counted by naked-eye observation. Unfortunately, this method is time-consuming, has a low spatial resolution potential and can lead to accuracy bias and misidentifications. To resolve these shortcomings, high-resolution analytical methods could be proposed, as X-ray computed tomography or hyperspectral imaging. When coupled with algorithms, hyperspectral imaging allows automatic identifications of these events.

Here, we propose a new method of flood layer identification and counting, based on the combination of two high-resolution techniques (hyperspectral imaging and high-resolution XRF core scanning). This approach was applied to one sediment core retrieved from the Lake Le Bourget (French Alps) in 2017. We use two hyperspectral sensors from the visible/near-infrared (VNIR, pixel size: 60 μm) and the short wave infrared (SWIR, pixel size: 200 μm) spectral ranges and several machine learning methods (decision tree and random forest, neural networks, and discriminant analysis) to extract instantaneous events sedimentary signal from continuous sedimentation. The study shows that the VNIR sensor is the optimal one to create robust classification models with an artificial neural network (prediction accuracy of 0.99). This first step allows the estimation of a classification map and then the reconstruction of a chronicle of the frequency and the thicknesses of the instantaneous event layers estimated.

High-resolution XRF core scanning (XRF-CS) analyses were performed on the same core with a 200 μm step. Titanium (Ti) and Manganese (Mn) were selected as a high-resolution grain size indicator

and a redox-sensitive element that shows abrupt inputs of oxygenated water-related to floods, respectively. Both elements have thus been added to the model in order to refine the chronicle derived from hyperspectral sensors. The combination of both hyperspectral and XRF-CS signal indicator allows to decipher floods from instantaneous deposits (e.g slump). This combined chronicle is in good agreement with the expected frequency obtained from the naked-eye chronicle realized on the same core ($r^2 = 0.8$). In this study, we present for the first time, an innovative approach based on machine learning which allows to propose fast automatized flood frequencies chronicles. This work was assessed by traditional deposits observations, but it can be easily applied to very micrometric deposits, undistinguishable to the naked eye. Finally, this model can be implemented with other indicators. It then represents a promising tool not only for flood reconstructions but also for other paleoenvironmental issues.