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1.4 kyrs of flash flood events in the Southern European Alps: implications for extreme precipitation patterns and forcing over the north-western Mediterranean area

B. Wilhelm (1), F. Arnaud (1), P. Sabatier (1), C. Crouzet (2), E. Brisset (3,6), F. Guiter (3), J.L. Reyss (4), E. Chaumillon (5), K. Tachikawa (6), E. Bard (6), and J.J. Delannoy (1)

(1) EDYTEM, University of Savoie-CNRS, Le Bourget-du-Lac, France (wilhelm_bruno@yahoo.fr, 00 33 [0] 4 79 75 87 77), (2) ISTERRE, University of Savoie-CNRS, Le Bourget-du-Lac, France, (3) IMEP, Univ. Aix Marseille-CNRS, Aix-en-Provence, France, (4) LSCE, Univ Versailles St-Quentin-CNRS-CEA, Gif sur Yvette, France, (5) LIENSS, Univ. du Littoral-CNRS, La Rochelle, France, (6) CEREGE, Univ. Aix Marseille-CNRS, Aix-en-Provence, France

Extreme precipitation events trigger flash floods causing large human and economic losses. Their frequency and/or intensity are expected to increase in the context of global warming, especially in the Mediterranean region. However, the relationship between such events and past climate change remains difficult to assess. Indeed, the stochastic nature of extreme event occurrence precludes the identification of trends. This is reinforced by a lack in long-term instrumental data. It is hence essential to reconstruct long-term geological records of intense events to extend documented records beyond the observational data. This will enable a better understanding of local to regional flood hazard patterns in the context of global warming and hence improve predictive models.

In the framework of Pygmalion research program, a multiproxy investigation of the Lake Allos (2230 m a.s.l., Southern French Alps) sediment sequence revealed the presence of 160 flood-triggered interbedded layers within a 1400-long sequence. Owing to sedimentary and geochemical characteristics and the frequent occurrence, such deposits were interpreted as the result of high-energy sediment inputs during intense torrential floods (i.e. flash-floods), related to extreme precipitation events. Furthermore the significant relationship between the thickness and the basal grain size of the graded beds allowed using the thickness as a proxy of the flood intensity. Trough the comparison with local historic flood reconstructions over the last 400 years, we argue that these flash floods were mostly triggered by autumnal meso-scale intense precipitation events. Since the Medieval Climate Anomaly (MCA), the absence of major change in erosion processes and local vegetation dynamics linked to anthropogenic impact led us to interpret the Allos flood record as the proxy for the occurrence of such extreme precipitation events over the last millennium.

The frequency of Allos flash-flood events appeared consistent with the general moisture, the hydrology of large rivers and temperature patterns of the south-western European region, i.e. a low flood activity during the warm/dry MCA and conversely during the cold/wet Little Ice Age (LIA). At a sub-centennial scale, a high variability of the flood frequency is superimposed to the general increase during the LIA and appeared in phase with solar maximum. Moreover peaks of flood frequency seem to be correlated with negative autumnal NAO phases, in agreement with previous paleoflood reconstructions of Mediterranean Spanish rivers. Finally the comparison of flood frequency patterns from north-western Mediterranean sites suggests a 50-150 years oscillation mode, probably related to a NAO-like pattern, in two main NW Mediterranean atmospheric circulation patterns triggering extreme precipitations either over the Southern Alps or the Cevennes-Vivarais region.