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A coupled environmental monitoring and lake sediment study to understand factors generating torrential floods in an alpine catchment (Giffre valley, NW French Alps)

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During the last decades, mountain areas have been subjected to a number of environmental changes such as glacier retreat, permafrost degradation and a higher frequency of extreme events. All of these changes affect sediment production and flux within alpine catchments, potentially generating destructive torrential floods. Lakes represent a natural trap for the mobilized sediments during such events and thus offer the possibility to reconstruct the response of geomorphologic processes to past climate changes. Such data are urgently needed to better predict the effects of future climate scenarios in alpine areas. However, to understand and calibrate the data obtained from lacustrine sediment archives it is crucial to include studies of actual processes within the catchments of these lakes.

We present monitoring data obtained at Lake Anterne (2061 m asl), north-western French Alps. Considerable parts of the catchment area consist of barely vegetated scree slopes formed by easily erodible calcareous schists. Consequently, the sediments deposited in the lake basin are highly minerogenic and contain information of past erosion events. The monitoring program includes sediment traps, thermistors and a turbidity sensor within the lake, a weather station, soil temperature and humidity sensors at different slopes, automatic time-lapse cameras and a hydrological station recording water level and turbidity of the main tributary.

Our data cover the last two years and show considerable variation in sediment transfer and deposition processes. On July 17th, 2007, a thunderstorm occurred and initiated numerous debris flows within the catchment and caused the deposition of a several centimetres thick, graded deposit in the lake. This event was particularly violent and generated torrential floods in the Giffre valley downstream of Lake Anterne, causing considerable damage. In particular, the destruction of a medieval bridge indicates that such an intense event was not observed in recent historical times. Two other rainfall events are subsequently visible in the breakdown of the thermocline of Lake Anterne as well as in the precipitation data. In 2008, no such conspicuous deposition events were recorded in the lake or at the weather station. The meteorological data indicate that the average summer precipitation was only 30 % lower than in 2007, but rainfall intensities reached similar values in both years. One possible explanation for the observed differences in sediment transfer is sediment exhaustion within the river channels or the passing of a threshold value in precipitation in connection with water saturated soils. Regardless of the actual factors responsible for sediment mobilization during extreme events in the summer months, such events seem to be the main mode of sediment transfer whereas snowmelt appears to be negligible. Our results show that even in small catchments the response of geomorphologic processes to (climatic) forcings is complex and several years of monitoring data are needed to fully understand the factors controlling the sediment transfer.