



The first annually-resolved lake record of extreme precipitation events since AD 1374 in NE Iberian Peninsula

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Lake Montcortès is a small (0.14 km² surface area), 30 m deep, karstic lake located in the eastern Pre-Pyrenees (NE Spain). The permanent anoxic hypolimnetic conditions in this lake have favored the preservation of finely annually laminated sediments in central-distal areas of the lake basin for the last three millennia. A robust age model has been established through varve counting on petrographic thin sections combined with radiocarbon and ²¹⁰Pb dating. The good correlation of the varve counting with the ¹⁴C AMS dates underlines the annual nature of the lamination.

Three main types of detrital microfacies have been distinguished in the varves: i) non-continuous detrital layers; ii) continuous detrital layers; iii) matrix-supported layers. In addition, two types of turbidite layers have been identified. Transport mechanisms have been proposed for those deposits including slope reworking processes as well as interflow and underflow events. Annual number of detrital layers interbedded within this varve record was compared against instrumental records of extreme daily rainfalls (available since 1917) providing minimum rainfall thresholds and return periods associated to the identified types of clastic microfacies. Non-continuous detrital layers are deposited during rainfall events higher than 80 mm (> 2 years in average recurrence interval) while graded detrital layers and turbidites were associated with even higher amplitude rainfall events (> 90mm and > 4 years recurrence interval).

The frequency distribution of extreme hydro-meteorological events during the last centuries is not stationary and its pattern coincides with historical floods from the nearby Segre River. Higher heavy rainfall frequency occurred during AD 1347-1400 and AD 1844-1894, while less rainfall events happened at AD 1441-1508, 1547-1592, 1656-1712, 1765-1822 and 1917-2012. Variations in extreme rainfall frequencies prior to the 20th century show a positive correlation with solar activity, suggesting solar induced-changes in atmospheric circulation patterns. The 20th century stands out as the longest interval of low number of extreme rainfall events within the studied period and contradicts foreseen regional trends of increasing frequency of extreme rainfalls under warmer climate scenarios.