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Flash floods of the last 1000 years in central Europe documented by laminated freeze cores from Eifel maar lakes

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Three 2 m long sediment cores have been retrieved by freeze core technology from the Holzmaar, Schalkenmehrener Maar and Ulmener Maar in the Eifel (Germany). Stratigraphy is based on the Chernobyl ^{137}Cs spike at 20 cm depth in two of these cores and varve counting for one core down to 1100 AD. The cores thus cover the times of Global Warming, the Little Ice Age (LIA) and the Medieval Warm Period (MWP). Sedimentation in all three lakes is dominated by biogenic particles but includes about 25 clastic layers during the last 1000 years with a distinct grain size signature and μXRF geochemical fingerprint. Excellent sorting of quartz grains indicates a fluvial origin for these layers which apparently settled from riverine suspensions entering the lake during flash floods. Holzmaar retrieves fluvial suspensions continuously from a small river, where as the other two maar lakes get in contact with nearby creeks only during extreme creek water high stands, i.e. during local flash floods. A comparison of modern Eifel water high stands with other rivers in Germany gives evidence that the timing of Eifel flash floods are tightly associated with flash floods also in the large rivers of southern and western Germany. Reconstructions from the Eifel maar lakes are thus representative for a large part of central Europe.
Most of these suspension layers lack organic matter, except for one distinct layer at 130-140 cm, which is associated with 50 different plant remains, all of which are derived from the summer season. The only extreme summer flash flood of the last

1000 years was in early July 1342, which apparently can be used as a stratigraphic marker between the maar lakes. The varve counted time series of the last 1000 years is compared to historically documented flash floods. Apparently, the Eifel suspension layer succession is most similar to the documented high water stands of the Rhine at Cologne, just 100 km away from the Eifel.

All 12 large flash floods during the Little Ice Age were late winter extremes and were associated with fast ice discharge after severe cold or abrupt snow melt after strong snow fall. The flash floods of the Medieval Warm Period were also winter extremes, except for the 1342 July event. Flash floods were almost absent from about 1805 to 1900. Events during the last century are difficult to detect in the maar sediments because modern man stabilized the lake levels. Large flash floods in central Europe during the last 20 years under Global Warming conditions were mostly summer events. In contrast, flash floods during the Little Ice Age were winter events throughout. The frequency of winter flash during the LIA was higher compared to modern times. Flash floods during the MWP were also winter events and also more frequent than during modern times. This matches the evidence from historical records, which had documented that the MWP had a very strong seasonality, i.e. mostly warm summers from about 1000 AD to1310 AD, but severe winters, and apparently with very frequent flash floods as documented in the maar lake records.

The flash flood record is extended at the moment to the entire Holocene.