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Abrupt climate events recorded in speleothems from the ante penultimate glacial

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Millennial-scale climate variability, especially abrupt stadial-interstadial transitions, are a prominent feature of the last glacial as recorded in Greenland ice core records (Dansgaard-Oeschger events). Event abruptness and presence of statistical early warning signals before these transitions indicate that they involve repeated crossing of a tipping point of the climate system. However, only little information is available for periods before the last glacial period as Greenland ice cores and many other high-resolution records do not extend beyond the last glacial cycle. Given the lack of understanding of the triggering mechanism responsible for glacial millennial-scale variability with palaeoclimate data from the last glacial, it is essential to investigate this phenomenon during earlier glacial periods.

Here, we present a new highly resolved, precisely U-Th-dated speleothem oxygen isotope record from the Northern European Alps, a region which has been previously shown to resemble the glacial millennial-scale climate variability obtained from Greenland ice core records very well. Our new data covers the time interval from the ante-penultimate glacial to the penultimate glacial (MIS8-MIS6) with a high degree of replication. For both glacial periods, we find phases of pronounced millennial-scale variability but also several, ~10 ka long phases with the climate system being exclusively in stadial conditions. We compare our data with conceptual model results and investigate the occurrence and absence of abrupt climate transitions of the last 300,000 a.