High-resolution records of atmospheric ^{14}C based on Hulu cave speleothems

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The calibration of atmospheric radiocarbon ($\Delta^{14}C$) is significant, because it is essential not only for the precision and accuracy of ^{14}C dating, but also for our understanding of carbon cycle, climate change, solar activity and geomagnetic variation. Currently, few ^{14}C calibration datasets are available beyond the reliable dendro-dated tree ring record ended at ~14 ka BP (before 1950 AD), and yet the uncertainties of the ^{14}C calibration derived from these datasets remain large and complex. Here we present high-resolution ^{230}Th-dated ^{14}C records from speleothems MSD (~18.5–50 ka BP) and MSL (~36–50 ka BP) from Hulu cave, China, extending the current Hulu record of H82 (10.6–26.8 ka BP) further back to the complete ^{14}C calibration range. The three Hulu speleothem $\Delta^{14}C$ records are coherent in contemporary time periods, and the corrections to ^{230}Th ages for initial detrital ^{230}Th are typically negligible. For reasons that remain unclear, the dead carbon fractions for the three speleothems are unusually small (5–6%) and stable across major climate shifts. Our new ^{14}C data are in good agreement with published marine, speleothem and lake records used to construct the InCal13 (around their average). Because the new Hulu dataset has high resolution and relatively low $\Delta^{14}C$ uncertainties, it is now evident that the millennial-scale variability of atmospheric $\Delta^{14}C$ broadly tracks geomagnetic changes during the last glacial period from 50 to 25 ka BP, including two high $\Delta^{14}C$ excursions that correlate respectively to the Laschamp and Mono-lake geomagnetic events. In contrast, the $\Delta^{14}C$ variability during the last deglaciation is typically gradual, possibly modulated by atmospheric CO_2 concentration, which is in turn regulated by changes in the Southern Ocean. The new Hulu $\Delta^{14}C$ dataset will provide important new constraints on the calendar ages for $\Delta^{14}C$ variations, and will further expose the relationships between $\Delta^{14}C$ variations and changes in the carbon cycle, geomagnetic field, and climate as inferred from the Hulu $\delta^{18}O$ record.