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Summer temperature reconstructions based on cave ice deposit from the Carpathian Mountains, Central Europe

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The Carpathian Mountains host several ice caves that preserve a large variety of geochemical information on past climate and environmental changes. In such caves, ice forms in winter by the freezing on infiltrating water, the later accumulating during the rainy season, between early summer and late autumn (depending on site-specific conditions). Here, we present the first reconstruction of summer temperature during the last 1000 years based on the d18O and d2H values measured in Focul Viu Ice Cave (Western Carpathian Mountains, Romania).
Focul Viu (FV) is short (107 m long) descending cave, located at ca. 1165 m above sea level on the windward (western) side of the mountains. A stratified ice block, with a volume of ∼25000 m3 and ∼20 m thickness, occupies the floor of the cave. In May 2016 we have extracted a 4.86 m long ice core from the cave glacier and measured the stable isotope composition of ice in order to derive information on past climate variability. The chronology of the core is based on six 14C measurements on organic matter embedded in the ice. Monitoring of the stable isotope composition of precipitation in the vicinity of the cave shows that most of the summer precipitation is originating in the Atlantic Ocean, ca. 30 % percent of it being locally recycled during heavy summer storms.
We have found a near-perfect correlation between d18O (and d2H) of the ice core and instrumental summer temperatures measurements at three local stations, located west, north and east of the cave's location and have used this correlation to reconstruct summer temperature variability during the past ∼1100 years. Our results show little centennial-scale variability during this period, suggesting that summer temperatures were likely similar between the Medieval Warm Period (MWP) and the Little Ice Age (LIA). In contrast, winter temperatures reconstructed from the nearby Scărișoara Ice Cave clearly show lower temperatures during the LIA, compared to the MWP, suggesting that the well-known temperature contrast between the two periods was a the result of winter climatic conditions. On a decadal scale, both during the MWP and the LIA, summer temperatures fluctuated with a periodicity of ∼20/30 years, the minima and the maxima matching the fluctuations recorded by the Atlantic Ocean sea surface temperatures. Both the periodicity and the observed variability are similar to those of the Atlantic Multidecadal Oscillation, suggesting the d18O and d2H values in FV cave ice are recording climatic changes at hemispheric scale, thus being an important new proxy for both past temperatures and large-scale circulation changes.