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Solar and volcanic forcing of summer air temperatures – a combined ice core and tree ring perspective form the Carpathian Mts. (Europe)

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In order to improve our understanding of natural and anthropogenic influences on climate, high resolution reconstruction of the climate changes (and associated forcings) during the recent past (last millennium) are strongly needed. While these types of records are available for numerous regions, they are still scarce and with low resolution in the Eastern half of the European continent. In this paper, we present a high-resolution (decadal and better) reconstruction of summer air temperatures from the Carpathian Mts. (Romania), using water stable isotopes in cave ice cores (from Scărişoara Ice Cave) and tree-rings as proxies for summer air temperatures (late and early, respectively). Our combined results show that periods of low solar activity (Wolf, Spörer and Dalton) and the main volcanic eruptions of the past millennium had had a clearly visible - in both isotope and tree ring data – impact on summer temperatures in the area. Worth to mention is that the "year without a summer" occurred in 1818 in both records, two years later than in most of the reconstructions in the vicinity. The Medieval Warm Period is seen as a relatively warm ($\sim$0.5 °C warmer than the 1960-1990 period) and stable period in the ice core data, but it's not clearly recorded by the tree rings, while the Little Ice Age (starting at around 1350 in the 14C-dated ice core chronology, and in 1370 in the annually resolved tree ring data) is marked by lower than present (by $\sim$ 1 °C) air temperatures and increased variability. The ice core record stops at 1870 AD due to enhanced ice melting in the 20th century, associated with drier and warmer summer, as seen in the tree ring reconstruction. Our results provide a unique picture of the climate during the past millennium for a region where such information is mostly missing, strengthening the general view of 1) a relatively variable climate during the past 1000 years and 2) rapid warming during the past $\sim$100 years.