



Harsh winters over the last two millennium in the eastern part of Europe

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The variability of harsh winters is considered to be a sensitive indicator for climate change. As such, in this study we present a reconstruction of 2000 years of harsh winters in the Eastern Europe based on historical documents. In total, 360 harsh winters were extracted for the period from AD 0 to 2000, and it's the longest one, on record, over this area. Our investigations spans over five distinct periods: the Roman Warm Period (RWP), the Dark Age (DA), the Medieval Warm Period (MWP), the Little Ice Age (LIA) and the Modern Period (MD), respectively. The results obtained show that the number years of harsh winters has decreased considerably during the RWP (AD 0 – 550) and have an occurrence rate $< 0.1/\text{year}$. During the Dark Age is observed a small increase in the number of harsh winter and the occurrence rate is found to be $> 0.15/\text{year}$. The period which covers the MWP (AD 850 – 1250) shows very small variation in number of severe winters and a slight decline in occurrence rate (~ 0.05 to $0.08/\text{year}$). Overall, the biggest changes have been observed during the LIA (AD 1400 – 1850), when the occurrence rate of harsh winters show an increasing trend of $\sim 0.75/\text{year}$, due to a decreasing in the winter mean temperature over the eastern part of Europe. During the MD (AD 1900 – 2000) the number of harsh winters is decreasing ($0.4 - 0.3/\text{year}$) due to an increasing the winter mean temperature. Based on these information we can reconstruct 2000 years of winter air temperature variability over the Eastern Europe, with warming winters during the RWP, cool during the Dark Age, warm and dry during the MWP, and very cold winters during the LIA. In conclusion the harsh winters reconstruction can be used as a proxy indicator for the air temperature variability in winter, over the eastern part of Europe.