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1000-year summer temperature reconstruction from an Alpine ice core

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For the first time in the Alpine region, a 1,000 year stable isotope ice core record was used to reconstruct temperatures. The isotope/temperature relationship is based on physical laws but the signal in the ice is affected by various ice core specific and site specific processes introducing additional noise. We found a significant positive correlation between instrumental summer air temperature (May-July) and mean annual δ^{18}O from Colle Gnifetti ice core (Swiss Alps, 4450 m a.s.l.) for AD 1900-2007 (r=0.56, $p<0.06$ for 5-yr filtered time series). The correlation is, however, not stable through time as indicated by instrumental data reaching back to AD 1760. Analysis of the residuals revealed significant correlations (r=0.39, $p<0.08$ for 5-yr filtered time series, AD 1800-2007) to the deuterium excess. Thus, long-term changes in moisture source regions and pathways, as indicated by the d-excess, seem to affect the δ^{18}O signal of the ice core. Alpine precipitation originating from the Atlantic or from the Mediterranean differs remarkably in its stable isotope composition. Changes in the relative contribution due to changes in atmosphere circulation or the ocean system thus have influence on the δ^{18}O/temperature relation. Using the d-excess record we propose a correction function derived from multiple linear regression to account for this bias otherwise reflected in the temperature reconstruction.

We quantitatively reconstruct past May-July temperatures for the last 1,000 years. During the calibration period (1760-2007) the reconstruction is significantly correlated with instrumental data (r=0.75, $p<0.08$ for 21-yr filtered time series). Before the instrumental period, our data agree closely to independent reconstructions using documentary evidence and natural archives and to observations of regional glacier fluctuations. Based on our reconstruction, the warmest periods over the last 500 years are AD 1530-1550, 1720- 1740, 1790-1805, 1940-1950 and 1980-2000. Time periods before AD 1500 are characterized by strong decadal scale variability of temperatures. Short warm spells with values comparable to the 20th century occurred at AD 1400 and 1220. Short cool periods are recorded at AD 1180, 1250, 1350 and 1500. Persistently warm conditions prevailed from AD 980-1100 before temperatures gradually decreased.