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Cold-season temperature in the Swiss Alps from AD 1100-1500; trends, intra-annual variability and forcing factors

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To fully understand past climatic changes and their forcing factors, detailed reconstructions of past summer and winter temperatures are required. Winter temperature reconstructions are scarce, however, because most biological proxies are biased towards the growing season. This study presents a detailed reconstruction of winter temperatures based on Chrysophyte stomatocysts, silicious scales formed by so-called 'golden algae'. Previous studies (Kamenik and Schmidt, 2005; Pla and Catalan, 2005) have demonstrated the sensitivity of these algae to cold-season temperatures.

Chrysophyte stomatocyst analysis was carried out on varved sediments from Lake Silvaplana (1791 m a.s.l.) at annual to near-annual resolution for two periods; AD 1100-1500 and AD 1870-2004. For both periods the reference date 'date of spring mixing' (Smix) was reconstructed using a transfer function developed for the Austrian Alps (Kamenik and Schmidt, 2005). In the Austrian Alps, Smix was primarily driven by air temperature in the cold season. The strength of stomatocysts as a proxy for winter temperature was tested by directly comparing reconstructed Smix with measured temperatures from nearby meteostation Sils Maria for the period AD 1870 – 2004. Correlation was highest ($R = -0.6$; $p < 0.001$) with mean October-April temperatures. The good agreement between reconstructed Smix and mean winter temperatures was interrupted only from AD 1925 - AD 1951, which was related to exceptionally high winter precipitation (thick snowpack) extending the ice-covered period. Strong lake eutrophication after AD 1950 only weakly affected the reconstruction of winter temperature.

The winter temperature reconstruction (AD 1100-1500) shows strong interdecadal variability, superimposed on a cooling trend from around AD 1400 onwards. A direct comparison to summer temperature reconstructions based on biogenic silica and chironomid analysis from the same cores (Trachsel et al., in review; Larocque-Tobler et al., accepted manuscript) indicated strong fluctuations in intra-annual variability. A comparison to forcing factors shows that throughout the studied period, large tropical volcanic eruptions (Crowley, 2000) coincided with relatively warm winters in the study area. This is consistent with results from GCM experiments and observations of the limited number of eruptions during the much shorter instrumental period (Fischer et al., 2007).

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