Extending the high elevation larch ring width chronology from the Simplon region in the Swiss Alps over the past millennium

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Introduction

A number of tree ring-based temperature reconstructions that span the last centuries to millennia were recently published for the European Alps (e.g., Frank & Esper 2005, Frank et al. 2005, Büntgen et al. 2005, 2006, 2009, 2011). These records are generally composed of several hundred of annually resolved and absolutely dated ring width and density measurements from living conifers, historical timbers, and sub-fossil remains. A prerequisite for all this material is the origin from high-elevation Alpine sites. The Simplon region in the western Swiss Alps represents a unique source for larch (*Larix decidua* Mill.) construction timbers, with the oldest buildings dating back into late medieval times (Tab. 1). Here, we introduce a continuous tree-ring width chronology from historical high elevation larch wood from the Simplon village in the Swiss Alps spanning the 738-1852 AD period. The chronology provides an ideal basis for the development of an Alpine summer temperature reconstruction.

Data, methods and results

A total of 126 larch samples from 14 buildings in the Simplon village (46°12'N, 8°03'E, 1476 m asl; Fig. 1) were compiled and analysed over the past years, involving different studies (Tab. 1).

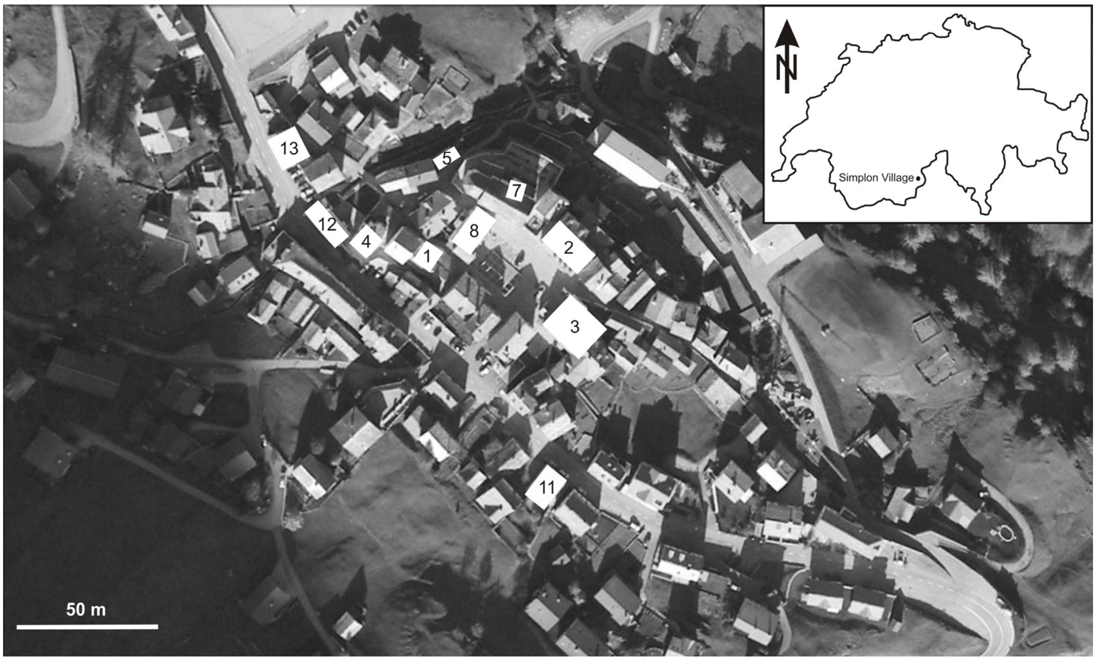

Figure 1: Aerial image of the Simplon village in the western Swiss Alps. Those buildings that were considered for tree-ring sampling are indicated: 1) Stall Dorsaz, 2) Weisses Kreuz, 3) Alter Gasthof, 4) Turru, 5) Heidenhaus Zenklusen, 7) Kirchturm, 8) Haus auf dem Dorfplatz, 11) Haus Peter Arnold, 12) Postgebaeude, and 13) Kaplanneigebaeude. Buildings 6) Hittae-Maiensaesshaus, 9) Alte Sust in der Engi, 10) Sidegga Haus Gerold, and 14) Rossbodenhuette-Andermatten Hans are located outside of the village. Location of Simplon village is marked on the map of Switzerland in the upper right.

In Büntgen et al. (2005) 64 larch samples from 7 buildings (Tab. 1, Fig. 1) were used for a 1000-year composite tree-ring proxy record to reconstruct alpine summer temperatures. This existing dataset is updated with 62 samples from 12 buildings (Tab. 1, Fig. 1). We eliminated the age-related growth inherent to the raw measurement series by calculating residuals from individually filtered negative exponential functions after power transformation (Cook and Peters 1997) and variance stabilisation (300 year spline) using the computer software ARSTAN (Cook 1985). This procedure emphasizes high- to mid-frequency variations in the resulting index chronologies, which were calculated as bi-weight robust means (Cook and Kairiukstis 1990). The existing tree-ring width chronology presented in Büntgen et al. (2005) do not have a continuous replication of ≥ 5 series throughout the entire past millennium (Fig. 2a). The new update chronology improve this existing chronology particularly during this low replication periods. The advantage is that the low replication periods in both chronologies complement one another to a sufficient replication (Fig. 2 a and b).

Table 1: Historical buildings in the Simplon village. Table lists total number of samples from each building, the existing samples (Büntgen et al. 2005), and the new samples used to update the long-term chronology from the Simplon valley.

Building	**Number of samples**	**Number of samples Büntgen et al. (2005)**	**Number of samples update**	**Time span AD**
Stall Dorsaz	27	26	1	685-1200
Weisses Kreuz	3	2	1	984-1424 and 1588-1681
Alter Gasthof	34	19	15	1160-1338, 1372-1618 and 1634-1852
Turru	4	4	/	1198-1487
Heidenhaus Zenklusen	8	8	/	1249-1416
Hittae-Maiensaesshaus	5	/	5	1292-1696
Kirchturm	10	/	10	1368-1458
Haus auf dem Dorfplatz	4	3	1	1398-1698
Alte Sust in der Engi	10	/	10	1406-1537
Sidegga Haus Gerold	7	/	7	1439-1629
Haus Peter Arnold	3	2	1	1491-1989
Postgebaeude	6	/	6	1652-1811
Kaplaneigebaeude	2	/	2	1718-1856
Rossbodenhuette-Andermatten Hans	3	/	3	1841-1922
Summ	126	64	62	685-1989

The residuum from both chronologies and the standard deviation between the Büntgen et al. (2005) and the new chronology are relatively low between 1220 and 1800 AD (Fig. 2c), indicating that the new chronology bits represent the same populations and can be used to update the chronology by Büntgen et al. (2005). A slight negative correlation between the standard deviation and the product of the two replications results in r = -0.13 (p<0.0001), indicating that the higher residuum and standard deviation from 800 to 1220 AD and after 1800 AD are due to the low replication in one or both chronologies during these periods. Because of this relatively low residuum and standard deviation between the two chronologies, we suggest that the records can be composed to one single chronology representing common TRW variability in the Simplon valley (Fig. 3).

This composite chronology has a continuous replication of ≥ 5 series from 738-1852 AD. Periods with slightly lower replication between 1600 and 1700 AD as well as after 1800 AD will be improved with samples from living trees from the Simplon region reaching ages up to 500 years. It is thus intended to combine the updated historical chronology with samples from living trees to develop an improved climate reconstruction spanning the past millennium.

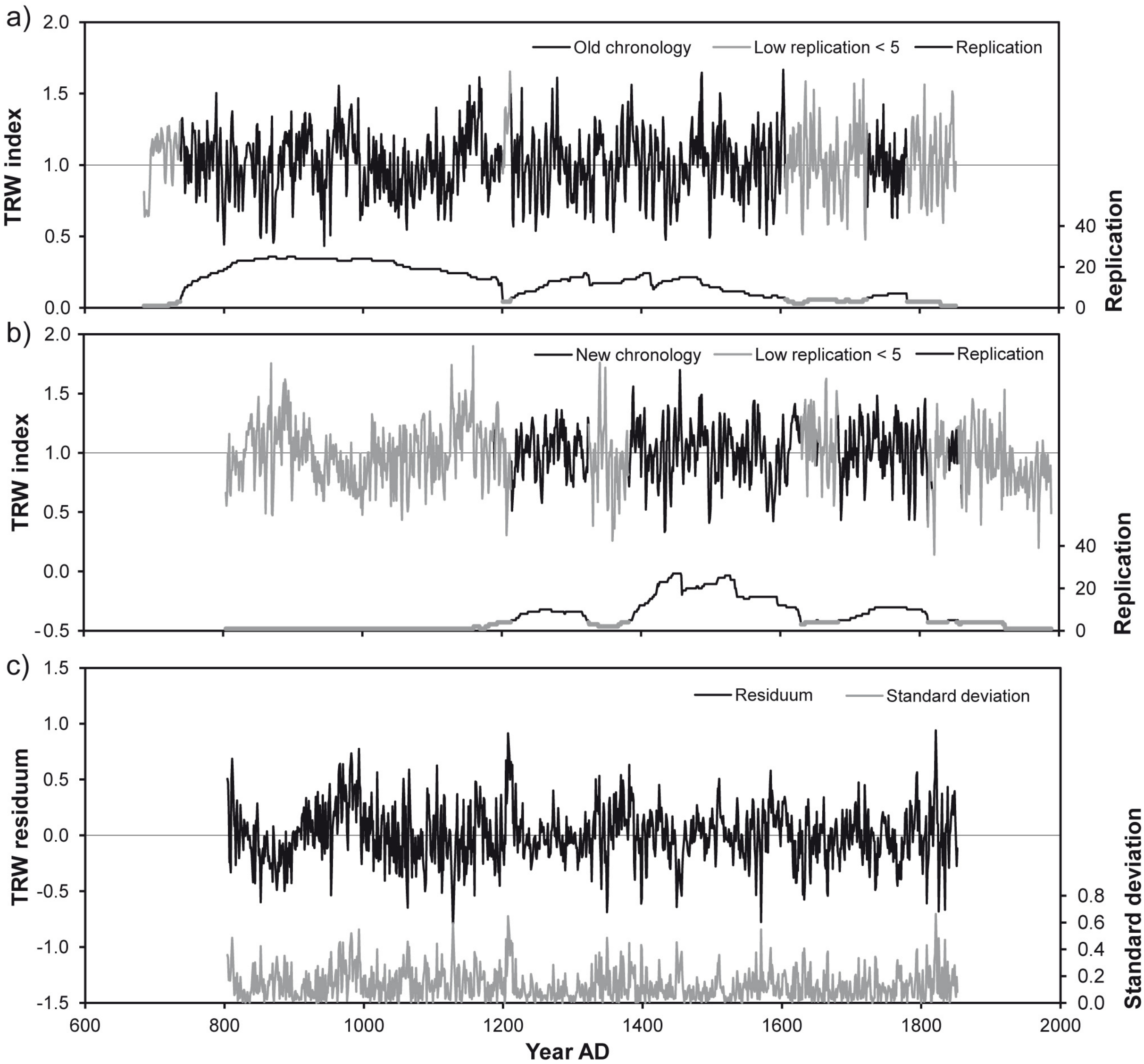

Figure 2: a) Old tree-ring width chronology (Büntgen et al. 2005) detrended with negative exponential functions together with the sample replication. b) New tree ring width chronology detrended with negative exponential functions together with the sample replication. Parts with a replication < 5 are marked in grey in both the chronologies and replication curves. c) Residuum of the old and the new chronology together with the standard deviation between existing (Büntgen et al. 2005) and new chronology.

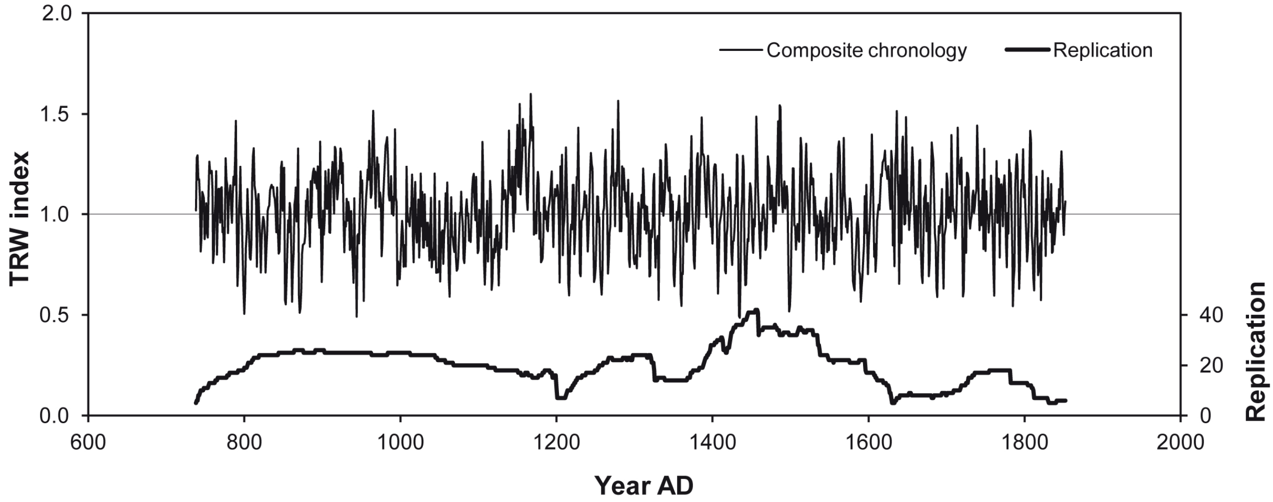

Figure 3: Composite tree-ring width chronology detrended with negative exponential functions and sample replication ≥ 5.

Conclusion and Outlook

Our new composite chronology provides a well-founded 1114-year long tree-ring record, which can serve as a basis for a homogeneous millennial-long climate reconstruction from the Simplon valley in Switzerland. Next steps include sampling of living larch trees along altitudinal transects in Simplon valley. Larch trees from different elevations from the valley bottom at 1400 m asl to the tree-line at 2200 m asl will be analysed to assess changing climate sensitivities with elevation (Affolter et al. 2010). The assessment will include southwest and northeast facing slope to evaluate the changing influence of larch bud-moth (*Zeiraphera diniana*) outbreaks on TRW data (Esper et al. 2007). These outbreaks can differ in their intensity with elevation and also with slope exposure due to preferred environmental conditions of the larch bud-moth (Baltensweiler & Rubli 1999).

Provenancing the historical wood samples with respect to elevation and perhaps even exposure will be a further step. This will be done by growth pattern analysis among the different sampling sites and historical timber samples (Wilson et al. 2005), and will support the development of a millennium-length chronology integrating ecologically homogeneous samples. It is intended to systematically reduce sample homogeneity during recent centuries to match the generally more heterogeneous character of the historical portion of the chronology. This procedure will likely enable a more realistic calibration scheme to transfer the TRW chronology into estimates of climate variability (Tegel et al. 2010).

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