Clim. Past Discuss., 4, C793–C804, 2010
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Climate of the Past Discussions

Interactive comment on "Millennium-long summer temperature variations in the European Alps as reconstructed from tree rings" *by* C. Corona et al.

C. Corona et al.

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1. General comments: 1. BuÌĹntgen et al. have already published a European Alpine reconstruction covering past millennial summer temperature variability. Guiot et al. 2005 published a millennial long Western-European summer temperature reconstruction. You state your findings to be significantly similar with other alpine reconstructions. Please, clarify and highlight more what is new in your study.

The new findings of our study have been highlighted in the introduction. We may summarize the innovations in this paper as follows: 1. the use of new unpublished series widely distributed in the Alpine arc has been highlighted in the introduction: "Unlike previous reconstruction, our reconstruction is built from series widely distributed in the Alpine arc, and, in particular, series from Western Alps are incorporated in the dataset."

2. As this study was performed to best preserve inter-annual to multi-centennial scale summer temperature variations, we use a refined version of the well-established RCS technique for tree-ring detrending (as highlighted in the original introduction) 3. We use an analogue-based method preserving the variance of the temperature and are thus able to work on unequal proxy series lengths; the interest of this method has been detailed in section 3.2.

2. You mention 36 series in the abstract, however Table 1, Table 3, Table 5, as well as Fig. 1 and Fig. 2 display 38 series. Please, clarify. A typo occurs in the abstract: 38 series have been used.

3. Interestingly, with artificial neural networks a different method than used predominantly for climate reconstruction at the European and NH scale has been used. Please expand on what motivates the choice of your method and bed in your approach into the latest methodological discussion on summer temperature reconstruction.

It has been highlighted in introduction that the ANN method differs from linear statistical methods in that it uses a nonlinear approach and that it was particularly adapted to tree-ring based reconstructions: "In an effort to capture the natural range of high- to low- frequency temperature variations and to provide a refined reconstruction of their amplitude over past millennium, we used a refined version of the well-established RCS technique for tree-ring detrending, an analog method for data aggregation, and a novel neural network approach for reconstruction (Guiot et al. 2005) This technique been applied successfully in palaeoclimatology (Peyron et al. 1998; Guiot et al. 2005) and in dendroclimatology (Guiot and Tessier, 1997; Keller et al. 1997; Carrer and Urbinati, 2005). It differs from linear statistical methods in that it uses a nonlinear approach and appears particularly adapted to tree-ring based reconstructions due to the complexity of tree growth, dependent on climate but also on time, tree geometry and other factors."

Specific comments: p.1160, line 4 Is it 36 or 38? Clarify. A typo occurs in the abstract: 38 series have been used.

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p.1160, line 17: with summers that are? “That” has been added: The Little Ice Age (1420-1830) appears particularly cold between 1420 and 1820 with summers that are 0.8° C cooler than the 1901-2000 period.

p.1161, line 25: method instead of methods Methods has been replaced by method

p.1161, line 26: Please, specify what you consider as novel about the approach. The method is a combination of new standardization, data infilling by analogues and calibration by ANN. According to Guiot et al (2005), the first step is the major innovation.

p.1162, lines 20, 21: As the paper is about reconstructing the past millennium, please state more precisely how the series compare to the full reconstruction length back to the year 1000 AD and especially between 1000 and 1500 AD

The number percentage of missing values has been added in table 3. The percentage of available series compare to the full reconstruction is precisely stated in the paragraph 4.1, “chronology characteristics”:

The proxy matrix has 38 columns (chronologies) and 1001 rows (years) with many gaps, especially before 1500. The percentage of missing values, considering the reconstruction (AD 1000-2000) as 100% is provided in fig. 2. It varies between 0 and 68% with a mean of 49%. Only 8 chronologies are available before AD 1400 and only 5 before AD 1200 (fig. 3a, f).

p.1163, line 17: applied to. Applied has been replaced by “applied to”

p.1163, line 17: Replace various and state the exact number of the test you have carried out. Five calibration and validation tests are finally carried out to assess the reliability of the reconstruction. It was highlighted in the revised version.

p.1164, line 22: Use a formal editor to display t as indices. t has been displayed as indices

p.1165, lines 9 to 13: You compare your approach to the nested (due to decreasing

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number of proxies back in time), regression-based techniques of e.g. Mann et al. and Luterbacher et al. used in the past. Schneider et al. 2001, Rutherford 2005 and Mann et al. 2007 introduced with RegEM a technique, which also imputes/ infills missing values, thus allowing for missing values in the input data. Your methodological argument seems therefore. Please, adapt your argumentation and expand your motivation.

A paragraph concerning the comparison between RegEM and analogue techniques has been introduced in section 3.2. We explain that the analogue technique relies on the Euclidian distance and is not based of the correlation between variables but between the years. This method does not have the same weakeness as the other methods, as the number of predictors is maintained constant in time. It conserves the spatial variability of the original dataset and maintains the variance back in time.

Moreover, such methods do not account for missing values within proxy series. An alternative more and more frequently used is the regularized expectation maximization (REGEM), which imputes missing values on the basis of the regression between variables (Schneider et al. 2001), in a manner that make optimal use of spatial and temporal information in the dataset. Here, infilling of missing data is done using an analogue technique introduced by Guiot et al. (2005). This technique has not the same weakness as REGEM, as the number of predictors is maintained constant in time. In order to replace a missing year for any given tree ring series, we compared the existing vector of data with all other series available during this time on the basis of the Euclidian distance and not on the basis of the correlation between variables, as most of the methods do.

Results will show below that the method has an interesting characteristic as compared with the regression based methods: the correlations between estimated series are not better than those of the observed series as the estimation process is not based on the similarity between variables but between the years. The method is then conservative for the observed spatial variability. Moreover, it has been demonstrated that variance is well maintained independent of the number of predictors (Nicault et al. 2008b).

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p.1165, line 26: Where are the critical limits to fill in missing values (the thresholds) in your analogue technique? What is the maximal accepted amount of missing values in your technique? The number of analogues varies according to the data available. There is not a priori rules. Usually we proceed by trials.

p.1165, lines 28: Why 20%? Please, explain. This threshold was arbitrary chosen.

p.1166, line 4: Please, state what truncation criterion you apply with regard to the choice of principal components. We have successively tested the inclusion of 10 to 19 principal components and selected the number (14) which maximizes the RE.

p.1166, line 7: mentioned instead of mentionned? Mentioned has been replaced by mentioned

p.1166, line15: 50 iterations are rather few. Please, state why you consider 50 iterations to be enough. 50 iterations are indeed rather few if compared to numerous statistical analysis. This number is sufficient as shown by Guiot et al (Methods of calibration, veriïňĄcation and reconstruction. In Cook, E. and Kairiukstis, L., editors, Methods of denrochronology, application in the environmental sciences. Dordrecht: International Institute for Applied Systems Analysis, Kluwer Academy Publications, 163 ôŔřĂ/217). We agree that in the literature a rather larger number is taken, but we have not found that the results were better.

p.1167, lines 20, 21 It seems that there are actually only 10 series available before 1400 AD, and before 1200 AD only 5 series. Thus, be more precise about your statement there. Please, provide the percentage of missing values of each series considering your reconstruction period (1000 to 2000) as 100%.

The percentage of missing values considering the reconstruction period (AD1000-2000) as 100% has been indicated for each serie in the first column of the table 3. The percentage of available series compare to the full reconstruction is precisely stated in the paragraph 4.1, “chronology characteristics” :

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The proxy matrix has 38 columns (chronologies) and 1001 rows (years) with many gaps, especially before 1500. The percentage of missing values, considering the reconstruction (AD 1000-2000) as 100% is provided in fig. 2. It varies between 0 and 68% with a mean of 49%. Only 8 chronologies are available before AD 1400 and only 5 before AD 1200 (fig. 3a, f).

p.1168, lines 1 to 4: Please explain what exactly you consider as interesting, and what might be the physical cause of this statistical relationship.

"Interestingly, for larch chronologies (Fig. 3c), the correlations before 1200, between 0.38 and 0.55, reveal a fairly robust signal in the four oldest populations from Switzerland/Austria (Swiss 1, Swiss 2) and France (Merveilles, Nevache)".

The sentence has been explicated: Despite the distance and the composite nature of these populations, these correlations reveal a common climate-related signal in the Alps during the early part of the millennium for which regional temperature reconstructions considerably differ at regional scale (Mann 2007).

p.1169, lines 18 to 20: I do not understand your argument for your proof here. Please, clarify and explain. An error occurs in the computation of R2 in the original manuscript. The original sentence, For the 20-yr low pass curves, R2 is similar (0.45) before and after 1819. (Fig. 4d), which proves that the reconstruction is better in the high frequency domain than in the low frequency one. Is replaced by the following sentence : "For the 20-yr low pass curves, R2 is 0.45 before 1819 and increases to 0.81 between 1819 and 2000. (Fig. 4d). This statement shows that the reconstruction has a good behaviour in the low frequency domain.

p.1170, title: Discussion instead of Results? Results has been replaced by discussion

p.1172 to 1174, 5.2 Alpine climate history: Please, improve the structure of the whole paragraph. I found it difficult to orientate. Maybe state how the paragraph is build up and how you proceed in the text. The whole paragraphe has been rearranged. Two

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subparts have been distinguished :

5.2.1. Raw reconstruction: high frequencies (year-to-year) variations This subpart has been divided in three subsections : - Warm years anomalies (AD 1000-1900) - Cold years anomalies (AD 1000-1900) - The 20th century 5.2.2. Smoothed reconstruction: low-frequencies climatic variations and possible related forcing This subpart has been divided in three subsections : - Overview - Solar activity - Volcanic activity Anthropogenic activity

p.1173, lines 14 to 16: Please, state more clearly how you investigated this findings methodologically. The correlations between the solar activity and the reconstruction have been calculated for periods of 100 years. Correlations between the low-frequency solar activity and the 20 year-smoothed temperature reconstruction are 0.21 over their common period respectively. Even though, the correlation is not significant at $p<0.05$ level, records share high values (0.41) during the twelfth and thirteenth centuries (great solar maximum; Eddy 1976) a prolonged depression during 1300– 1600 (0.21) and and increasing values toward the twentieth century (0.31). The prominent interdecadal solar minima, Oort, Wolf, Spörer, Maunder, Dalton, and Damon as well as the corresponding maxima are superimposed upon this secular trend.

p.1174, regional-scale comparisons: Would not it make much more sense to compare your result to Casty et al. 2005? The comparison between Luterbacher et al. 2004 and our reconstruction has been finally deleted and replaced in the discussion by a more-sensed comparison with Casty et al. 2005 more centered on the Alps.

Casty05 is calibrated against different instrumental target records. Yet, the amplitude between the coldest and the warmest year over the past 500 years are close, i.e. 4 °C (between 1807 and 1816) for Casty05 and 4.5°C (between 1639 and 1998) here. The smoothed Casty05 correlates at 0.50 with our record over their 1500–2000 common period and similar courses are observed during the periods 1500-1620 and 1800-2000. A major discrepancy occurs around 1750. During this period, our reconstruction

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might be influenced by differences between larch and pine datasets (Fig.3). Before 1800, Casty05 is systematically higher than our reconstruction but also displays increasing uncertainties related to inhomogeneities in the instrumental data before the mid-19th century as reported by Luterbacher et al. (2004). A bias as 0.7 to 0.8âŮęC (Möberg et al., 2003) and up to 1–2âŮęC (Etien et al., 2008) before 1860, could exist in temperatures, likely because of insufficient or inadequate shading apparatus of the thermometers, and explain the differences between both reconstructions.

p.1174 line 24 to p.1176 line 13: I suggest to delete as rigorous as possible all information that is not absolutely needed in this part. The background information is rather a lot, and the explanations rather long. The section would improve being shorter. The structure of the paragraph has been improved and the section has been shortened. For each reconstruction, we strictly maintained information about: the length of the reconstruction, its resolution, its spatial extent, the proxies and the meteorological data used for calibration.

p.1177, lines 1,2: There are considerable differences in scales between Luterbacher et al. 2004 and your reconstruction. To my knowledge the target in Luterbacher et al. is a highly resolved spatial grid composed of a couple of thousands of grid points. Thus, the spatial differences of the targets should be more highlighted here. The comparison between Luterbacher et al. 2004 and our reconstruction has been finally deleted and replaced in the discussion by a more-sensed comparison with Casty et al. 2005 more centered on the Alps.

p.1178, hemispheric-scale comparisons This section is rather too short and seems a bit odd proportionally compared to the sections Alpine climate history and regional-scale comparisons. Please, balance the three sections more. Several authors show that important differences exist between local/regional and hemispheric reconstructions with phase differences and gaps in the amplitudes of the reconstructions. According to these discrepancies, we consider that the section about regional-scale comparisons can be concise.

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p.1179, line 10: Replace properly by a more precise statement about how you measured (and assessed quantitatively) this match. It is only a qualitative match, as it is always possible that the response of temperature was lagged. Only climate modeling is able to provide more quantitative assessment.

Interactive comment on Clim. Past Discuss., 4, 1159, 2008.

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No.	Serie	% of missing values	Correlation	Number of observations	correction factor (ratio of std.dev)
1	Aleve	49.3	0.87	507	1.39
2	Alpe Musella	57	0.89	430	1.09
3	Berchtesgaden	47.2	0.91	528	1.57
4	Cadini Lago di Misurina	57.5	0.89	425	1.41
5	Chalets de l'Orgère	56.4	0.91	436	1.35
6	Chardonnet	55	0.91	450	1.44
7	Clapouse	62.6	0.88	374	1.38
8	Comasine	46.3	0.91	537	1.36
9	Fodara Vedla Alm	55.6	0.91	444	1.37
10	Freyssinières	56.3	0.88	437	1.52
11	Merveilles	2.6	0.98	974	_
12	Moutieres	48.6	0.89	514	1.45
13	Muestair	61.6	0.89	384	1.69
14	Névache Granges	15.8	0.99	842	1
15	Obergurgl	36.7	0.89	633	1.72
16	Oriol	41.8	0.93	582	1.55
17	Passo Cinque Croci	46.8	0.81	532	1.46
18	Ravin de Congerman	62.4	0.84	376	1.56
19	Ventina	31	0.97	690	1.26
20	Swiss1 (TRW)	0	0.91	1001	_
21	Swiss2 (MXD)	0	0.99	1001	_
22	Aleve	53.9	0.86	461	1.48
23	Ambrizzola	56	0.92	440	1.37
24	Bois des Ayes	51.6	0.88	484	1.47
25	Buffères	68	0.83	313	1.53
26	Chaussettaz	53.2	0.87	468	1.59
27	Clavieres	51.2	0.90	488	1.38
28	Fodara Vedla Alm	51.2	0.90	488	1.46
29	Formin	68	0.87	320	1.36
30	Isola	66.5	0.86	335	1.36
31	Jalavez	60.1	0.87	399	1.54
32	La Joux	51.6	0.87	484	1.42
33	Lac Mirroir	59.2	0.84	408	1.46
34	Manghen	63.7	0.91	363	1.35
35	Obergurgl	58.4	0.87	416	1.43
36	Roubinettes	61.6	0.85	384	1.52
37	Val di Fumo	63.8	0.87	362	1.40
38	Vallee du Tronchet	62.8	0.88	372	1.41
	Mean	**49**	**0.90**		

Table 3. Estimation of the missing data by analogue method.

The first column represents the percentage of missing values considering the period AD 1000-2000 as 100%.

The statistics are calculated between observed values and estimates, when they are available.

Fig. 1. table 3 modified

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Interactive Discussion

Discussion Paper

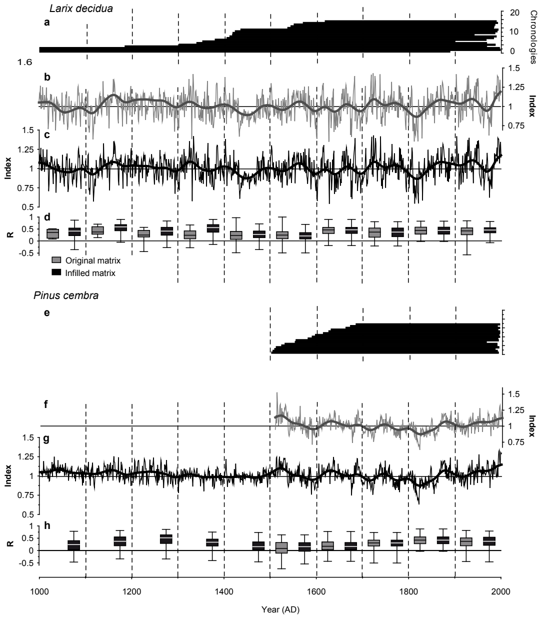

Fig. 3. Adaptative Regional Growth Curve (ARGC) detrended alpine chronologies and signal robustness. **(a), (e),** distribution of the chronologies with each bar representing a single chronology. The alpine larch **(b), (c)** and pine **(f), (g)** ARGC detrended chronologies are calculated for original ((b), (f), grey) and infilled ((c), (g), black) matrixes. The thick lines derive from 20-years low-pass filtering. The box-plots **(d), (h)** display the mean correlations computed for 100-years segments in each matrix.

Fig. 2. figure 3 modified

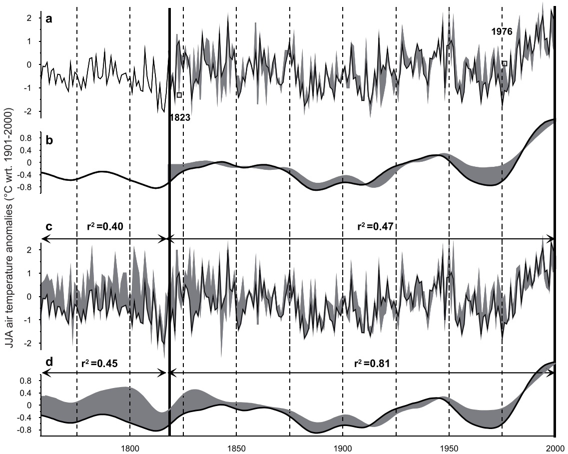

Figure 4. Comparison of the bootstrap ANN reconstruction of the JJA temperatures against the high-elevation (a, grey) JJA mean temperatures (1818-2003) and extra verification using low-elevation data (c, grey) back to 1760. b, d : the 20-year low-pass filter of the bootstrap ANN reconstruction (black) and JJA mean temperatures at high and low elevations (grey). Temperatures are expressed as anomalies with regard to 1901–2000. Grey shadings denote the offset between (warmer) early instrumental and (colder) proxy data.

Fig. 3. figure 4 modified