Foralps WP5 / ZAMG-I

Homogenisation of long term snow data
„Fliri dataset“ 1895-2000
Short summary

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Motivation/Goal:

To hold the quality of long term studies as high as possible, it is fundamental to have the possibility working with homogenous data.

During measuring and monitoring long term climatological data it is impossible to avoid inhomogenities with no climatological background in the data. Reasons for such deviations can be of a wide range – such as changes of instruments, modern observation techniques, changes of the position of a station, different observers, changes of the surrounding area of the station, etc. Those deviations lead mostly to deviations in the observed data.
With the help of indirect (statistical) methods for homogenisation there are possibilities to locate such inhomogenities and correct the data with the following schema:

1) Analysis of existing metadata
   Existing Metadata can show possible inhomogenities.

2) Quality control
   With the help of area plots, quality control is an important Stepp in the homogenisation process. Data exceeding selected tresholds will be removed or corrected.

3) Reference-series
   During the homogenisation process, comparison of reference series with tested series showing fingerprints of possible inhomoginities.

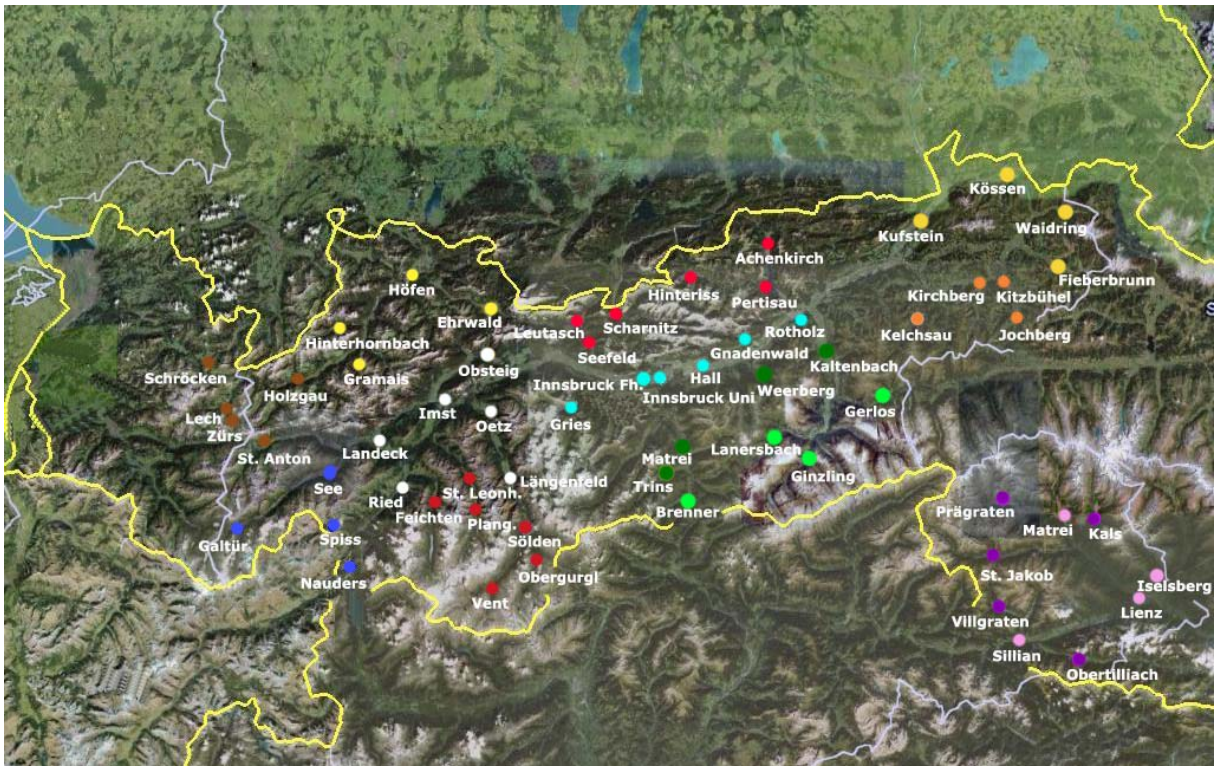
4) Locate break points
   Statistical tests (Craddock, T-Test) locate break points.

5) Data assimilation
   Quality of break points are controlled with the help of metadata, experts or other criterions.
   Corrections factors will be computed and data corrected.

Method:

62 selected stations of the „Fliri dataset“ have been classified in 13 regions with similar characteristics of snow fall and have been selected for the homogenisation process. For Homogenisation monthly sums has been used of fallen fresh snow from 1895-2000.

Overview of the selected stations and regions (Same colour dots have been used for every region):



13 regions have been selected and used fort he homogenisation process in the following order. In every region one „jumping station“ has been selected to „jump“ into the next region as a homogenous reference series.

1) Inntal	Cyan	Jumper: Gnadenwald
2) Karwendel	Red	Jumper: Oberleutasch
3) Ausserfern	Yellow	Jumper: Gramais
4) Arlberg	Brown	Jumper: Holzgau
5) Paznaun	Blue	Jumper: Nauders
6) Pitz- und Ötztal	Dark Red	Jumper: Plangeross
7) Oberland	White	Jumper: Längefeld
8) Tux/Gschnitz	Dark Green	Jumper: Matrei am Brenner
9) Zillertaler	Green	Jumper: Ginzling
10) Osttirol/low	Bright Violett	Jumper: Iselsberg
11) Osttirol/high	Violett	Jumper: Kals
12) Kitzbühler	Red Gold	Jumper: Kelchsau
13) Unterland	Gold	Jumper: Waidring

Following table shows the classification of the stations and regions:

Stations - Regions Fliri dataset						
nr.	station	data	°N	°E	altitude	region
50	See im Paznaun (Ref)	1905-2000	47.08	10.47	1070	Blau
36	Nauders	1895-2000	46.89	10.50	1360	Blau
6	Galtür	1895-2000	46.97	10.18	1583	Blau
56	Spiss	1911-2000	46.96	10.43	1715	Blau
16	Holzgau (Ref)	1895-2000	47.26	10.34	1095	Braun
48	Schröcken	1926-1999	47.26	10.09	1227	Braun
52	St. Anton/Arlberg	1895-2000	47.13	10.27	1289	Braun
32	Lech	1929-1999	47.21	10.14	1450	Braun
62	Zürs	1928-1999	47.17	10.17	1720	Braun
12	Hall	1895-1967	47.28	11.51	560	Cyan
19	InnsbruckUni (Ref)	1929-1996	47.26	11.38	577	Cyan
18	InnsbruckFlug	1952-2000	47.26	11.36	578	Cyan
46	Rotholz	1896-2000	47.39	11.80	590	Cyan
9	Gnadenwald	1895-2000	47.32	11.56	875	Cyan
11	Gries im Sellrain	1908-2000	47.19	11.16	1240	Cyan
23	Kaltenbach	1895-1994	47.30	11.87	600	Dunkelgrün
61	Weerberg	1895-2000	47.30	11.67	880	Dunkelgrün
34	Matrei am Brenner	1895-2000	47.14	11.45	970	Dunkelgrün
57	Trins (Ref)	1895-2000	47.08	11.42	1210	Dunkelgrün
4	Feichten	1895-1997	47.03	10.75	1300	Dunkelrot
54	St. Leonhard	1907-1997	47.07	10.85	1370	Dunkelrot
55	Sölden	1911-2000	46.97	11.01	1380	Dunkelrot
43	Plangeross	1918-2000	46.98	10.87	1620	Dunkelrot
58	Vent	1895-2000	46.86	10.92	1906	Dunkelrot
39	Obergurgl (Ref)	1912-2001	46.86	11.02	1950	Dunkelrot
15	Höfen	1895-2000	47.47	10.68	890	Gelb
3	Ehrwald	1895-2000	47.40	10.92	1015	Gelb
13	Hinterhornbach	1900-2000	47.36	10.46	1100	Gelb
10	Gramais (Ref)	1895-2000	47.27	10.53	1320	Gelb
28	Kufstein (Ref)	1905-2000	47.57	12.17	495	Gold
27	Kössen	1895-2000	47.67	12.41	590	Gold
60	Waidring	1895-2000	47.58	12.57	775	Gold
5	Fieberbrunn	1895-1999	47.47	12.54	780	Gold
8	Ginzling	1911-2000	47.10	11.81	1000	Grün
31	Lanersbach	1895-1997	47.16	11.72	1270	Grün
7	Gerlos	1896-2000	47.22	12.03	1280	Grün
2	Brenner (Ref)	1895-2000	47.01	11.51	1375	Grün
33	Lienz (Ref)	1895-2000	46.83	12.77	676	Hellviolett
35	Matrei inOsttirol	1896-2000	47.00	12.54	1050	Hellviolett
51	Sillian	1895-1996	46.75	12.42	1075	Hellviolett
20	Iselsberg	1895-2000	46.84	12.84	1205	Hellviolett
1	Achenkirch (Ref)	1895-2000	47.52	11.71	920	Rot
14	Hinteriss	1895-2000	47.47	11.47	930	Rot
42	Pertisau	1900-2000	47.44	11.70	935	Rot
47	Scharnitz	1915-2000	47.39	11.26	960	Rot
37	Oberleutasch	1900-1991	47.37	11.12	1130	Rot
49	Seefeld	1895-2000	47.33	11.18	1204	Rot
26	Kitzbühel	1895-2000	47.44	12.40	763	Rotgold
24	Kelchsau	1895-2000	47.39	12.13	815	Rotgold
25	Kirchberg (Ref)	1896-2000	47.45	12.31	830	Rotgold
21	Jochberg	1895-2000	47.38	12.42	980	Rotgold
44	Prägraten	1895-1994	47.02	12.37	1340	Violett
22	Kals	1895-2000	47.01	12.64	1347	Violett
59	Villgraten	1895-1991	46.81	12.37	1400	Violett
53	St. Jakob im Def.	1895-1996	46.92	12.33	1410	Violett
38	Obertilliach (Ref)	1895-2000	46.71	12.62	1430	Violett
41	Oetz	1895-1991	47.20	10.90	775	Weiß
17	Imst	1895-2000	47.24	10.74	785	Weiß
30	Landeck	1895-2000	47.14	10.56	818	Weiß
45	Ried im Oberinntal (Ref)	1895-2000	47.05	10.65	880	Weiß
40	Obsteig	1895-2000	47.30	10.92	950	Weiß
29	Längenfeld	1895-2000	47.07	10.97	1180	Weiß

Homogenisation has been executed with HOCLIS – Software components. Visualisations of quality control and HOCLIS software was done by MATLAB 7.0.

Inhomogenities have been located with Craddocktest (Schönwiese & Malcher 1985). From experiences from former studies (ZAMG-W) this test has been classified as effective and easy to handle. Craddocktest is a sum of standardized differences between two series after following formula:

$$s_i = s_{i-1} + b_m/a_m * a_i - b_i$$

with b for the tested series and a fort he homogenous reference

For snow data no smoothing has been applied.

Data assimilation and filling of missing data, HOCLIS (HOMOGEN2 und COMPLETE) has been apllied.

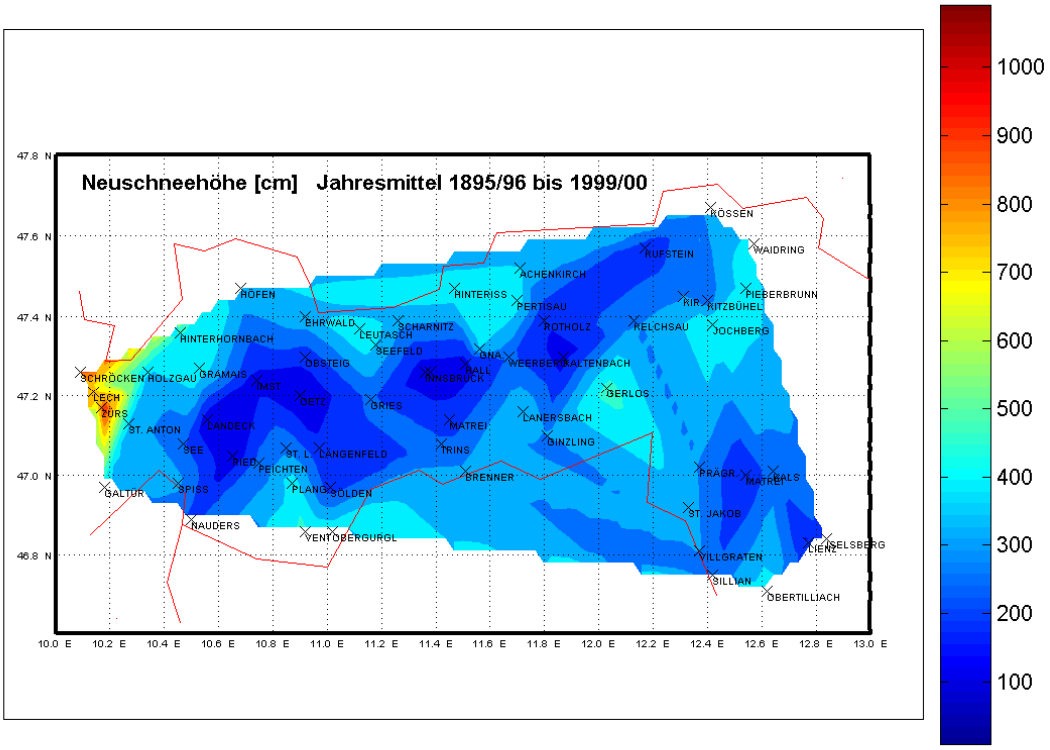
Quality control:

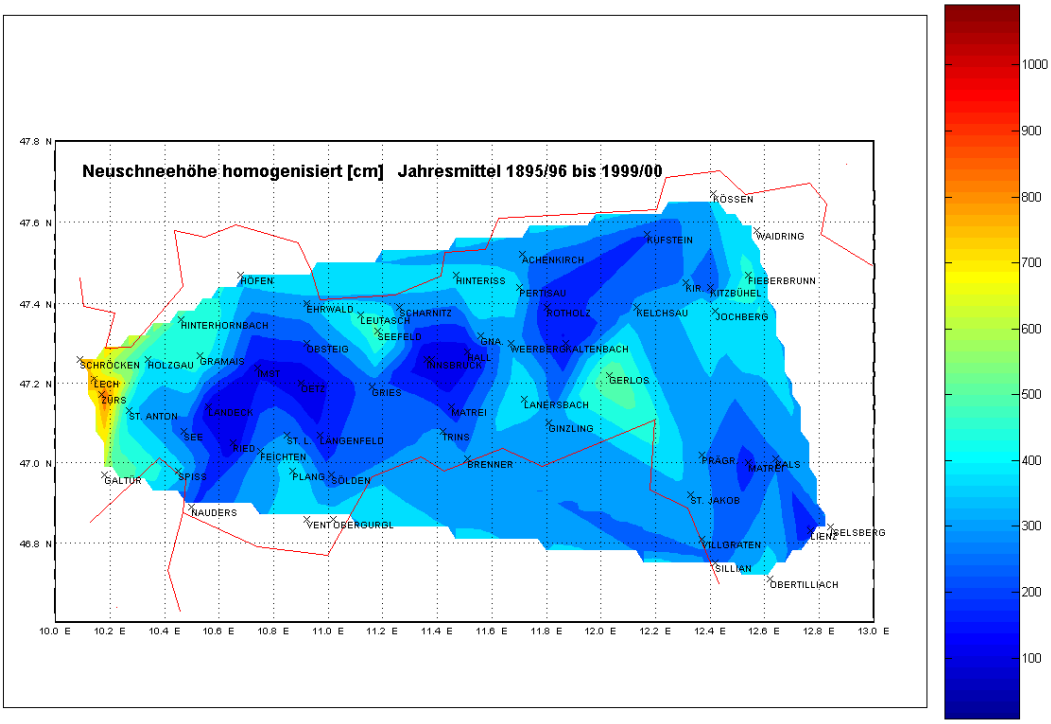
To keep a clear view over this huge data field winter sums have been built for quality control. Therefore every winter has been visualised and classified in similar flow groups, for example NW+ means a strong winter with the major snow falls and flow from Northwest. Ureliable data has been located and removed.

Statistics:
62 Stations, 105 years

Data field:	6510 data points (100%)
Existing data field:	5568 data points (86%)
Missing data:	962 data points (14%)
Unreliable data:	401 data points (6%)
Data field for homogenisation:	5167 data points (79%)

The folllowing two figures show the average of the visualised winter sums from 1895-2000. Upper figure is before homogenisation, lower figure after the homogenisation. Fallen fresh snow is shown in [cm].



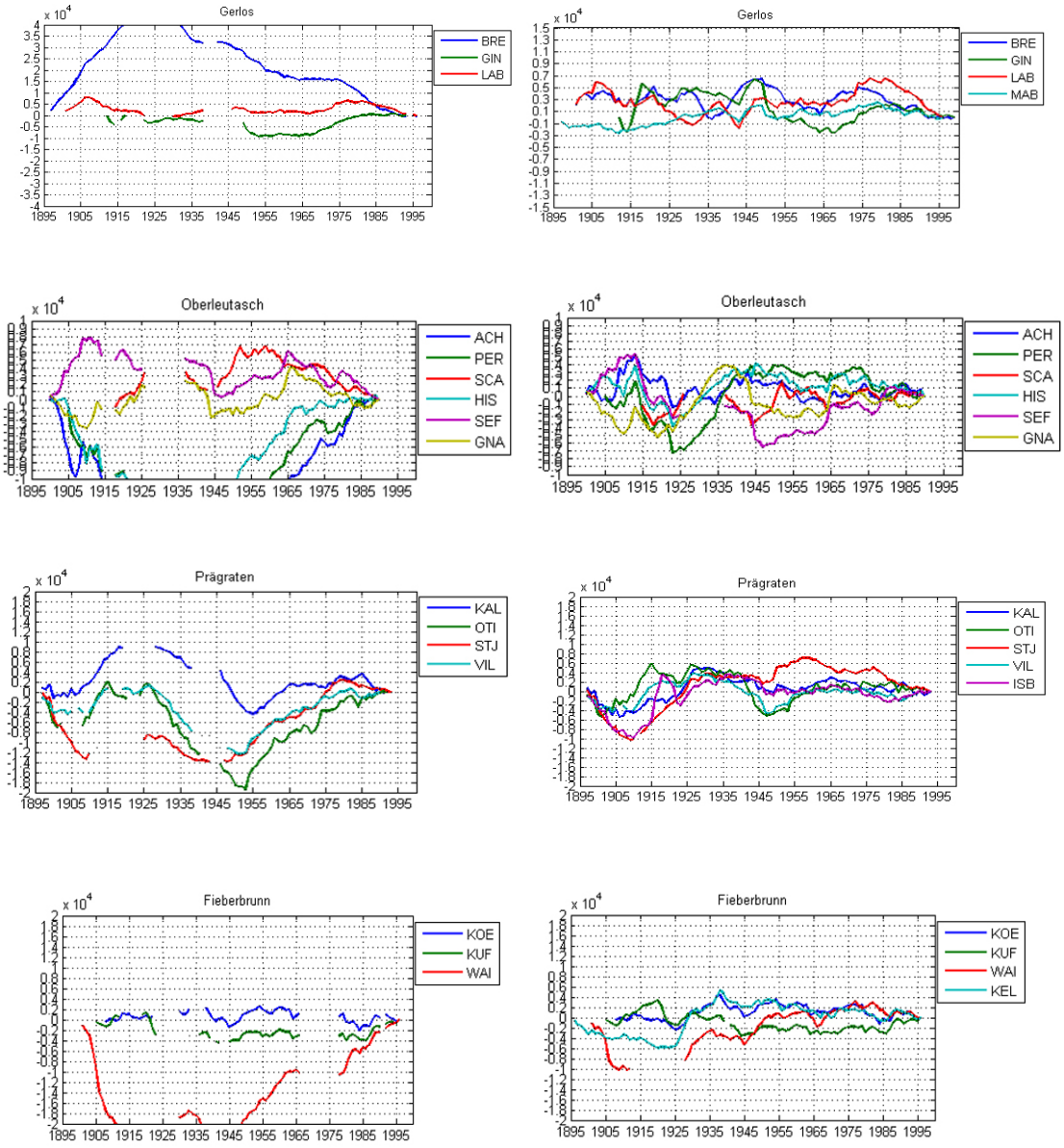


Data assimilation:

To avoid influences to the natural climatological fluctuations as much as possible, only the most striking break points have been corrected. Following table shows a summary of the applied steps in the homogenisation process. Year of break point and reference stations are shown for every station, jumping stations are marked with (S):

Region	Farbe	Station (Springer)	Hom 1	Ref	Hom 2	Ref	Hom 3	Ref	Hom 4	Ref
Inntal	Cyan	Hall	1955	IBU	1923	GNA				
Inntal	Cyan	InnsbruckUni	1965	GRI						
Inntal	Cyan	InnsbruckFlug	1971	ROT						
Inntal	Cyan	Rotholz	1977	IBF	1953	GNA	1936	GNA		
Inntal	Cyan	Gnadenwald (S)	1972	IBF	1961	GRI	1944	GRI	1935	GRI
Inntal	Cyan	Gries	1923	HAL						
Karwendel	Rot	Achenkirch	1945	GNA(S)						
Karwendel	Rot	Hinteriss	1955	GNA(S)	1944	ACH				
Karwendel	Rot	Pertisau	1945	GNA(S)						
Karwendel	Rot	Scharnitz								
Karwendel	Rot	Oberleutasch (S)	1965	GNA(S)						
Karwendel	Rot	Seefeld	1910	ACH						
Ausserfern	Gelb	Höfen	1977	GRA	1969	GRA	1955	LEU		
Ausserfern	Gelb	Ehrwald	1982	GRA	1953	LEU(S)				
Ausserfern	Gelb	Hinterhornbach	1979	HOE	1924	HOE	1913	HOE		
Ausserfern	Gelb	Gramais (S)	1955	LEU(S)	1924	LEU(S)				
Arlberg	Braun	Holzgau (S)	1979	STA						
Arlberg	Braun	Schröcken	1979	GRA(S)						
Arlberg	Braun	St. Anton/Arlberg	1965	HOL	1955	HOL				
Arlberg	Braun	Lech	1976	ZUE						
Arlberg	Braun	Zürs	1987	GRA(S)	1979	GRA(S)	1961	GRA(S)		
Paznaun	Blau	See im Paznaun								
Paznaun	Blau	Nauders (S)								
Paznaun	Blau	Galtür	1989	NAU	1987	HOL(S)	1933	HOL(S)		
Paznaun	Blau	Spiss								
Pitz/Ötztal	Dunkelrot	Feichten	1965	NAU(S)						
Pitz/Ötztal	Dunkelrot	St. Leonhard								
Pitz/Ötztal	Dunkelrot	Sölden								
Pitz/Ötztal	Dunkelrot	Plangeross (S)								
Pitz/Ötztal	Dunkelrot	Vent	1965	NAU(S)						
Pitz/Ötztal	Dunkelrot	Obergurgl	1964	NAU(S)						
Oberland	Weiß	Oetz								
Oberland	Weiß	Imst	1983	OBS						
Oberland	Weiß	Landeck								
Oberland	Weiß	Ried im Oberinntal								
Oberland	Weiß	Obsteig	1964	RIE						
Oberland	Weiß	Längenfeld (S)	1964	LAN						
Tux/Gschnitz	Dunkelgrün	Kaltenbach	1955	WER						
Tux/Gschnitz	Dunkelgrün	Weerberg	1952	LAE(S)						
Tux/Gschnitz	Dunkelgrün	Matrei am Brenner (S)	1961	WER						
Tux/Gschnitz	Dunkelgrün	Trins	1972	LAE(S)	1945	LAE(S)				
Zillertaler	Grün	Ginzling (S)								
Zillertaler	Grün	Lanersbach	1953	MAB(S)	1908	MAB(S)				
Zillertaler	Grün	Gerlos	1977	MAB(S)	1967	BRE	1953	MAB(S)	1924	MAB(S)
Zillertaler	Grün	Brenner	1990	MAB(S)	1975	MAB(S)				
Osttirol/low	Hellviolett	Lienz	1985	SIL						
Osttirol/low	Hellviolett	Matrei inOsttirol	1924	LIE						
Osttirol/low	Hellviolett	Sillian	1932	ISB						
Osttirol/low	Hellviolett	Iselsberg (S)	1983	SIL						
Osttirol/high	Violett	Prägraten	1982	VIL	1953	KAL	1926	OTI		
Osttirol/high	Violett	Kals (S)	1955	VIL	1946	VIL				
Osttirol/high	Violett	Villgraten								
Osttirol/high	Violett	St. Jakob im Def.	1909	ISB(S)						
Osttirol/high	Violett	Obertilliach	1984	VIL						
Kitzbühler	Rotgold	Kitzbühel	1949	KEL	1912	KIR				
Kitzbühler	Rotgold	Kelchsau (S)	1952	KIZ						
Kitzbühler	Rotgold	Kirchberg	1969	KIZ	1948	KIZ				
Kitzbühler	Rotgold	Jochberg	1976	KEL	1969	KEL	1951	KIR	1912	KEL
Unterland	Gold	Kufstein								
Unterland	Gold	Kössen								
Unterland	Gold	Waidring (S)	1953	KEL	1938	KEL				
Unterland	Gold	Fieberbrunn								

Aim of Craddocktest is to bring the Craddockcurves as close and smooth as possible to the zero line. Automating this process would mean to ignore natural climatological fluctuations and therefore it is to avoid. Following figure shows Craddockcurves for 4 selected stations before and after homogenisation process:



Left: before homogenisation – break points are visible with a change of the slope of the curve – right: after homogenisation – curves are smoother and closer to zero line

Filling missing data:

With selection of a homogenous reference series, missing data can be completed by using COPLETE of the HOCLIS software group. COMPLETE has only been used, when missing data had existing data before and after the data gap.
598 data points (9%) have been completed using this software tool. After homogenisation the data set had 5746 data points (88%). 764 data points (12%) still remained without a value.

Following table shows the results of COMPLETE:

COMPLETE – filling missing data points										
Region	**Farbe**	**Station**	**Comp 1**	**Ref**	**Comp 2**	**Ref**	**Comp 3**	**Ref**	**Comp 4**	**Ref**
Inntal	Cyan	Hall	1945-1952	IBU						
Inntal	Cyan	InnsbruckUni	1939-1942	ROT						
Inntal	Cyan	InnsbruckFlug								
Inntal	Cyan	Rotholz	1924-1926	HAL	1919-1946	GNA	1954-1955	IBU	1988-1992	IBU
Inntal	Cyan	Gnadenwald	1921-1930	ROT	1994	IBU				
Inntal	Cyan	Gries	1939-1944	ROT	1994	IBU				
Karwendel	Rot	Achenkirch	1945	GNA						
Karwendel	Rot	Hinteriss	1927-1937	GNA	1994	ACH				
Karwendel	Rot	Pertisau	1927-1935	GNA	1939-1942	GNA				
Karwendel	Rot	Scharnitz	1944-1946	GNA	1991-1992	GNA				
Karwendel	Rot	Oberleutasch	1915-1918	GNA	1927-1937	GNA				
Karwendel	Rot	Seefeld								
Ausserfern	Gelb	Höfen	1940-1946	LEU	1991	GRA				
Ausserfern	Gelb	Ehrwald	1920-1929	LEU	1939-1946	LEU				
Ausserfern	Gelb	Hinterhornbach	1926-1937	HOE	1945-1947	HOE	1991	GRA		
Ausserfern	Gelb	Gramais	1929-1937	HOE	1941-1945	LEU	1994-1995	HOE		
Arlberg	Braun	Holzgau	1899-1903	STA	1931-1936	GRA	1945	GRA		
Arlberg	Braun	Schröcken	1944-1946	HOL						
Arlberg	Braun	St. Anton/Arlberg	1943-1946	GRA						
Arlberg	Braun	Lech	1944-1946	GRA						
Arlberg	Braun	Zürs	1938-1946	SCR	1991-1992	SCR				
Paznaun	Blau	See im Paznaun	1908-1911	GAL	1997-1999	GAL				
Paznaun	Blau	Nauders	1924-1926	GAL						
Paznaun	Blau	Galtür								
Paznaun	Blau	Spiss	1948-1954	GAL	1997-1999	GAL				
Pitz/Ötztal	Dunkelrot	Feichten	1939-1945	NAU						
Pitz/Ötztal	Dunkelrot	St. Leonhard	1924-1932	PLA	1939-1946	PLA				
Pitz/Ötztal	Dunkelrot	Sölden	1997-2000	NAU						
Pitz/Ötztal	Dunkelrot	Plangeross	1997-2000	NAU						
Pitz/Ötztal	Dunkelrot	Vent								
Pitz/Ötztal	Dunkelrot	Obergurgl	1924-1932	PLA						
Oberland	Weiß	Oetz	1918-1919	LAN	1939-1942	LAN				
Oberland	Weiß	Imst	1922-1931	LAE	1940-1947	LAN				
Oberland	Weiß	Landeck	1924-1927	LAE						
Oberland	Weiß	Ried im Oberinntal	1903-1905	LAN	1939-1942	LAN	1991-1992	LAN		
Oberland	Weiß	Obsteig	1912-1931	LAE	1939-1944	LAN	1952-1954	LAN		
Oberland	Weiß	Längenfeld	1944-1946	LAN	1991	LAN				
Tux/Gschnitz	Dunkelgrün	Kaltenbach	1917-1918	LAE	1922-1923	LAE	1964-1966	WER		
Tux/Gschnitz	Dunkelgrün	Weerberg	1899-1902	LAE	1904-1931	TRI	1946-1949	TRI	1991-1992	MAB
Tux/Gschnitz	Dunkelgrün	Matrei am Brenner	1939-1944	LAE						
Tux/Gschnitz	Dunkelgrün	Trins	1919-1928	LAE						
Zillertaler	Grün	Ginzling	1915-1916	MAB	1919-1922	MAB	19139-1949	MAB	1994-1999	BRE
Zillertaler	Grün	Lanersbach	1923-1930	MAB	1939-1946	MAB				
Zillertaler	Grün	Gerlos	1919-1942	MAB	1994-1999	BRE				
Zillertaler	Grün	Brenner	1901-1928	LAB						
Osttirol/low	Hellviolett	Lienz	1913-1918	GIN	1920-1931	MAO	1939-1949	MAO		
Osttirol/low	Hellviolett	Matrei inOsttirol	1897-1904	ISB	1919-1921	ISB	1991-1992	ISB	1997-2000	ISB
Osttirol/low	Hellviolett	Sillian	1916-1931	GIN	1939-1946	MAO				
Osttirol/low	Hellviolett	Iselsberg	1915-1923	GIN	1943-196	MAO				
Osttirol/high	Violett	Prägraten	1944-1946	VIL						
Osttirol/high	Violett	Kals	1920-1928	VIL	1939-1945	STJ	1992-1993	STJ		
Osttirol/high	Violett	Villgraten	1916-1919	PRA	1939-1943	STJ	1947-1948	KAL		
Osttirol/high	Violett	St. Jakob im Def.	1913-1925	PRA	1945-1947	VIL				
Osttirol/high	Violett	Obertilliach	1903-1908	KAL	1921-1924	VIL	1941-1945	STJ	1997-2000	KAL
Kitzbühler	Rotgold	Kitzbühel	1916-1919	KIR	1925-1928	KIR	1940-1943	JOC	1945-1947	JOC
Kitzbühler	Rotgold	Kelchsau	1927-1930	JOC	1997-2000	KIZ				
Kitzbühler	Rotgold	Kirchberg	1901-1903	JOC	1940-1943	JOC	1945-1947	KEL	1997-2000	KIZ
Kitzbühler	Rotgold	Jochberg	1997-2000	KIZ						
Unterland	Gold	Kufstein	1913-1919	KEL	1924-1936	KEL	1943-1945	KOE		
Unterland	Gold	Kössen	1923-1928	KEL	1934-1938	KEL	1997-2000	KEL		
Unterland	Gold	Waidring	1941-1946	KEL	1997-2000	KEL				
Unterland	Gold	Fieberbrunn	1926-1930	KEL	1967-1978	KOE	1991	KOE		

Conclusion:

Recapitulatory it can be said that the homogenisation process of the „Fliri – dataset“ had a positive effect to the data, even when not every data point could be completed and not existing every break could be detected.