Homogenization of the historical series from the Coimbra Magnetic Observatory, Portugal

A. L. Morozova[1], P. Ribeiro[1,2], and M. A. Pais[1]

[1] University of Coimbra, CITEUC, Department of Physics, Coimbra, Portugal
[2] University of Coimbra, CITEUC, OGAUC, Coimbra, Portugal

Correspondence to: A.L. Morozova (annamorozovauc@gmail.com)

Supplementary Material

Tables S1-S4 contain metadata (dates of the instrument replacements, relocations, changes in the measurement/calculation procedures etc.) for the COI H, I, Z and D geomagnetic field components, respectively.

Table S5 contains a list of European geomagnetic observatories whose data were used as reference series for the COI H, I and Z series.

Figure S1 shows variations of the COI SV series.

Figure 2 shows differences between COV-OBS model estimations calculated with all available stations data and without COI data.

Figures S3-S9 show homogeneity tests statistics for the original and corrected COI H (S3-S5), I (S6-S7) and Z (S8-S9) series.

Figure S10 shows time derivative of the COI H, I and Z series on the month-to-month time scale.

Figure S11 shows ΔH series for COI and several reference observatories (SFS, PRA, PER, OSL, PSM and GRW).

Figure S12 allows to compare COI Z variations for the 1990-2006 period with monthly mean COI temperature series.

Table S1
Metadata for the H data set: dates of the instrument replacements, relocations, changes in the measurement/calculation procedures etc.

	date	metadata
Cumeada	1866 June	beginning of measurements at *Cumeada*
	1878 January	installation of the Unifilar of Elliott, precision 1 nT
	1929 May	opening of the electrical tram services
	1932 January	relocation to *Alto da Baleia*
	1941 December	interruption of measurements
Alto da Baleia	1951 October	Measurements are restated with the Unifilar of Elliott
	1952 January	installation of the QHM (nn. 190-191), precision 1 nT
	1952 November – 1953 January	installation of the QHM (nn. 220-221), precision 1 nT
	1953 September	comparison with 3 instruments (QHM nn. 228, 229, 230) from the Committee on International Comparisons of Magnetic Standards, $\Delta = -5.4$ nT, in average
	1955 July	QHM n. 220 is replaced by QHM n. 307
	1959 August	comparison with instruments from the Committee on International Comparisons of Magnetic Standards, $\Delta = -9.3$ nT, in average
	1968 April	comparison with instruments from the Committee on International Comparisons of Magnetic Standards, $\Delta = -18$ nT, in average
	1976 August	comparison with instruments from the Committee on International Comparisons of Magnetic Standards, $\Delta = +24$ nT, in average
	2006 May	end of measurements

Table S2
Metadata for the I data set: dates of the instrument replacements, relocations, changes in the measurement/calculation procedures etc.

	date	metadata
Cumeada	1876 September	Inclinometer of Dover, precision 1'
	1922 November	New needles
	1928 September	New needles
	1929 May	opening of the electrical tram services
	1931 January	Simultaneous measurements at 2 sites
Alto da Baleia	1932 January	relocation to *Alto da Baleia*
	1935 October	Sartorius earth inductor, precision 0.2-0.5'
	1938 December	end of measurements
	1939 January – 1940 May	The data for this time interval are absent from the COI annual books

Table S3
Metadata for the Z data set: dates of the instrument replacements, relocations, changes in the measurement/calculation procedures etc.

	date	metadata
Alto da Baleia	1951 October	beginning of absolute measurements with BMZ n. 69
	1953 January	installation of BMZ (n. 80); comparison of instruments BMZ_{69} - BMZ_{80} = 25 nT
	1963 January	no specific records about Z measurements in the Observatory logbooks before this date
	1963 June	mirror adjustment of the Askania variometer implied a baseline change
	1977 January	installation of BMZ (n. 130)
	2006 May	end of measurements

Table S4. Metadata for the D data set: dates of the instrument replacements, relocations, changes in the measurement/calculation procedures etc. (adapted from Morozova et al., 2014).

	date	metadata
Cumeada	1875 July (?)	new method to calculate D was applied; new azimuth mark was calculated
	1878 January	Unifilar of Elliot was installed
	1919 January	new procedure to compute the data
	1930 January	tram line installation
Alto da Baleia	1932 January	relocation to *Alto da Baleia*
	1948 October – 1951 March	no measurements, data in the annual books were interpolated
	1951 October	reinstallation of variographs; new routines for absolute measurements
	1955 July	installation of a new declinometer (Askania) – after comparison with former Elliot no significant differences were found
	1989 May	small instrumental problems and construction in the nearby area
	1990 June-July	small instrumental problems and construction in the nearby area
	1994 May	change of the suspension wire
	2003 March	change of the suspension wire; correction already applied
	2006 January	new instrument was installed in 2006/06; the correction of -6' was applied to the data starting in 2006/01

Table S5.
A list of European observatories (EOs) used to obtain the reference series for H, I and Z. Some stations have changes in the instruments and/or were re-located.

	name	code	country	lat.	long.	period	Used as reference series for...
1	Parc Saint-Maur (Paris)	PSM	France	48º 49'	2º 30'	1883-1900	H, I, Z
	Val Joyeux	VLJ		48º 49'	2º 01'	1901-1936	
	Chambon-la-Foret	CLF		48º 01'	2º 16'	1936-1956; 1957-1967; 1968-1982; 1983-2011	
2	Nantes	NTS	France	47º 15'	358º 26'	1923-1958	H, I
3	Perpignan	PER	France	42º 42'	02º 53'	1886-1901; 1907-1910	H, I
4	Toledo	TOL	Spain	39º 53'	355º 27'	1947-1981	H, Z
	San Pablo de los Montes	SPT		39º 33'	355º 39'	1981-2011	
5	Ebro (Tortosa)	EBR	Spain	40º 49'	0º 30'	1909-1937; 1943-1983; 1995-2009	H, I, Z
6	Logrono	LGR	Spain	42º 27'	357º 30'	1957-1976	H, Z
7	San Fernando	SFS	Spain	36º 28'	353º 48'	1880-1963; 1964-1969; 1970-1979	H, I, Z
	San Fernando	SFS2		36º 30'	353º 53'	1991-2005	
8	Oslo	OSL	Norway	59º 55'	10º 43'	1843-1930	H, I
9	Prague	PRA	Czech Republic	50º 05'	14º 25'	1830-1926	H
10	Eskdalemuir	ESK	UK	55º 19'	356º 48'	1908-2011	H, I, Z
11	Greenwich	GRW	UK	51º 29'	0º 0'	1840-1925	H
12	Munich	MNH	Germany	48º 09'	11º 37'	1841-1886; 1899-1926	H, I
13	Potsdam	POT	Germany	52º 23'	13º 4'	1890-2011	H, I, Z
14	Lisbon	LIS	Portugal	38º 43'	350º 51'	1858-1900	H, I
15	L'Aquila	AQU	Italy	42º 23'	13º 19'	1960-2009	H, Z
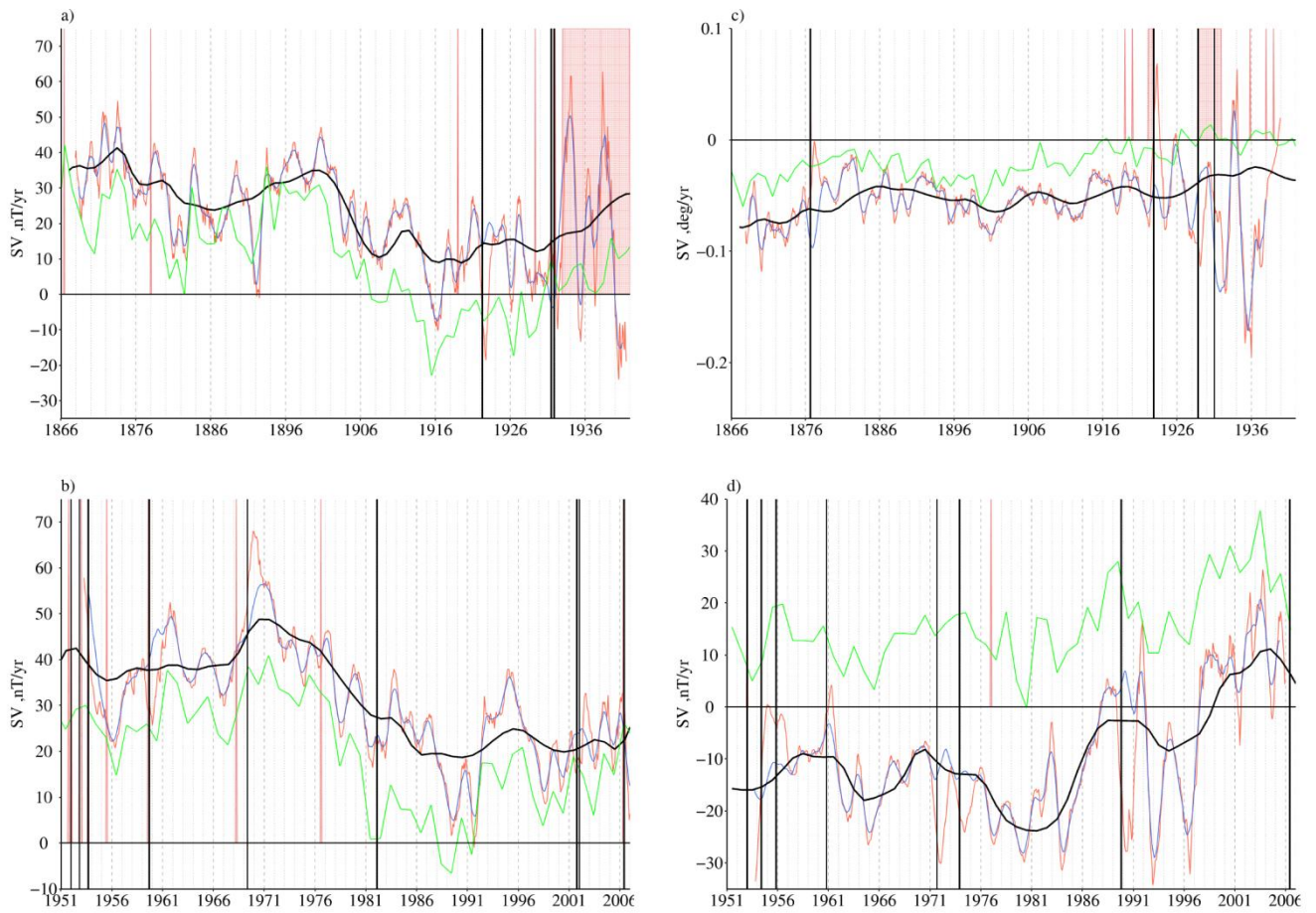
Figure S1. Original (red lines) and corrected (blue lines) COI SV H (a and b), I (c) and Z (d) series smoothed by the moving averaging with 12-month long window, SV from the corresponding COV-OBS model (black lines) and SV of the reference series from the EO observatories (green lines). Pink vertical lines/rectangles mark possible dates of HB, black vertical lines mark dates of corrections.
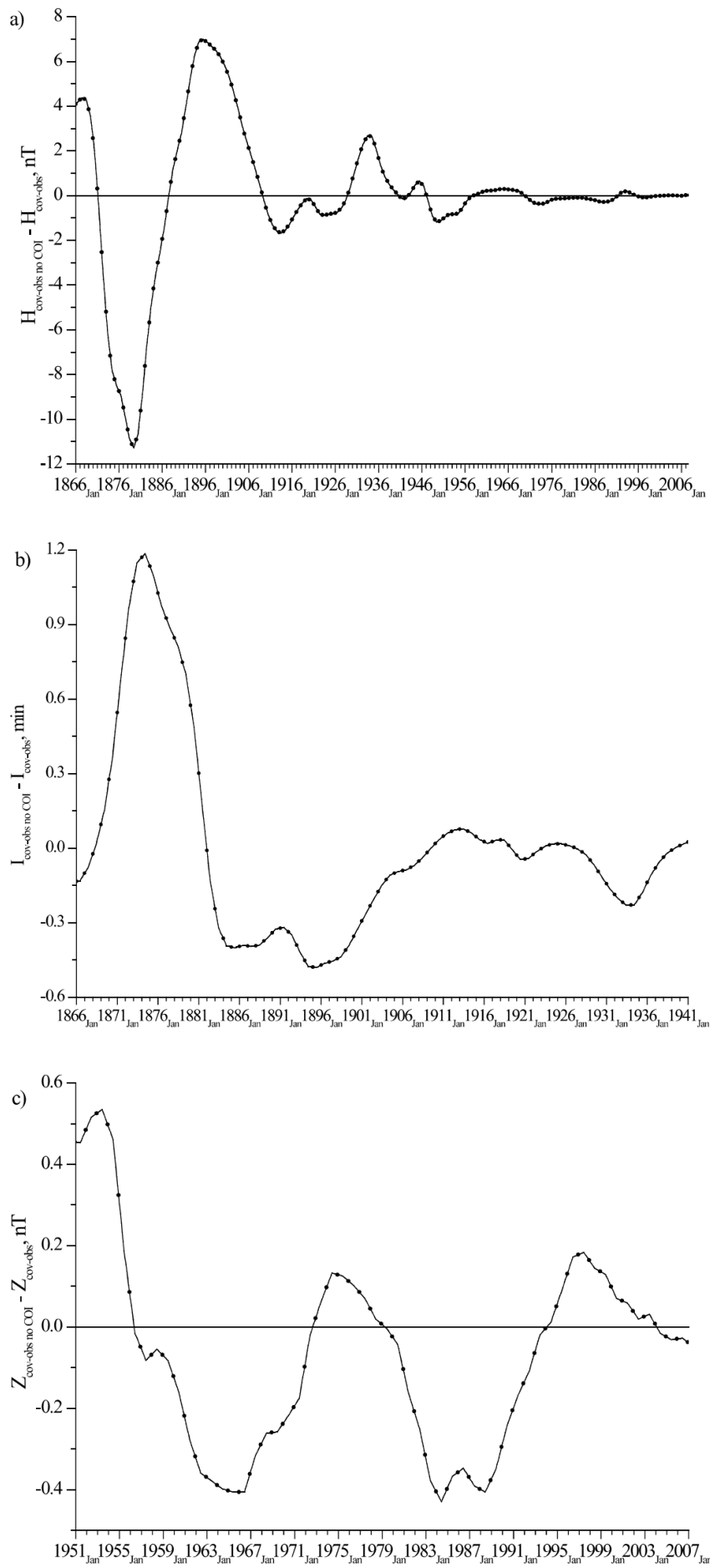
Figure S2. Differences between two models: COV-OBS and COV-OBS without COI: H (a), I (b), and Z (c) components.
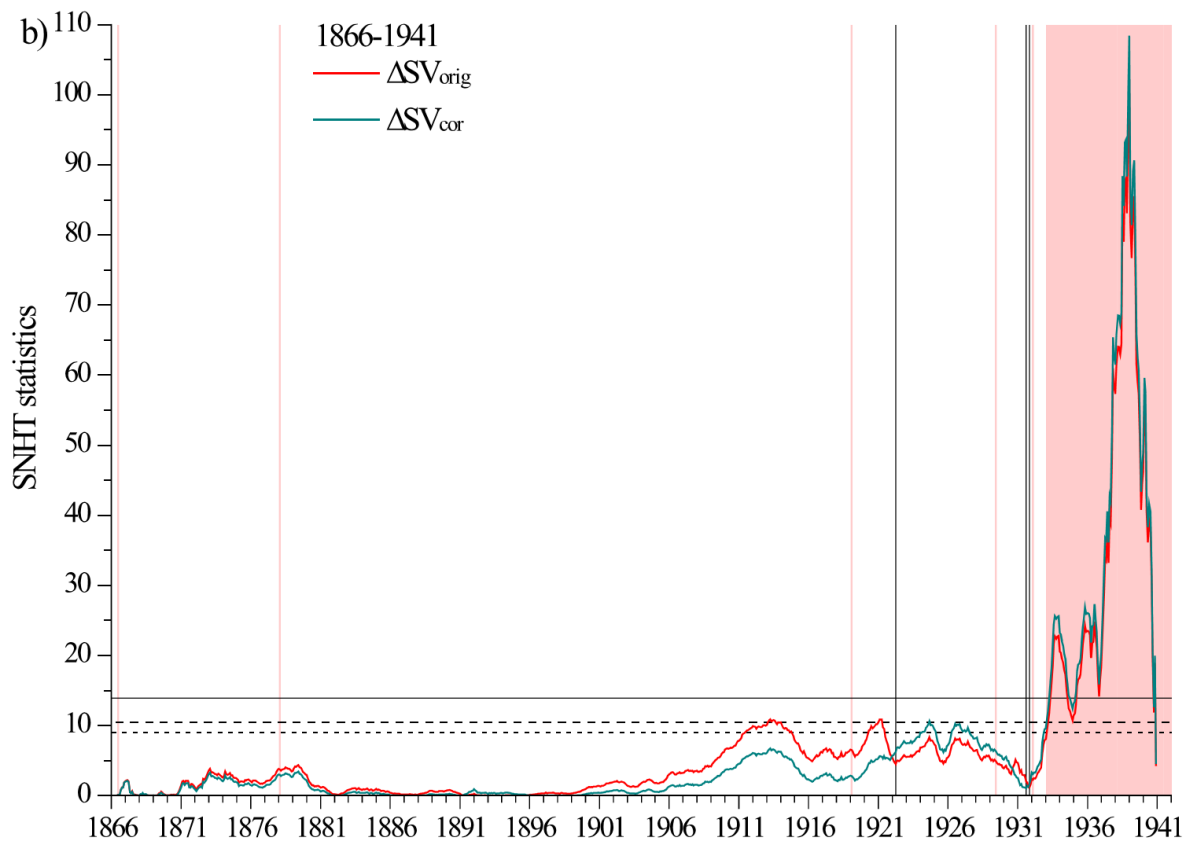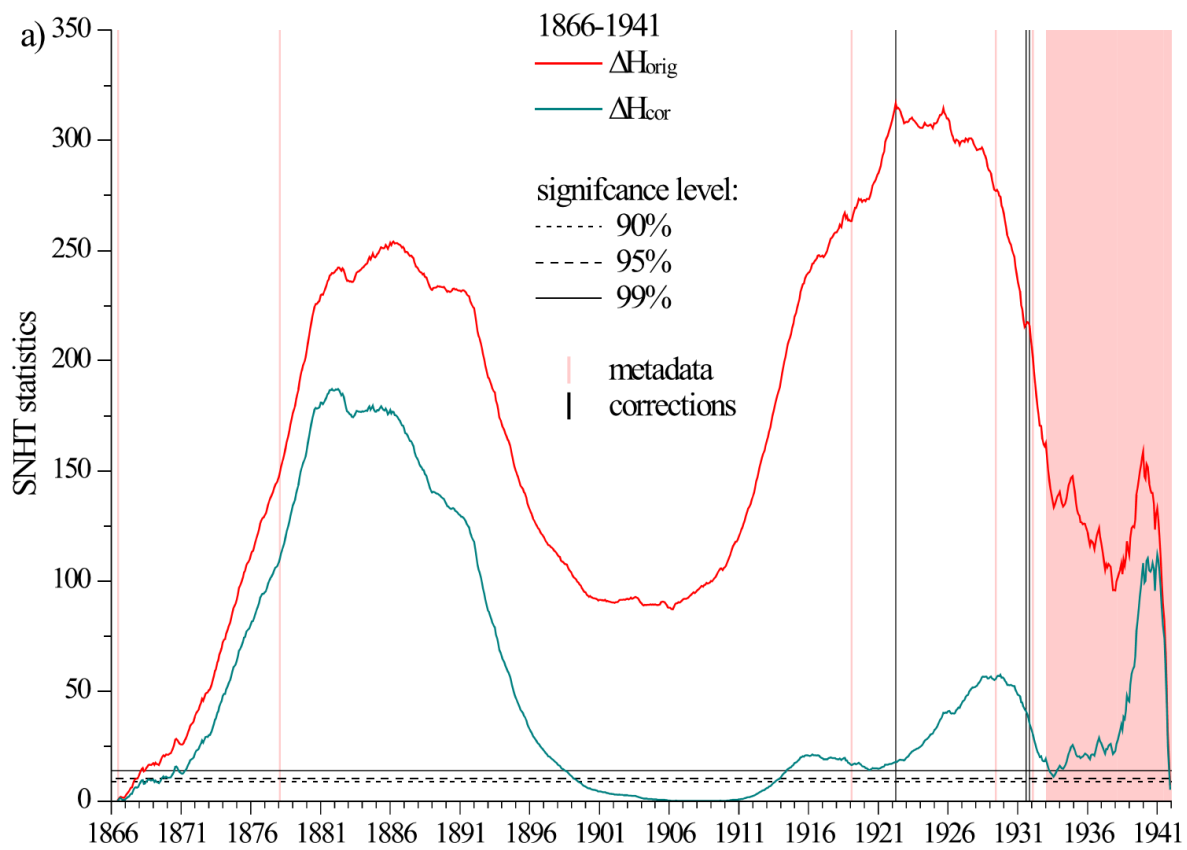
Figure S3. Homogeneity tests statistics for COI: H (a) and SV (b) original (red) and corrected (dark cyan) series for the time interval 1866-1941. Pink vertical lines/rectangles mark possible dates of HB, black vertical lines mark dates of corrected HBs. Dotted, dashed and solid horizontal lines mark levels of 90%, 95% and 99% of the statistical significance of HBs.
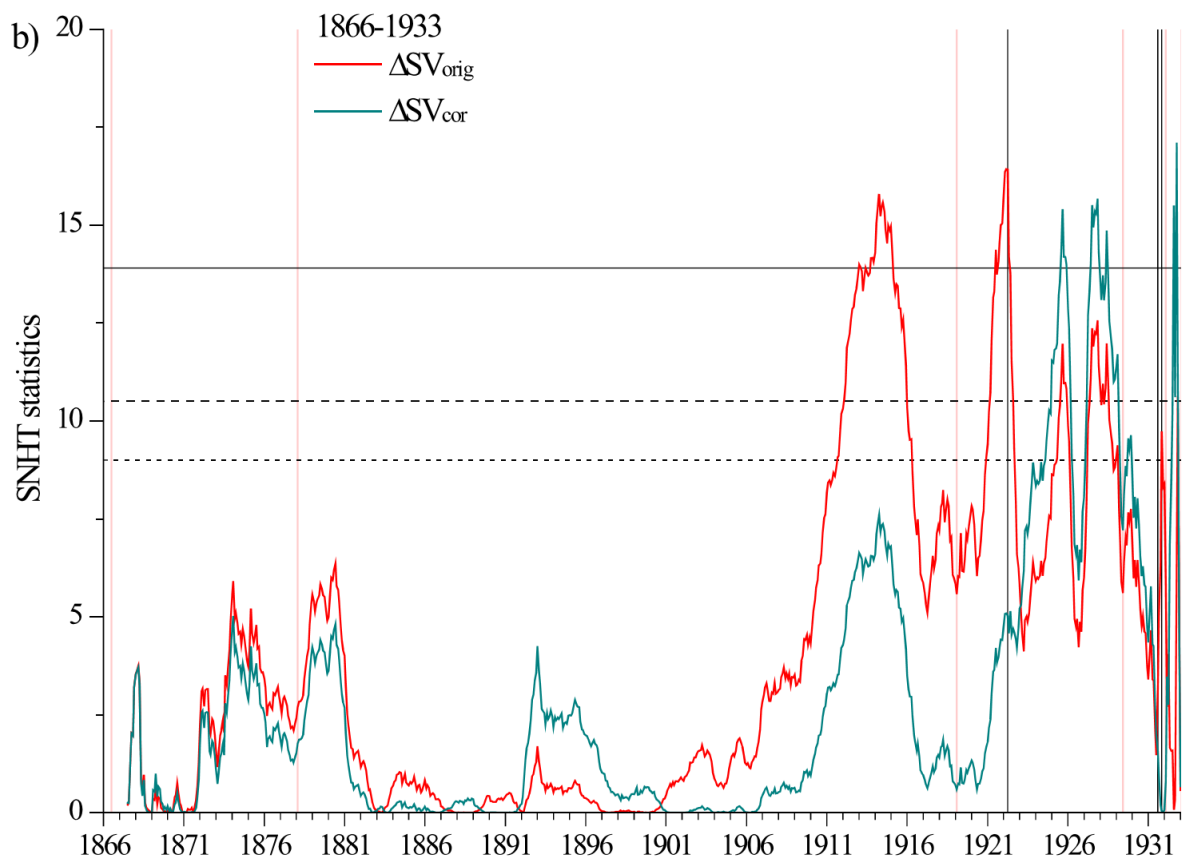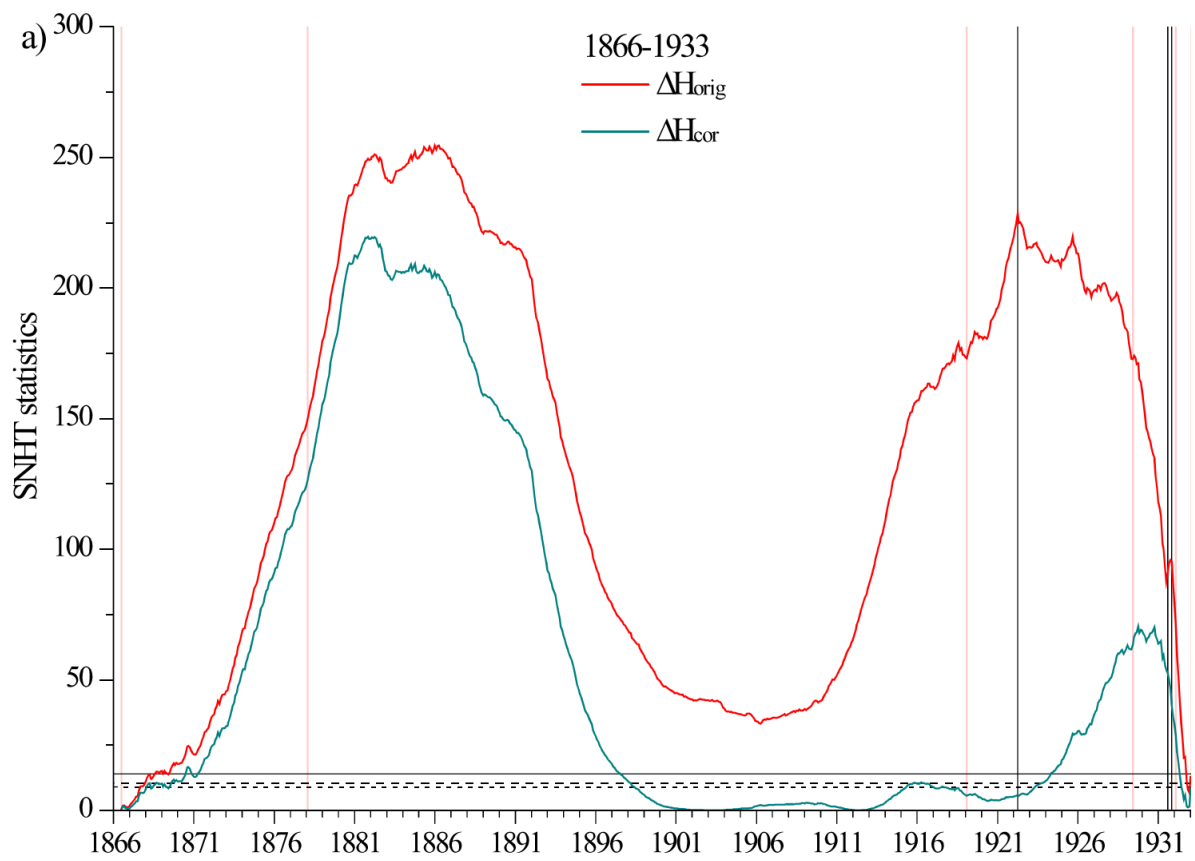
Figure S4. Same as Figure S3 but for the time interval 1866-1933.
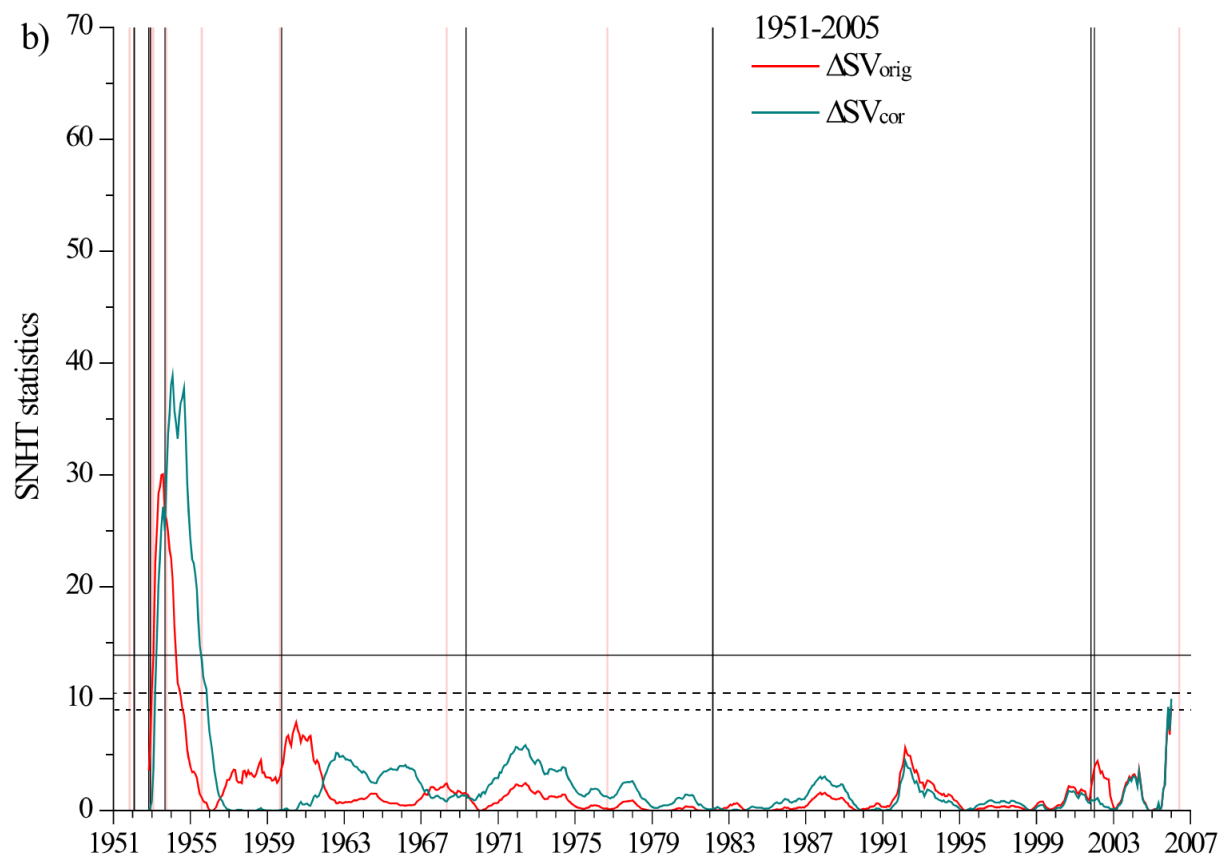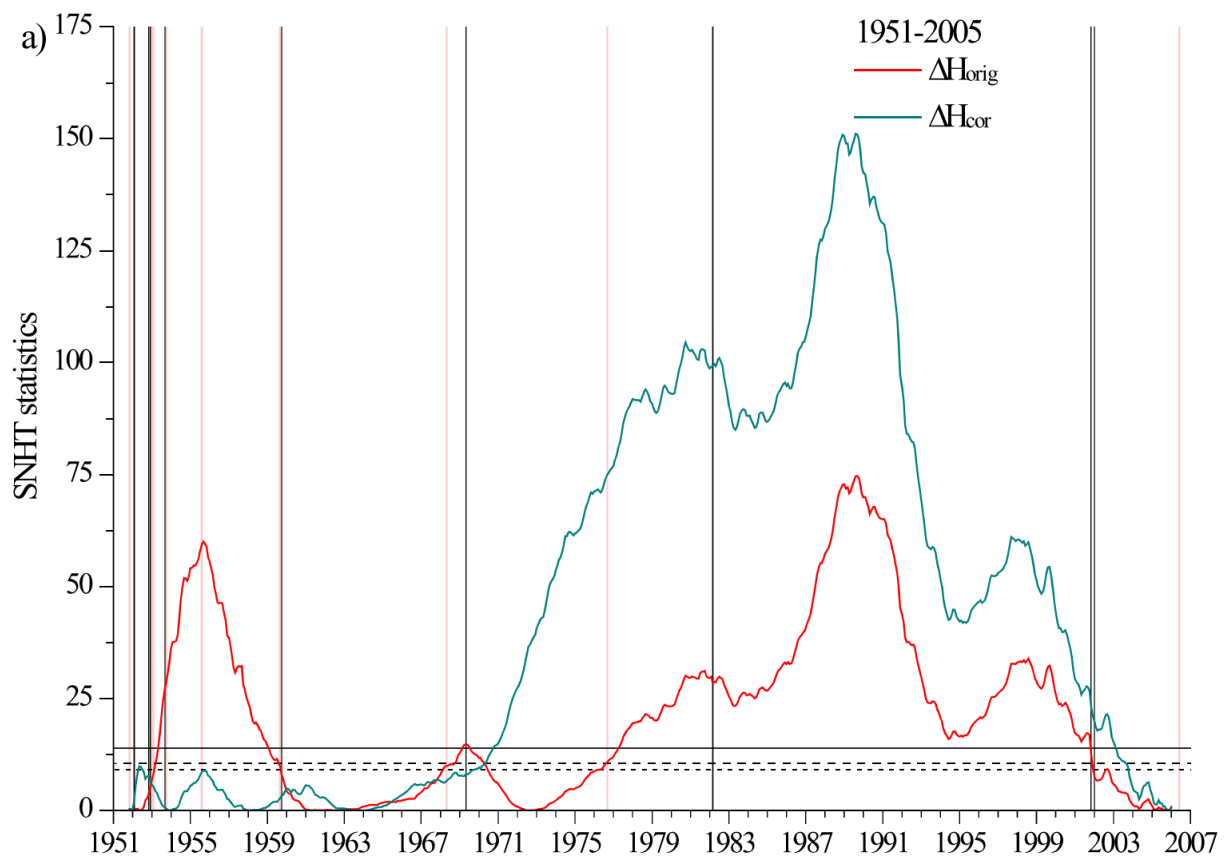
Figure S5. Same as Figure S3 but for the time interval 1951-2005.
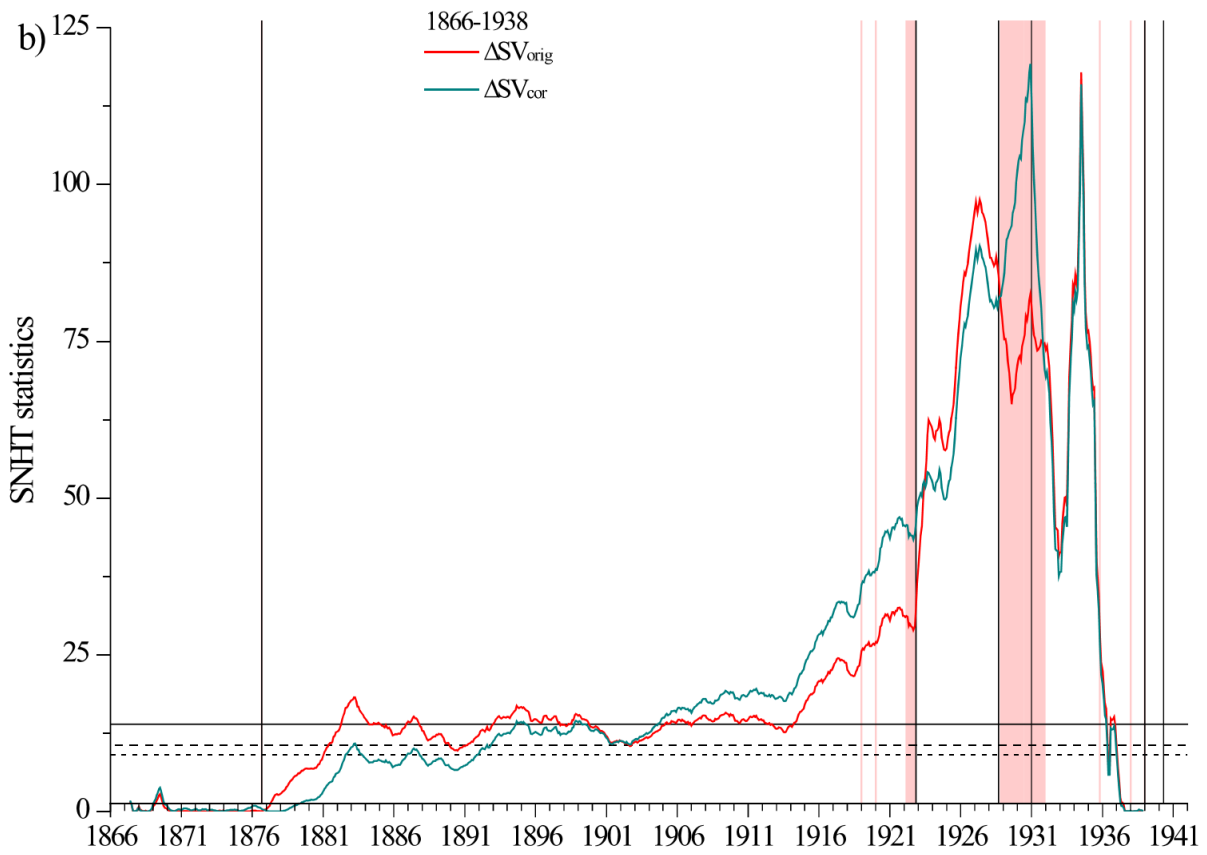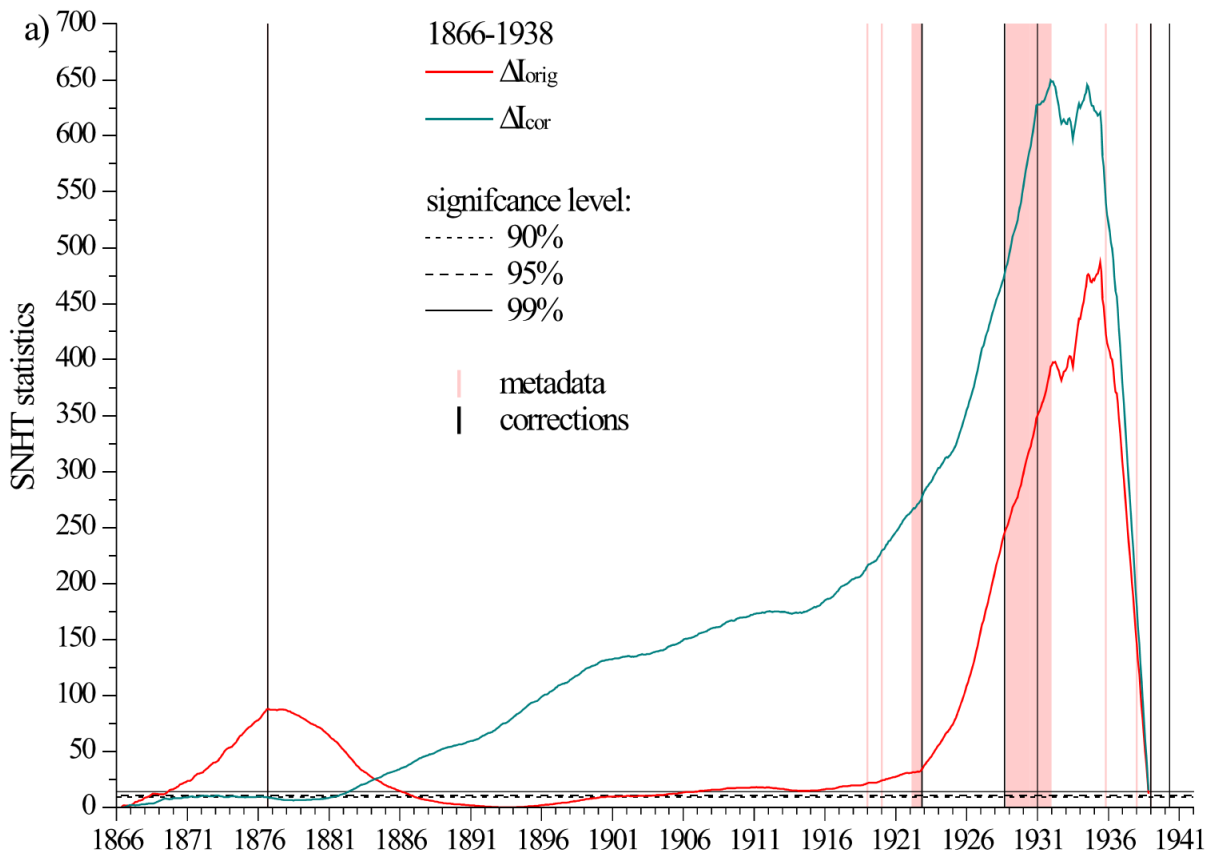
Figure S6. Same as Figure S3 but for COI I. Time interval: 1866-1938.
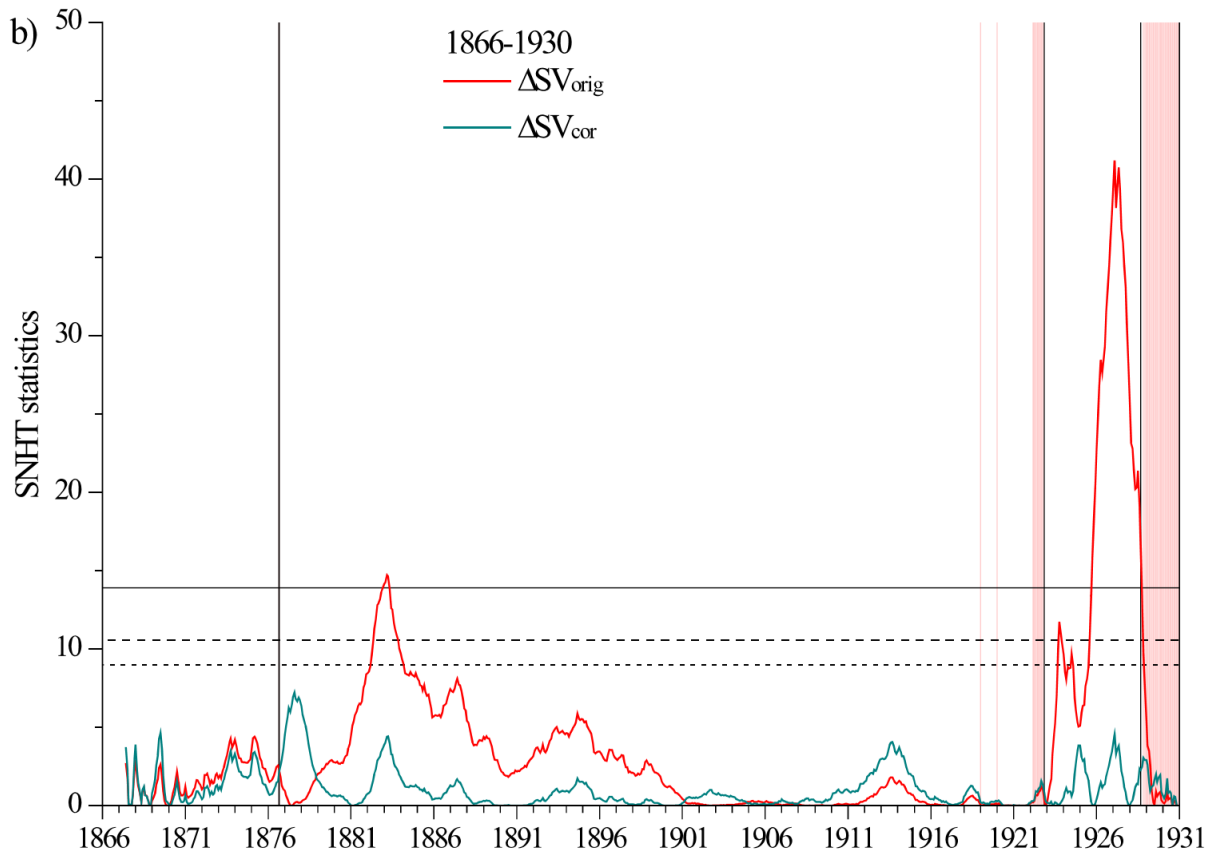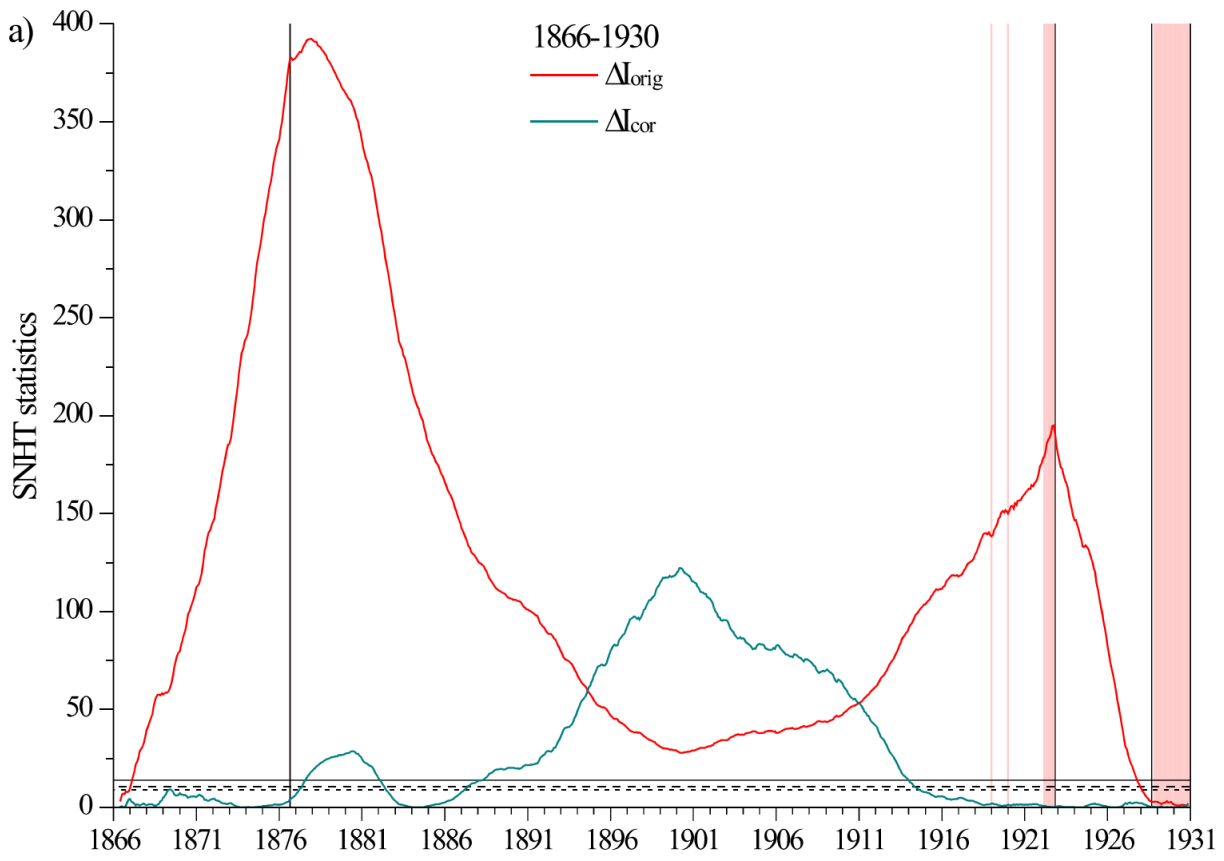
Figure S7. Same as Figure S6 but for the time interval 1866-1930.
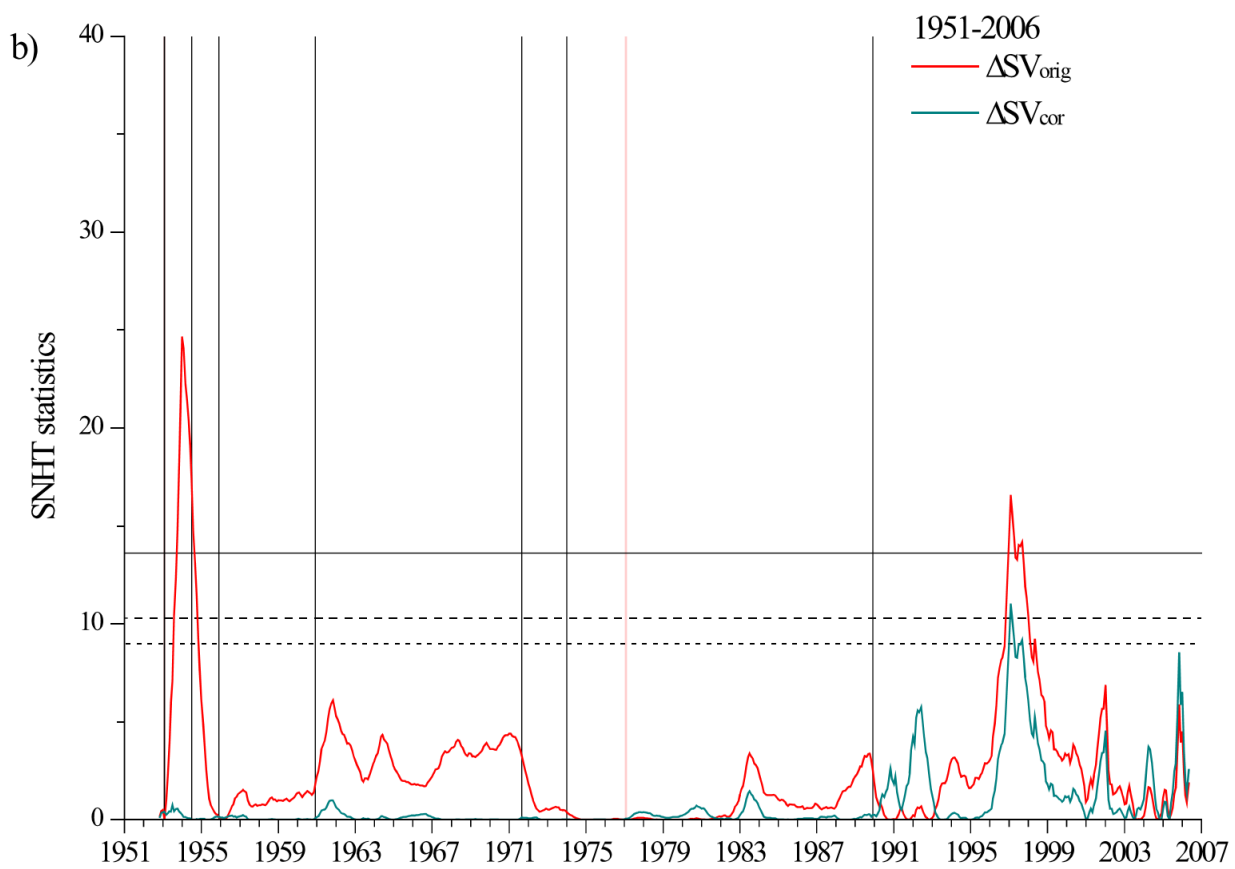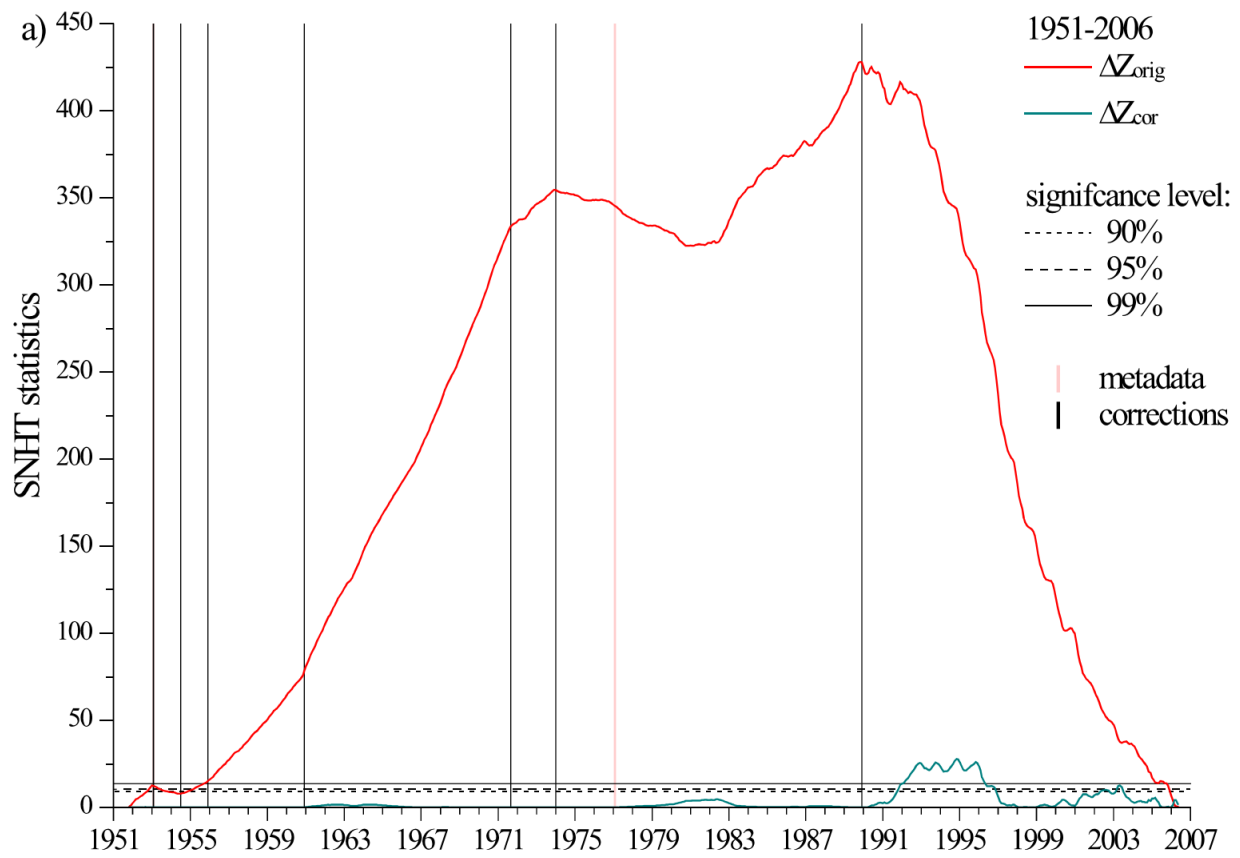
Figure S8. Same as Figure S3 but for COI Z. Time interval: 1951-2006.
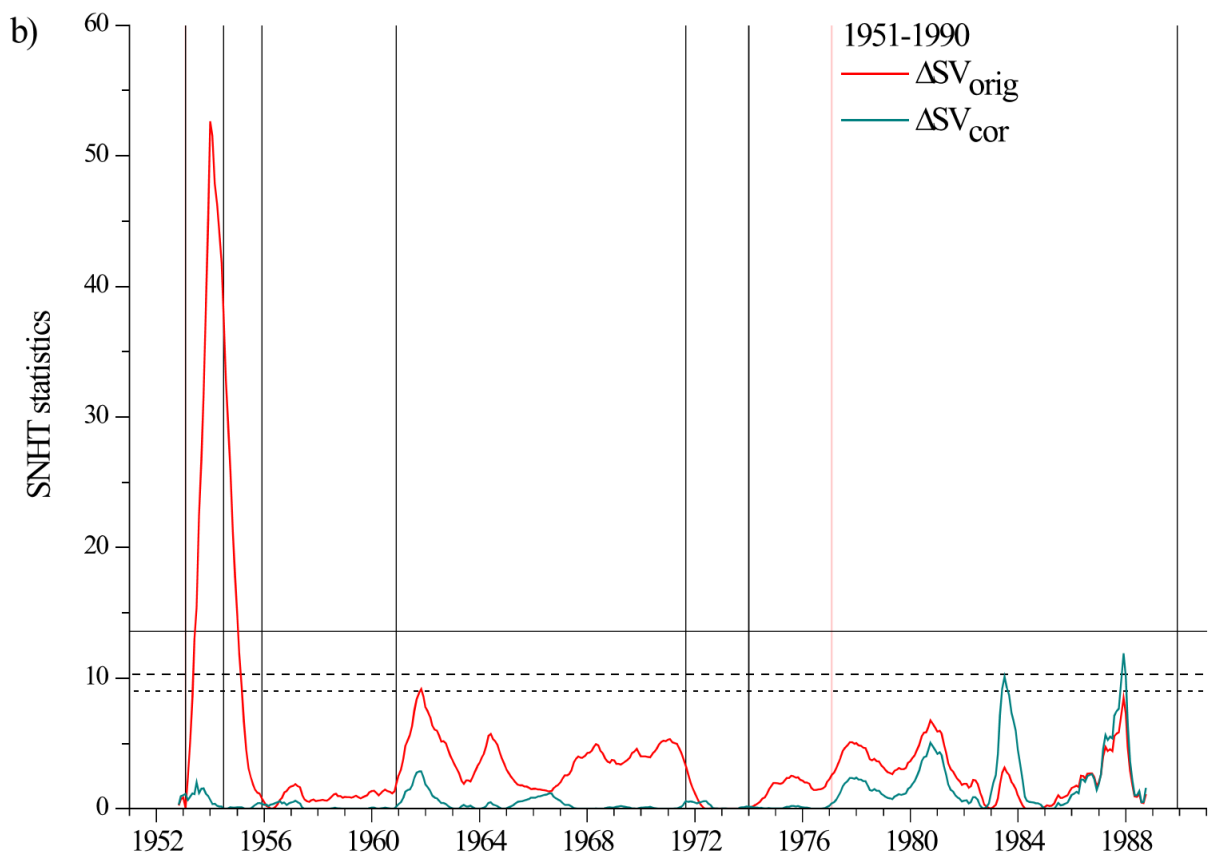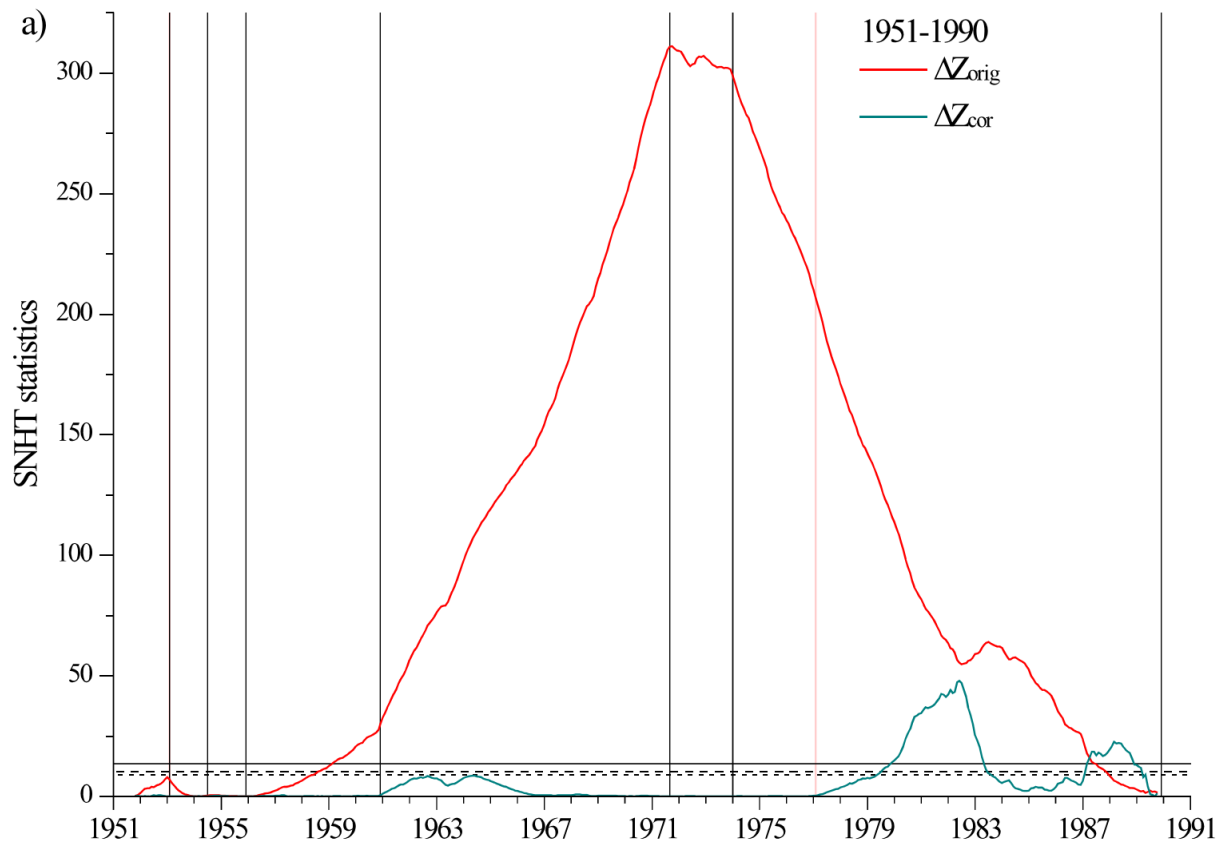
Figure S9. Same as Figure S8 but for the time interval 1951-1990.
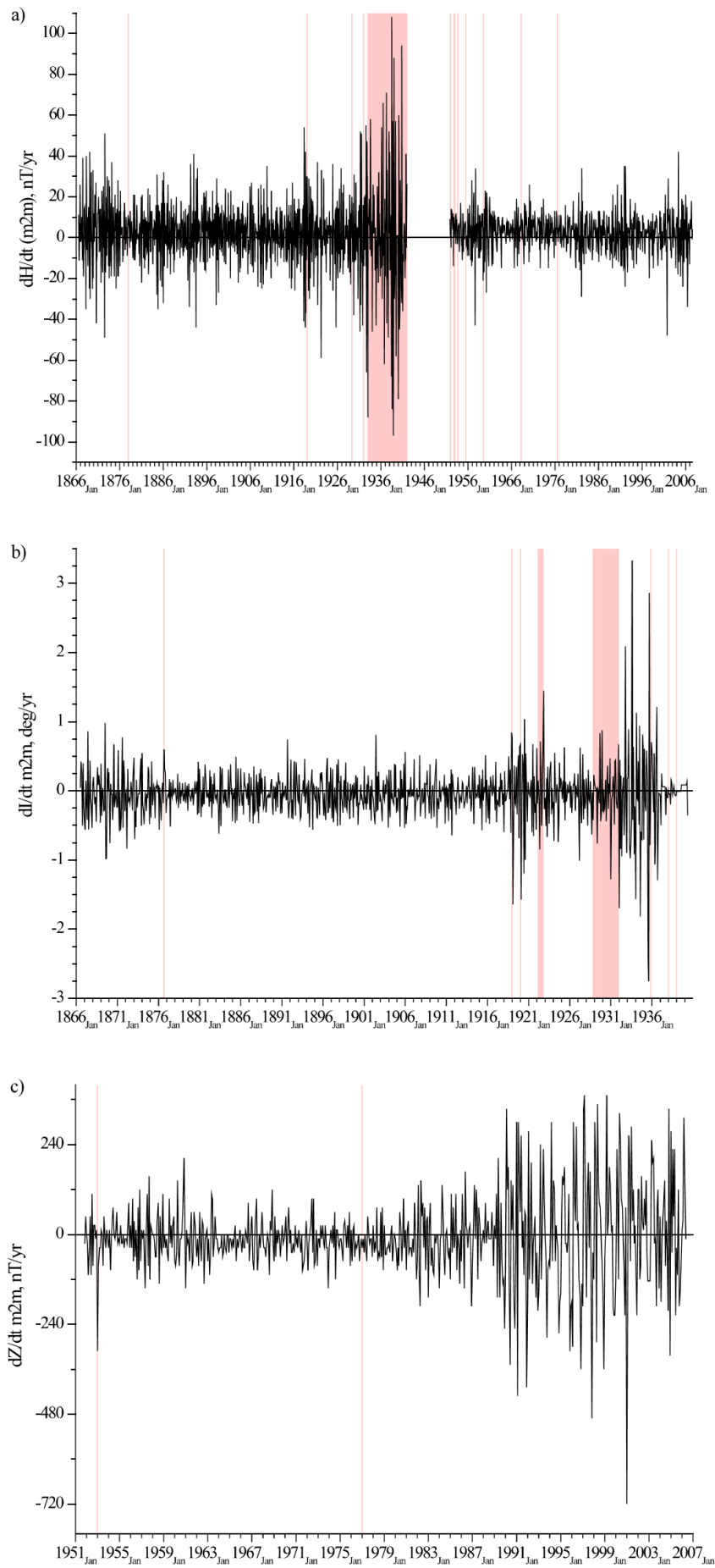
Figure S10. Time derivative of the original COI: H (a), I (b) and Z (c) series on month-to-month time scale. Pink vertical lines/rectangles mark possible dates of HB.
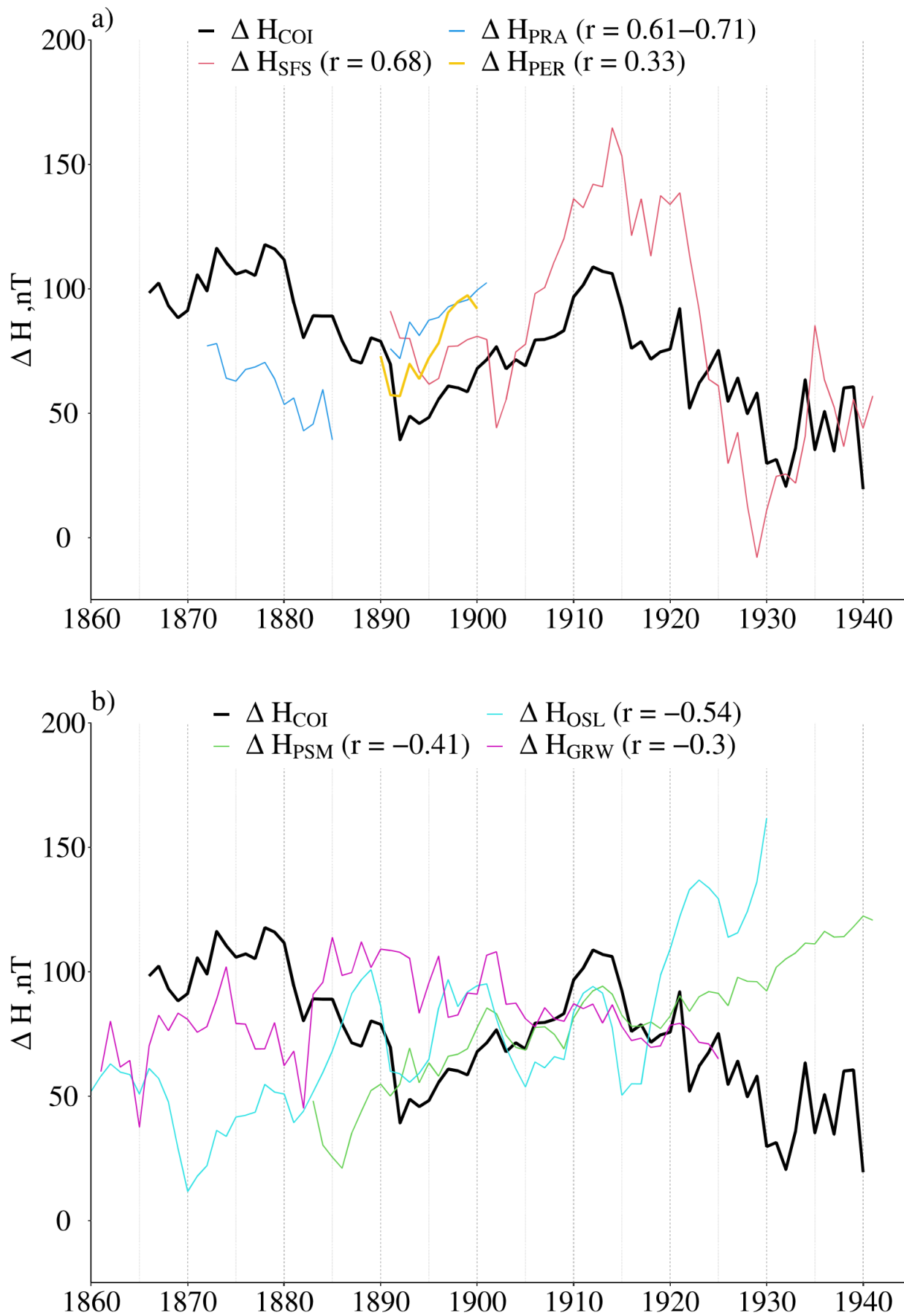
Figure S11. ΔH series for the 1860-1940 time interval for seven European stations. (a) COI (thick black), SFS (red), PRA (blue) and PER (yellow). (b) COI (thick black), PSM (green), OSL (cyan) and GRW (magenta).
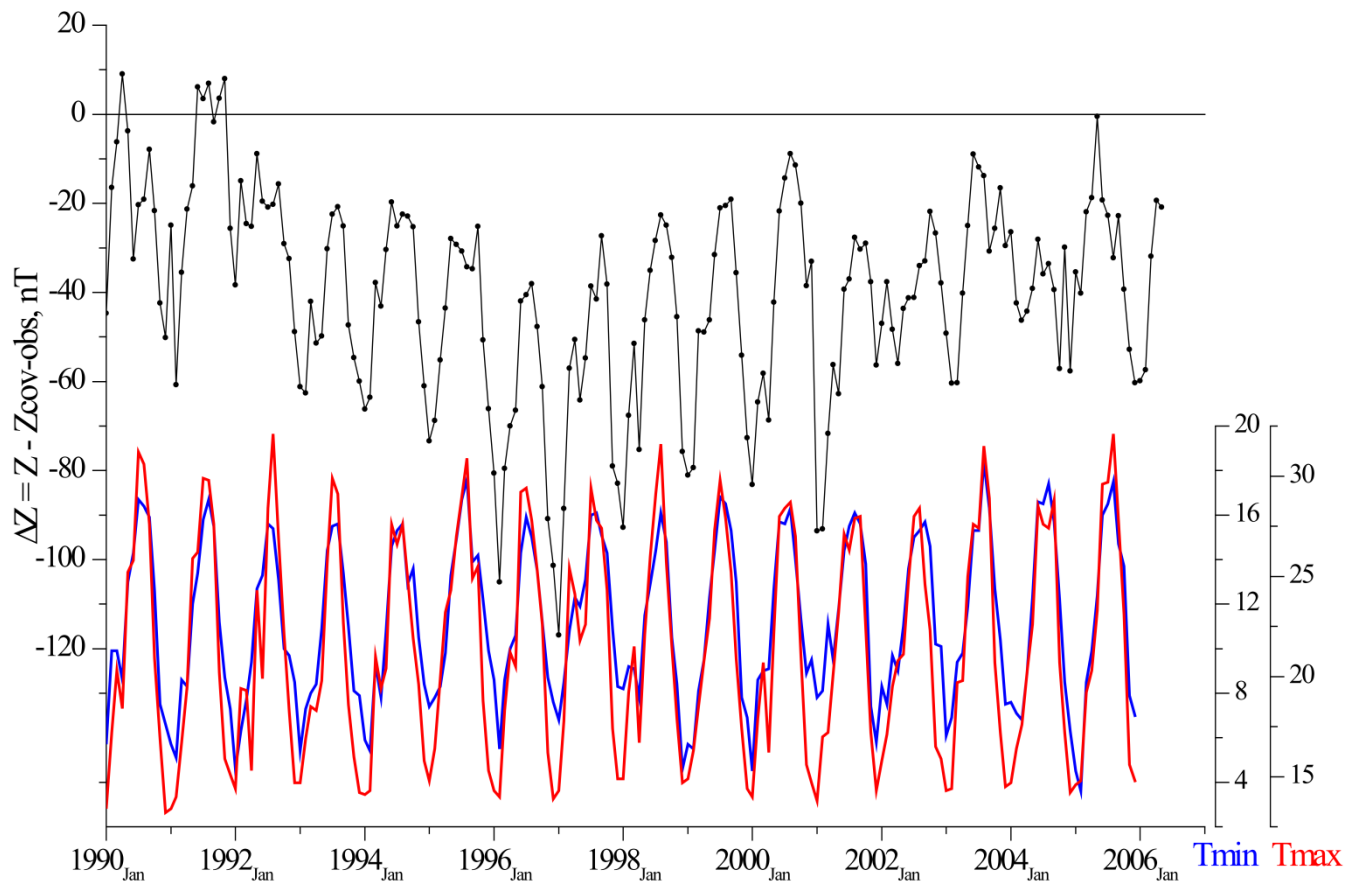
Figure S12. ΔZ (black line with dots) for the 1990-2006 period together with monthly mean COI temperature series (red - Tmax, blue - Tmin).