



*Supplement of*

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

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Table S1 contains COI metadata (dates of the instrument replacements, relocations, changes in the measurement/calculation procedures etc.) for the D geomagnetic field element.

Table S2 gives information about sets of geomagnetic field elements measured at COI at different epochs between 1866 and 2015.

Table S3 lists instruments used for the absolute measurements of geomagnetic field elements at COI at different epochs between 1866 and 2015

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

	date	metadata
<i>Cumeada</i>	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
<i>Alto da Baleia</i>	1932 January	relocation to <i>Alto da Baleia</i>
	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 S2.** Measured geomagnetic field elements at COI between 1866 and 2015.

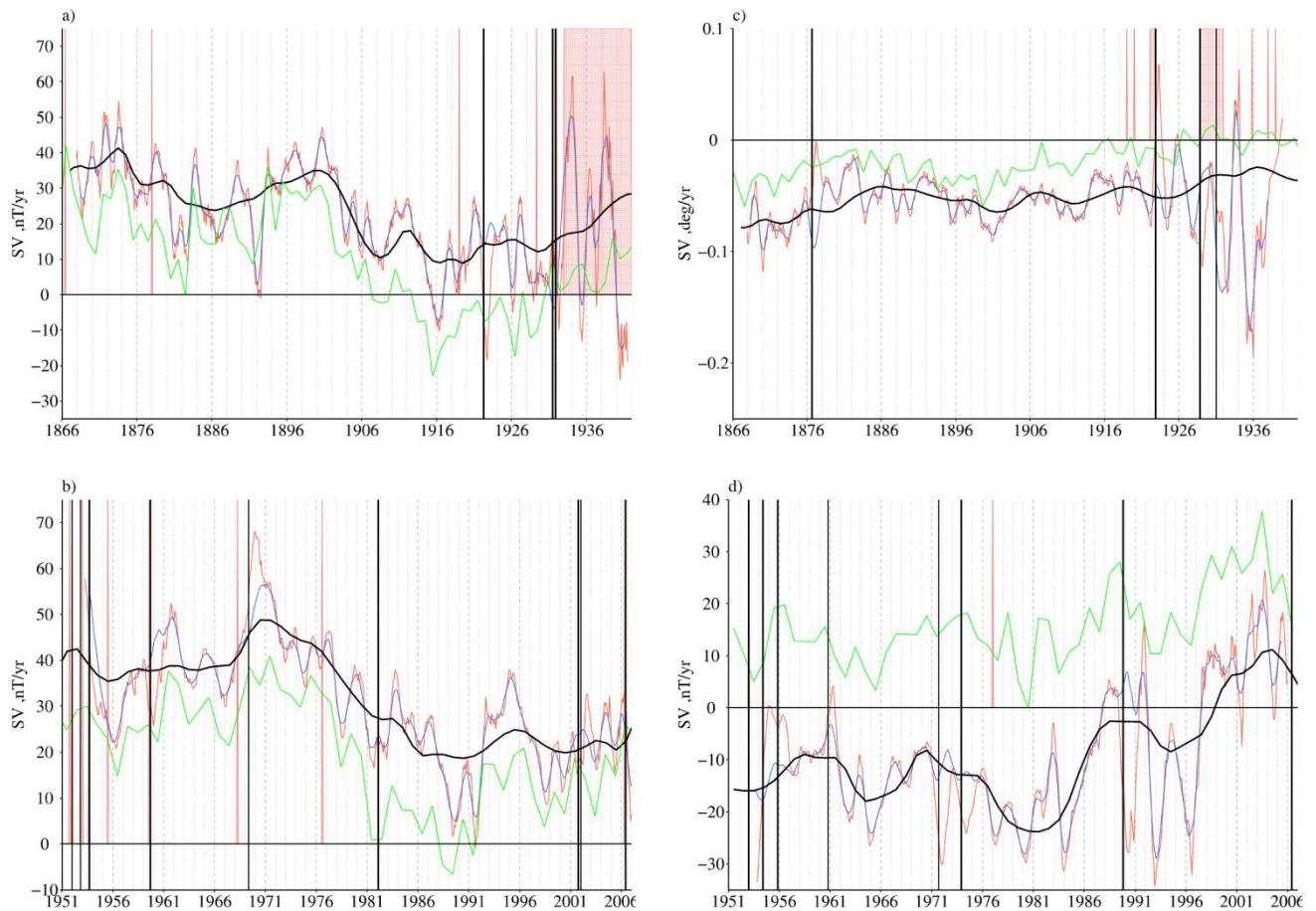
Component	<i>Cumeada</i> site	<i>Alto da Baleia</i> site		
D	1866-1932	1932-1951 1951-2015		
H	1866-1932	1932-1941 1951-2006		
I	1866-1932	1932-1940 2007-2015		
Z	—	1951-2006		
F	—	2007-2015		
Measured elements				
	1864-1931	1932-1941	1951-2006	2007-2015
Absolute measurements (baselines)	HDI	HDI	HDZ	DIF
Relative measurements (magnetograms)	HDZ	HDZ	HDZ	HDZ

**Table S3.** Instruments used at COI for the absolute measurements of the geomagnetic field elements.

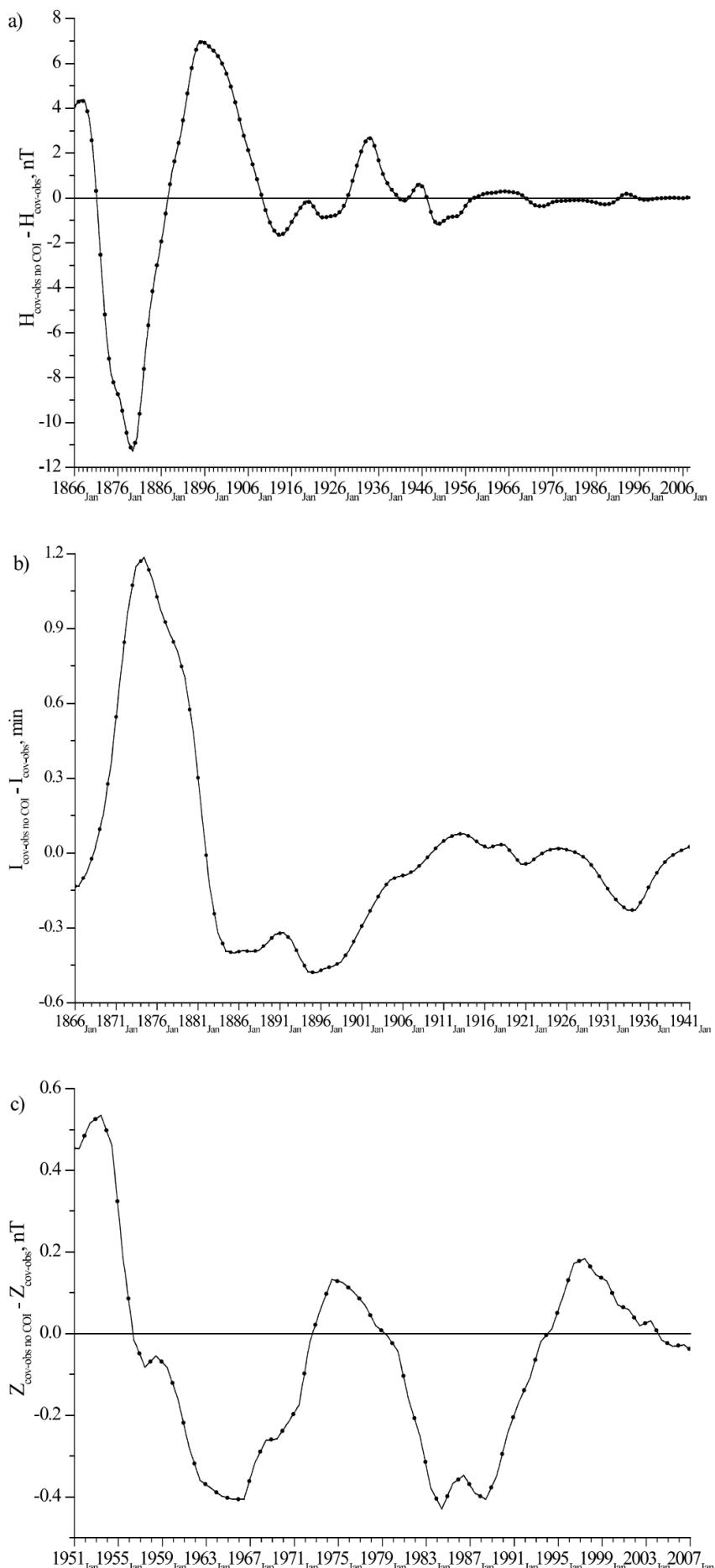
Element	Instrument	Time interval.
D	Gibson unifilar magnetometer	JUL 1867 – DEC 1877
	Elliott & Bros. unifilar magnetometer	JAN 1878 to 1948 1951-1955
	Askania declinometer	JUL 1955 – DEC 2005
	DI-flux: fluxgate Mag-01H magnetometer (Bartington) & universal theodolite YOM MG2Kp	JAN 2006 – present time
H	Gibson unifilar magnetometer	JUN 1866 – DEC 1877
	Elliott & Bros. unifilar magnetometer	JAN 1878 to 1948 OCT 1951 – DEC 1951
	<u>quartz horizontal magnetometers (QHM):</u>	1951 – 2006
	QHM nos. 190 and 191	JAN – OCT 1952
	QHM nos. 220 and 221	NOV – DEC 1952
I	QHM no. 220	JAN 1953 – JUN 1955
	QHM no. 307	JUL 1955 – MAY 2006
	inclinometer of Barrow	JUN 1866 – AUG 1876
	John Dover inclinometer	SEP 1876 – SEP 1935
Z	Sartorius Earth inductor	OCT 1935 – DEC 1938
	DI-flux ( <i>see D element</i> )	JAN 2006 – present time
	<u>zero balance magnetometers (BMZ):</u>	1951 – 2006
	BMZ no. 69	OCT 1951 – JAN 1952
F	BMZ no. 80	JAN 1953 – DEC 1976
	BMZ no. 130	JAN 1977 – MAY 2006
	proton magnetometer Geometrics G-856	JUN 2006 – APR 2007
F	proton magnetometer Geometrics G-856	MAY 2007 – JUN 2007
	Overhauser GSM-90F1 magnetometer (GEM systems)	JUL 2007 – present time

**Table S4.** A list of European observatories (EOs) used to obtain the reference series for H, I and Z. Some stations suffered changes in the instruments and/or were re-located.

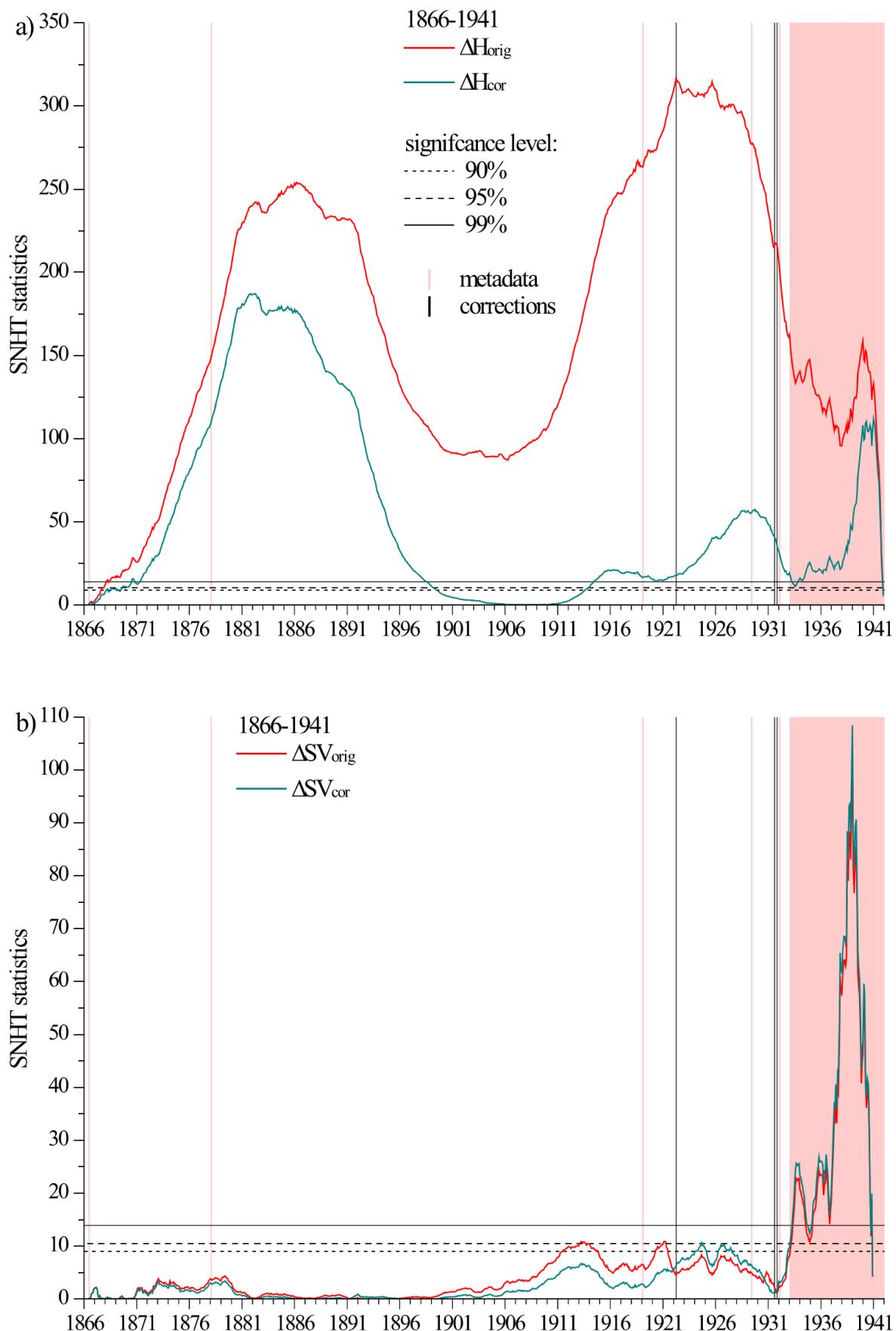
	name	code	country	lat.	long.	period	Used as reference series for...
1	Parc Saint-Maur (Paris)	PSM	France	48° 49'	2° 30'	1883-1900	
	Val Joyeux	VLJ		48° 49'	2° 01'	1901-1936	
	Chambon-la-Foret	CLF		48° 01'	2° 16'	1936-1956; 1957-1967; 1968-1982; 1983-2011	H, I, Z
2	Nantes	NTS	France	47° 15'	358° 26'	1923-1958	H, I
3	Perpignan	PER	France	42° 42'	02° 53'	1886-1901; 1907-1910	H, I
4	Toledo	TOL	Spain	39° 53'	355° 27'	1947-1981	
	San Pablo de los Montes	SPT		39° 33'	355° 39'	1981-2011	H, Z
5	Ebro (Tortosa)	EBR	Spain	40° 49'	0° 30'	1909-1937; 1943-1983; 1995-2009	H, I, Z
6	Logrono	LGR	Spain	42° 27'	357° 30'	1957-1976	H, Z
7	San Fernando	SFS	Spain	36° 28'	353° 48'	1880-1963; 1964-1969; 1970-1979	
	San Fernando	SFS2		36° 30'	353° 53'	1991-2005	H, I, Z
8	Oslo	OSL	Norway	59° 55'	10° 43'	1843-1930	H, I
9	Prague	PRA	Czech Republic	50° 05'	14° 25'	1830-1926	H
10	Eskdalemuir	ESK	UK	55° 19'	356° 48'	1908-2011	H, I, Z
11	Greenwich	GRW	UK	51° 29'	0° 0'	1840-1925	H
12	Munich	MNH	Germany	48° 09'	11° 37'	1841-1886; 1899-1926	H, I
13	Potsdam	POT	Germany	52° 23'	13° 4'	1890-2011	H, I, Z
14	Lisbon	LIS	Portugal	38° 43'	350° 51'	1858-1900	H, I
15	L'Aquila	AQU	Italy	42° 23'	13° 19'	1960-2009	H, Z



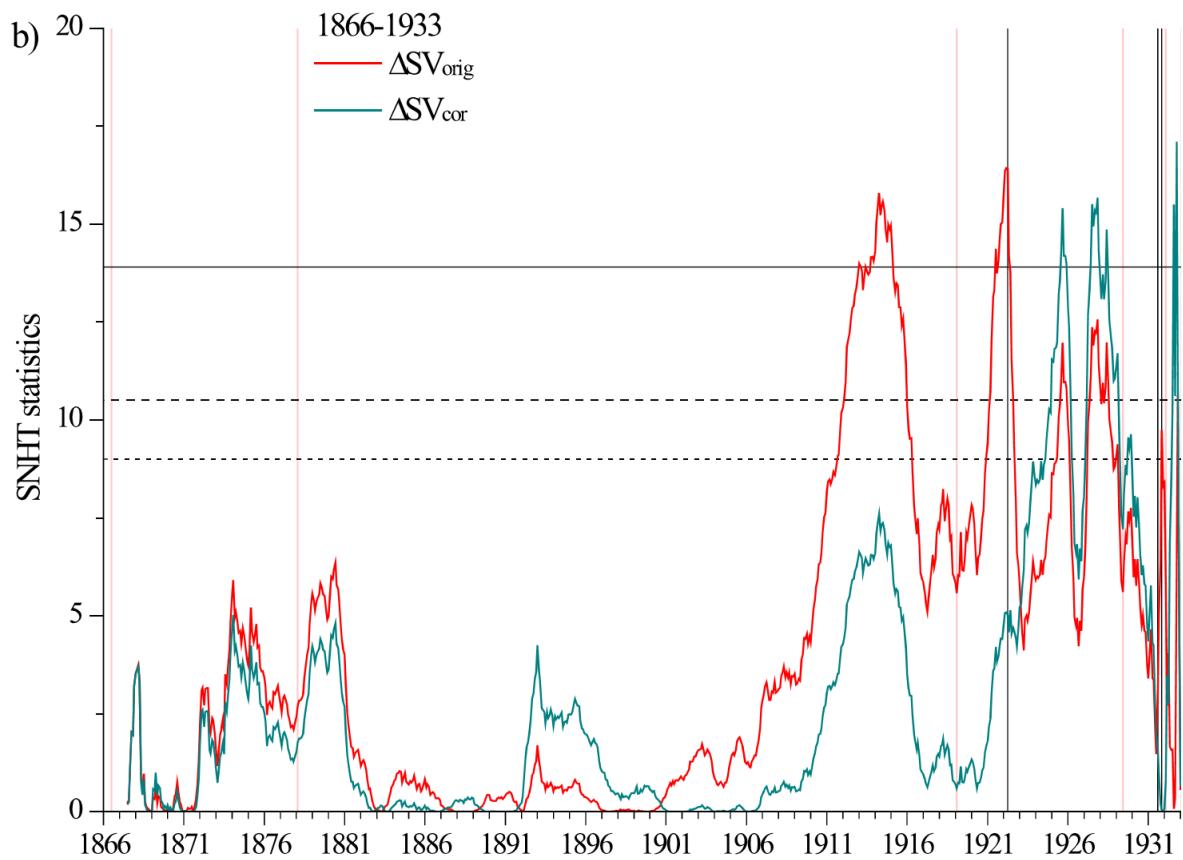
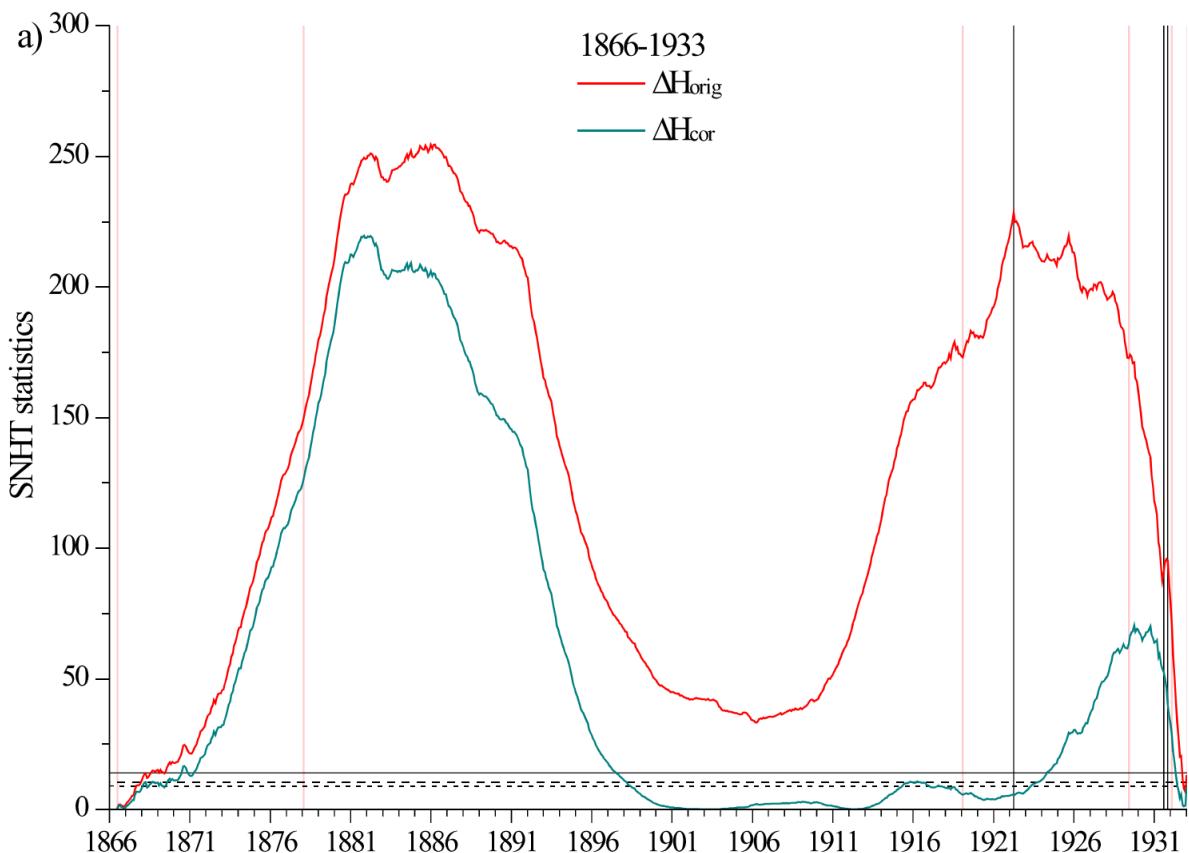
**Figure S1.** Original (red lines) and corrected (blue lines) COI SV H (a and b), I (c) and Z (d) series smoothed by the moving averaging with 12-month long window, SV from the corresponding COV-OBS model (black lines) and SV of the reference series from the EO observatories (green lines). Pink vertical lines/rectangles mark possible dates of HB, black vertical lines mark dates of corrections.



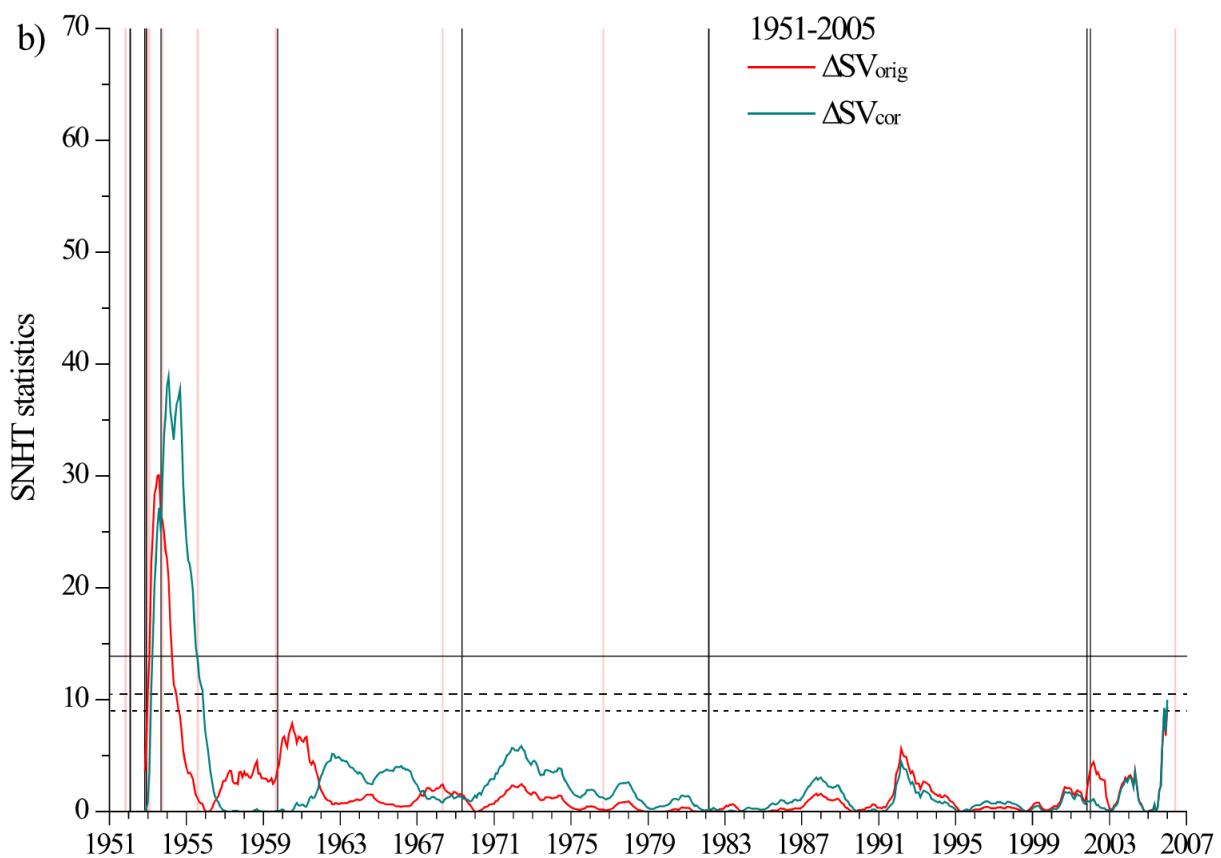
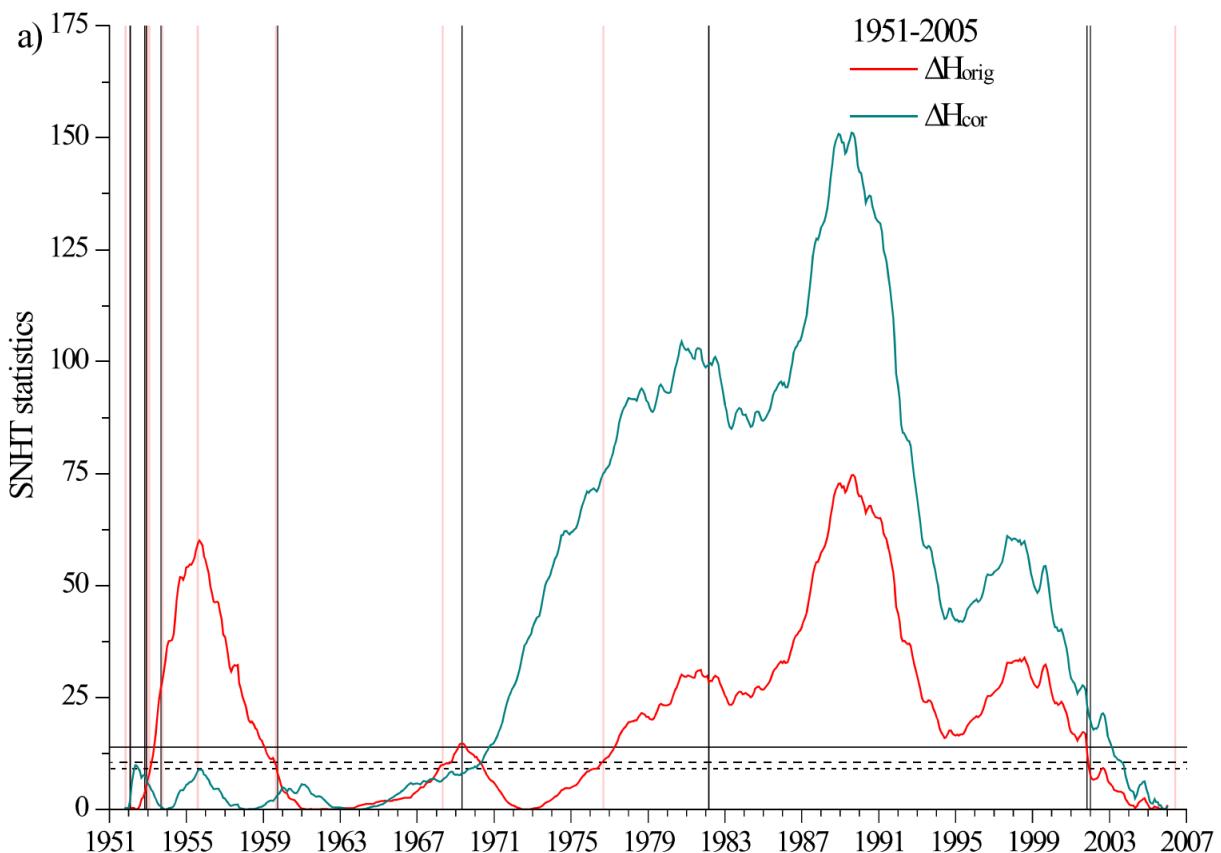
**Figure S2.** Differences between two models: COV-OBS and COV-OBS without COI: H (a), I (b), and Z (c) components.



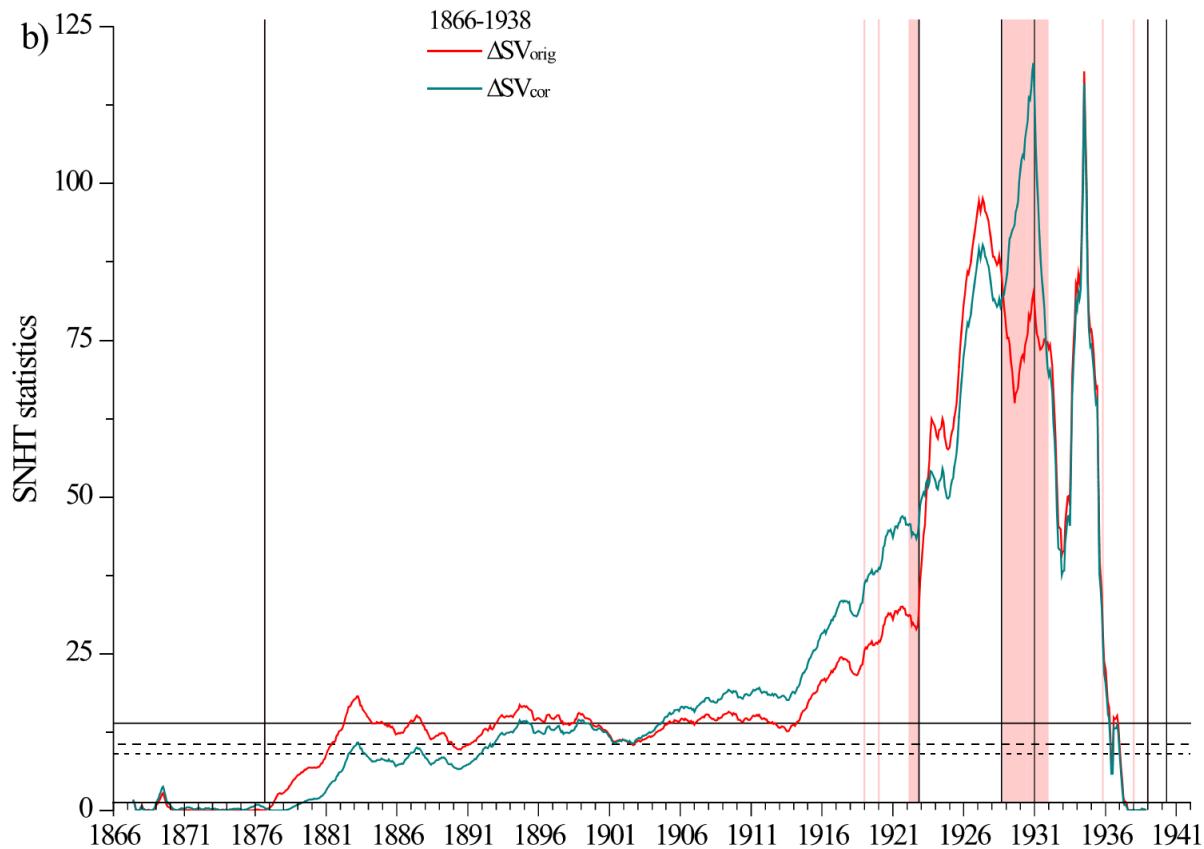
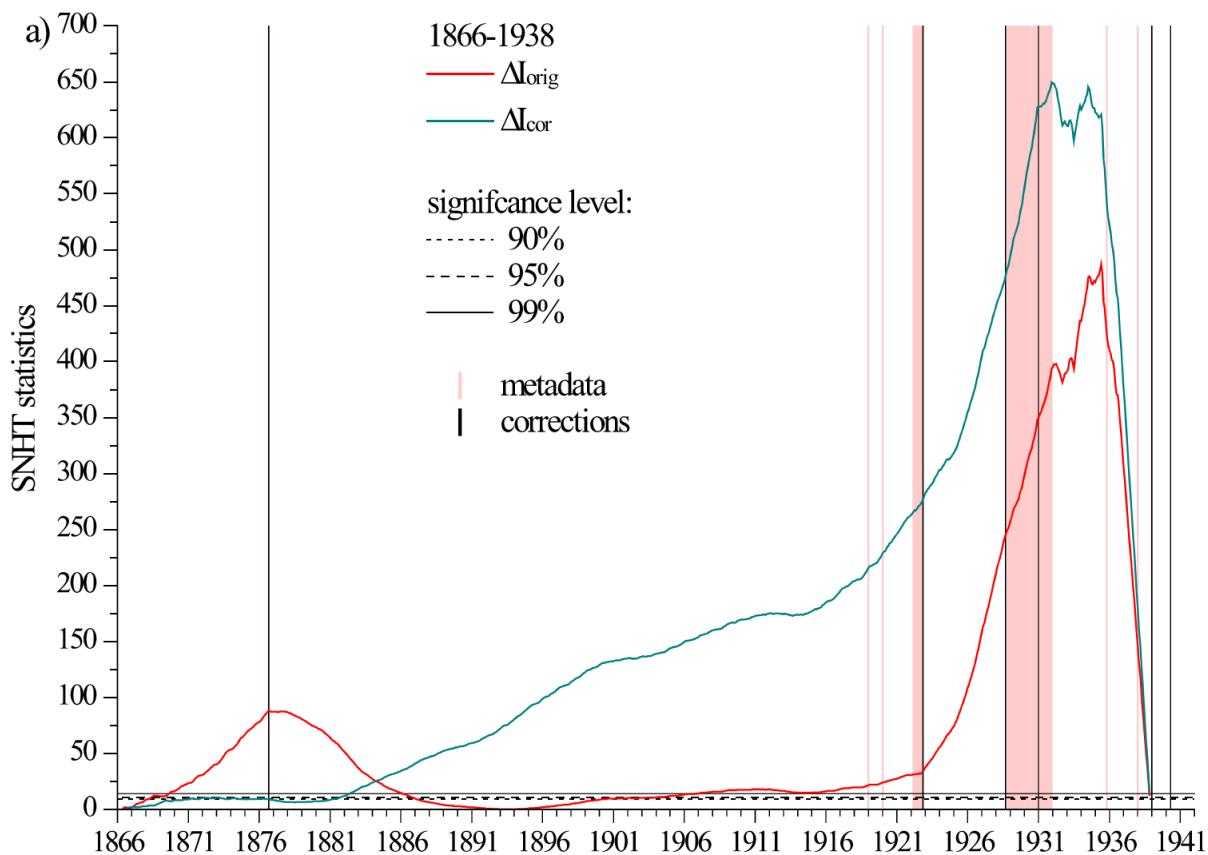
**Figure S3.** Homogeneity tests statistics for COI: H (a) and SV (b) original (red) and corrected (dark cyan) series for the time interval 1866-1941. Pink vertical lines/rectangles mark possible dates of HB, black vertical lines mark dates of corrected HBs. Dotted, dashed and solid horizontal lines mark levels of 90%, 95% and 99% of the statistical significance of HBs.



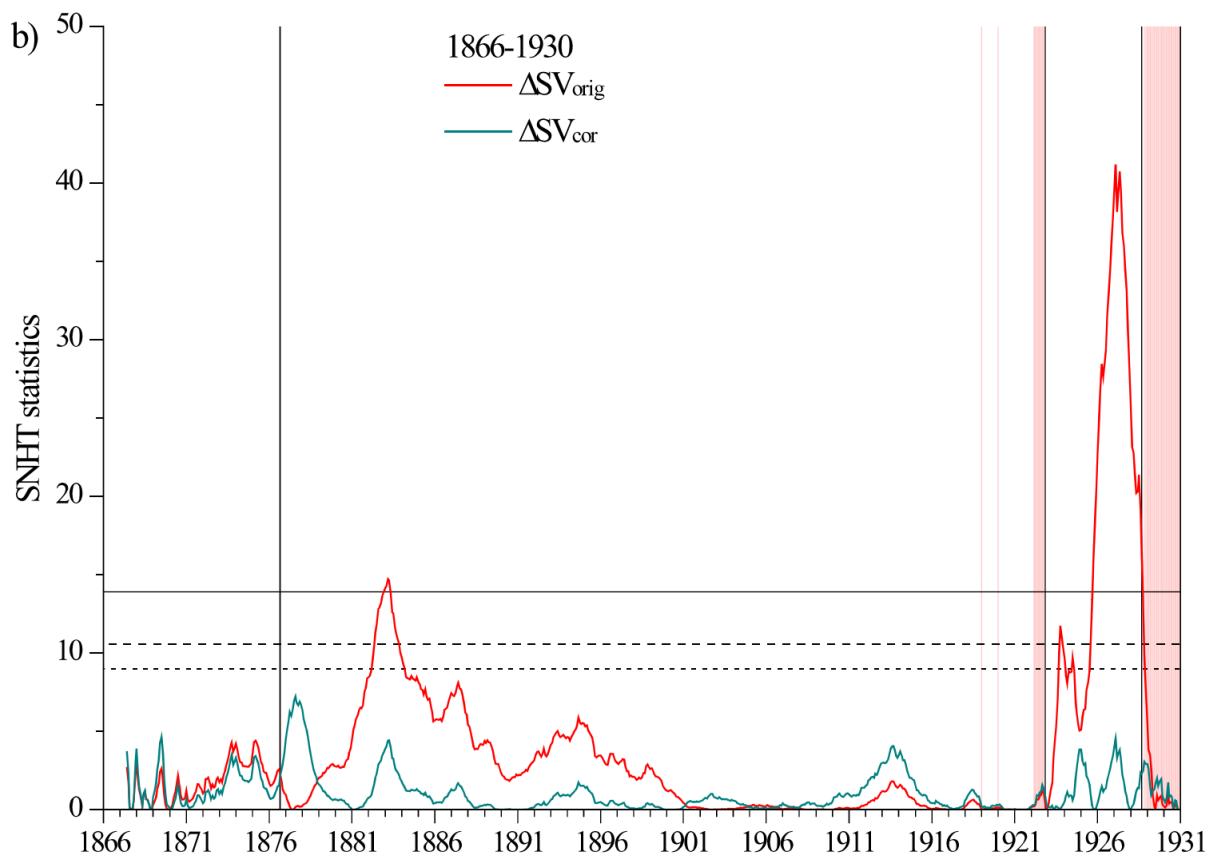
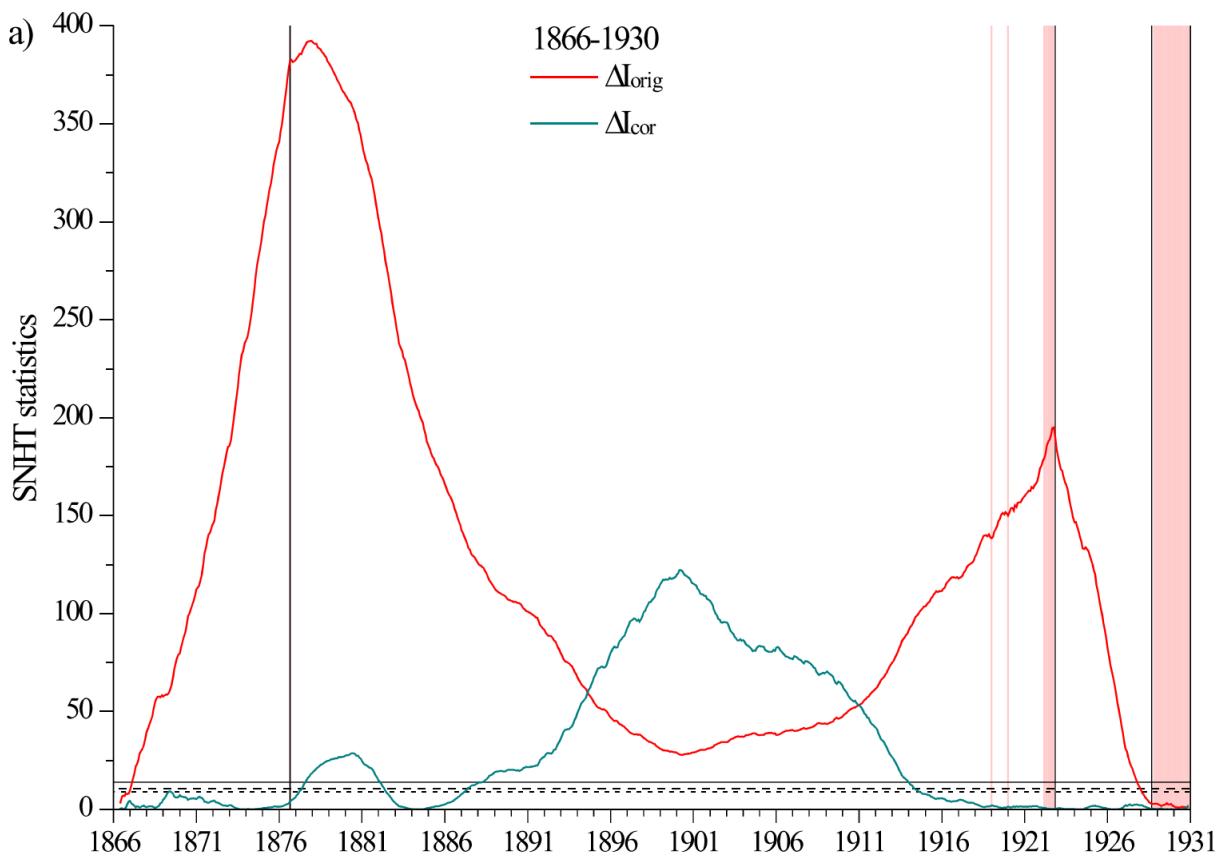
**Figure S4.** Same as Figure S3 but for the time interval 1866-1933.



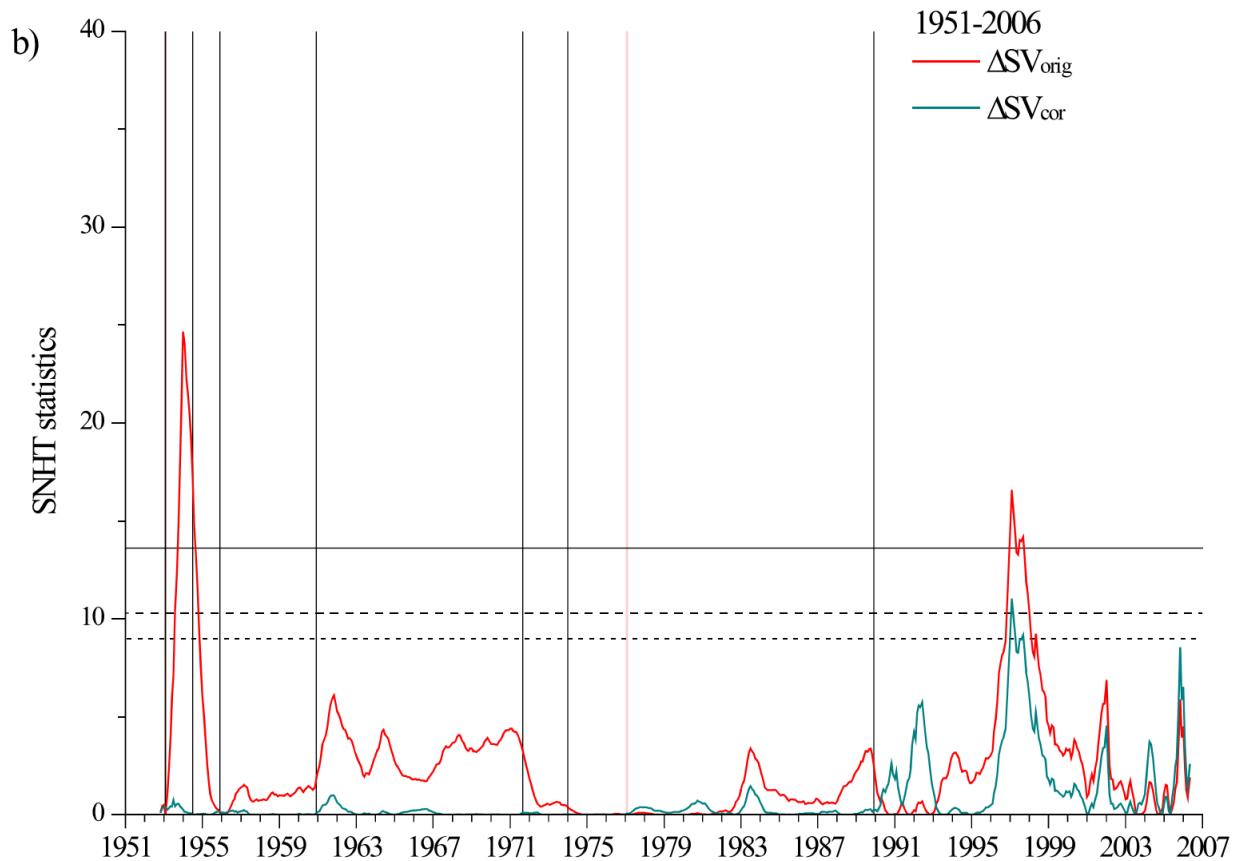
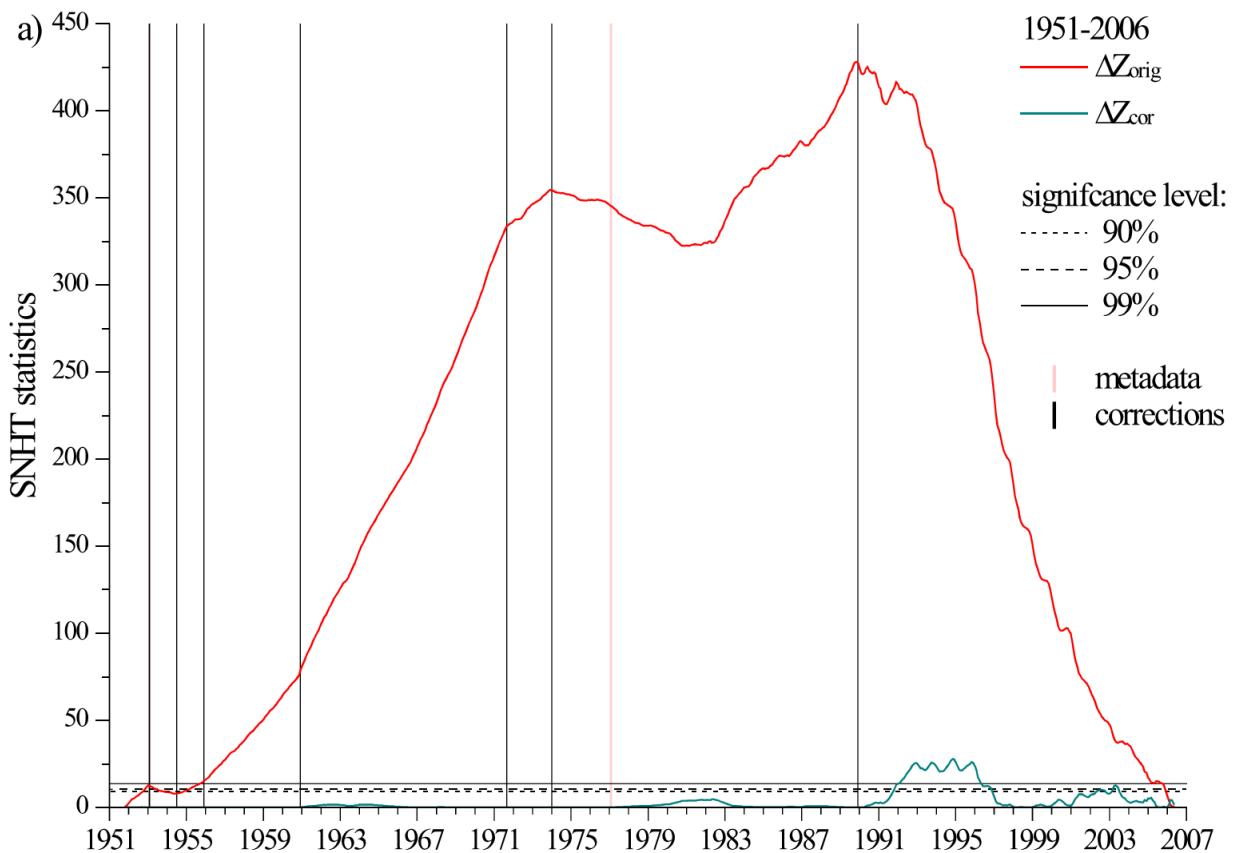
**Figure S5.** Same as Figure S3 but for the time interval 1951-2005.



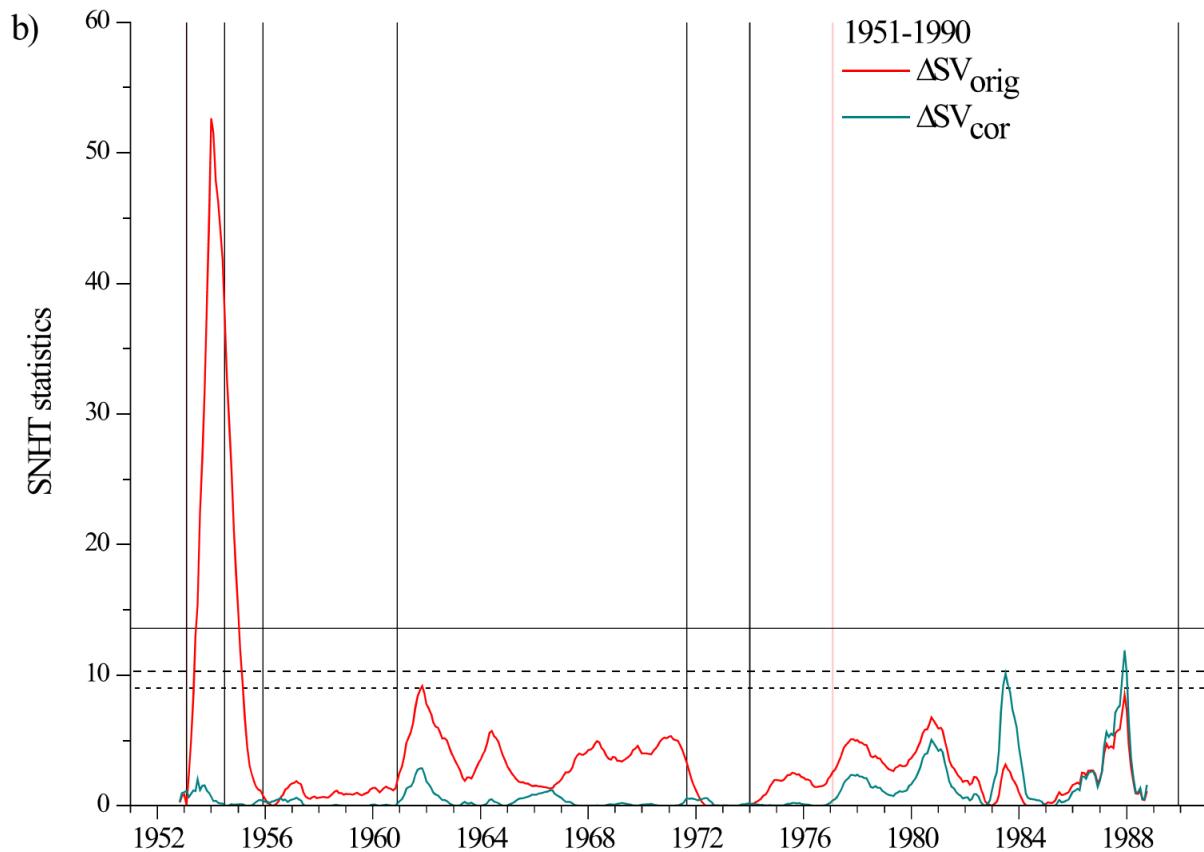
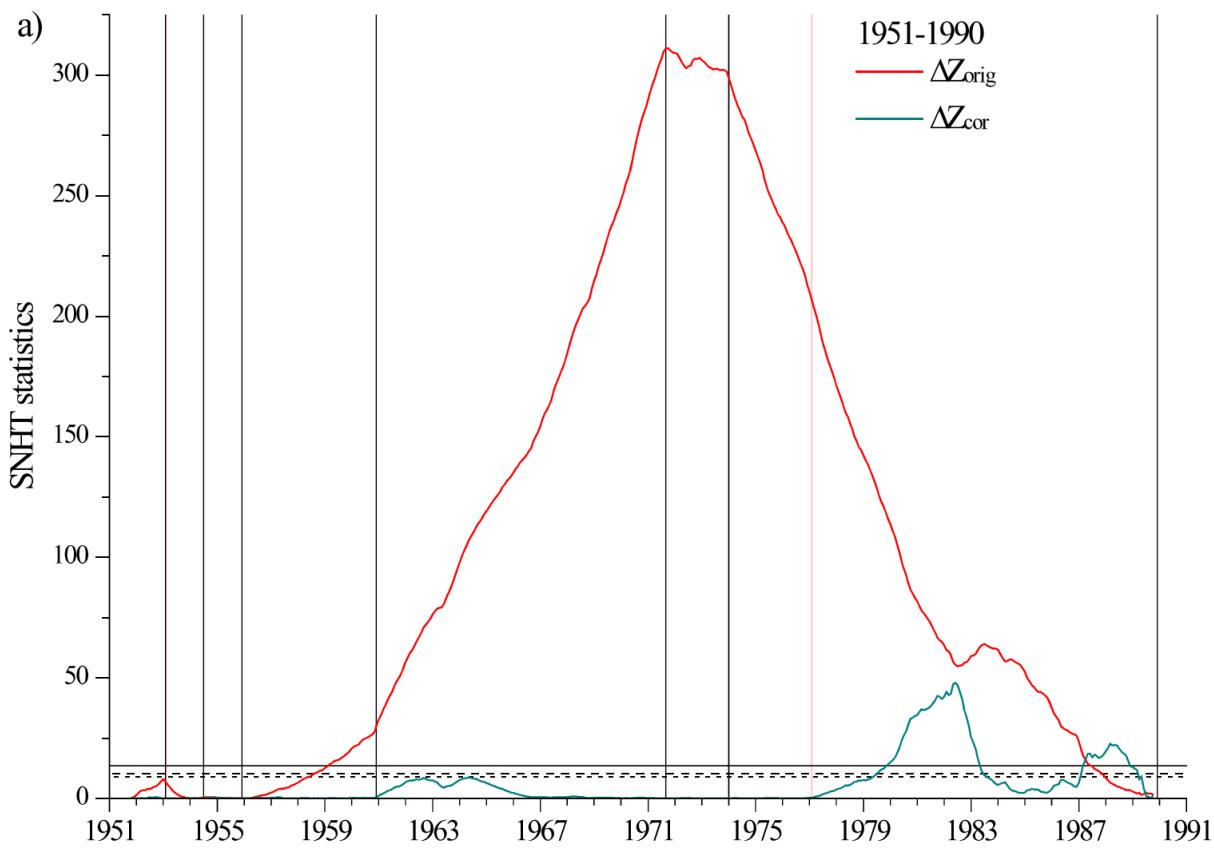
**Figure S6.** Same as Figure S3 but for COI I. Time interval: 1866-1938.



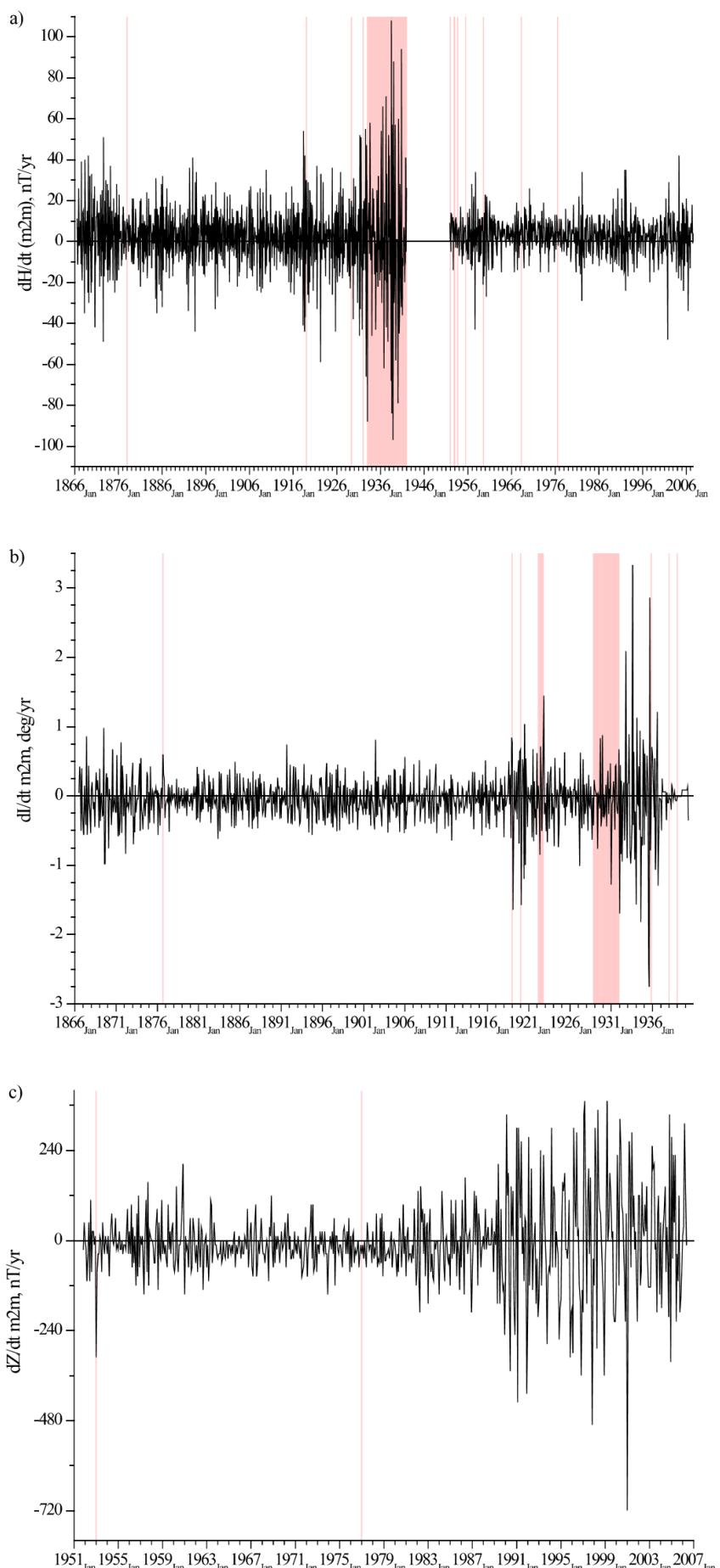
**Figure S7.** Same as Figure S6 but for the time interval 1866-1930.



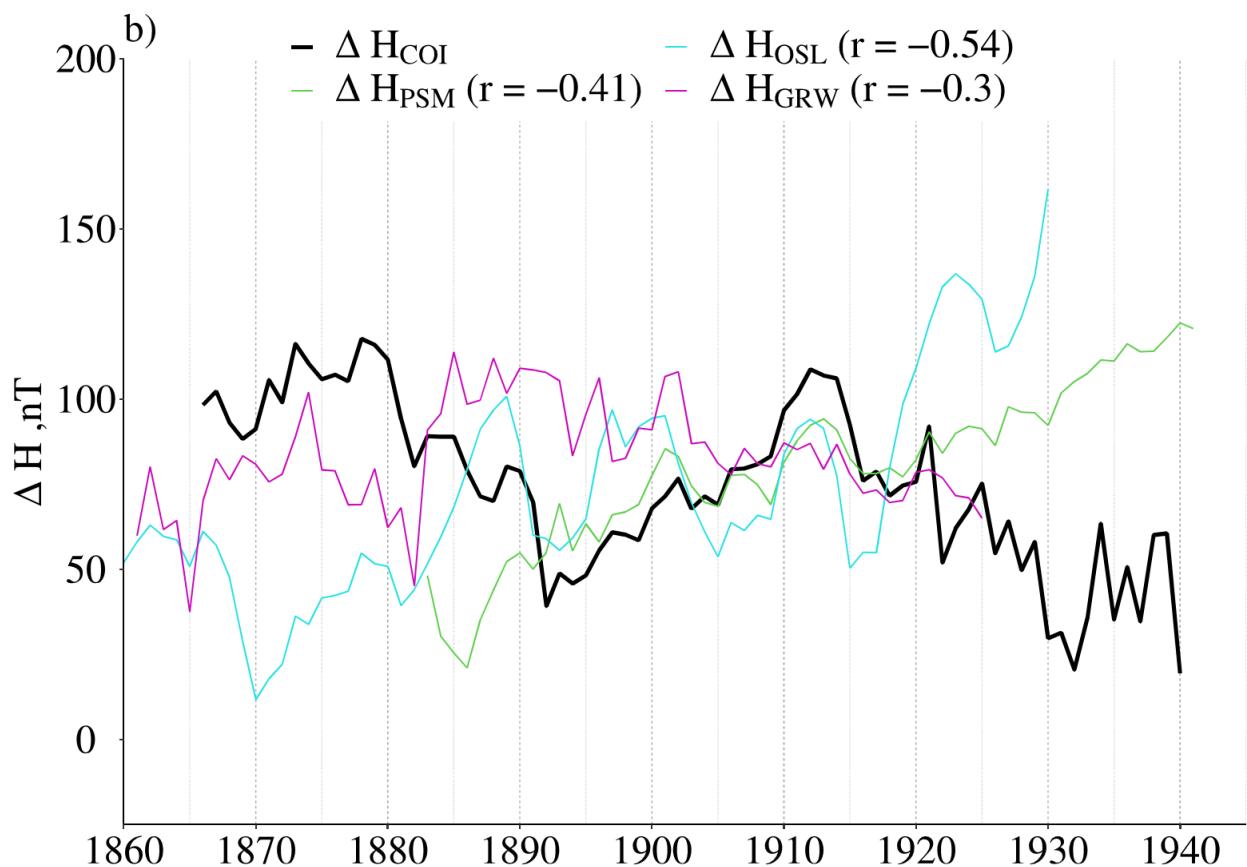
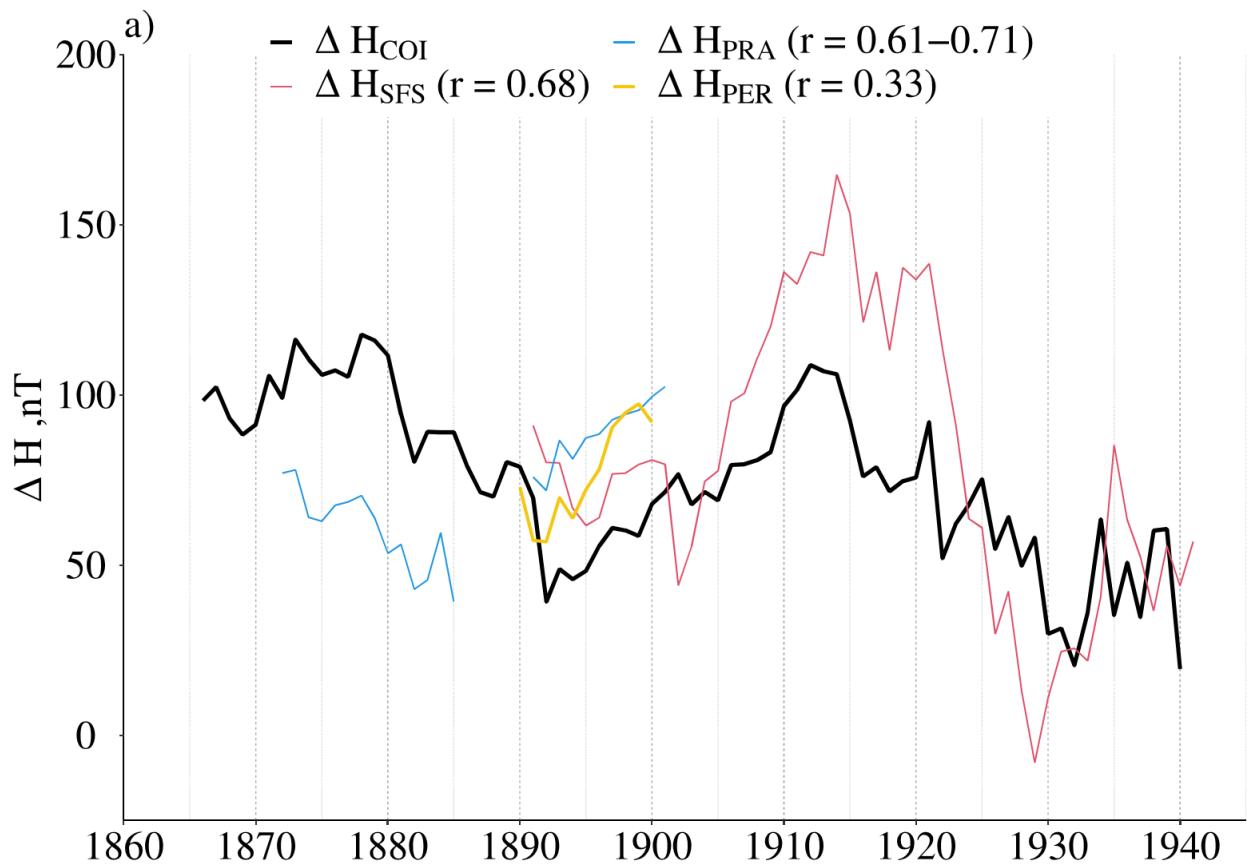
**Figure S8.** Same as Figure S3 but for COI Z. Time interval: 1951-2006.



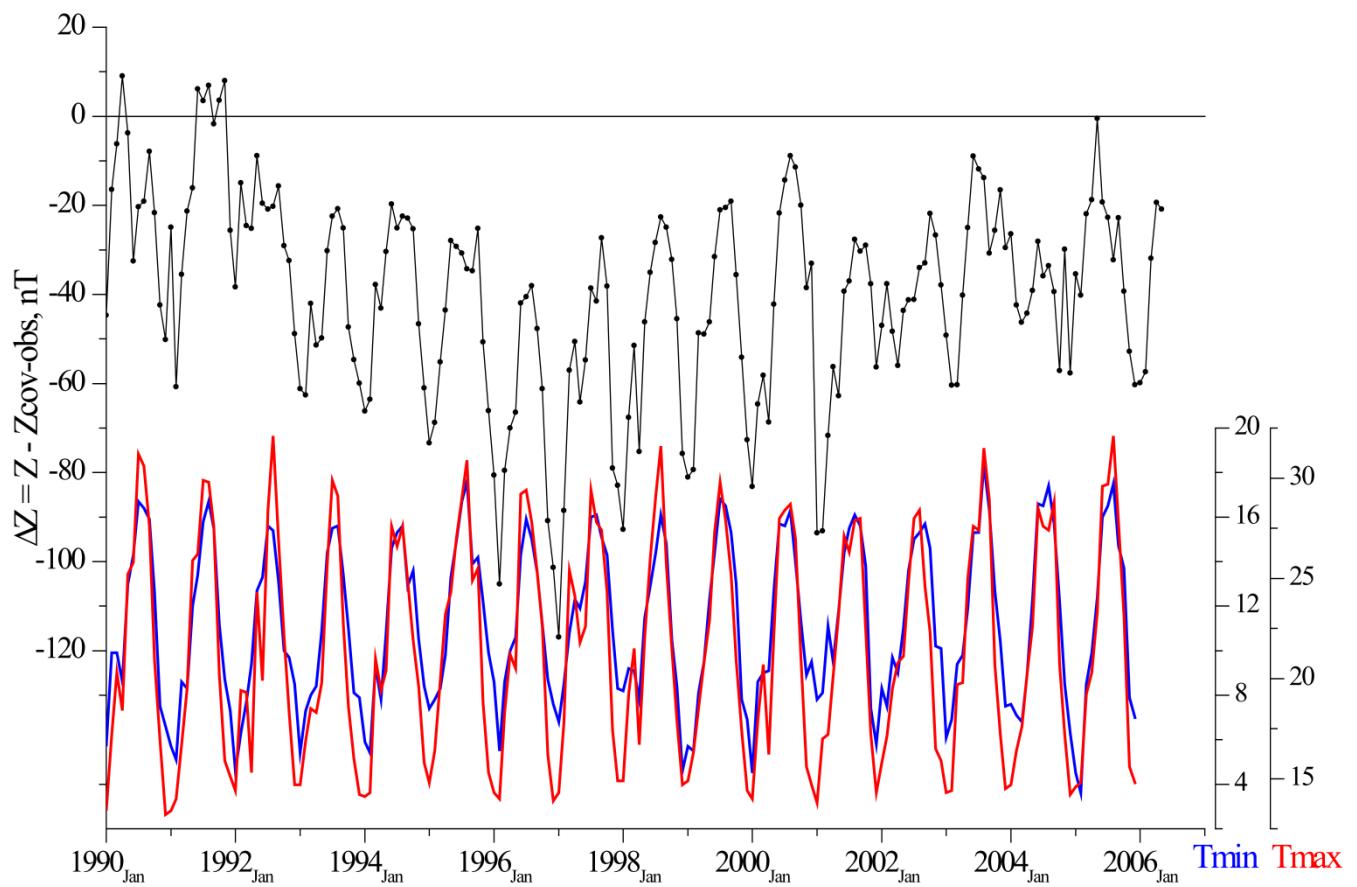
**Figure S9.** Same as Figure S8 but for the time interval 1951-1990.



**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.**  $\Delta H$  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.**  $\Delta Z$  (black line with dots) for the 1990-2006 period together with monthly mean COI temperature series (red -  $\text{Tmax}$ , blue -  $\text{Tmin}$ ).