Supplementary Materials

Variability of River Runoff in Poland and Its Connection to Solar Variability

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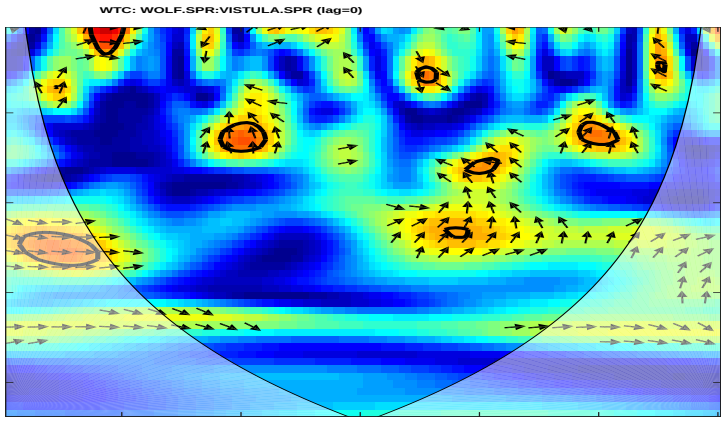
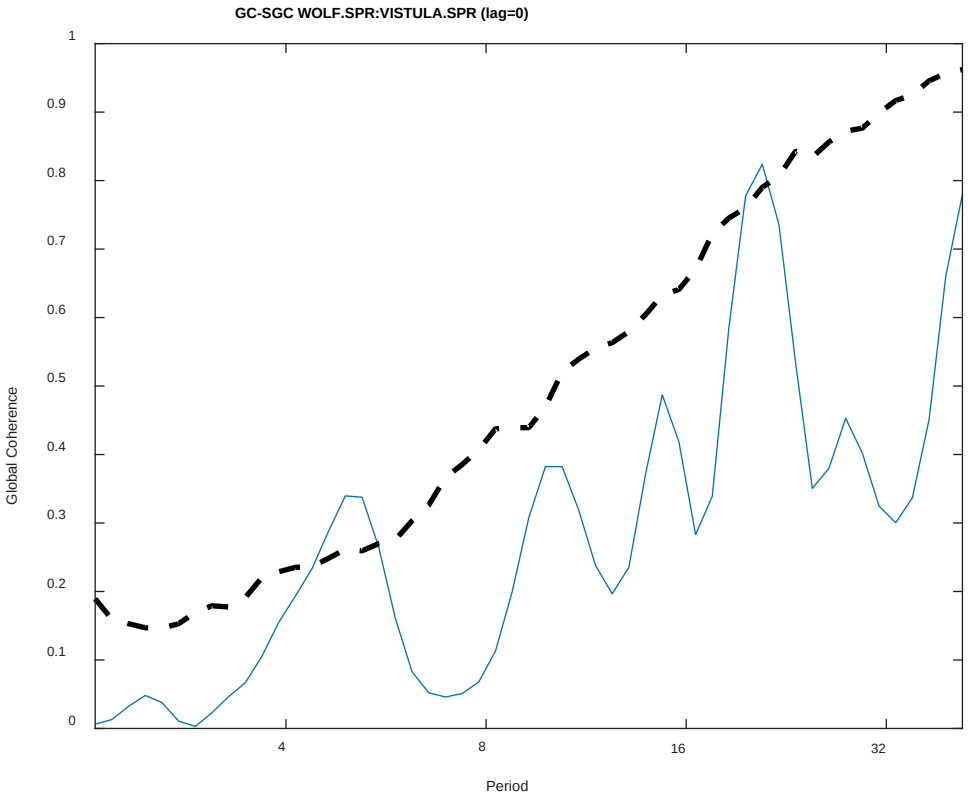
In the Figure S1, the link between SSN (Wolf inside the figure) and discharge (Q) at Vistula in spring (SPR) at lag=0 is presented. In this case NLR much higher than |R|. Even in this case, the results are not easy to interpret, the coherences between SSN and Q - Vistula are not very high, except for short time intervals. Figure S1b indicates a significant global coherence (GC) (CL>95%) corresponding to the double solar cycle. The details in Figure S1a show that this coherence is reflected in the time intervals 1901-1940 and 1980-2020, intervals for which the two time series are exactly in phase.

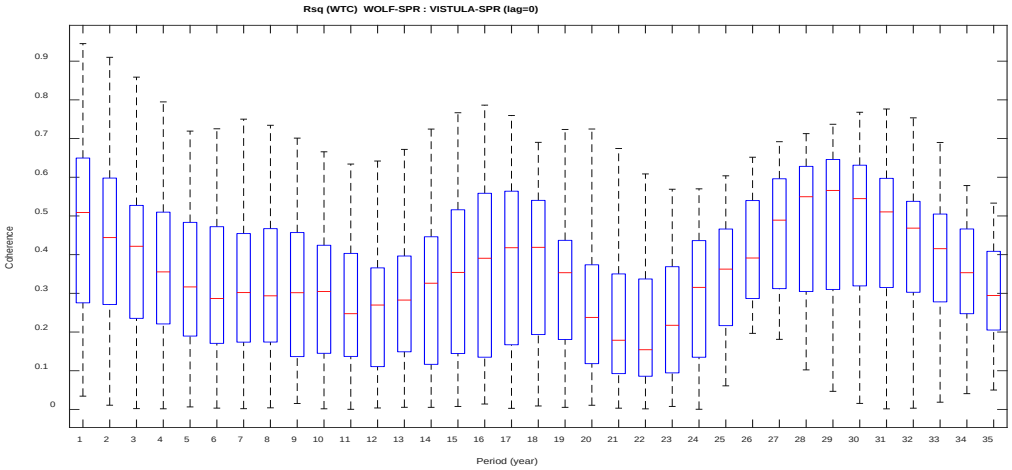
Regarding the solar cycle signal of approximately 11 years, it is not evident in the GC, because as can be seen in Figures S1a and S1d (red curve), there is a period around the year 1950, when the coherence is very low.



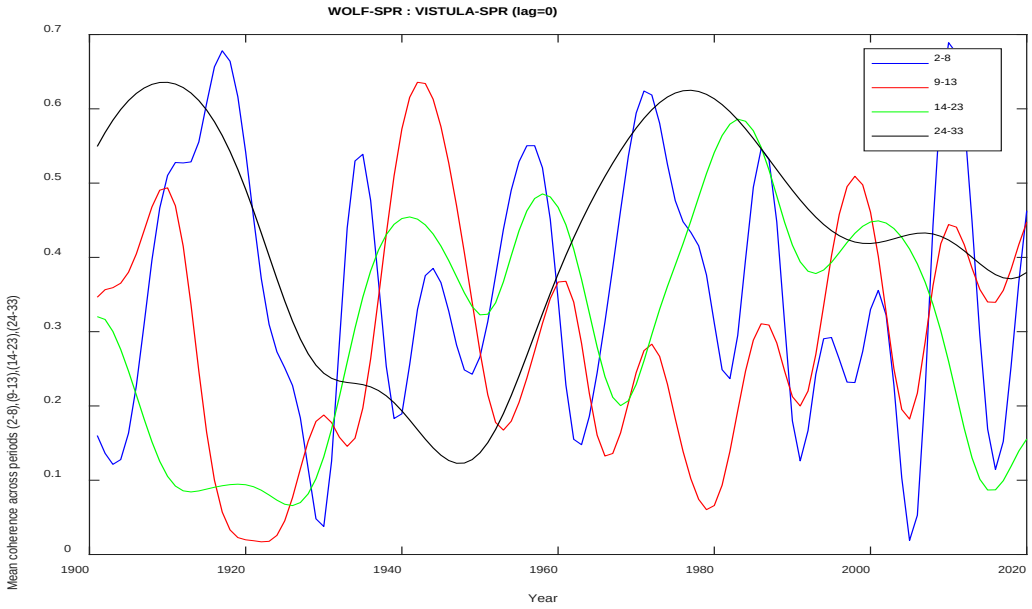
(a)


GC-SGC WOLF.SPR:VISTULA.SPR (lag=0)
Global Coherence
Period
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4
8
16
32

(b)


Rsq (WTC) WOLF-SPR : VISTULA-SPR (lag=0)
Coherence
Period (year)

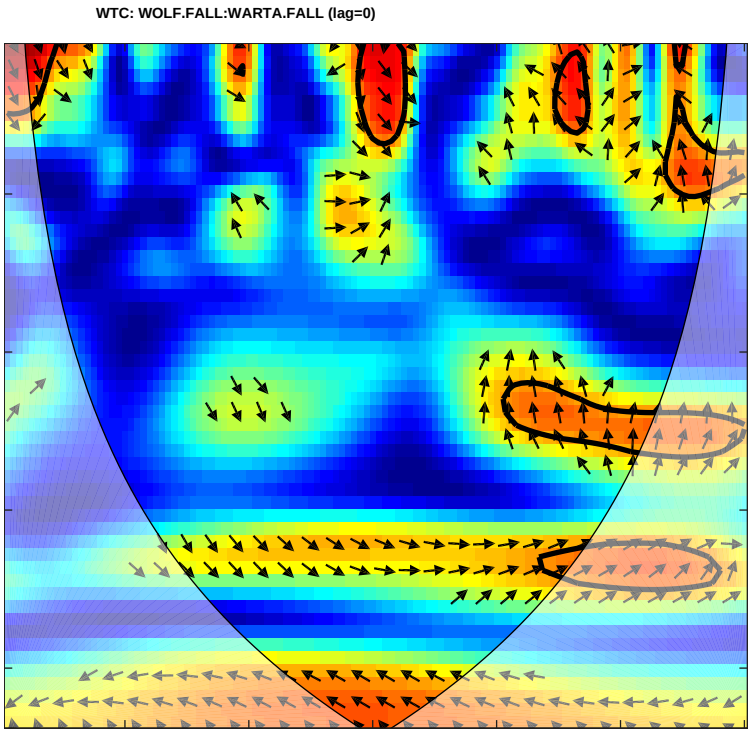
(c)



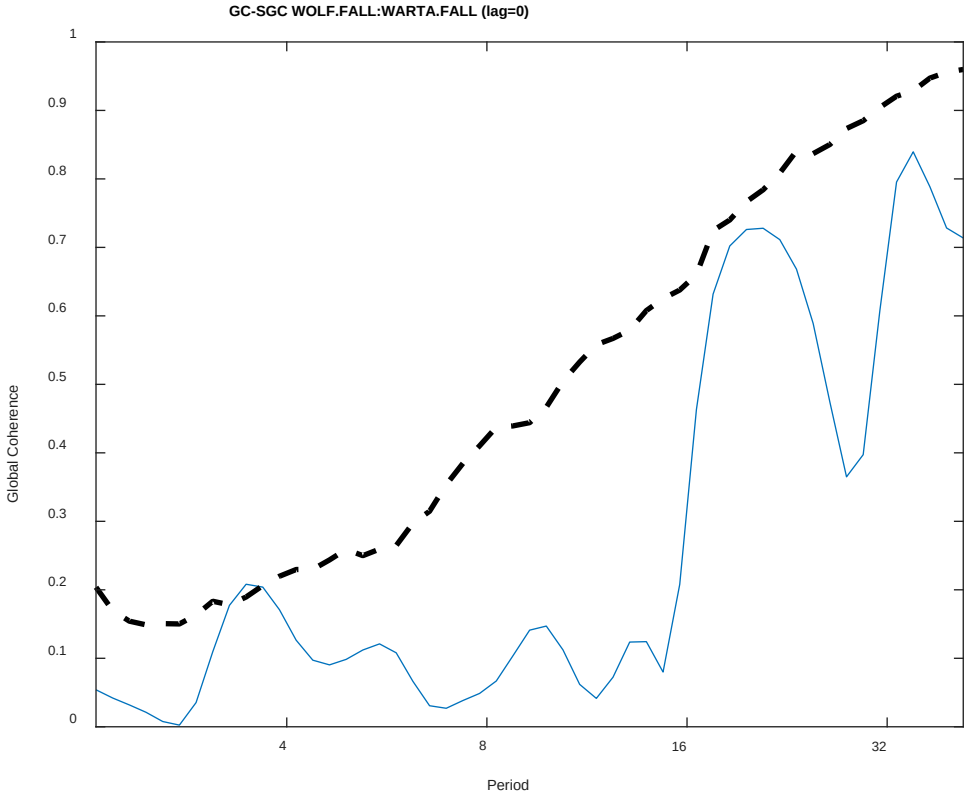
(d)

Figure S1. Relationship between solar activity (SSN) and the Vistula discharge for spring at lag=0: (a) WTC (wavelet coherence), (b) Global Coherence (GC), solid line, and Significance of GC (SGC), dashed line. SGC indicates a 95% CL, (c) boxplot for the coherence obtained by WTC, (d) average of WTC for a band of 4 periods.

Also at lag=0, it can also be considered a significant case for Q-Warta FALL, as NLR approaches 0.3 with a CL about 90% and NLR > |R|. The results are shown in Figure S2.
From Figure S2a, a good coherence can be observed as a whole for periods 2-4, highlighted also by GC from Figure A1b, where the coherence has a significance higher than 95%. This is also highlighted by Figures A2c and A2d. Regarding the connection with solar cycles, for the 11-year cycle, Figure S2a highlights a coherent significance only for the time interval 1980-2020. Obviously, being only a portion of the entire GC interval does not indicate any significance. Instead, for the coherence corresponding to the double solar cycle, Figure S2a indicates a significant coherence for an interval between 1920-2020, with the highest intensity in 1990-2020. Global coherence from Figure S2b even if it does not exceed a CL of 95%, but is very close to this significance. It should also be noted that for these wavelengths around the Hale cycle, the discharge in autumn at Warta is in phase with the SSN, that is, there is a positive correlation between the two time series.


WTC: WOLF.FALL:WARTA.FALL (lag=0)

(a)


GC-SGC WOLF.FALL:WARTA.FALL (lag=0)
Global Coherence
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0.5
0.4
0.3
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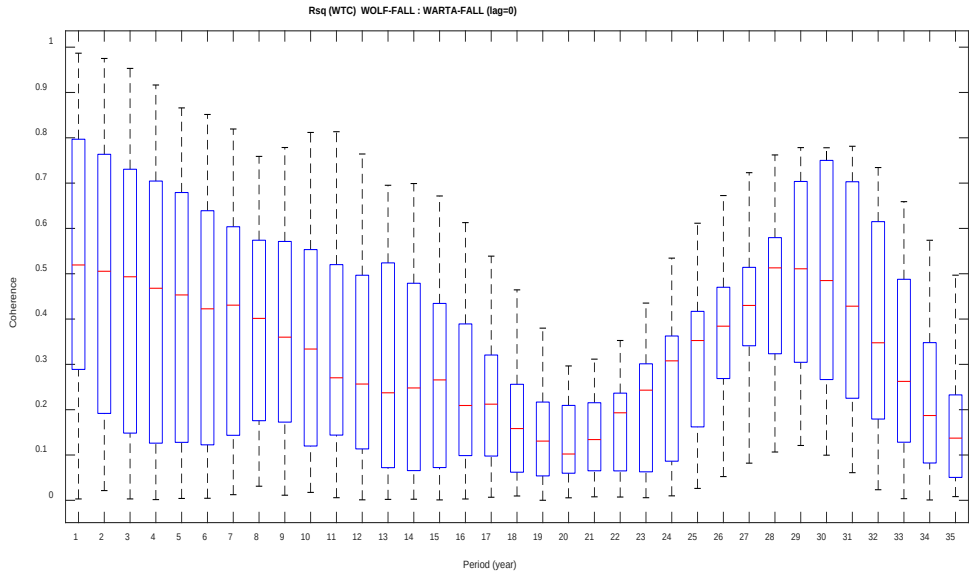
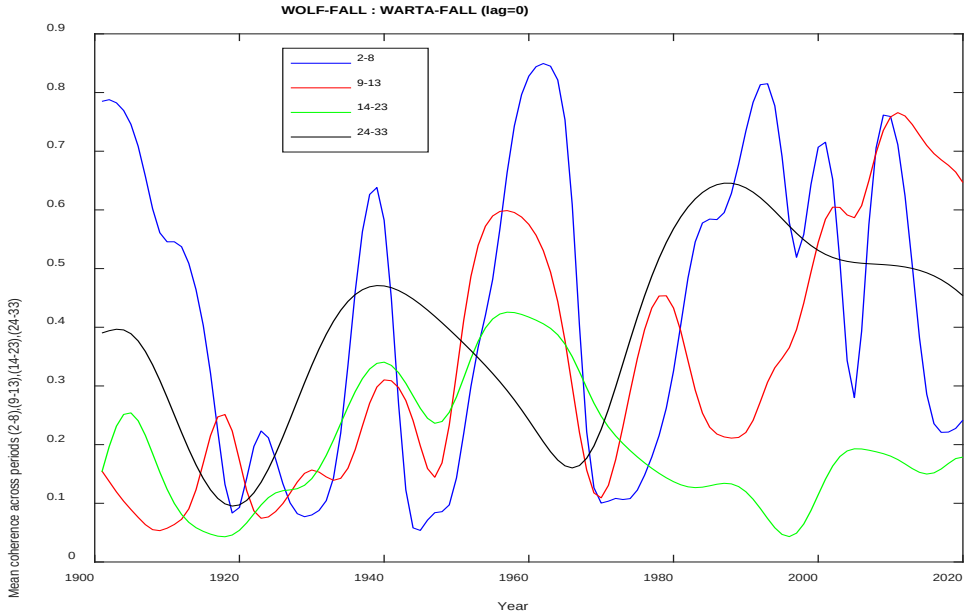
0.1
0
4
8
16
32

(b)



(c)



(d)

Figure S2. Relationship between solar activity (SSN) and the Warta discharge for fall at lag=0: (a) WTC (wavelet coherence), (b) Global Coherence (GC), solid line, and Significance of GC (SGC), dashed line. SGC indicates a 95% CL, (c) boxplot for the coherence obtained by WTC, (d) average of WTC for a band of 4 periods.