Asymmetry in the solar hemispheric poloidal and toroidal cycles

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Abstract

The hemispheric solar cycles are different in their time profiles and intensities. It can be observable an alternating variation of the time profiles which means that the northern activity leads during four Schwabe cycles while the southern one leads during the next four cycle. This variation can also be recongnized in the magnetic field reversal data which indicates that this is a long term property of the entire solar dynamo mechanism. My latest results based on the Greenwich Photoheliographic Results and Debrecen Photoheliographic Data which cover cycles 12-24 extended by the earlier Staudacher's and Schwabe's data as well as the data of Spörer covering cycles 1-4 and 7-10 and 10-11.

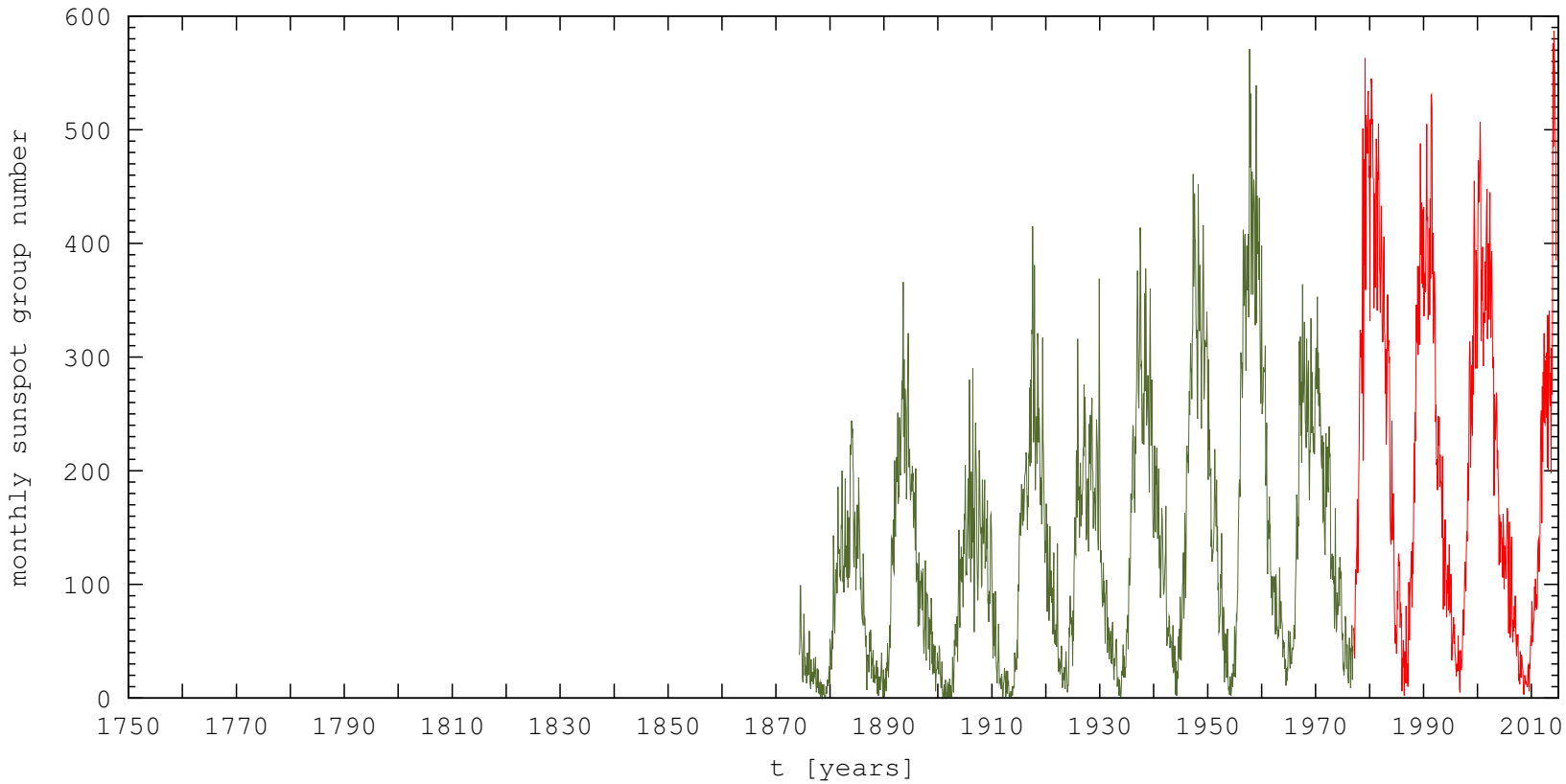
Outlook

- Earlier results
  - References
  - Own results
- New results
  - on earlier data
  - on the data of present cycle
- Summary

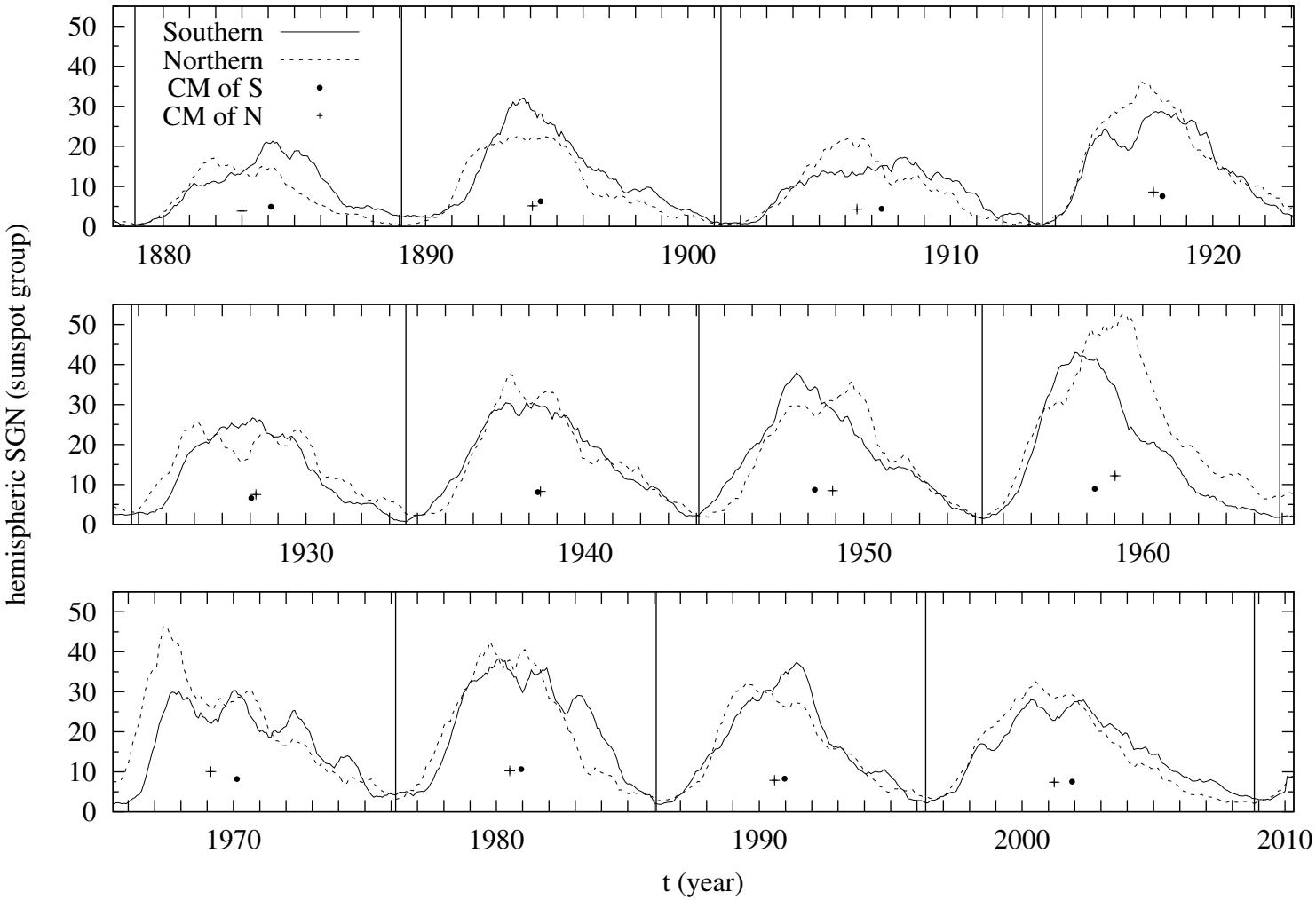
- Zolotova & Ponyavin: 2006, *A&A*, **449**, L1: found that ”the north-south sunspot asymmetry is due to phase asynchrony between Northern and Southern hemispheric activities.”
- Swinson et al.: 1986, *Sol.Phys.*, **106**, 35: found a 22-years periodicity in the normalized asymmetry index.
- Carbonell et al.: 1993, *A&A*, **274**, 497: found that the N-S asymmetry can not be obtained from random distribution, rather is a real feature of sunspots.
- Verma : 2000, *JApA*, **21**, 173: studied solar flares and sunspot groups and found a 110-years periodicity in the N-S asymmetry.
- Temmer et al. : 2006, *A&A*, **447**, 735: analized the absolute N-S indices for sunspot number time-series, and they confirm the weak magnetic interdependence between N-S hemispheres, but they did not confirm a 22-years magnetic cycle periodicity for absolute asymmetry.

Databases

- GPR (Greenwich Photoheliographic Results) - 1874-1976,
- SD (Solnechnye Danie) - 1977-1985,
- DPD (Debrecen Photoheliographic Data) - 1986-2011,

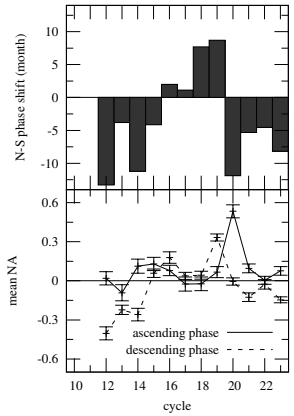


Hemispheric cycles after 1874



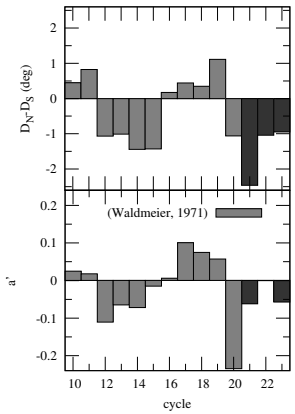
(Muraközy & Ludmány: 2012, *MNRAS*, **419**, 3624)

Hemispheric phase lags after 1874



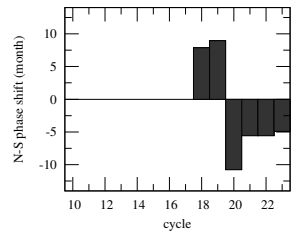
N-S phase shift (+: Southern leading; -: Northern leading)

normalized asymmetry indices [$NA = (N_N - N_S)/(N_N + N_S)$]



hemispheric phase lags obtained from the hemispheric Spörer diagram from the data of Waldmeier (1971)

yearly variation of the transformed asymmetry index from the data of Waldmeier (1971)



N-S phase shift by using the data of Temmer et al. (2006)

(Muraközy & Ludmány: 2012, *MNRAS*, **419**, 3624)

And the forever QUESTION...

What guarantees that this variation will be continued before the GPR-era and after Cycle 23?

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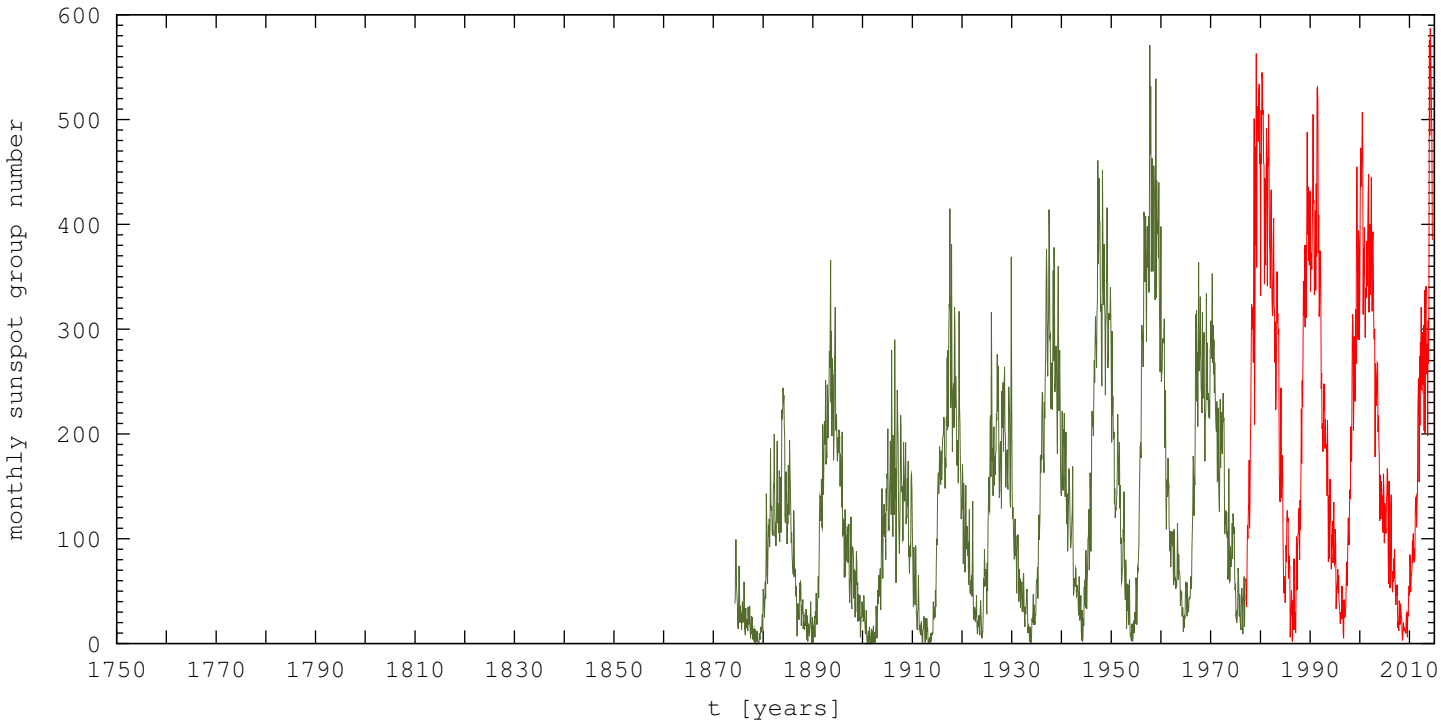
What guarantees that this variation will be continued before the GPR-era and after Cycle 23?

And the answer: Nothing guarantees, but this variation worked also on Cycles 10-11 (Waldmeier data). We need more hemispheric data...

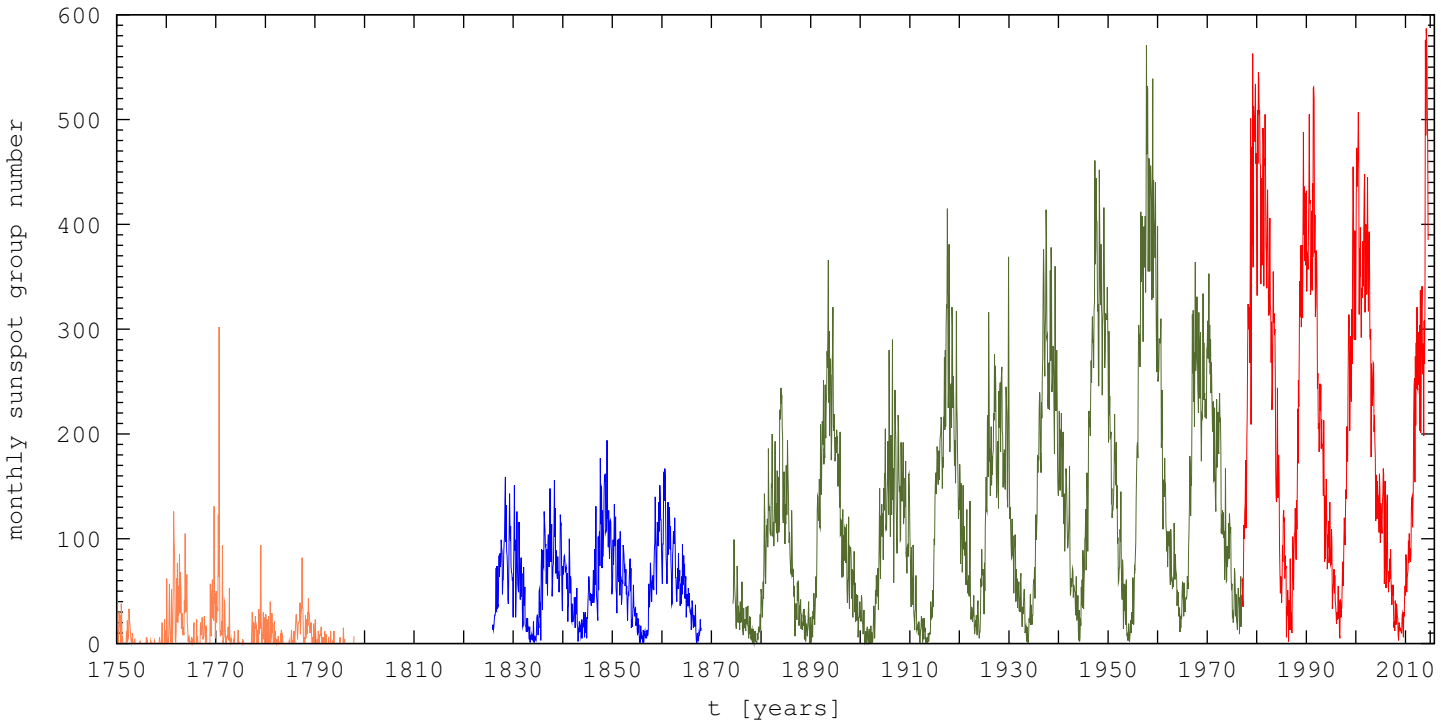
Databases

- GPR (Greenwich Photoheliographic Results) - 1874-1976,
- DPD (Debrecen Photoheliographic Data) - 1977-2015

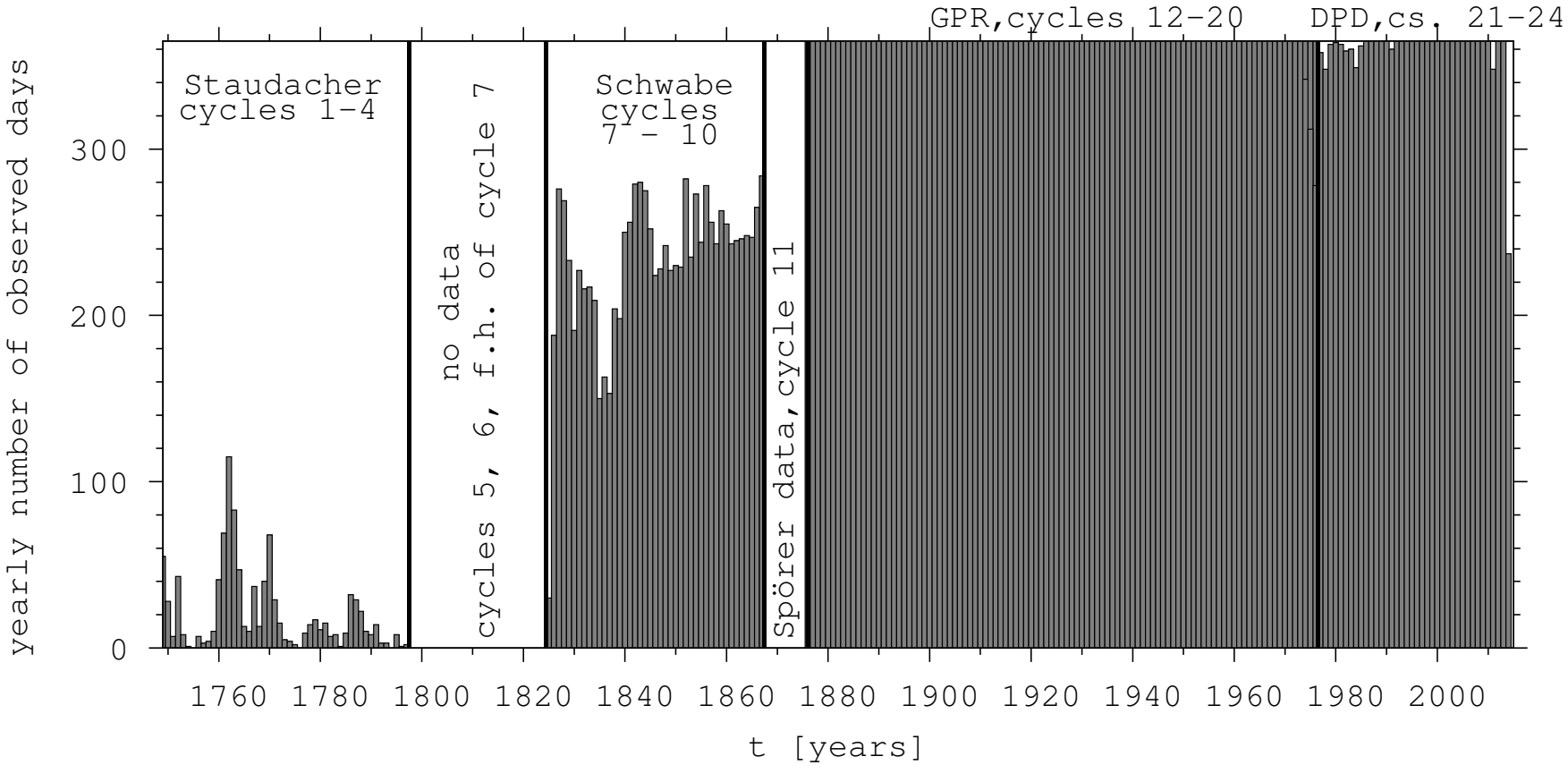


Databases

- GPR (Greenwich Photoheliographic Results) - 1874-1976,
- DPD (Debrecen Photoheliographic Data) - 1977-2015
- Staudacher Data 1749 - 1797 (Provided by Dr. Rainer Arlt),
- Schwabe Data 1825-1867 (Arlt et al.: 2013, *MNRAS*, **433**, 3165),



Number of observed days

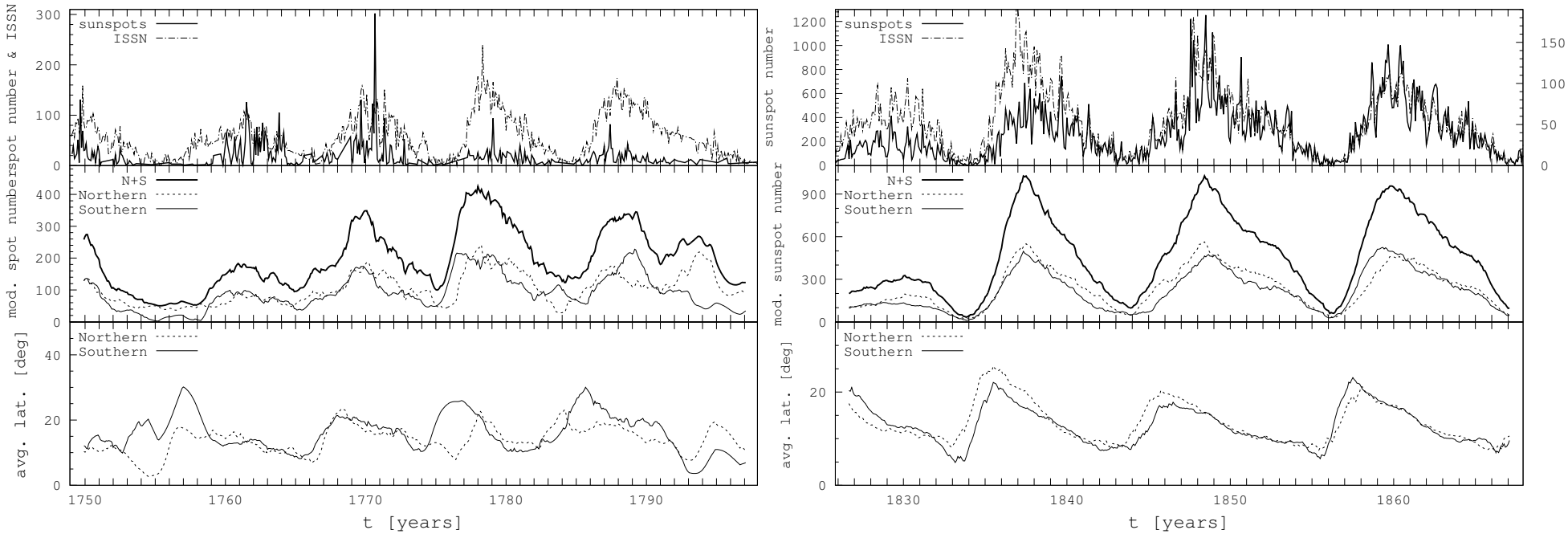


(Muraközy, J.: submitted to *ApJ*)

Staudacher cycles: observation series covering 49 years, the observations were sparse, in certain years only a few observations were made

Schwabe cycles: observation series covering 43 years, identification of sunspot groups

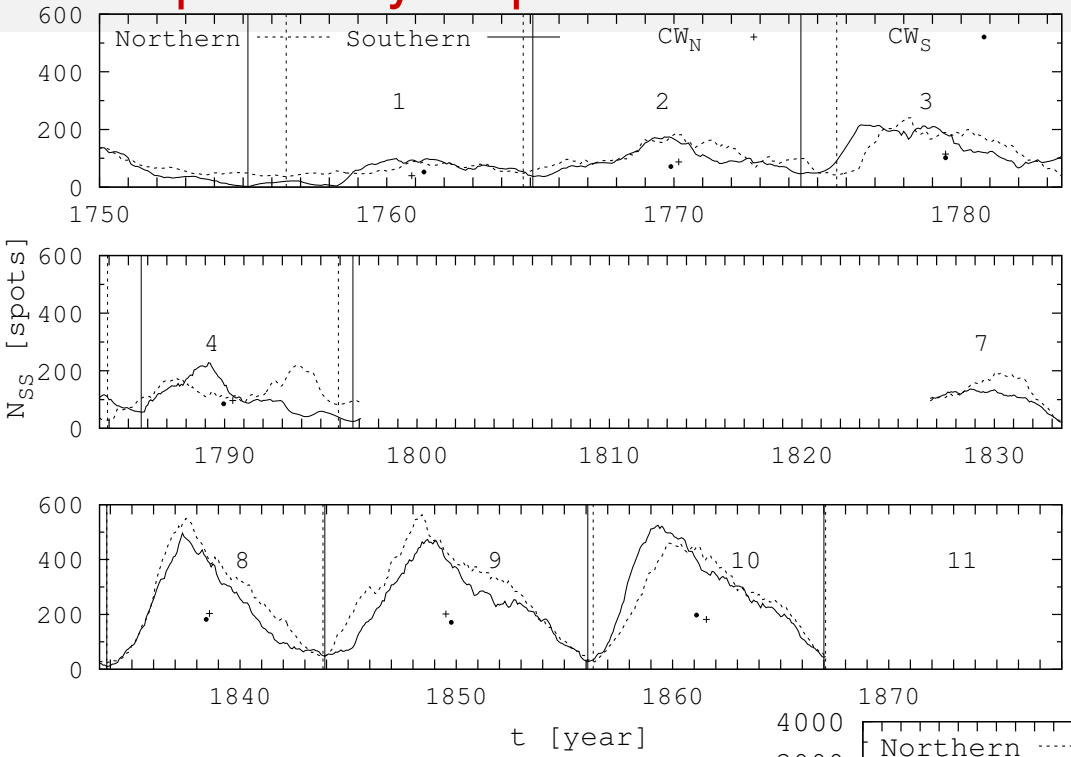
Reconstruction of the Staudacher and Schwabe data



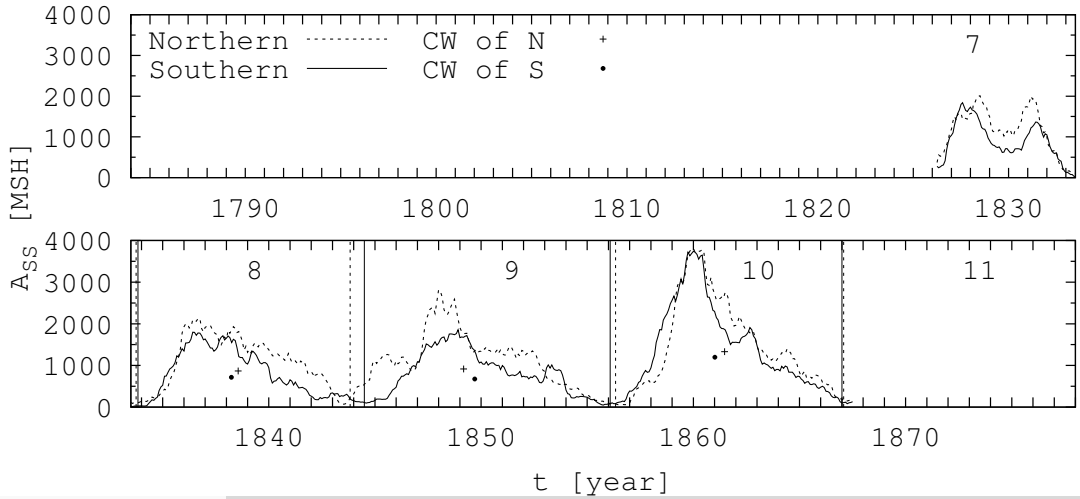
(Muraközy, J.: submitted to *ApJ*)

The observational gaps filling method: the monthly mean value of the observed days was applied for the missing days and these daily values have been summed up for the month. By applying this method the amplitudes of cycles fit to the amplitudes of the ISSN cycles. Lowermost panel: monthly mean hemispheric latitudes -> ”lost cycle”?

Hemispheric cycle profiles

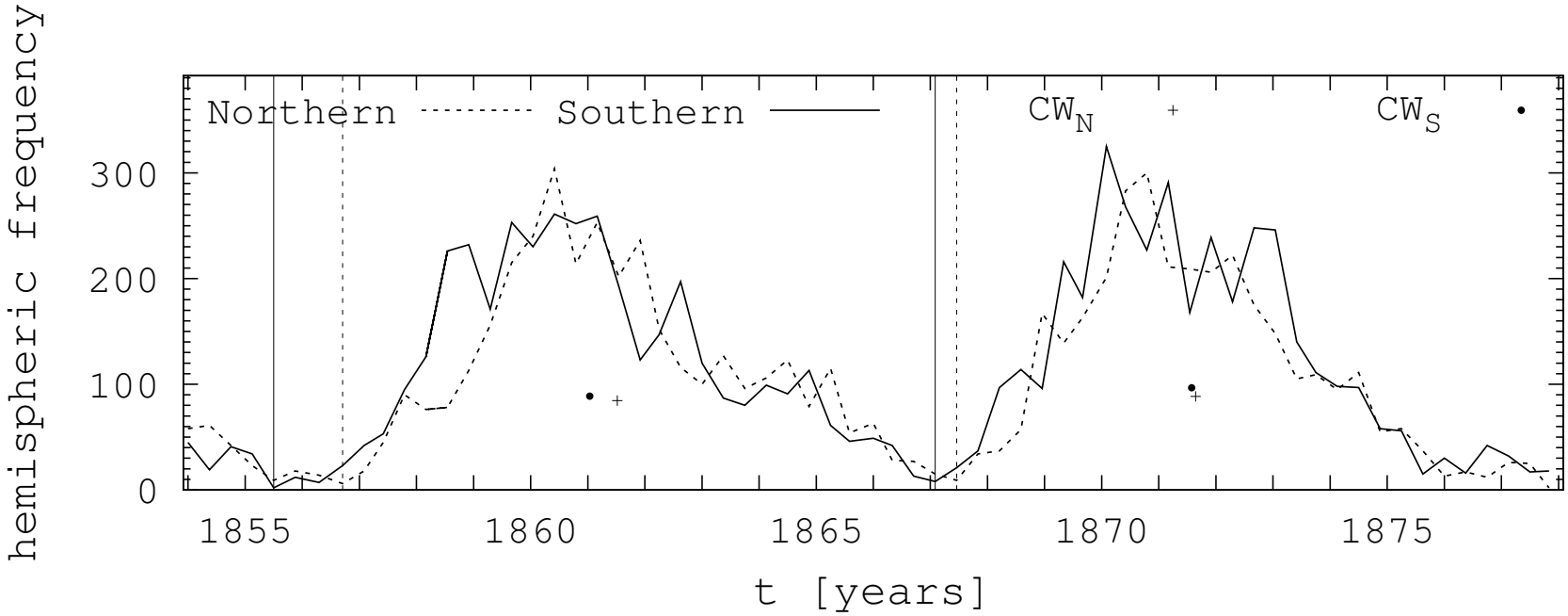


Cycle 7 disregarded, because it is not a whole cycle!
This method can be applied only on whole cycles.



(Muraközy, J.: submitted to *ApJ*)

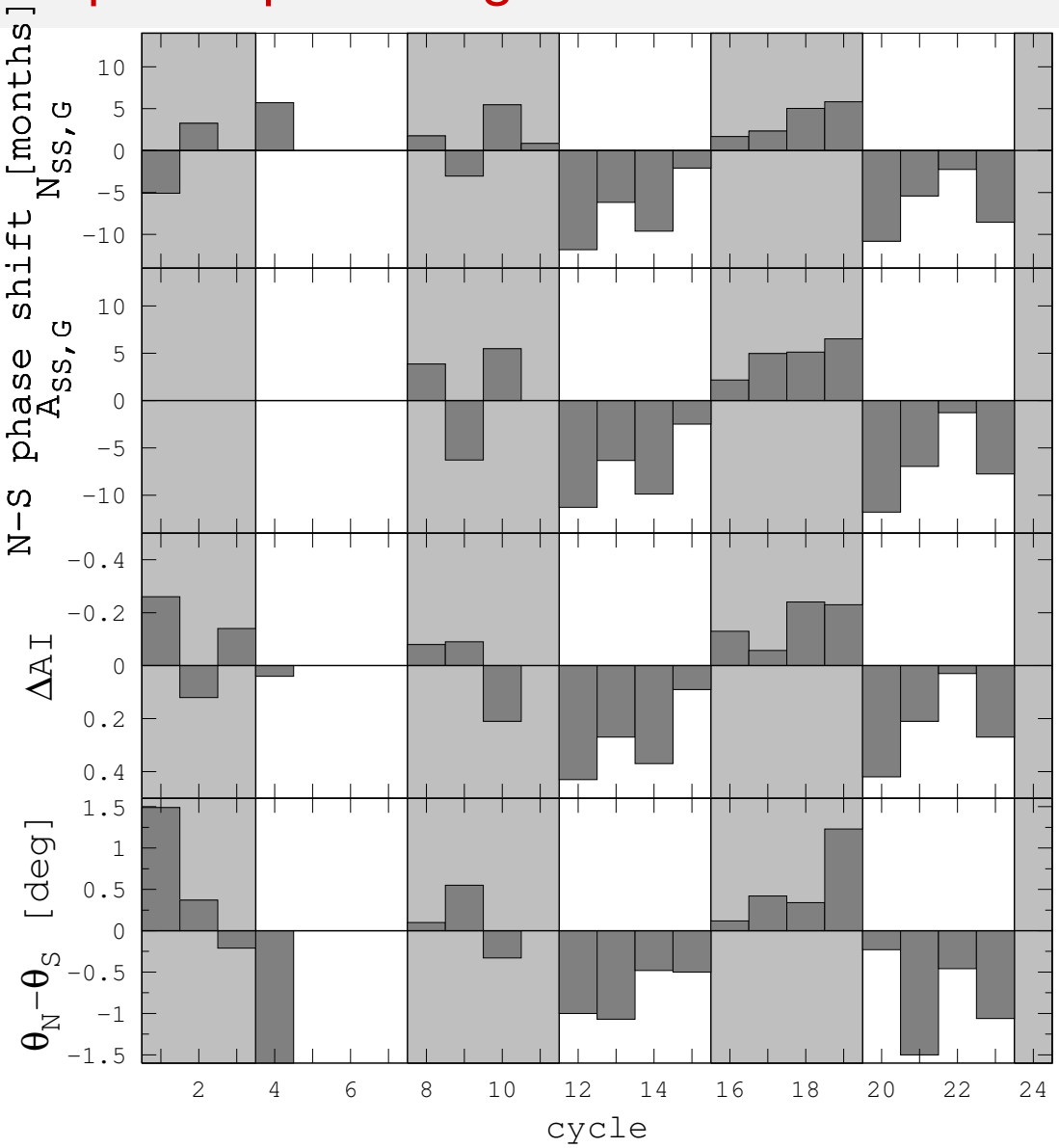
Hemispheric cycle profiles on the Spörer & Carrington data



(Muraközy, J.: submitted to *ApJ*)

Spörer data: The observed sunspot groups have been taken into account once and weighted them by their area summarizing in five Carrington rotation (named hemispheric frequencies).

Hemispheric phase lags



hemispheric phase lags on sunspots

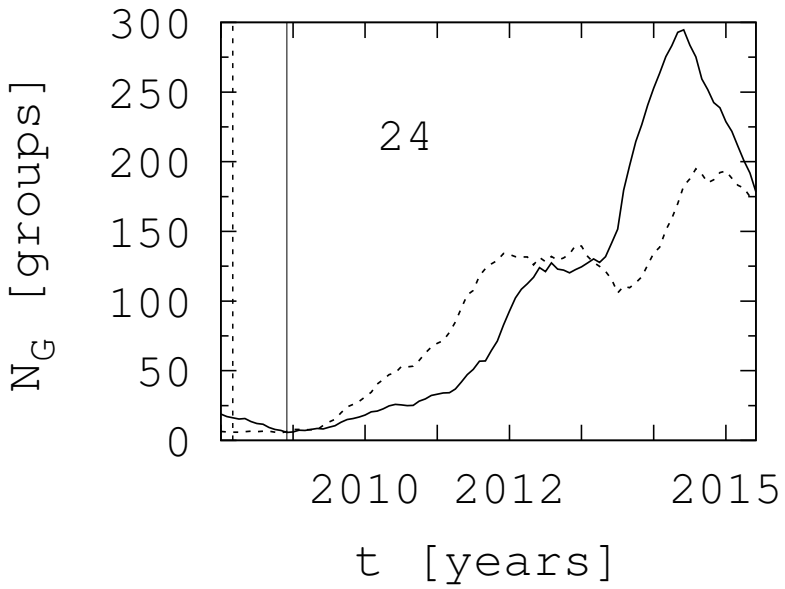
hemispheric phase lags on sunspot area

differences between the normalized hemispheric asymmetry indices of the ascending and descending phases

hemispheric latitudinal differences

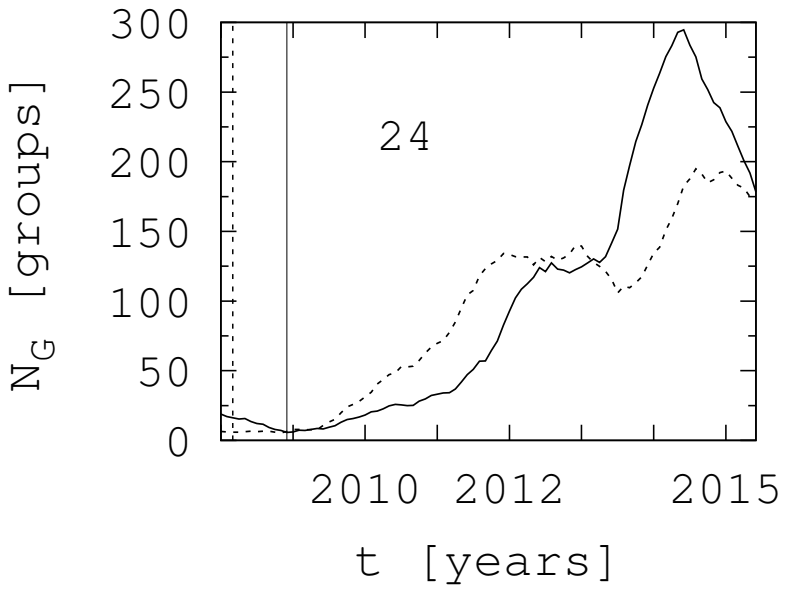
(Muraközy, J.: submitted to *ApJ*)

Hemispheric cycle profile of the present cycle



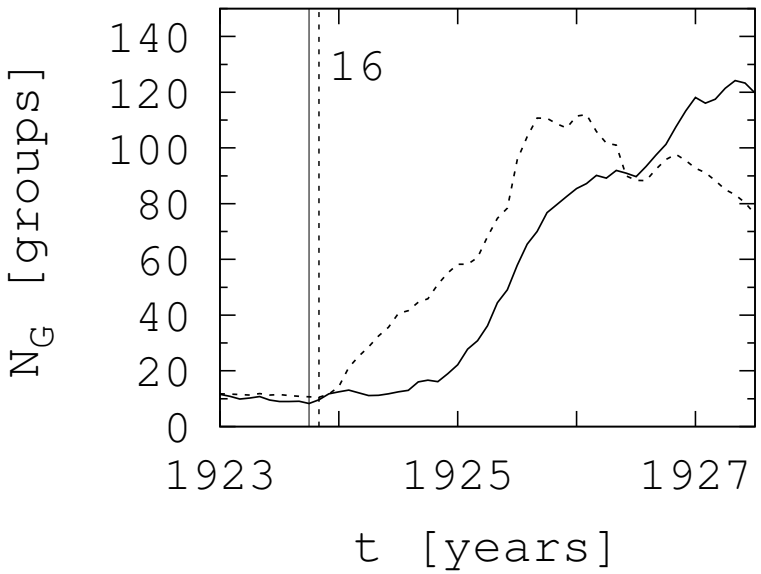
Strong northern leading?

Hemispheric cycle profile of the present cycle vs. Cycle 16

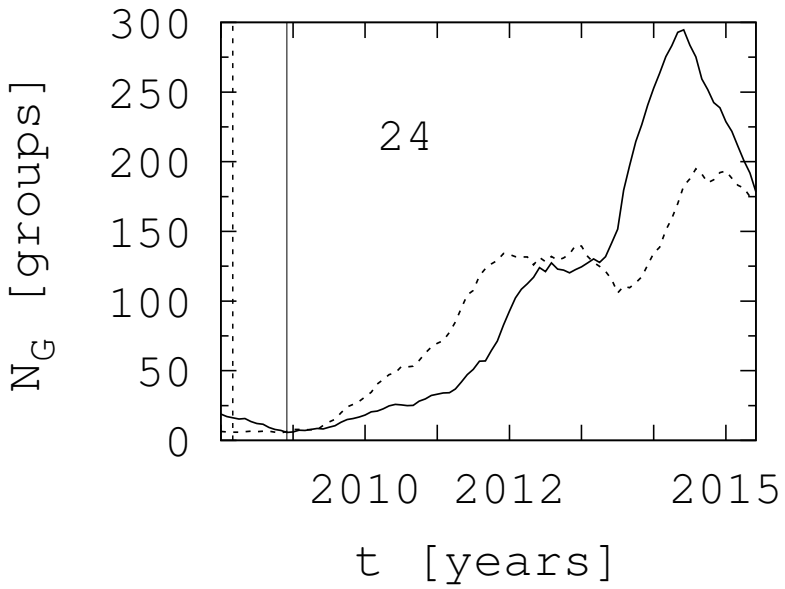


Strong northern leading?

Like in the case of the ascending phase of Cycle 16.

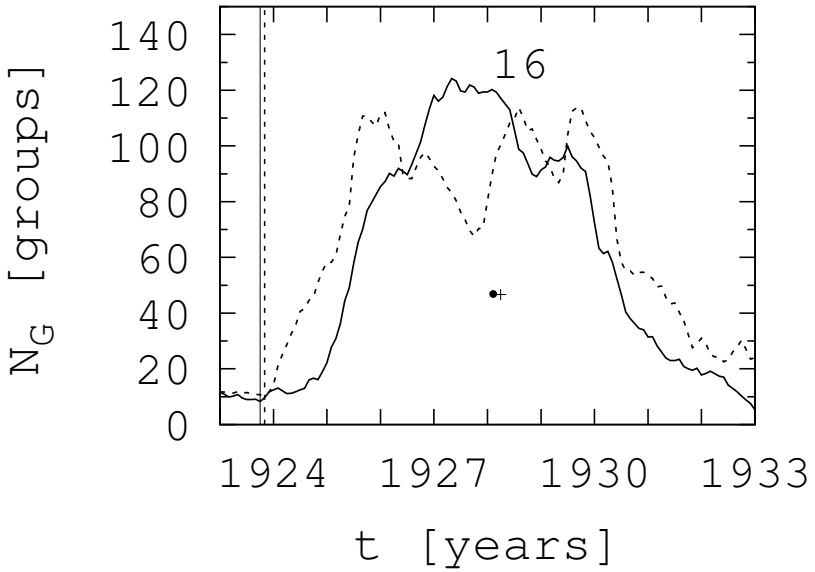


Hemispheric cycle profile of the present cycle vs. Cycle 16

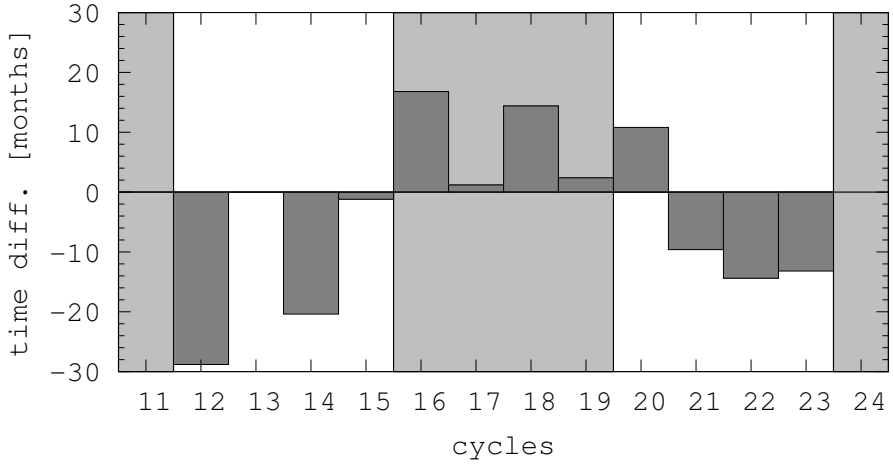


Strong northern leading?

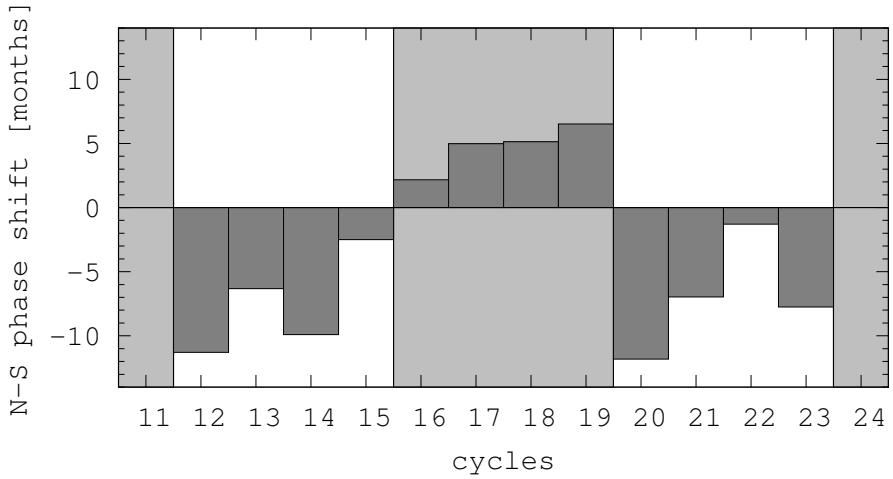
Taking into account the whole profiles of Cycle 16 the southern hemisphere leads in time. ->
The phase lag of Cycle 24 cannot be established by only considering the developing phase.



Toroidal - poloidal relationship



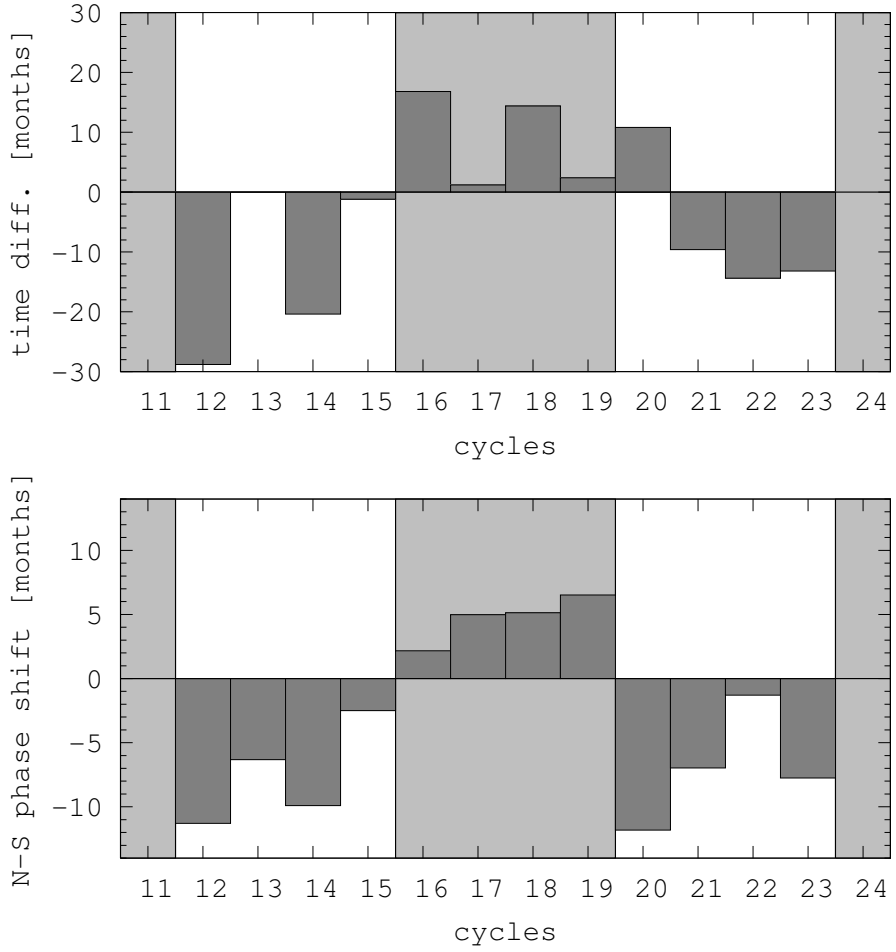
Poloidal phase shift (polarity reversal data are from Makarov& Sivaraman (1986))



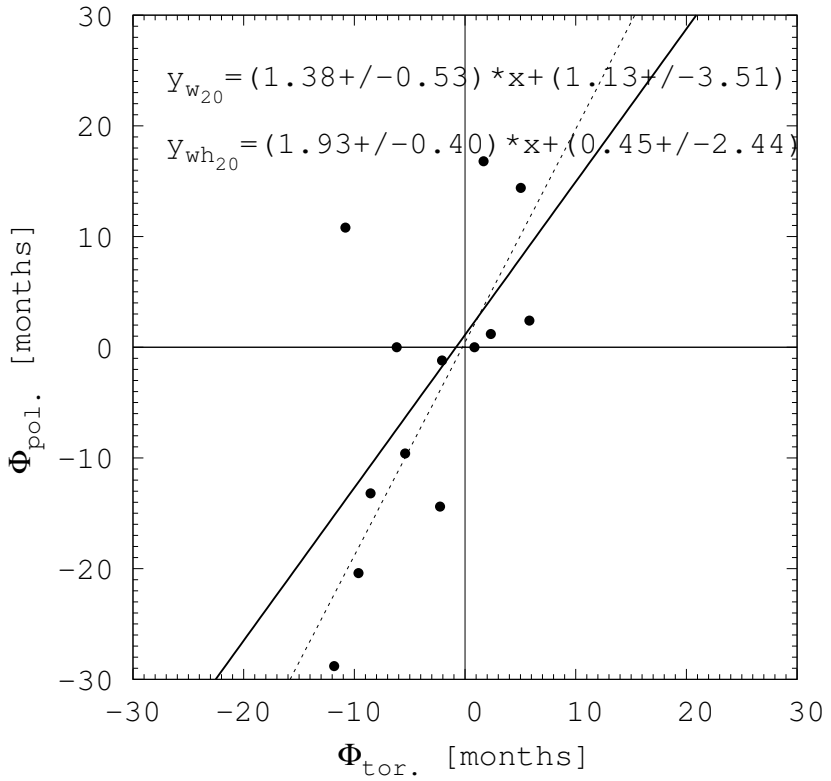
Toroidal phase lags (based on GPR and DPD)

(Muraközy, J.: submitted to *ApJ*)

Toroidal - poloidal relationship



Toroidal phase lags and the corresponding poloidal phase shifts show linear relationship.
The 4+4 variation of the phase lags is a common property of the toroidal and poloidal fields.



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Conclusion

- 4+4 cyclic variation can be pointed out from the beginning of GPR until Cycle 23
- The above mentioned variation cannot really be pointed out (5 good cases / 8 cases) with these methods on the Staudacher and Schwabe data
- These methods cannot really predict the hemispheric leading role in the case of Cycle 24 (because it is in progress), however the ascending phase of Cycle 24 is similar than Cycle 16...
- There is a notable linear relationship between the hemispheric phase lags and the poloidal field reversals; the variation of 4+4 cycles in the phase lags is a common property of the toroidal and poloidal fields. The two topologies are continuously alternating by being transformed into each other.

This is why the long-term, homogeneous observations and/or databases are so important for such kind of study.