Cent. Eur. J. Geosci. • 1(2) • 2009 • 152-156
DOI: 10.2478/v10085-009-0010-y

VERSITA

Central European Journal of **Geosciences**

# Variations in solar and geomagnetic activity with periods near to 1.3 year

**Research Article**

Jaroslav Střeštík*

*Geophysical Institute AS CR, 141 31 Praha, Czech Republic*

**Received 9 February 2009; accepted 3 April 2009**

**Abstract:** It is known that solar wind velocity fluctuates regularly with a period of about 1.3 years. This periodicity (and other signals with periods near to 1.1 and 0.9 years) has also been observed in biological data. The variation is a temporary feature, mostly being observed in the early 1990s. Here, the occurrence of these periodic signals in solar and geomagnetic activity between 1932 and 2005 has been investigated. The signal with 1.3 year period is present in geomagnetic activity only in a short interval after 1990 and to a lesser extent around 1942. At other times the signal is very weak or not present at all. Other periods are much lower amplitude and appear only sporadically throughout the time investigated. A connection between these periods and solar cycles (e.g. different even or odd cycles) has not been proven. It is possible that there is a long-term periodicity in the occurrence of the 1.3 year period but the time series data available is insufficient to confirm this. There are no such periodicities in solar activity. In order to gain a greater understanding of these periodic signals, we should search for their origin in interplanetary space.

**Keywords:** transyear variation • geomagnetic activity • solar activity • wavelet analysis



## 1. Introduction

In many physical, meteorological and biological processes on the Earth, significant variation is observed with a period of 1 year. This variation is caused by Earth's revolution around the Sun. Any other variations with a period close to but not equal to 1 year and with smaller amplitude are difficult to detect due to the high amplitude annual variation. In interplanetary space no annual variation is expected, so searching for possible variations with periods slightly longer or shorter than 1 year can be successful. In 1994, Richardson et al. [1] observed that solar wind velocities fluctuate with a period of about 1.3 yr in a dataset from around 1990. However, before 1987 this phenomenon has not been observed. Richardson et al. [1] suggest that it may be connected with a similar periodicity (1.4 yr) in aurora in Sweden (1721-1943), which appears regularly in cycles of between 60-65 years in length [2]. Other studies [3–5] confirmed the existence of the 1.3 yr signal in solar wind and interplanetary magnetic field measurements, but only after 1987. Paularena et al. [3] stated that this variation was also present with lower amplitude around 1942. Mursula and Zieger [6] processed a time series of observed solar wind velocity (since 1964) and geomagnetic activity indices (since 1932) and showed a strong 1.3 yr variation at the end of the 1980s and beginning of the 1990s. They found that in even numbered solar cycles a higher amplitude 1.3 yr variation is present, especially

*E-mail: jstr@ig.cas.cz

in the 22nd and 18th cycle. In odd numbered cycles a variation with a longer period (1.5–1.7 yr) is present but with much smaller amplitude. Moreover, to the end of the 1980s, a signal appears with a period of about 0.7 yr, which coincidentally is about half the period of the 1.3 yr variation.

Halberg et al. [9] looked for similar periodicities in biological measurements in which no annual variation exists (e.g. the morbidity in tropical regions). Their idea was that a pronounced periodic signal in interplanetary quantities must reflect itself in processes on Earth that could be influenced by these extraterrestrial factors. Indeed, they found significant variations with exact the same 1.3 yr period e.g. [7–10]. Together with the 'main' 1.3 yr variation they found other periods in the vicinity, e.g. around 1.1 yr and 0.9 yr. Variations with a period longer than one year are termed 'transyear', whilst those shorter than one year are termed 'cisyear'. Halberg et al. [9] observed a pronounced transyear (1.3 yr) signal in the incidence of myocardial infarction and in variations of systolic and diastolic blood pressure during a long time period. On occasion the transyear variation was even stronger than the annual signal.

Obridko and Shelting [11] give an extensive review of results described in the literature. The 1.3 yr variation has been found by many authors in different parameters concerning processes in the Sun and in interplanetary space, and not only in solar activity itself. Some parameters display only a slight correlation with solar activity (which here is described by numbers of sunspots). Most authors confirm that this variation is not present continuously in the parameters investigated. Obridko and Shelting [11] claim that the 1.3 yr variation is present more often at maxima and in declining phases of solar cycles, without dependence on odd or even numbered cycles, or cycle amplitude. Moreover, this variation seems to be associated with the well known quasi-biennial oscillation (QBO). On the other hand, Kane [12] found many periodic signals in solar indices within the 18th- 23rd solar cycles in a broad period range (0.4 to 4 yr). However the 1.3 yr and 1.7 yr periods were not prominent in comparison with other signals. Nevertheless, the 1.3 yr and 1.7 yr periods appear in cosmic ray intensity measurements from the 21st and 22nd solar cycles [13]. In agreement with Mursula and Zieger [6], Kudela [14] found a significant 1.3 yr variation in the 20th and 22nd cycles, and a 1.7 yr variation in the 21st cycle.

In this paper I present results from a study of different parameters describing solar and geomagnetic periods in the interval 0.5–2.5 yr, and in more detail between 0.7 and 1.7 yr. The parameters used are: geomagnetic indices *Ap* and Σ*Kp* from 1932-2007, *Dst* index from 1957–2007, sunspot numbers *W* from 1932–2007, solar flare index *SFI* from 1966–2007, and solar radio flux on frequency 2800 MHz (hydrogen line Hα) from 1947–2007.

## 2. Spectral analysis

A spectrum of *Ap* indices for the whole interval 1932-2007 shows no significant maximum and the same is valid for all other quantities investigated. The spectrum is split into many low amplitude peaks, none of which possess any great significance. Better insight into the frequency content can be obtained using power spectra. With sufficiently short spectral window the resolution in frequency decreases and only significant peaks remain. Figure 1 shows power spectra with window lengths of 5 and 10 years. The peak in the period between 1.3-1.4 yr is clear, and lower amplitude peaks occur at shorter periods as reported by Halberg et al. [9, 10]. For periods shorter than displayed in Figure 1, only variation of the 0.5 yr period is significant, corresponding to the semi-annual variation of geomagnetic activity. For periods longer than displayed in Figure 1, a peak exists at approximately 2 yr which corresponds to the QBO. Using a longer window the power spectrum contains more peaks, similar to the amplitude spectrum. This suggests that the signal corresponding to the main peak (between 1.3-1.4 yr periods) is not present all the time, at least not with constant amplitude.

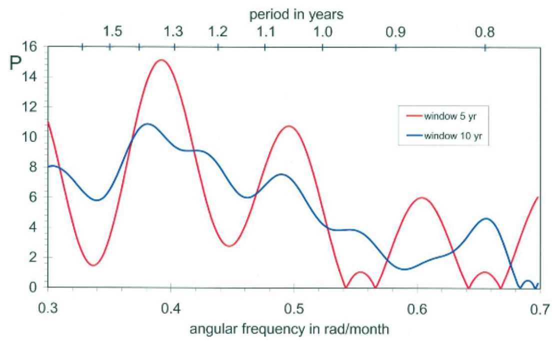


**Figure 1.** Power spectra of series of geomagnetic *Ap* indices between 1932-2007 with window lengths of 5 and 10 years.

As a result of these observations, the whole dataset was subdivided into 11 year intervals in such a way that these parts begin near to the year of minimum solar activity. The intervals have been selected as follows: 1932–1942, 1943–1953, 1954–1964, 1965–1975, 1976–1986, 1987–1997, and 1998–2007 (interval incomplete). Because solar cycles are not a constant length, the selected intervals do not correspond precisely to the cycles. However, the difference between the positions of cycles and of selected intervals

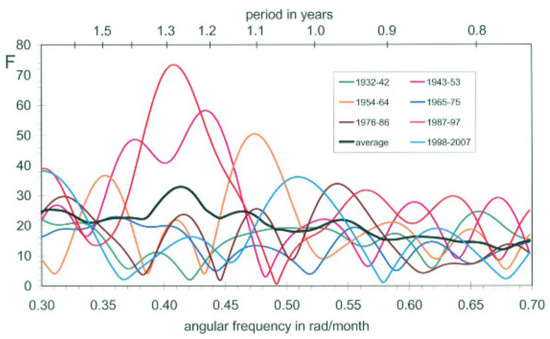


**Figure 2.** Spectra of series of geomagnetic *Ap* indices in 11-yr intervals between 1932 and 2007.

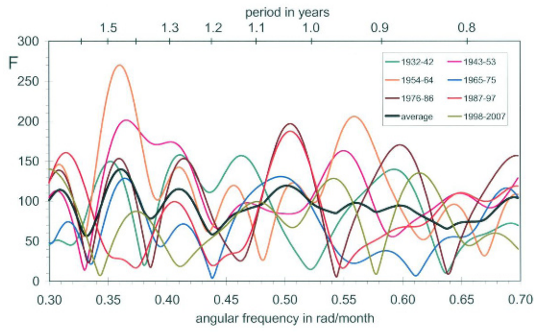


**Figure 3.** Spectra of series of sunspot numbers in 11-yr intervals between 1932 and 2007.

is small and the spectra of selected intervals differ very little from those calculated for the correct solar cycle.

Spectra of *Ap* indices for the selected intervals are presented in Figure 2. It is important that all spectra differ considerably from each other and no similarity can be seen. As expected, a significant peak occurs at a period of 1.25 yr in the spectrum for the interval 1987-1997 (solar cycle No 22). A less significant peak also exists for the interval 1943-1953 (solar cycle No 18) and a peak at 1.1 yr period for 1954-1964 (solar cycle No 19). No other peaks have significant amplitude. For longer periods (outside the range of Figure 2), peaks exist in the spectra for the three intervals mentioned above at periods between 2.3-2.7 yr, and with amplitudes of about 3/4 of the main peak. These correspond to sub-harmonics of the main signal.

The same analysis was applied to subsets of the individual cycles (ascending and descending phases of the solar cycle); however this yielded similar results to those in Figure 2. The only significant peaks occur in parts of solar cycle Nos 18 and 22 with periods between 1.3-1.4 yr. This observation is valid for both ascending and descending phases of the solar cycle.

Similar results have been obtained using spectra of other indices of geomagnetic activity. For the $\Sigma Kp$ index, amplitude differences are less than for *Ap* indices. For the *Dst* index, the peak at a period of 1.3 yr is more pronounced in solar cycle No 22 than it is in the equivalent spectrum of the *Ap* index. In addition, a peak at a period of 1.7 yr during solar cycle No 21 is also significant.

A different situation is evident for characteristics of solar activity. Figure 3 shows spectra of sunspot numbers for the same intervals as those for *Ap* indices in Figure 2. The peak with the greatest amplitude lies at a period of 1.45 yr and appears during solar cycle No 19, but it is not so pronounced in comparison with spectral peaks in Figure 2. In addition, its position does not correspond with peaks in the spectrum of *Ap* index in the same interval. For cycle Nos 18 and 22 no significant peak exists. The same is valid for flare indices and for solar radio flux (however this data is not available for cycle No 18).

## 3. Dynamic spectra

The frequency content of the analyzed data series and its temporal variation can be successfully investigated using wavelet analysis [15]. Here I use freely available software which makes it possible to conduct all calculations inline[1]. The resolution, especially of frequency, is not high. Nevertheless, output from this program provides a good insight into which periodic waves are present in the data and at what times they are most pronounced. In other words, the 'dynamic spectrum' shows the variation of the spectrum with time.

Figure 4 shows the dynamic spectrum of A*p* indices for 1932-2007. The wavelet analysis is plotted in grayscale in order to make it easier to identify high and low spectral densities. The darkest areas correspond to the most pronounced signal and show its prevailing period and location through time. In Figure 4, the region of highest amplitude is centered at a period of approximately 1.3 yr during the interval 1988-1994. A lower amplitude peak occurs at the same period from 1942-1948. Both of these spectral peaks are accompanied by peaks at a period of about 2 yr or longer. Other peaks appear sporadically at shorter periods, the strongest of which lies at about 2.0 yr between 2002-2005. These observations are in agreement with the corresponding spectra (Figure 2). The wavelet analysis for the $\Sigma Kp$ index is very similar to that of the *Ap* index. The same is true of the *Dst* index, except for

[1] *http://paos.colorado.edu/research/wavelets*

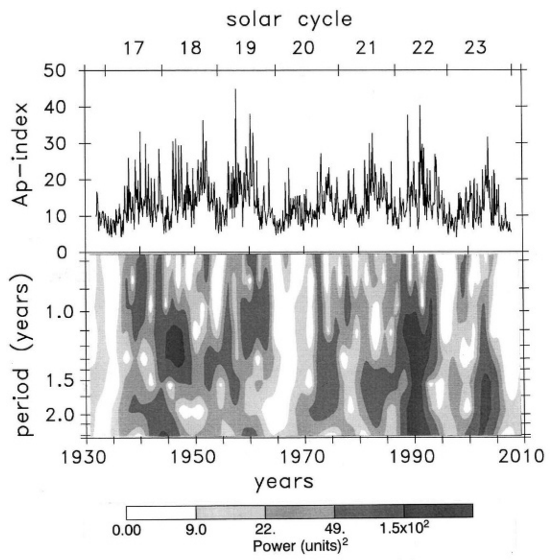


**Figure 4.** Dynamic spectrum of geomagnetic A*p* indices between 1932-2007 in the period range 0.8–2.5 years. Top – time series of A*p* indices. Bottom – wavelet analysis.

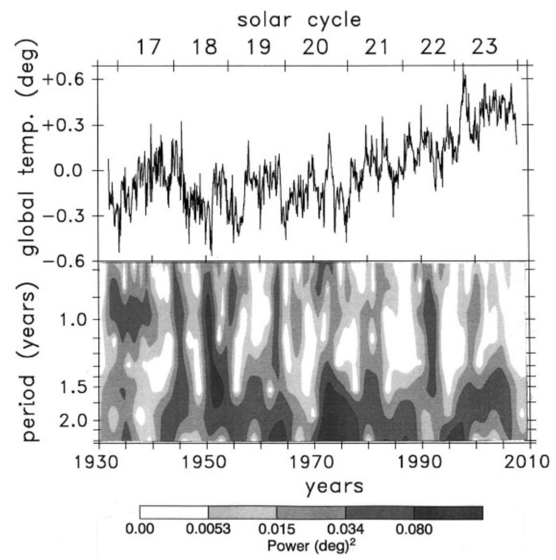


**Figure 6.** Dynamic spectrum of global temperature from 1932-2007 in the period range 0.8–2.5 years. Top – time series of global temperature. Bottom – wavelet analysis.

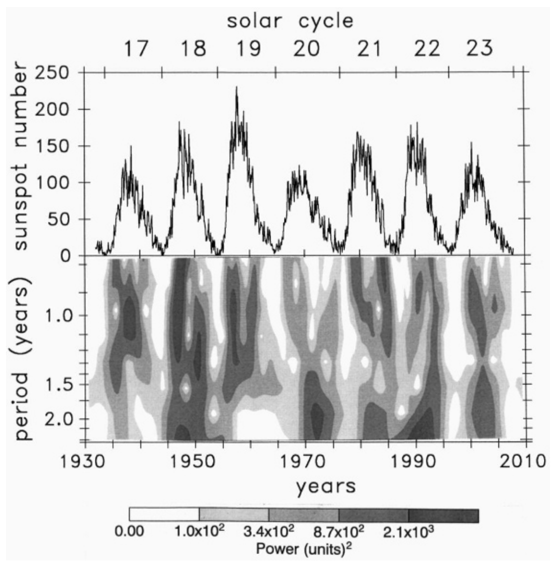


**Figure 5.** Dynamic spectrum of sunspot numbers from 1932-2007 in the period range 0.8–2.5 years. Top – time series of sunspot numbers. Bottom – wavelet analysis.

the absence of the peak at 2.0yr period after 2000.

The wavelet analysis results are quite different for sunspot activity (Figure 5). There is no significant spectral peaks at a period of around 1.3 yr. Spectral peaks in the sunspot data are narrow and their position does not correspond with peaks in Figure 4. Very similar results are obtained from flare index data, but again there is no peak after 2000 for periods of about 2.0 yr.

Wavelet analysis of average global temperature change gives results very similar to those for solar activity (Figure 6). Since global temperature is averaged for the whole Earth, no annual variation is expected. Transyear and cisyear periodicities, if they exist, should be obvious. Nevertheless, no such variation is pronounced in Figure 6. Only occasionally an annual variation appears, more often a variation with the period of about 2 yr prevails. This biennial signal is probably directly related to the QBO. This result implies that global temperature change is very weakly influenced by geomagnetic activity, or not at all.

## 4. Conclusions

The transyear variation with the period of 1.3 yr appears in geomagnetic activity but not in solar activity. However, some authors have found it in other solar phenomena, in interplanetary space and in cosmic rays, which are usually not correlated with parameters of solar activity (e.g. sunspot numbers). This suggests that the origin of this variation should be from within interplanetary space.

The transyear variation in all phenomena occurs only in some limited time intervals which repeat on approximately a 45 year time scale. These intervals display no correlation with solar cycles, since it was not confirmed that these variations occur more often in even cycles or in selected parts of cycles.

Other transyear and cisyear variations are much weaker and cannot be discovered so easily. Their occurrence is sporadic and not correlated with the 'main' 1.3-yr variation or solar cycles.

The occurrence of transyear variation in some biological data supports the idea that these are affected by the solar-terrestrial environment. However, this is only valid in the case where the transyear variation appears at the same time in solar-terrestrial signals as well as in biological data. Otherwise the occurrence of transyear variations in biological data will have a different origin.

## Acknowledgements

This research has been supported by the Grant Agency of the Academy of Sciences of the Czech Republic, grant No A 300 12 06 08.

### References

[1] Richardson J.D., Paularena K.I., Belcher, J.W., Lazarus, A.J., Solar wind oscillations with a 1.3 year period, Geophys. Res. Lett., 1994, 21, 1559-1560

[2] Silverman S.M., Shapiro R., Power spectral analysis of auroral occurrence frequency, J. Geophys. Res., 1983, 88, 6310-6316

[3] Paularena K.I., Szabo A., Richardson J.D., Coincident 1.3-year periodicities in the Ap geomagnetic index and the solar wind, Geophys. Res. Lett., 1995, 21, 3001-3004

[4] Szabo A., Lepping P., King J.H., Magnetic field observations of the 1.3-year solar wind oscillation, Geophys. Res. Lett, 1995, 22, 1845-1848

[5] Gazis P.R., Long-term enhancements in solar wind speed, J. Geophys. Res.-Atmos, 1996, 101, 415-424

[6] Mursula K., Zieger B., The 1.3-year variation in solar wind speed and geomagnetic activity, Adv. Space Res., 2000, 25, 1939-1942

[7] Cornélissen G., Halberg F. et al., Multiple resonances among time structures, chronomes, around us. Is an about 1.3-year periodicity in solar wind built into the human cardiovascular chronome?, Human Physiology (Fiziologiya cheloveka), 2004, 30, 202-208

[8] Cornélissen G., Halberg F. et al., Yearly and perhaps transyearly human natality patterns near the equator and at higher latitudes, Biomed. Pharmacother., 2005, 59, Suppl. 1, S117-S122

[9] Halberg F., Cornélissen G. et al., Blood pressure self-surveillance for health also reflects 1.3-year Richardson solar wind variation: spin-off from chronomics, Biomed. Pharmacother., 2003, 57, Suppl. 1, 58-76

[10] Halberg F., Cornélissen G., Bakken E.E. et al., Transyears: new endpoints for gerontology and geriatrics or confusing sources of variability? J. Gerontol. A.-Biol., 2004 59, 1344-1347

[11] Obridko V.N., Shelting B.D., Occurrence of the 1.3-year periodicity in the large-scale solar magnetic field for 8 solar cycles, Adv. Space Res., 2007, 40, 1006-1014

[12] Kane R.P., Short-term periodicities in solar indices, Sol. Physi., 2005, 227, 155-175

[13] Kato C., Munakata K., Yasue S., Inoue K., McDonald F.B., A ∼1.7-year quasi-periodicity in cosmic ray intensity variation observed in the outer heliosphere, J. Geophys. Res., 2003, 108, A10, 1367, DOI:10.1029/1003JA009897

[14] Kudela K., Rybák J., Antalová A., Storin, M., Time evolution of low frequency periodicities in cosmic ray intensity, Sol. Phys., 2002, 205, 165-175

[15] Torrence C., Compo G.P., A practical guide to wavelet analysis, B. Am. Meteorol. Soc., 1998, 79, 61-78