The wavelet analysis of the solar and cosmic ray data

J. Rybák (choc@astro.sk) and A. Antalová (antalova@astro.sk)
Astron. Institute, Slovak Academy of Sciences, 05960 Tatr. Lomnica, The Slovak Republic

M. Storini (storini@fis.uniroma3.it)
Instituto di Fisica dello Spazio Interplanetario/CNR, Area di Ricerca Roma–Tor Vergata, Via del Fosso del Cavaliere, 100 - 00133 Roma, Italy

Abstract. Results of the wavelet power spectrum (WPS) analysis (which covers the 1969–1998 years) obtained using the daily data of the following parameters: (i) the Mt. Wilson Magnetic Plage Strength index (MPSI), (ii) the solar LDE–type flare index (LDE–FI) and (iii) the Calgary cosmic ray (CR) intensity, are reported for periods ranging between 64 and 1024 days. The temporal distribution of the WPS during the last three solar activity cycles is extremely discontinuous. A clear resemblance between the CR and LDE–FI WPS is obtained only for the 22–nd solar activity cycle. Nevertheless, the CR multiperiod peak, observed in 1982, can well be identified with the WPS peaks obtained in both solar parameters under consideration. In the 21–st cycle, we found significant the MPSI periods around 850–880 days (2.3 – 2.4 yr), while such periods are present in the LDE–FI data of the 22–nd cycle. In the CR data we discerned a net periodicity around 650–days (1.7 yr).

1. Data treatment and analysis

The 11–yr and 27–day periods are well-established main periodicities of solar activity and the related solar output. Over a wide range of solar periods, different intermediate–term periods were predicted (Wolff, 1992) and also found (Bouwer, 1992; Ballester, Oliver and Baudin, 1999, and references therein), depending on the time interval and data set analysed. Lean and Brueckner (1989) found a periodicity near 155 days in the sunspot blocking function, the 10.7 cm radio flux, and the sunspot number, but not in the Ca II plage index, in data sets of the 19, 20 and 21 solar activity cycles. Lean and Brueckner (1989) revealed that power at 155 days is weaker in the cycle 20 than in the 19 and 21 cycles. The aim of this paper is to continue in the study of the time – period relations of *Mt. Wilson Magnetic Plage Strength Index* (MPSI), *the LDE–type flare index* (LDE–FI) representing the strong local magnetic fields associated with the presence of the flare–rich active regions and *the Galactic Cosmic Ray* (CR) intensity (Venkatesan et al., 1989) in 1969 – 1998 years. We have already reported (Rybák et al., 2000 as well as Antalová et al., 2000) the intermittent character of the 150–day solar periodicity in the 20, 21 and 22 cycles for solar soft X–ray parameters. We found that the power of the 155-day periodicity of solar SXR data is remarkably better during the 21–st cycle than in the 20–th cycle, similar as Lean and Brueckner (1989) declared in their data sets. Due to the absence of the 150–day solar periodicity in Lean and Brueckner plage index we studied the Mt. Wilson Magnetic Plage Strength Index, which reflects the weaker magnetic fields of the solar disk. We also investigated the existence of an approximately 1.3 yr (475–days) period, which was revealed in the speed of the solar wind (Richardson et al., 1994) and in the helioseismic measurements (Komm et al., 2000). A detailed description of the used data sets is given in Rybák et al. (2000) and Antalová (1999). The wavelet transform computational algorithm of Torrence and Compo (1998) has been used for calculation of the WPS. The main results of our WPS analysis are illustrated in Figure 1. The thick solid line stems for the 95% confidence level.

2. Main results and conclusions

• The peaks in the WPS at 150–day periodicity occur in all three time series. The strongest 150–day peaks are displayed in the WPS of the LDE–type flare index, during the 21–st cycle. In contrast to Lean and Brueckner (1989), where the 155 day periodicity was absent, or very weak, in the Ca II K emission data of the 19, 20 and 21 cycles, this periodicity is prominent in our WPS of the Mt. Wilson Magnetic Plage Strength index, mainly in the 21–st solar cycle.
• The WPS peak around the 1.3 yr (475 days) period, which was reported from the helioseismic measurements, is displayed mainly in the MPSI (in 1980 and 1982 and somewhat less prominent in 1991–1992 years). We can infer that this periodicity is the most conclusively detected in the global distribution of the faint magnetic flux on the disk. In CR, the 1980 and the 1991 year WPS peaks have the 475–day period well defined.
• The CR multiperiod peaks coincide well with multiperiod peaks of our solar parameters (see the 1982 and 1991 WPS peaks). In the 22-nd solar cycle, we found a striking resemblance between the CR and the LDE–type flares.
• Each parameter studied here has the distribution of WPS very different in periods larger than 500 days. The solar data series exhibit similar, 850–880 day periods, but coincidence is missing (the MPSI periods belongs to the 21–st cycle, that of the LDE–FI to the 22–nd solar cycle).
• The temporal distribution of WPS of all 64 – 475 day periods of the MPSI, LDE–FI and CR data sets, strongly supports the dual–peaked structure of the solar activity cycle discussed by Feminella and Storini (1997). The concept of *the Gnevyshev gap* (a time interval during the maximum solar activity phase, in which a decrease in the solar atmospheric activity is observed) was introduced by the Rome Cosmic Ray Group during the nineties. Results on the topic can be seen in Astafyeva and Bazilevskaya (1999), Kudela et al. (1999), Storini and Hofer (1999), Antalová et al. (2000) as well as Bazilevskaya et al. (2000) and Rybák et al. (2000).

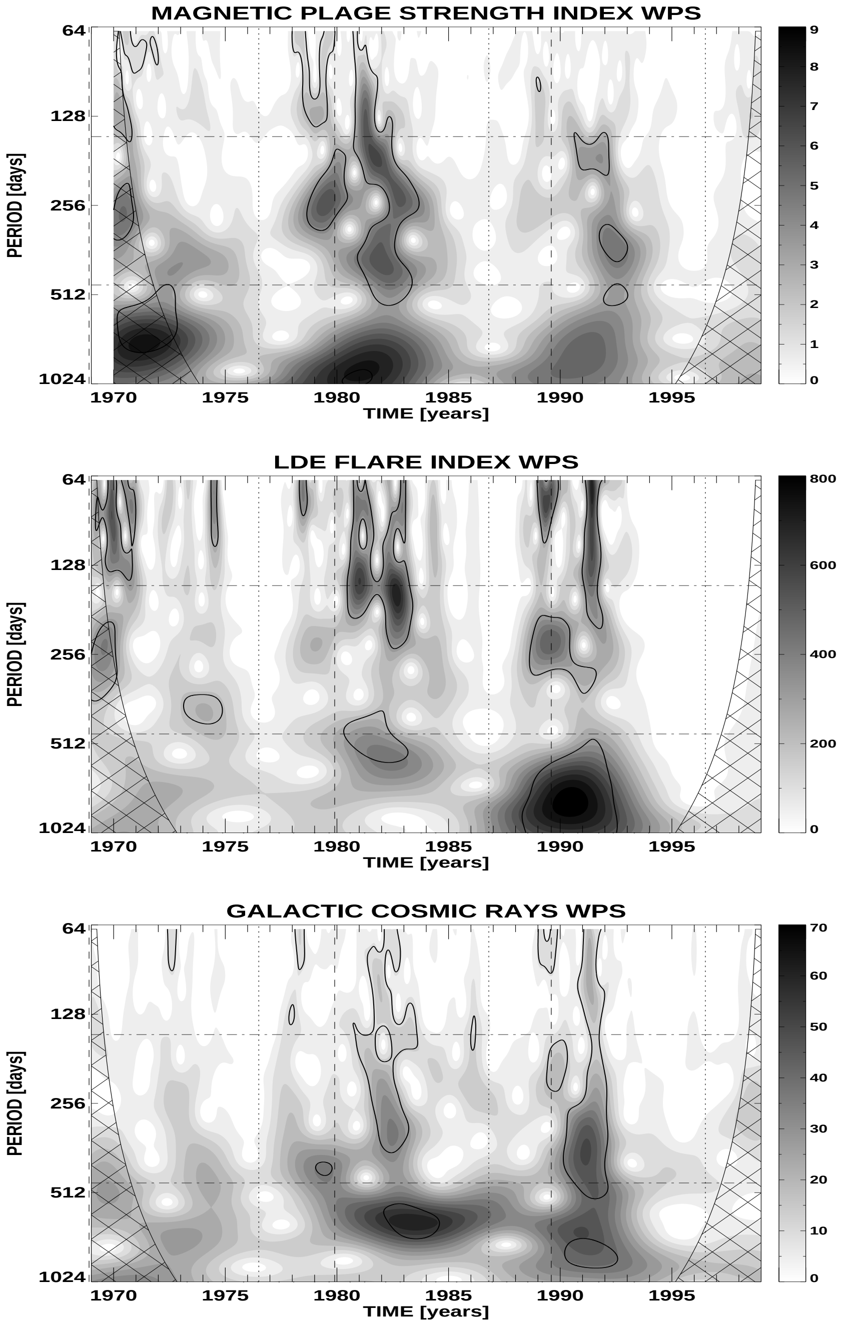

Figure 1. The WPS of the MPSI, LDE–FI and CR. The thick solid line stems for the 95% confidence level. The coin of incidence is marked by the cross-hatched regions. The time spacing parameter of the series is 1 day, the scale resolution is 48 scales per octave. The solar activity cycle maxima and minima are denoted, respectively, by vertical dashed and dotted lines after Wolf's sunspot index. The horizontal dash–point lines are located at the 150–day and 475–day (1.3 yr) periods.

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