The solar and cosmic ray synodic periodicity (1969–1998)

A. Antalová and K. Kudela
Institute of the Experimental Physics, Slovak Academy of Sciences, Watson str. 47, 043 53 Košice, The Slovak Republic

J. Rybák
Astron. Institute, Slovak Academy of Sciences, 05960 Tatr. Lomnica, The Slovak Republic

Abstract. The synodic recurrence of the Mt. Wilson plage index (MPSI) and the Calgary cosmic ray (CR) intensity is investigated, using the wavelet power spectra in the range of 18–38 days, during the last three solar cycles. The unique temporal coincidence between the quasi–synodic MPSI and the CR periods is detected in 1978 – 1982 years (the 21–st solar cycle). In the 22–nd cycle there is very strong MPSI synodic recurrence, from 1989.5 to 1990.5, but it is absent in the CR data. In 1992.5–1993.5 years the MPSI and CR recurrence phenomenon is in good accordance with the solar wind speed and cosmic ray modulation as measured during the first Ulysses passage around the Sun. The Gnevyshev gap is present in the 27–day recurrence of CR, in agreement with Kudela et al. (1999).

1. Introduction, data treatment and results

The existence of the 27–day synodic recurrence in cosmic ray data is accepted as a good indicator of global sectoral pattern of heliospheric magnetic fields. It is generally believed that the synodic periods in solar and cosmic ray data can be expected when the solar wind sources are located at low heliographic latitudes. In this paper we would compare the synodic recurrence of the solar and cosmic ray data. We have selected the Mt. Wilson Magnetic Plage Strength Index (MPSI), which is a good indicator of the long lived large-scale solar magnetic fields flux, and Calgary cosmic rays (CR) with the vertical cutoff 1.09 GV (Venkatesan et al., 1989). The wavelet analysis (Torrence and Compo, 1998) has used the daily data of MPSI and CR, similarly as in Rybák et al. (2000). Figures 1 and 2 illustrate the wavelet power spectra (WPS) from which the the following results have be derived: *Very good synodic synchronization between the MPSI and CR, through the maximum of the 21–st solar cycle:* in seven WPS peaks, the MPSI and CR are in good coincidence (1978.4, 1979.8, 1980.5, 1981.0, 1981.5, 1982.0 and 1982.5 years). *Through the maximum of the 22–nd solar cycle* the MPSI displays four remarkably high synodic recurrence peaks (the strongest in 1990), but the coincidence between MPSI and CR was found only in 1991.5 year. Valdés-Galicia and Dorman (1997) presented similar result, on the base of daily sunspot numbers and Deep River CR neutron data. Due to small data series, we cannot give the proper explanation of the obtained the 21–st cycle behaviour. *The first Ulysses passage around the Sun* displayed strong synodic effect on the fluxes 6–23

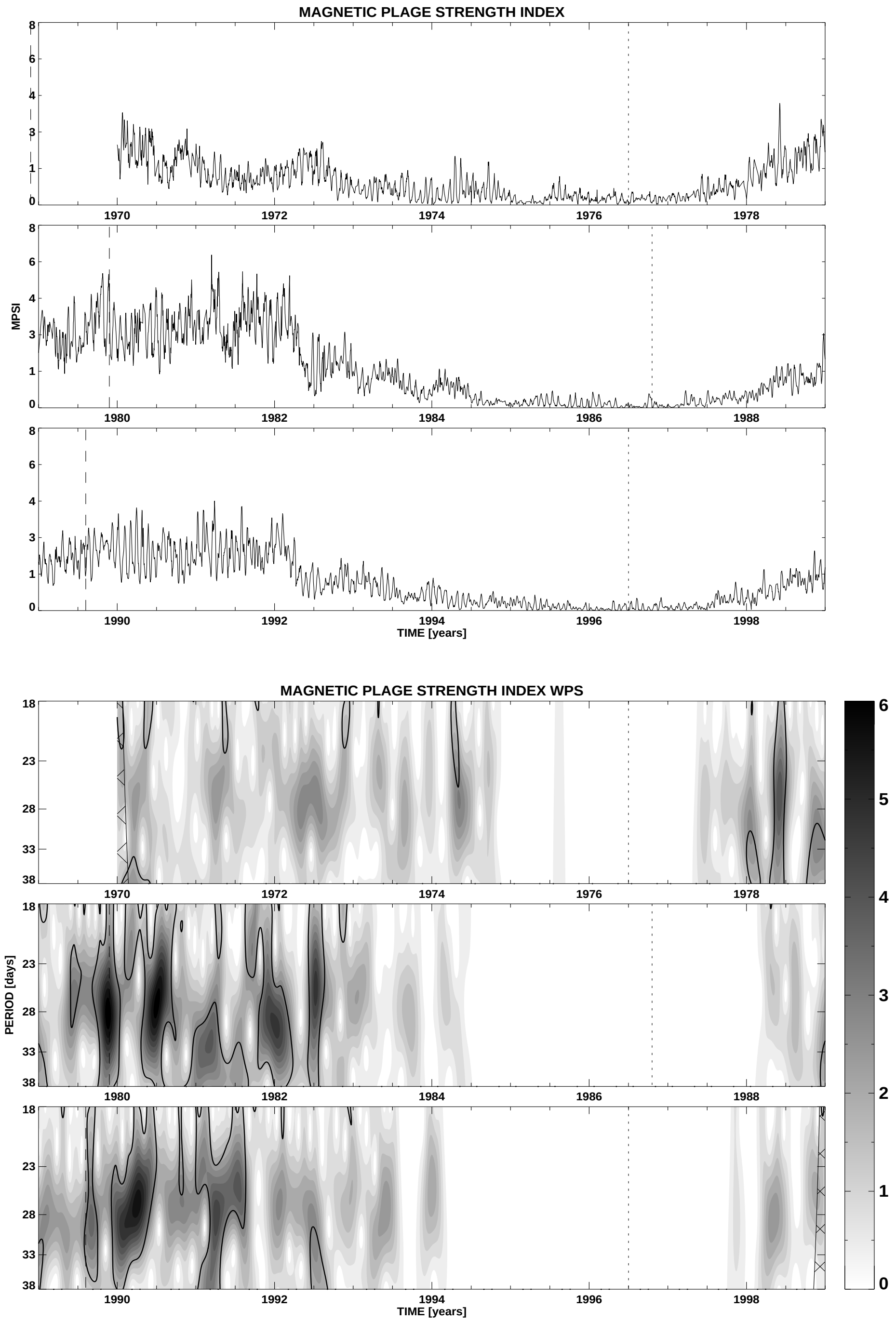

Figure 1. In upper panel there are the daily values of the Mt. Wilson Magnetic Plage Strength Index (MPSI). The vertical dashed and dotted lines represent the maxima and minima of the solar sunspot cycles respectively. The wavelet power spectra of the MPSI for periods ranging from 18 to 38 days are given in the bottom panel. The time spacing parameter of the series is 1 day, the scale resolution is 48 scales per octave.

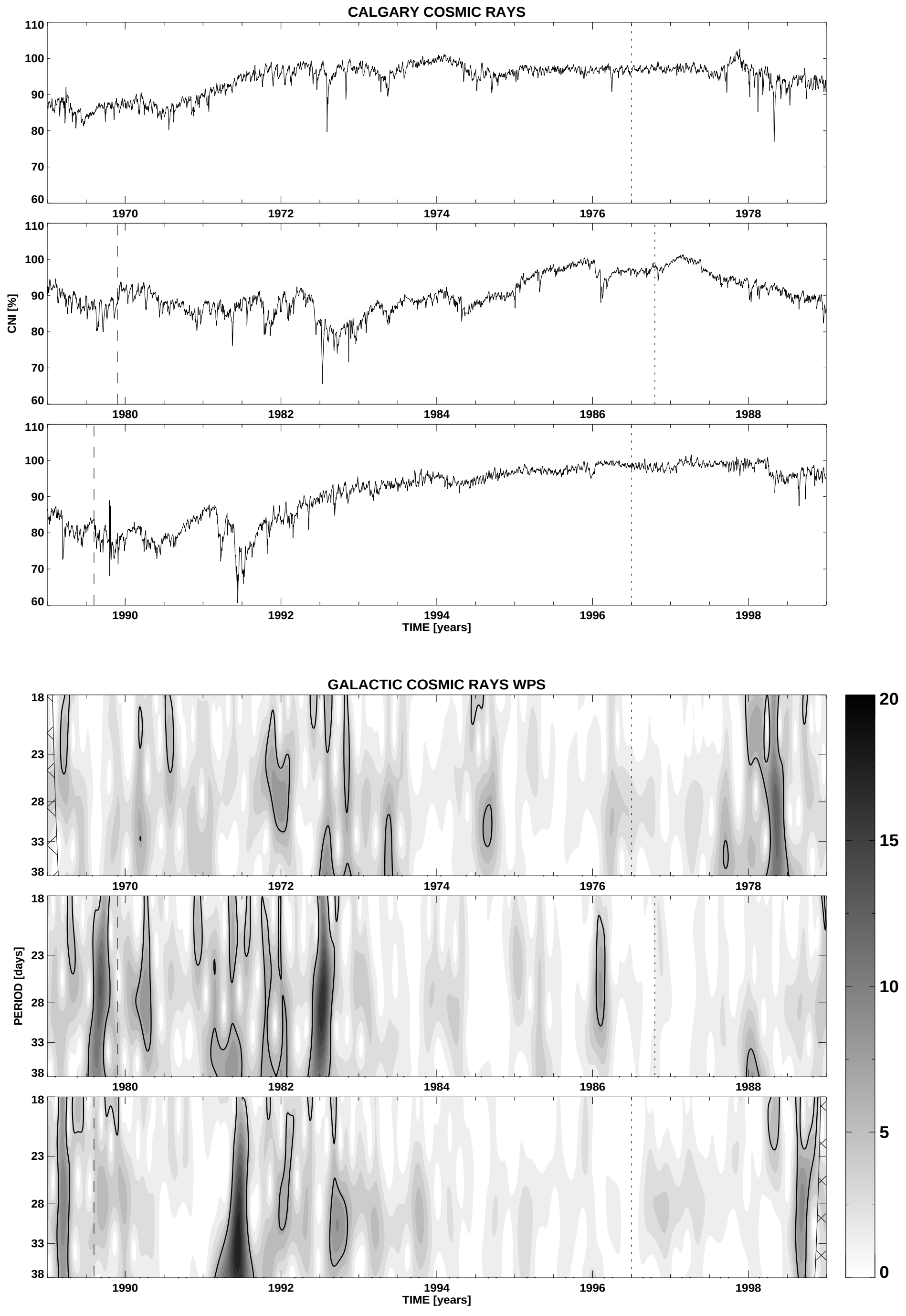

Figure 2. In upper panel there are daily averages cosmic ray intensities, as measured in Calgary. The maxima and minima of the solar cycles are signed by dashed and dotted vertical lines respectively. The wavelet power spectra (WPS) of the Calgary CR for periods ranging from 18 to 38 days.

MeV/N protons and solar wind speeds (McKibben et al., 1995, Dröge et al., 1996), when Ulysses was not far from ecliptic (13°S – 29°S, from the 1992.5 till 1993.5 years). Burlaga and Ness (1997) stated the sectoral distribution of the magnetic field at 1 AU (OMNI data) in 1990 – 1995 years. The question arises why Calgary CR data are sensitive to global sectoral pattern only in 1991.5 and 1992, 1993 years (Antalová et al., 1999).

Acknowledgements

This study includes the data from the synoptic program at the 150-Foot Solar Tower of the Mt. Wilson Observatory. The Mt. Wilson 150-Foot Solar Tower is operated by UCLA, with funding from NASA, ONR and NSF, under agreement with the Mt. Wilson Institute. We are grateful to Mr. H. Graumann for providing us with the daily cosmic ray data, taken at Calgary. The computations used the modified wavelet software, original of which is provided by C. Torrence and G. Compo at URL: `paos.colorado.edu/research/wavelets/`. This contribution was supported by the Slovak VEGA Grants 2/1147/21 and 2/7229/20. A. Antalová thanks the warm hospitality of the ESTEC during the 34–th ESLAB Symposium and expresses her gratitude to Space Science Department of ESA for financial support.

References

Antalová, A., K. Kudela and R. Langer: 1999, 'Synodic recurrence of cosmic rays', *ESA SP–488* **Vol. 2**, pp. 1125–1130.

Burlaga, L.F. and N.F. Ness: 1997, 'Global patterns of heliospheric magnetic field polarities and elevation angles: 1990 through 1995', *J. Geophys. Res.* **Vol.102**, pp. 19,731–19,742.

Dröge, W., H. Kunow, B. Heber, R.Müller–Mellin, H. Sierks, G. Wibberenz, A. Raviart, R. Drucos, P. Ferrando, C. Rastoin, C. Paizis and J.T. Gosling: 1996, 'Effects of corotating interaction regions on Ullysses high energy particles', *American Institute of Physics*

Kudela, K., S. Yasue, K. Munakata and P. Bobik: 1999, ' Cosmic ray variability at different scales: a wavelet approach', *26–th ICRC* **Vol. 7**, pp. 163–166.

McKibben, R.B, J.A. Simpson, M. Zhang, S. Bame and A. Balogh: 1995, 'Ulysses out–of–ecliptic observations of "27–day" variations in high energy cosmic ray intensity', *Space Sci. Rev.* **Vol. 72**, pp. 403–408.

Rybák, J., A. Antalová and M. Storini: 2000, 'The intermittency of the solar intermediate–term periodicity (1969 – 1998)', *ESA SP–463*, in press.

Torrence, C. and G.P. Compo: 1998, 'A Practical Guide to Wavelet Analysis' *Bulletin of the American Meteorological Society* **Vol. 79**, pp. 61–78 .

Valdés-Galicia, F. and L.I. Dorman: 1997, '27–day Cosmic ray variation and its relation to the interplanetary neutral current sheet tilt' *25–th ICRC* **Vol. 2**, pp. 121–124.

Venkatesan, D., T. Mathews, H. Graumann, and P. Sharman: 1989, *Calgary Cosmic Ray Intensity Records–Super Neutron Monitor*, The Calgary University.