Proceedings of ICRC 2001: 3887

ICRC 2001

Long-term forecast of space weather in real-time

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Abstract. The scaling character of the cosmic ray fluctuation dynamics detected in a wide interval of the scales of intensity decreases assumes the long-term (2–3 Bartel‘s rotations) forecast of the solar sporadic activity. It is achieved by using the cosmic ray scintillation index 5–min values averaged by Bartels rotations.

1 Introduction

The detection of the small–dimension ($d = 2.5 \pm 0.1$) attractor on the decrease branch of 11–year solar activity cycle (SA) points to the principal possibility of the forecast of a maximum sporadic activity by the GCR scintillation registration. Just the scaling character of cosmic ray fluctuation dynamics detected in a sufficient wide interval of the GCR intensity decrease scales has served as a basis for the conclusion on a possibility of the long-term (2–3 Bartel‘s rotations) forecast of the solar sporadic activity. In this case, the final stage of a reversal of the Sun‘s general magnetic field expected for the 23-rd cycle in 2001–2002 is of interest in terms of the geophysical activity.

2 Method

The fact established earlier by Kozlov (1999a,b); Kozlov and Markov (1999a,b); Kozlov (2000) that the cosmic ray scintillation index presedes sistematically the GCR intensity by 2–3 rotations during the whole 11–year solar actiivity cycle is used as the basis for the long-term forecast of the GCR intensity decreases. It is achieved by using the daily averaged by Bartel‘s rotation (see http://teor.ysn.ru/rswi/). In its turn, the daily averaged scintillation index values have been obtained by averaging of 5–min values of cosmic ray scintillation index. As a results, the ratio of signal/noise in the GCR scintillation index considerably increases (almost by a factor $\sqrt{7}776$) that essentially raises the reliability of the obtained results and conclusions.

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3 Results

Figure 1 presents the results of the monitoring and retrospective ”forecast” of the 23-rd solar cycle maximum phase by data of the test experiment carried out in 1999–2000. The corresponding mean values of the GCR intensity, IMF and the solar wind parameters are shown by the dashed lines. In the GCR intensity, IMF and solar wind parameters during the studied period of 1999–2000 three phases of activity are traced: the first (slow) phase — from August 1999 to March 2000 (2267–2274 rotations) the most powerful phases — from June to July 2000 (2277–2279 rotations) and third phase — from October to November 2000 (2282–2284 rotations). Data of the solar wind parameter direct measurement show that during the winter and spring periods the quasi-stationary high-velocity solar wind plasma flow practically dominated. Besides, against a background of quasi-stationary disturbance the non-stationary disturbances are also registered. As it was earlier shown in Krymsky et al. (1974) the quasi-stationary disturbances can give rise to a pair of stationary contact shock waves -forward and reverse ones. Really, on February 24, 2000 the typical pair consisting of the forward and the reverse shocks were revealed. The reverse shock is characterized by the inverse abrupt (a sharp drop) of the plasma density registered at the maximum solar wind speed. The similar pairs were registered in the last two rotations of the high–velocity flow: on February 24 and March 24, 2000. And only at the end of April the violation of the 27–day periodicity of the solar wind speed — recurrent variations takes place. In this case, the destruction of the quasi-stationary flux was observed on May 2 by a sufficiently sharp ”burst” of the out flow velocity of the solar wind plasma with a record value 900 km/s for the current 23-rd cycle. Perhaps, that in this case we turned out to be the eye–witnesses of the interesting phenomenon — non–stationary transitional process of the destruction of the long–term quasi–stationary structure of the heliospheric current sheet (HCS). From other side, according to the presentations developed in a number of papers by the research group from FIAN (Bazilevskaya et al. , 1995) the destruction of the 27 day periodicity means that already at the begining of May 2000, we achieved the onset of the 23-rd solar activity cycle maximum. Based on the established earlier relation of Space Weather with the usual weather on the Earth one can suppose that the sufficiently sharp global change of the weather, for example, the fall of temperature in Russia and a number of destructive typhoons in USA registered from April to May 2000 was just ”the Earthly Echo of Solar Storm” accompaning the process of the onset of a reversal of the general magnetic field of the Sun when the solar activity increases up to maximum.

Comparing the values of the scintillation index with the GCR intensity it is easy to notice that the gradual increase of the cosmic ray scintillation index reached its maximum to the onset of the 2267 rotation precedes the onset of the first ”recurrent” activity phase from August 1999 to March 2000 (rotations 2267–2274) manifested in the gradual increase of the IMF modulus. A sharp increase of the scintillation index reached its maximum value to the Bartel‘s rotation 2275 precedes a sharper decrease of the GCR intensity in June-July 2000 (rotations 2277–2279). It is seen that the scintillation index maximum is achieved by ~ 2 rotation of the Sun up before the onset of sufficiently sharp GCR intensity decreases in June–July 2000 signifying the maximum of the 23-rd cycle! In this case, a sharp decrease of GCR intensity in June–July 2000 coincides in time with the same sharp increase of the IMF modulus. It also confirms the conclusion on the approaching to the maximum of the solar activity cycle in the middle of 2000. The third maximum of the scintillation index in August 2000 (rotation 2280) also precedes geoeffective events in October–November 2000 (rotations 2282–2284). And in this case the scintillation index precedes the sporadic activity amplification by the Sun‘s rotation $\tau \approx 2$. Both this estimations are in good agreement with the value of Bartel‘s rotations $\tau = 2 \pm 1$ determined by results of retrospective analysis for the 21-st and 22-nd solar activity cycles (Kozlov (1999a,b); Kozlov and Markov (1999a,b); Kozlov (2000)).

Figure 2 presents the calculation results of 27 day values of galactic cosmic ray scintillation index (solid curve) for 22-nd and the current 23-rd solar activity cycles. For calculations we have used the 5–min registration data of galactic cosmic ray intensity at the station Oulu (Finland) for the 1995–2001 period. The maxima and minima of the 22-nd and 23-rd solar activity cycles are marked. On the time axis the numbers of Bartel‘s rotations are indicated. ***It is seem that the increase of the scintillation index in FEBRUARY 2001 (2287 — Sun’s rotation) precedes the sharp decrease of the GCR intensity in APRIL 2001 (2289 — Sun’s rotation).*** And in this case the scintillation index presedes the sporadic activity amplification by the Sun’s rotation $\tau \approx 2$. By analogy with the behaviour of the scintillation index in the 21-st and 22-nd cycles the continuation of the activity strengthening in May–September 2001 should be forthcoming !

4 Conclusion

The results of the monitoring and forecast for the current 23-rd solar activity cycle confirm the conclusion made earlier (Kozlov and Markov , 1999a), on a possibility of the long–term forecast of the high sporadic solar activity on the decline branch of the 11–year cycle. The advance of the forecast is equal to value of Bartels rotations $\tau = 2 \pm 1$. The strengthening of the solar activity in May–September 2001 is to be expected.

Acknowledgements. The authors thank the University of Oulu / Sodankyla Geophysical Observatory (Finland) for providing 5–min neutron monitor data from station Oulu for the 1985–2001 period. We also thank ACE team for providing interplanetary medium measurement LEVEL 2 data.

This work was supported by Russian Foundation for Basic Research grants (the leading scientific school by G.F. Krymsky No. 00-15-96669 and R98 - the Arctic, No. 00-02-96204).

References

Kozlov, V.I., Scale invariant of cosmic ray fluctuation dynamics at geoeffective solar cycle phases, Geomagnetism and Aeronomy, 39, 95–99, 1999a.

Kozlov, V.I., Estimation of scaling properties of cosmic ray fluctuation dynamics in the solar activity cycle, Geomagnetism and Aeronomy, 39, 100–104, 1999b.

Kozlov, V.I. and Markov V.V., Effect of Solar Magnetic Field Reversal by Dynamics of Cosmic Ray Scintillation, Proc. 26th ICRC, Salt Lake City, 7, 448–451, 1999a.

Kozlov, V.I. and Markov V.V., Sun Cycles as Interchange of Low-Dimensional Attractors in Haotic Dynamics of Solar Activity, Proc. 26th ICRC, Salt Lake City, 7, 147–150, 1999b.

Kozlov, V.I., Cosmic ray fluctuations in interplanetary space, Author‘s abstract of Doctorate thesis, ISZF, Irkutsk, 2000.

Krymsky, G.F., Transky, I.A., Yelshin, V.K., Piston shock waves in interplanetary space and Forbush-effects, Geomagnetism and Aeronomy, 14, 403–410, 1974.

Bazilevskaya, G.A., Krainev, M.B., Makhmutov, V.S. and Sladkova A.I. Long-Term Changes in Galactic Cosmic Ray Variation caused by the Solar Rotation, Proc. 24th ICRC, Roma, 4, 572–575, 1995.

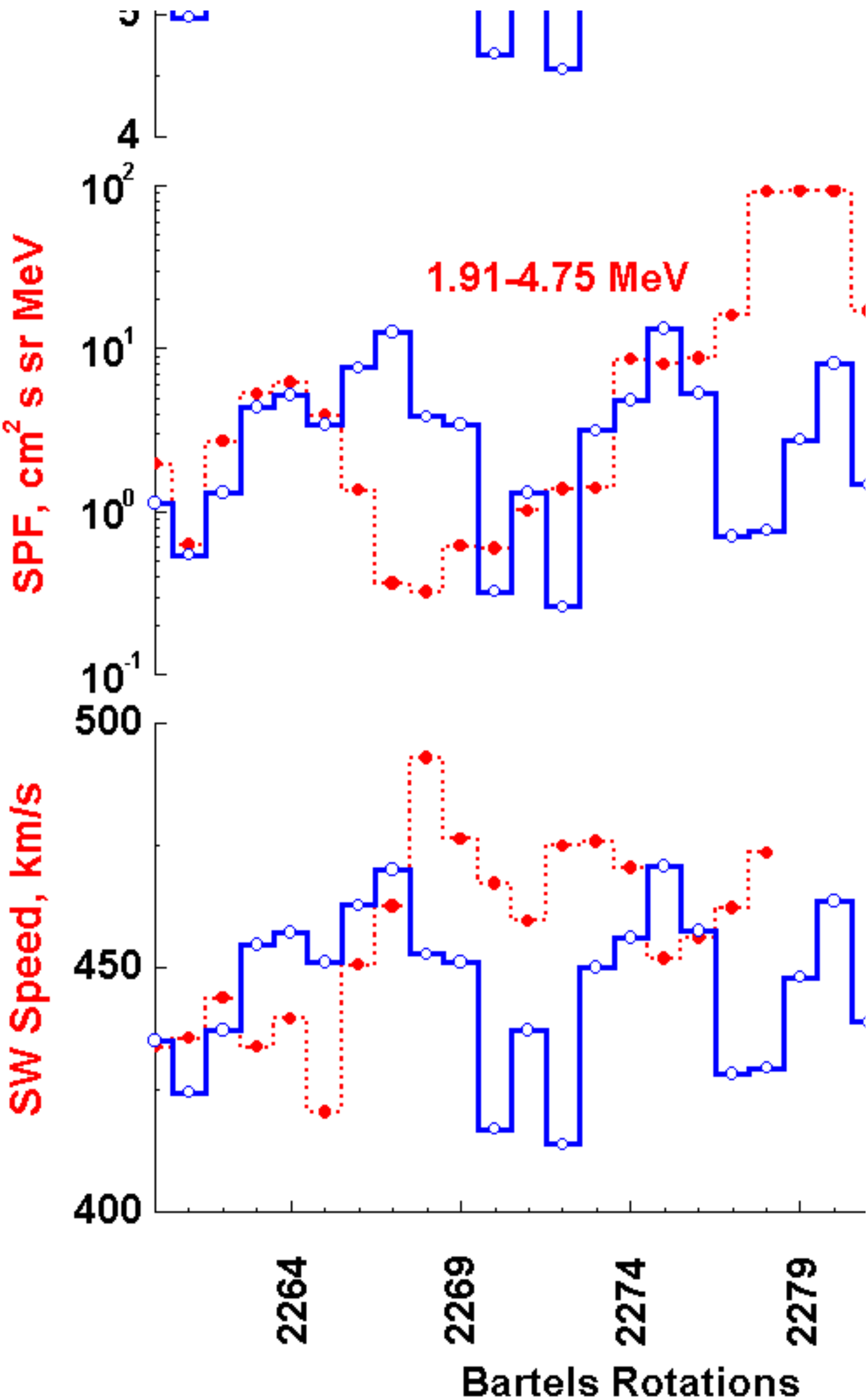

Fig. 1. Mean values of cosmic ray scintillation index (solid curve) and corresponding variations of GCR intensity, the IMF modulus, low-energy particles with energy 1.91-4.75 MeV and the solar wind speed (dashed curve) for 1999-2000 (2260-2286 Bartels rotations).

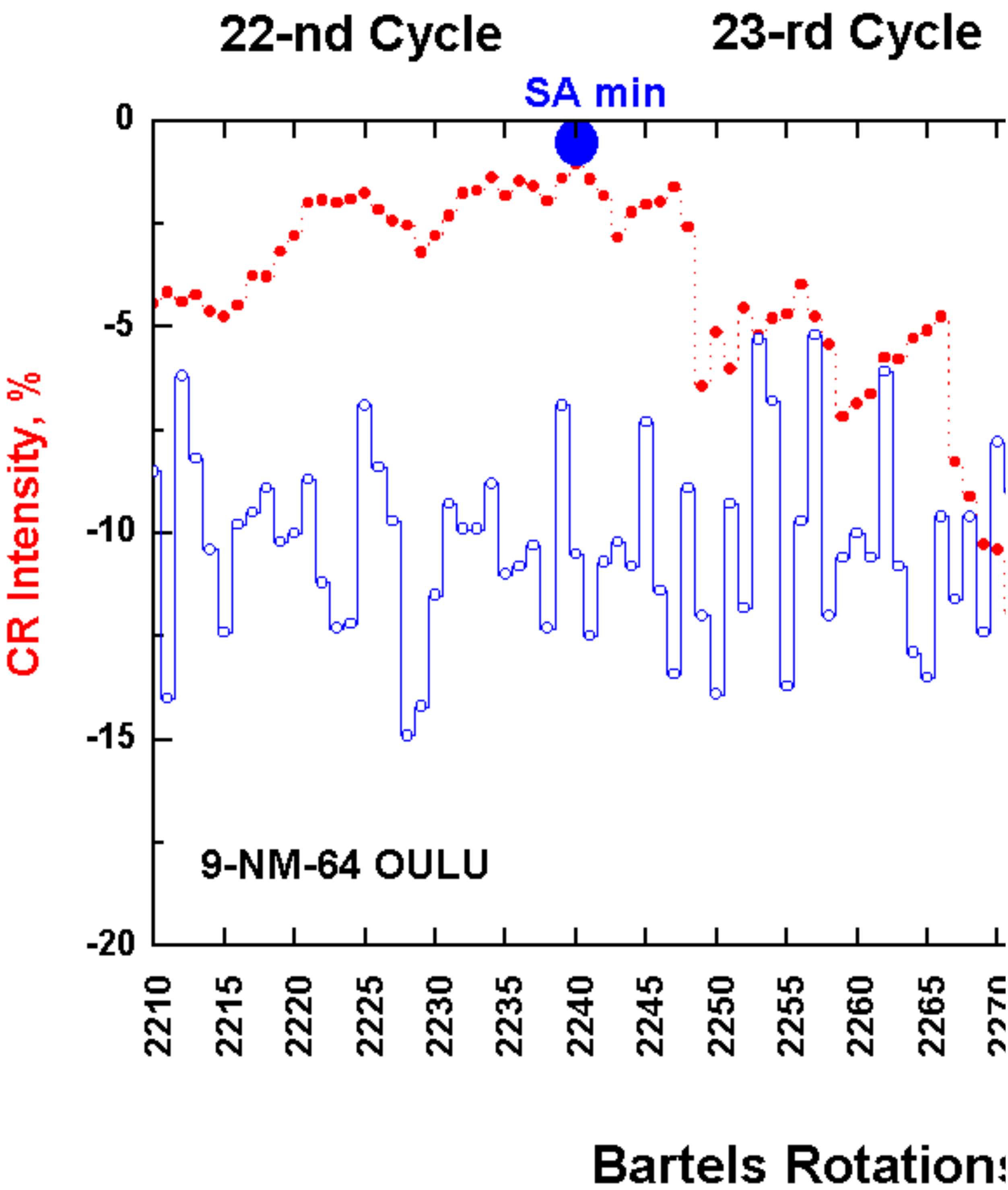

Fig. 2. The 27-days values of galactic cosmic ray scintillation index (solid curve) for the current 23-rd solar activity cycles and GCR intensity (dashed curve).