HIGH-SPEED SOLAR WIND STREAMS DURING THE LAST SOLAR CYCLES

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ВЫСОКОСКОРОСТНЫЕ ПОТОКИ СОЛНЕЧНОГО ВЕТРА В ТЕЧЕНИЕ ПОСЛЕДНИХ СОЛНЕЧНЫХ ЦИКЛОВ

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Высокоскоростные потоки солнечного ветра (High Speed Solar Wind Streams, HSS) выявлены как одна из основных причин геомагнитных бурь. После его идентификации в 1962, наше познание об этом проявлении солнечной активности стало более точным. Теперь у нас есть экспериментальные данные о параметрах солнечного ветра в течение последних четырех 11-летних циклов солнечной активности, и мы можем описать поведение HSS за относительно длительный период. Более того, кажется, что настоящий период векового цикла солнечной активности является "переходным" – от экстремально высокой солнечной активности, наблюдаемой в циклах 18–22, до сегодняшнего дня, когда мы наблюдаем чувствительно более низкую солнечную активность (цикл 24). Несколько моделей прогнозируют даже еще более низкую активность в следующих циклах. Имея измерения поведения HSS во время этих двух периодов (высокая и низкая солнечная активность), мы исследуем, как влияет на HSS вековая вариация солнечной активности.

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Introduction

High speed solar wind streams (HSS) and Coronal mass ejections (CME) are recognized as main geomagnetic storm drivers. According [1] HSS are responsible for at least 70% of geomagnetic activity at solar minimum and more than 30% at maximum. HSS are characterized with low speed, temperature and plasma density [2, 3]. They are geoeffective at most during the sunspot declining phase [4], when the second maximum in the geomagnetic activity is observed. Considering the year of identification of HSS (1962), early investigations of the solar cycle evolution of HSS has been presented by [5, 6]. They study variations of HSS during the period 1962–1974 (covering solar cycle 20) with emphasis on the solar wind speed fluctuation, the effect of the temporal evolution of stream structure on long-term averages of the solar wind flow speed, relationship between solar wind stream structure and the interplanetary magnetic field sector polarity. The major conclusion of these studies is that during the solar minimum the most stable streams with the largest amplitude occurred. The Mariner-2, Pioneer-6, 7, Vela and IMP programs are solar wind data sources at the time of solar cycle 20.

In this study solar cycle evolution of HSS for the cycles 21–24 as well as differences of the averaged parameters are discussed.

Data and methods

This work considers the solar wind data for the last four solar cycles. In Table 1 is presented information for Solar cycles 17–24, including the duration of the different cycles.

Table 1.

Cycle	Started	Finished	Duration (years)
Solar cycle 17	1933 September	1944 February	10.4
Solar cycle 18	1944 February	1954 April	10.2
Solar cycle 19	1954 April	1964 October	10.5
Solar cycle 20	1964 October	1976 June	11.7
Solar cycle 21	1976 June	1986 September	10.3
Solar cycle 22	1986 September	1996 May	9.7
Solar cycle 23	1996 May	2008 January	11.7
Solar cycle 24	2008 January	2018	~11

Several catalogues of HSS for Solar cycles 21–23 have been used to determine the time and duration of the events [7–9]. Using hourly values of the plasma parameters gathered in OMNI data base (<http://omniweb.gsfc.nasa.gov/>) the averaged values of the main parameters for every single event have been calculated.

312 HSS for Solar cycle 24 events have been identified using the criteria for a HSS – an increase of the solar wind velocity by at least 100 km/s in no more than one day to at least 450 km/s for at least five hours along with high proton temperature and low plasma density.

Results

In Fig. 1 and Fig. 2 averaged values of the HSS for solar cycles 21–23 of the maximum speed (red line), duration of the HSS (blue line) and sunspot number (black line) are presented. During the descending phase of these cycles the highest values of maximum speed and the longest duration of the HSS (8–10 days) are observed.

Fig. 1. Maximum speed of HSS for solar cycles 21–23.

Fig. 2. Maximum speed of HSS for solar cycles 21–23.

The main results about maximum speed and counts of HSS for solar cycle 24 are presented in Fig. 3. It can be seen that there are two peaks of the number of HSS occurrence – one during the ascending phase and one at the descending phase of the solar cycle. Unlike the previous cycles, there is no such well-defined peak in the maximum speed of HSS in the current/present solar cycle.

Fig. 3. Maximum speed and counts of HSS for solar cycle 24.

Table 2.

Parameter	SC21	SC22	SC23	SC24
Hours	7878	7161	9811	8690
Scalar B, nT	5.9	5.9	5.6	4.7
Bx, nT	-0.36	0.15	0.27	-0.18
By, nT	0.34	0.03	-0.09	0.08
Bz, nT	0.22	-0.01	-0.11	0.02
T, K	178230	146090	205240	132840
Dens, N/c	5.6	6.1	6.9	4.1
Speed, km/s	512	508	463	518
Press	2.7	2.8	2.5	1.9

In Table 2 the averaged values of the HSS parameters for the different cycles are shown.

Conclusions

This study considers the averages of the main HSS parameters in the last four solar cycles (21–24). The conclusion remarks are:

- The time in which Earth is under the HSS influence is more than 50% of the total time in each of the last four solar cycles.
- At SC23 the HSS influence is more than 75% of the total time.
- During the last SC24 the averaged HSS speed drops under 500 km/s while HSS temperature increases to more than 200000 K.
- During the descending phase of the solar cycles 21–23 the highest values of maximum HSS speed are observed.
- The duration of the HSS is the longest (8–10 days) during the descending phase of solar cycles 21–23.
- 302 HSS events have been isolated for the last 24th solar cycle and their maximum speed was estimated.
- The profile of the maximum speed of HSS within the 24th solar cycle is different compared to the previous solar cycles and no maximum value is observed.
- The count of the HSS is the greatest during the descending phase of the 24th solar cycle.

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