Variations of interplanetary parameters in different types of large-scale solar-wind phenomena during 21-24 solar cycles

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Abstract

We study the behavior of solar wind (SW) parameters over 21-24 solar cycles (SCs). We take into account that these variation can depend on three reasons: (1) type of SW, (2) phase of SC, and (3) SC number. Our catalog of large-scale SW types for 1976-2018 (see the website ftp://ftp.iki.rssi.ru/pub/omni/ [Yermolaev et al., 2009]) covers the period from the 21st to the 24th SC and allows us to analyze independently these three reasons, since we can select SW parameters for different types of SW (in particularly, slow and fast SW, Sheath, ICME, CIR) and at different phases of different SCs. Preliminary data show that with an increase in the SC number (1) the number of perturbed SW types decreases and (2) the values of plasma and magnetic field parameters decrease in each type of SW, and for each phases of SCs. The most rapid change in parameters was observed during the minimum period between the 22nd and 23rd cycles. The work was supported by the Russian Science Foundation, grant 16-12-10062. References Yermolaev, Y.I., Nikolaeva, N.S., Lodkina, I.G., Yermolaev, M. Y. (2009). Catalog of large-scale solar wind phenomena during 1976–2000. Cosmic Res 47, 81–94 https://doi.org/10.1134/S0010952509020014Yermolaev, Y.I., Nikolaeva, N.S., Lodkina, I.G., Yermolaev, M. Y. (2015). Dynamics of large-scale solar wind streams obtained by the double superposed epoch analysis, JGR, https://doi.org/10.1002/2015JA021274

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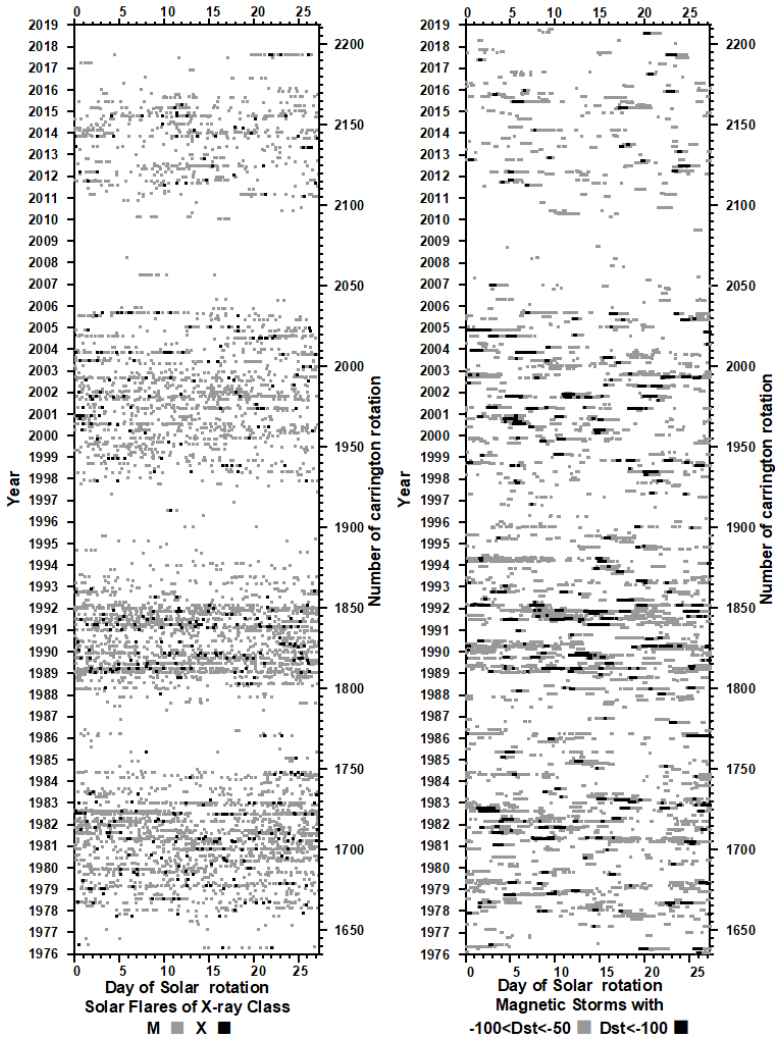
Introduction

- The sun has an ~ 11-year cycle of activity
- Cyclicity is usually studied by the sunspots number. "Representative" data available for 24 cycles.
- This cyclicity also manifests itself in the interplanetary variations and number of magnetospheric disturbances

Temporal distribution of magnetic storms and X-ray flares during 1976 - 2018



-When averaged over years, a correlation is visible,

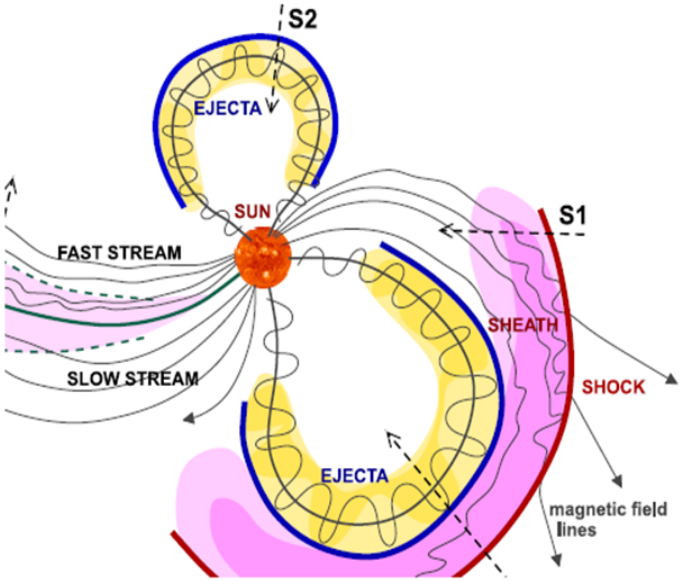
-however, when we try to compare "event-to-event" we will not find a noticeable correlation.

- As is well known, this is due to the presence of geoeffective types of solar wind, which depend in a complex way on solar phenomena.

Introduction(2)

- When trying to study the average properties of the solar wind (SW), the existence of SW phenomena is usually not taken into account (averaged without selection)
- We analyze separately the following SW phenomena

(1) SW/CIR/SW,
(2) SW/IS/CIR/SW,
(3) SW/Ejecta/SW,
(4) SW/Sheath/Ejecta/SW,
(5) SW/IS/Sheath/Ejecta/SW,
(6) SW/MC/SW,
(7) SW/Sheath/MC/SW, and
(8) SW/IS/Sheath/MC/SW



Некоторые последовательности СВ из работы *Kilpula et al., 2015*

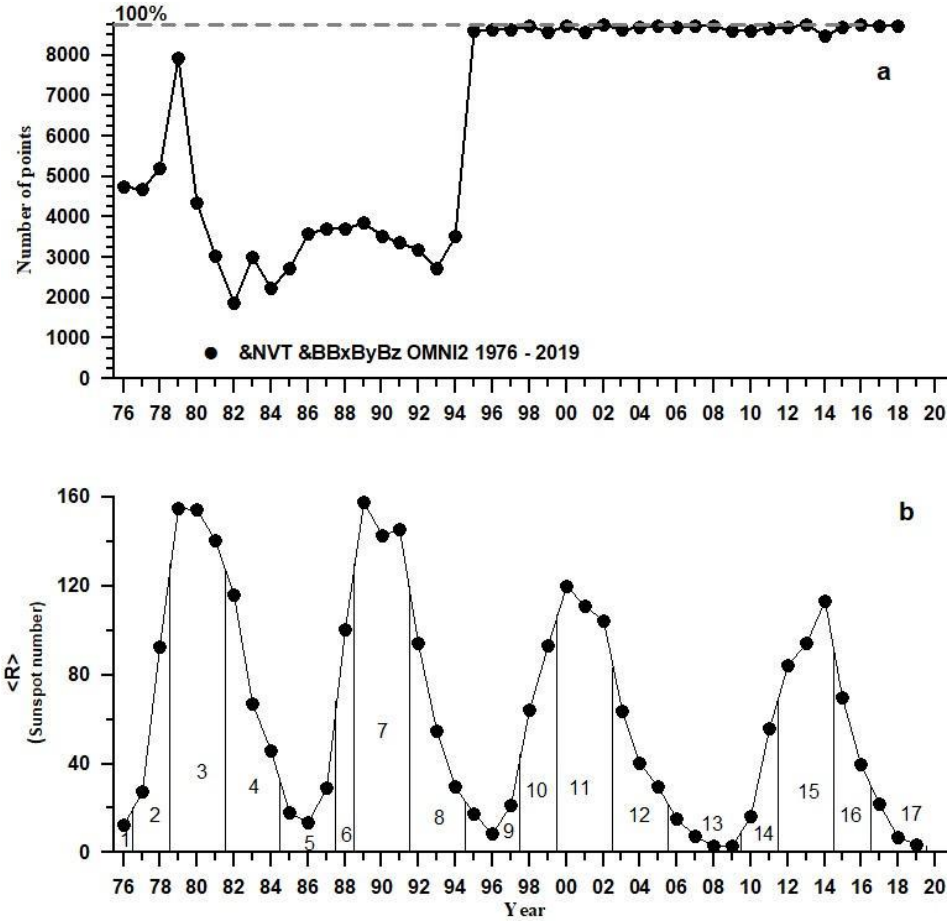
Data and methodology

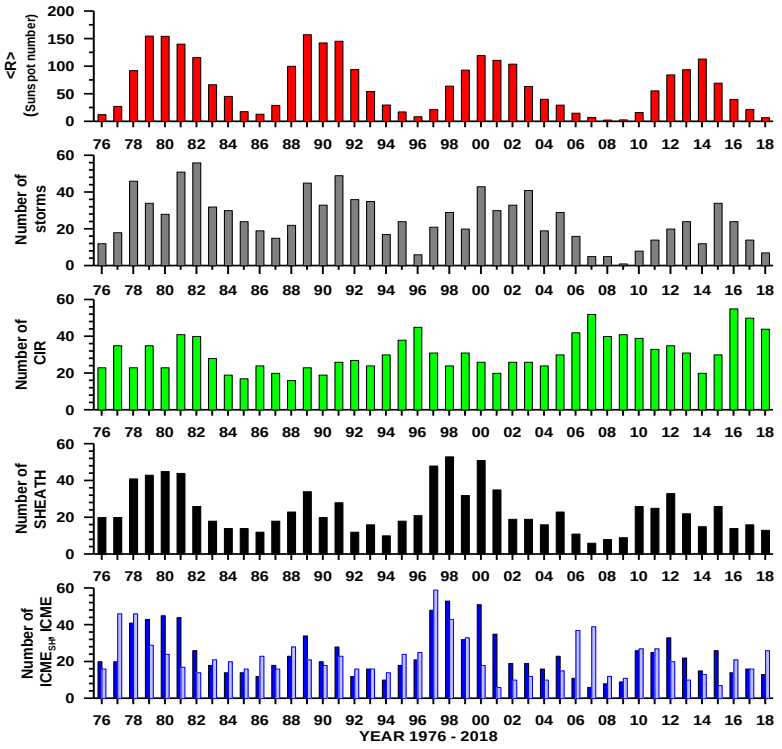
- Hourly data of parameters of the OMNI2 base for 1976-2018 (King and Papitashvili, 2004) https://spdf.gsfc.nasa.gov/pub/data/omni/low_res_omni
- Intervals of various types of SW of the catalog of large-scale phenomena (ftp://ftp.iki.rssi.ru/pub/omni/ Yermolaev et al., 2009)
- The average values of the parameters were calculated, selected
- 1) By type SW and
- 2) By phases of solar cycles 21-24

Averaging intervals over phases of solar cycle

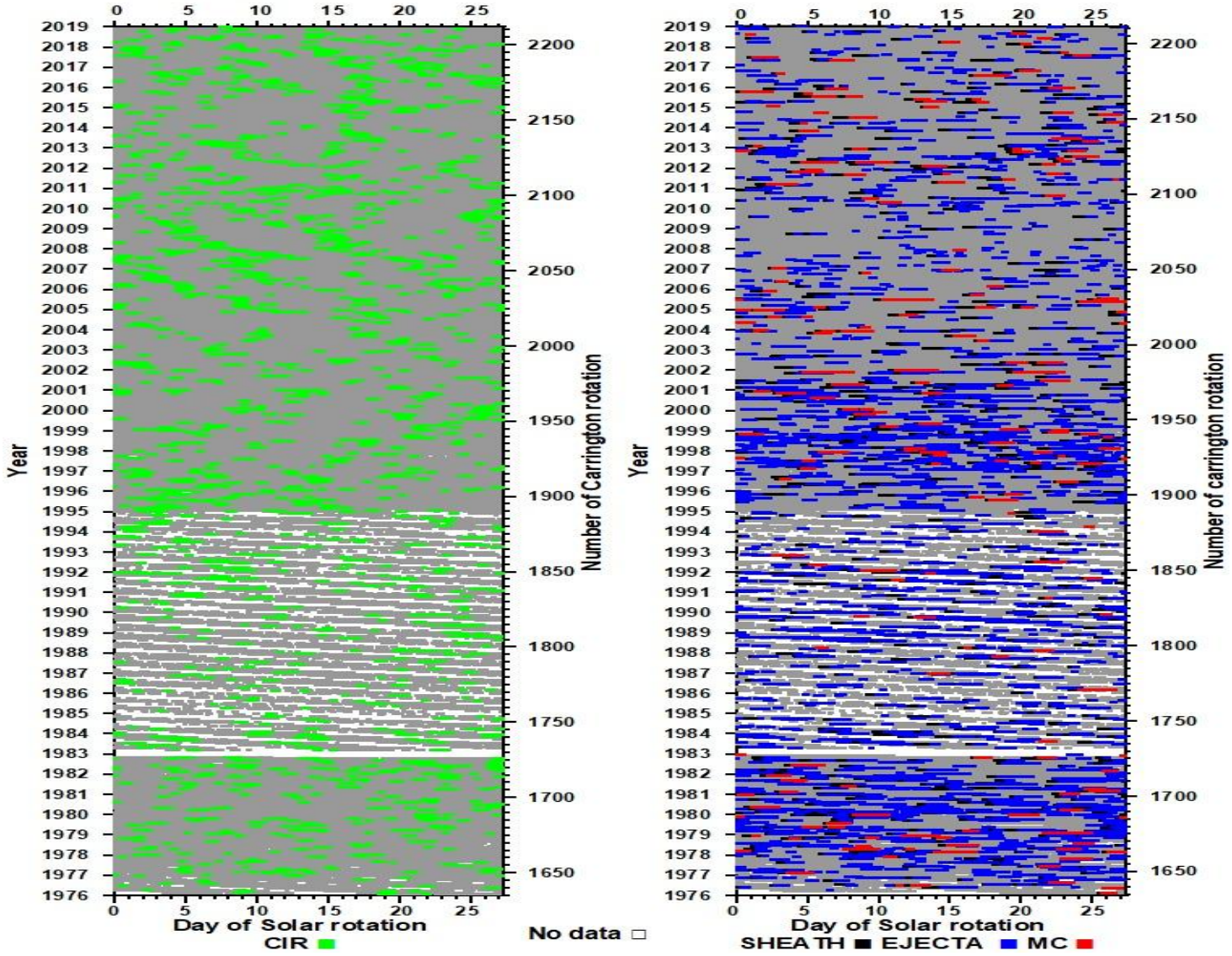
№ interval	Phase of solar cycle	Years	Cycle
1	minimum phase	1976	21
2	rising phase	1977,1978	
3	maximum phase	1979-1981	
4	declining phase	1982-1984	
5	minimum phase	1985-1987	
6	rising phase	1988	22
7	maximum phase	1989-1991	
8	declining phase	1992-1994	
9	minimum phase	1995-1997	
10	rising phase	1998-1999	23
11	maximum phase	2000-2002	
12	declining phase	2003-2005	
13	minimum phase	2006-2009	
14	rising phase	2010,2011	24
15	maximum phase	2012-2014	
16	declining phase	2015-2016	
17	minimum phase	2017-2019	

General data statistics

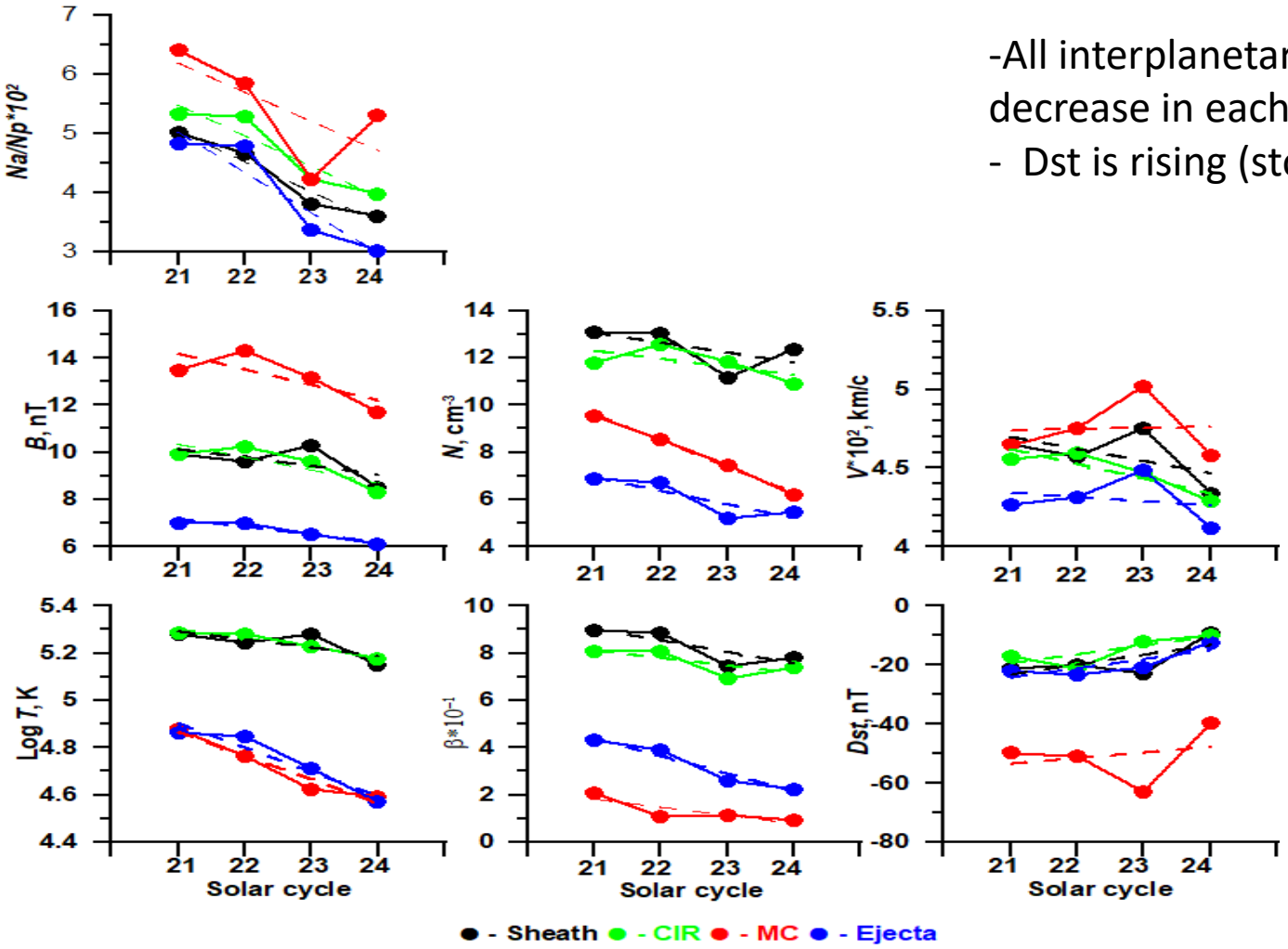




Temporal variation of CIR events (left) and Sheath, MC and Ejecta events (right) during 1976 - 2018

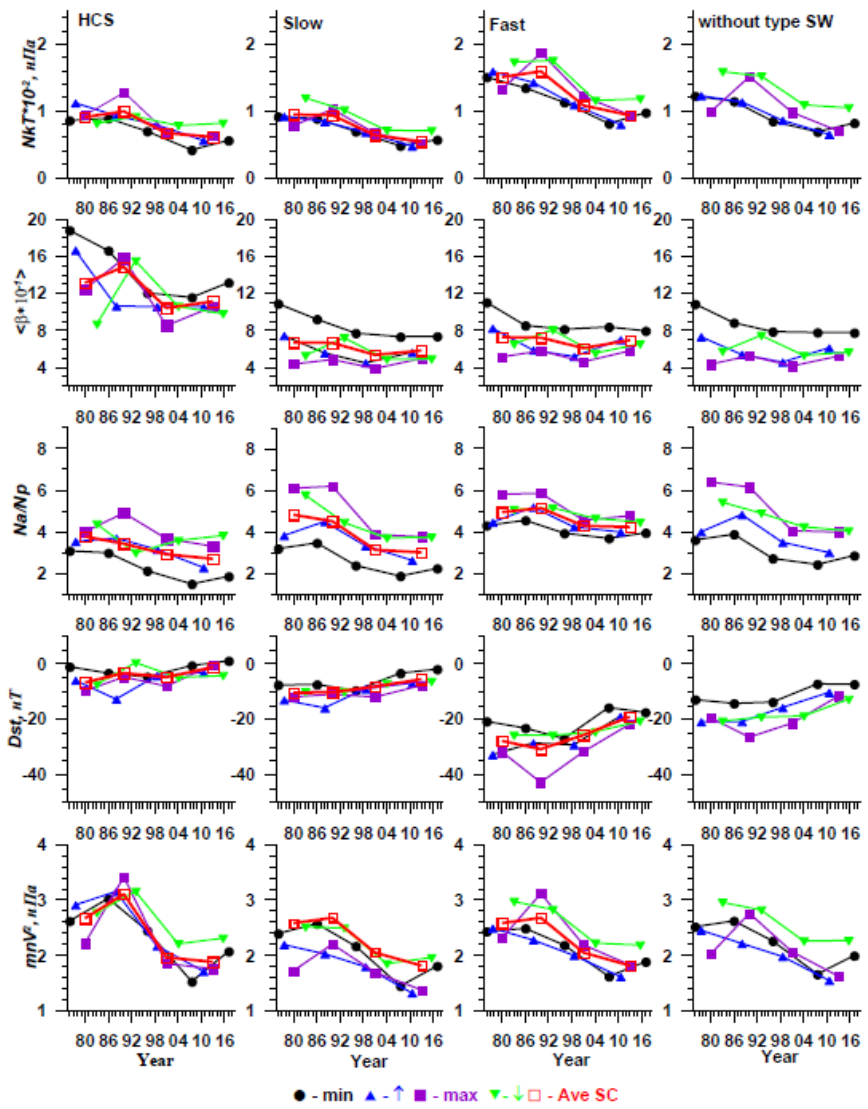


Behavior of the average values of the parameters N, V, B, T, β, Dst, Na / Np at 21-24 SCs in types of SW CIR, Sheath, Ejecta, MC



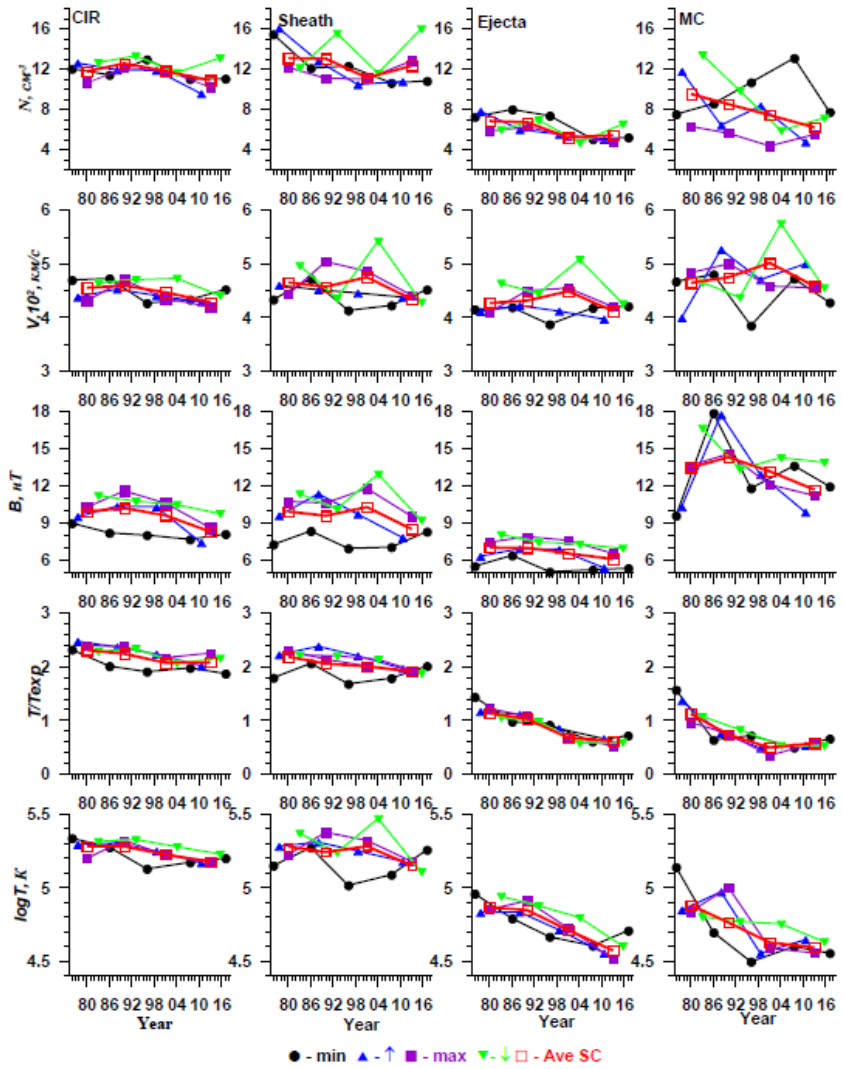
-All interplanetary parameters tend to decrease in each type of SW
- Dst is rising (storms are weakening)

Average values of the parameters NkT, β, Na / Np, Dst, mNV^2 at 21-24 SC, at all phases of SC in the types of SW: HCS, Slow, Fast and without considering the types of SW



- All interplanetary parameters have a tendency to decrease in each stationary type of SW
- the transition between the regimes took place in the period 1990-1995.

Average values of the parameters N, V, B, T / TEXP, T at 21-24 SC, at all phases of the SC in the types SW: CIR, Sheath, Ejecta, and MC.



Conclusion

- The time profiles of interplanetary parameters in SW phenomena has been analyzed for 43 years (1976-2018) on the OMNI database.
- The selection was carried out according to different types of SW and phases SC 21-24
- It was shown for the first time that all parameters have a tendency to decrease, regardless of the type of SW and the phase of the SC.
- This effect is associated with a sharp change in the time profiles of parameters in the period 1990-1995.
- The effect may depend on changes in data from different spacecraft, but this is unlikely.
- - **http://www.iki.rssi.ru/people/yyermol_inf.html**

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