Catalog of large-scale solar wind phenomena: Current status

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Several results have been published and may be found in
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Abstract

- On the basis of OMNI database of 1-h solar wind (SW) plasma and IMF parameters we have made the `Catalog of large-scale solar wind phenomena during 1976–2000` (see website ftp://ftp.iki.rssi.ru/pub/omni/ and paper [Yermolaev et al., 2009]) which identifies reliably 3 types of quasi-stationary streams of the solar wind (heliospheric current sheet (HCS), high speed streams from the coronal holes (HSS), and slow streams from the coronal streamers), and 5 disturbed types (compression regions before fast streams HSS (CIR), and interplanetary manifestations of coronal mass ejections (ICME) that can include magnetic clouds (MC) and Ejecta with the compression region Sheath (SHEMC and SHEEj) preceding them) as well as the interplanetary shock (IS). Now we continue filling of our catalog since 2001. In the report we will described the procedures of SW type identification, data processing and visualization, and web site using. The work is supported by the VarSITI grant.

- Reference:

- Yermolaev, Yu. I., N. S. Nikolaeva, I. G. Lodkina, and M. Yu. Yermolaev (2009), Catalog of Large-Scale Solar Wind Phenomena during 1976-2000, Cosmic Research, Vol. 47, No. 2, pp. 81-94.

Motivation

- Heliospheric physics: study of physical processes in the interplanetary space and boundaries of heliosphere
- Solar physics: large-scale structure of solar wind contains information of its formation areas in the solar corona
- Magnetospheric physics: study of magnetosphere reaction on the solar wind variations

Main aim

- Classification of solar wind types according to modern representations
- Formation method of identification of SW types
- Identification of each 1-hour point of solar wind measurements for all space era
- Cataloguing of identification results (visualization, INTERNET access etc.)

Data and methods

- **Data of OMNI and OMNI2 datasets** (http://omniweb.gsfc.nasa.gov [*King and Papitashvili , 2004]*)
- **+ calculated parameters:**
- *the solar wind bulk velocity V and its latitude theta and longitude ϕ angles,*
- *the ion density N,*
- *the proton temperature Tp,*
- *the magnitude and 3 components of IMF (B; Bx; By and Bz),*
- *the proton thermal pressure Pt = NkTp,*
- *the proton dynamic pressure Pd ~ NV^2,*
- *the proton plasma beta-parameters (ratio of proton thermal and magnetic field pressures),*
- *the ratio of measured temperature and temperature estimated on the basis of average velocity-temperature relation T/Texp [Lopez , 1987],*
- *the y-component of SW electric field Ey = Vx Bz,*
- *the sound and Alfven velocities Vs and Va,*
- *the sound and Alfven Mach numbers Ms=Vs/V and Ma=Va/V ,*
- *the magnetospheric AE; Kp; Dst and D*st indices*
- *and others*

Set of criteria

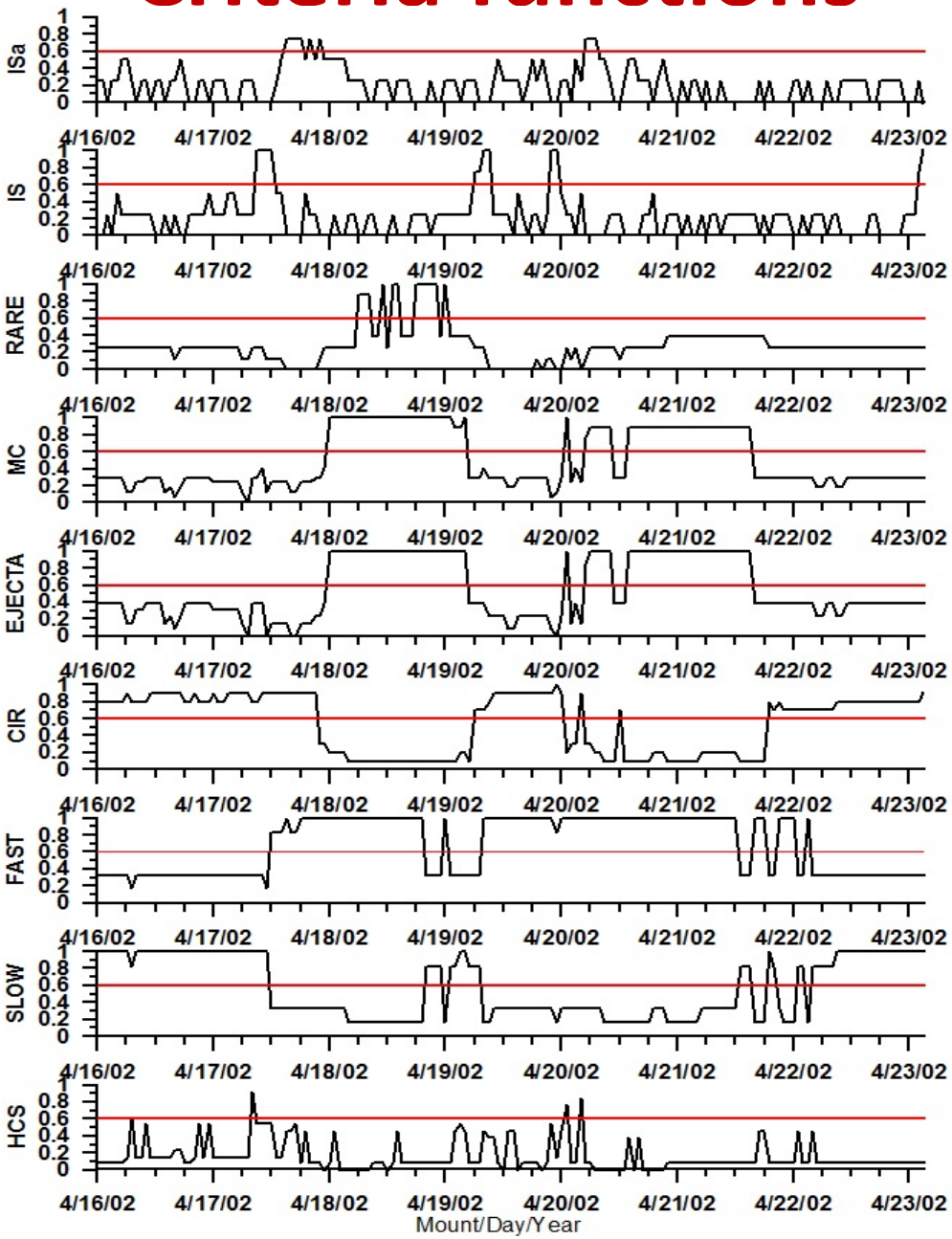
Yermolaev et al, Catalog of Large-Scale Solar Wind Phenomena during 1976-2000, Cosmic Research, 2009, Vol. 47, No. 2, pp. 81-94

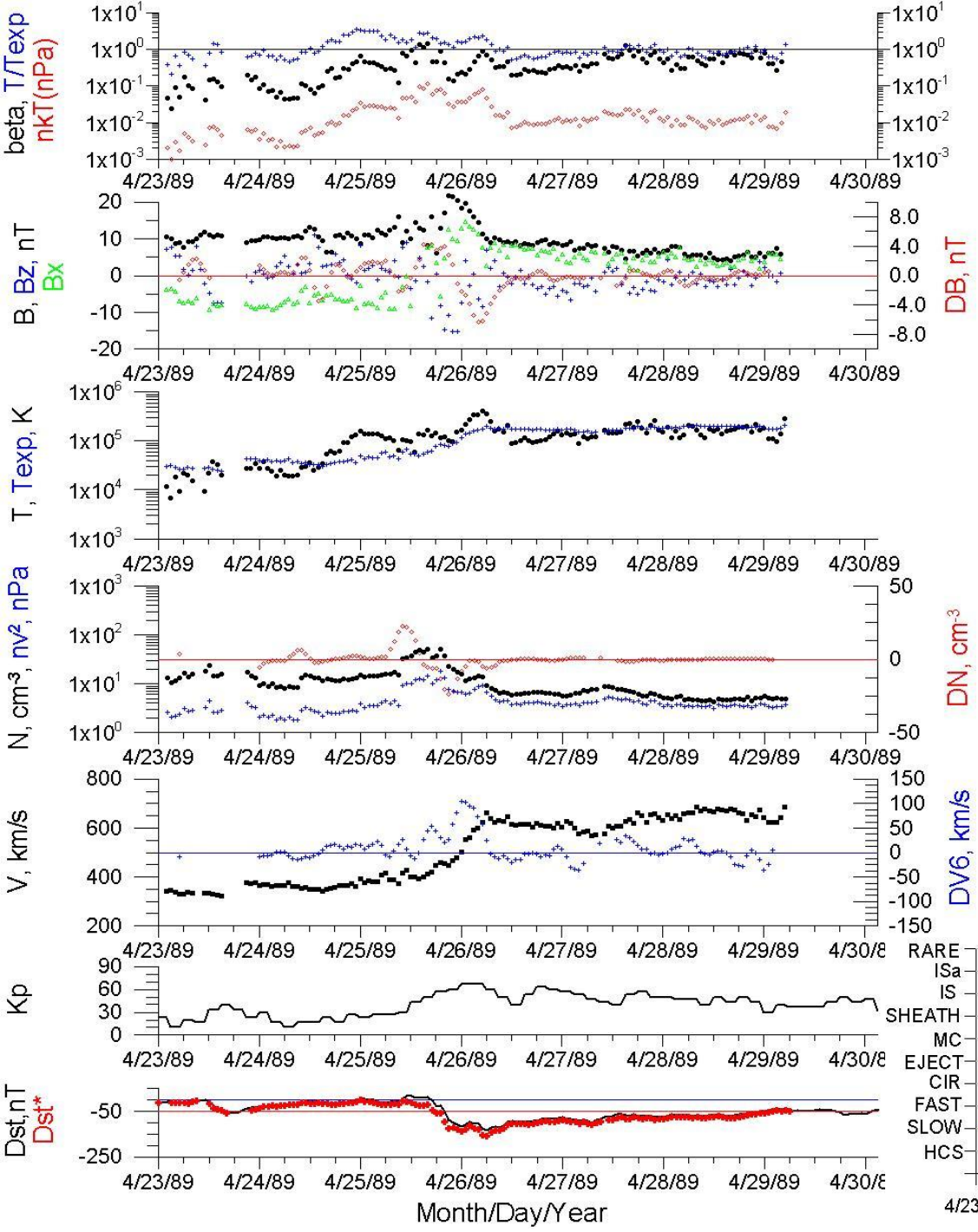
Table 1. The set of criteria used for identification of various types of solar wind streams

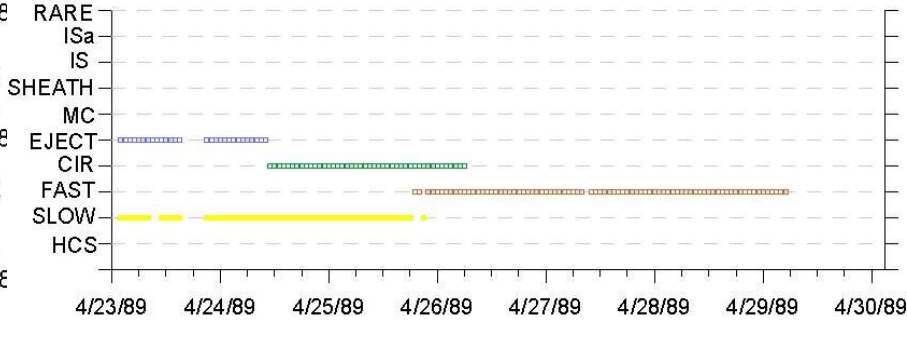
no.	SW type	P	N, **W**	V, **W**	B, **W**	T/T_{exp}, **W**	NkT, **W**	β, **W**	$DV6$, **W**	DN, **W**	DB, **W**	B_X, **W**	B_Y, **W**	T, **W**
1	HCS	5	>7	<500				>0.7				*	*	
			0.5	0.5				0.5				**2.5**	**2.5**	
2	SLOW	3	>3	**<450**				<1						
			0.5	**2.0**				0.5						
3	FAST	3	<20	**≥450**				<1						
			0.5	**2.0**				0.5						
4	CIR	5	>3		>5	**>1**	>0.007	>1						
			0.5		0.5	**3.0**	0.5	0.5						
5	EJECTA	4	<10			**<0.5**	<0.01	<0.5						
			0.5			**4.0**	1.0	1.0						
6	MC	5	<10		**>10**	**<0.5**	<0.01	<0.5						
			0.5		**3.0**	**3.0**	1.0	1.0						
7	RARE	4	**≤1**	<500		<1	<0.01							
			2.5	0.5		0.5	0.5							
8	IS	4							>50	>2	>2			**a
									1.0	1.0	1.0			1.0
9	ISA	4							<–50	<–2	<–2			**b
									1.0	1.0	1.0			1.0

Note: 1. HCS and IS (ISA) are boundaries rather than extended regions, therefore, for HCS * one should check reversals of B_X and B_Y components of the IMF relative to their preceding values, and for IS ** a and ISA ** b the increments of temperature $\Delta T > 0$ and $\Delta T < 0$, respectively, should be checked.
2. For SHEATH the same criteria as for CIR were used.

Criteria functions







Example of OMNI data and calculated parameters in our database

ftp://ftp.iki.rssi.ru/pub/omni

(← left)

and identification of solar wind types

ftp://ftp.iki.rssi.ru/pub/omni/catalog/

(↓ bottom)

Data for 1976-2000

Table 2. Statistics of visually selected events (number of intervals) over the entire period 1976–2000

Type of event	Total number	Minimum number per year	Maximum number	Average number	Standard deviation
HCS	1449	17	219	57.96	46.12
CIR	884	21	55	35.4	9.04
SHEATH	740	10	51	29.6	13.9
EJECTA	1567	36	123	62.68	23.45
MC	136	0	15	5.44	4.19
RARE	18	0	8	0.72	1.8
IS	319	2	43	12.8	10.2
ISA	14	0	5	0.56	1.3

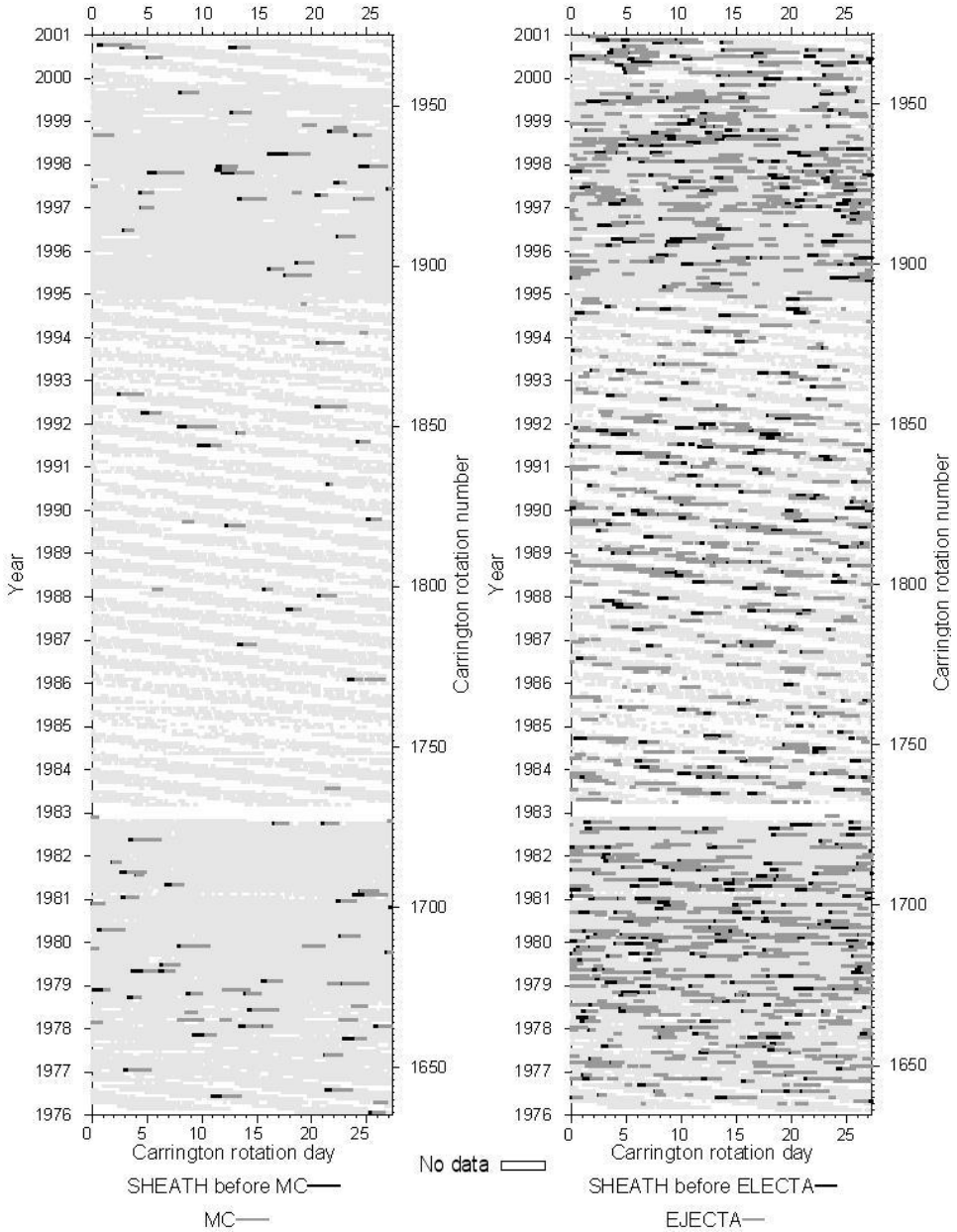
Table 3. Average values and standard deviations of parameters in various types of the solar wind during the 1976–2000 period

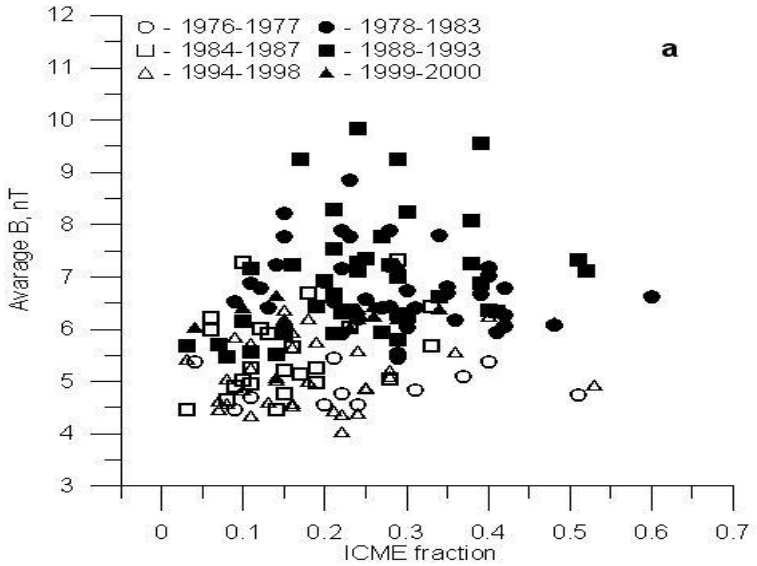
	HCS	SLOW	FAST	CIR	EJECTA	MC	SHEATH	RARE
Duration, h	4.67 ± 6.05			20.6 ± 12.2	29.8 ± 20.5	28.2 ± 13.4	15.7 ± 10.1	20.1 ± 14.3
Number of events	1443			718	1127	101	642	9
N, cm^{-3}	12.1 ± 6.6	10.8 ± 7.1	6.6 ± 5.1	14.1 ± 9.9	7.8 ± 5.3	10.1 ± 8.0	14.3 ± 10.6	1.7 ± 1.8
	6208	84299	44543	12647	27259	2225	8596	139
V, 10^2 km/s	3.8 ± 0.6	3.7 ± 0.4	5.4 ± 0.8	4.5 ± 0.9	4.1 ± 0.9	4.1 ± 1.1	4.5 ± 1.1	5.1 ± 1.6
	6214	84805	44798	12666	27310	2233	8615	146
B, nT	3.9 ± 2.2	5.9 ± 2.9	6.4 ± 3.5	8.7 ± 4.1	6.4 ± 2.8	12 ± 5.2	8.5 ± 4.5	6.7 ± 2.2
	6322	67719	36179	10493	23857	2237	7286	116
T/T_{exp}	0.8 ± 0.9	1.0 ± 1.4	1.0 ± 0.7	1.7 ± 2.0	0.7 ± 1.3	0.7 ± 1.5	1.5 ± 1.2	1.1 ± 0.9
	5950	75901	40026	11149	25275	2016	7851	124
T, 10^4 K	4.1 ± 4.1	4.4 ± 4.4	13.1 ± 11.8	13.8 ± 13.3	4.2 ± 5.3	4.5 ± 6.6	12.9 ± 17.6	11.1 ± 10.7
	5950	75901	40026	11149	25275	2016	7851	124
NkT, 10^{-2} nPa	0.6 ± 1.3	0.6 ± 1.3	1.3 ± 2.3	2.2 ± 2.8	0.4 ± 1.2	0.7 ± 2.0	2.2 ± 3.6	0.3 ± 0.5
	5950	75901	40026	11149	25275	2016	7851	124
β, 10^{-1}	9.5 ± 0.2	5.2 ± 0.0	6.1 ± 0.1	6.5 ± 0.1	3.1 ± 0.0	1.6 ± 0.1	6.5 ± 0.1	2.3 ± 0.5
	5878	59669	32244	8829	20518	1725	6465	100
B_Z, nT	–0.01 ± 2.3	0.08 ± 3.1	0.05 ± 3.4	0.2 ± 4.4	0.03 ± 3.3	–0.8 ± 7.7	0.10 ± 4.9	0.80 ± 2.8
	6322	67719	36179	10493	23857	2237	7286	116
D_{st}, nT	–6.5 ± 15.0	–10.7 ± 18.2	–28.7 ± 25.9	–18.0 ± 27.2	–21.1 ± 25.4	–52.1 ± 45.8	–21.5 ± 33	–27.0 ± 22.0
	6415	85459	45017	13120	29046	2571	6856	147
mNV^2, nPa	2.9 ± 1.4	2.4 ± 1.6	3.2 ± 2.8	4.4 ± 2.8	2.1 ± 1.7	3.3 ± 3.2	4.9 ± 4.7	0.8 ± 0.6
	6208	84299	44543	12647	27259	2225	8596	139

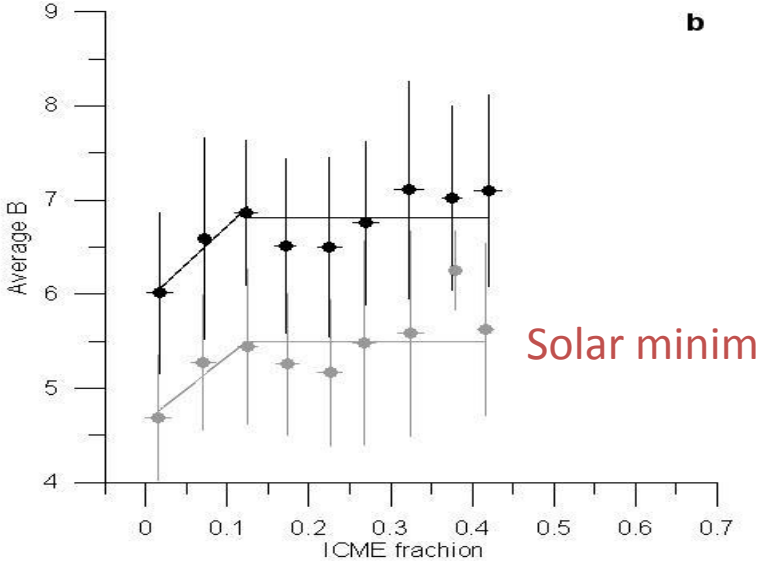
Estimation of Sun's open magnetic flux ("floor")

(IMF at minimum of cycle and minimum of ICME fraction)

(from Yermolaev et al., Sol.Phys., 2009)

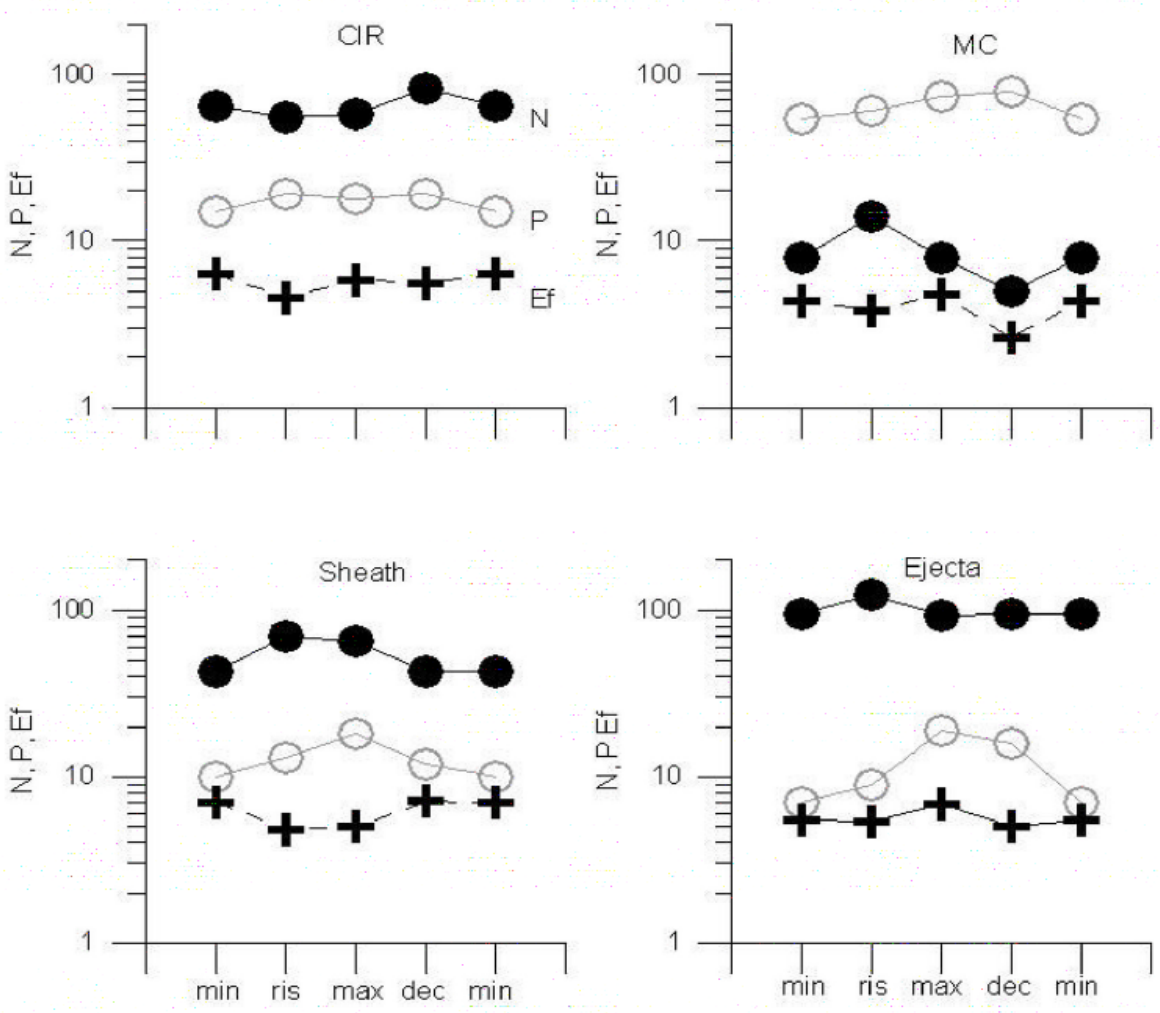






Solar minimum

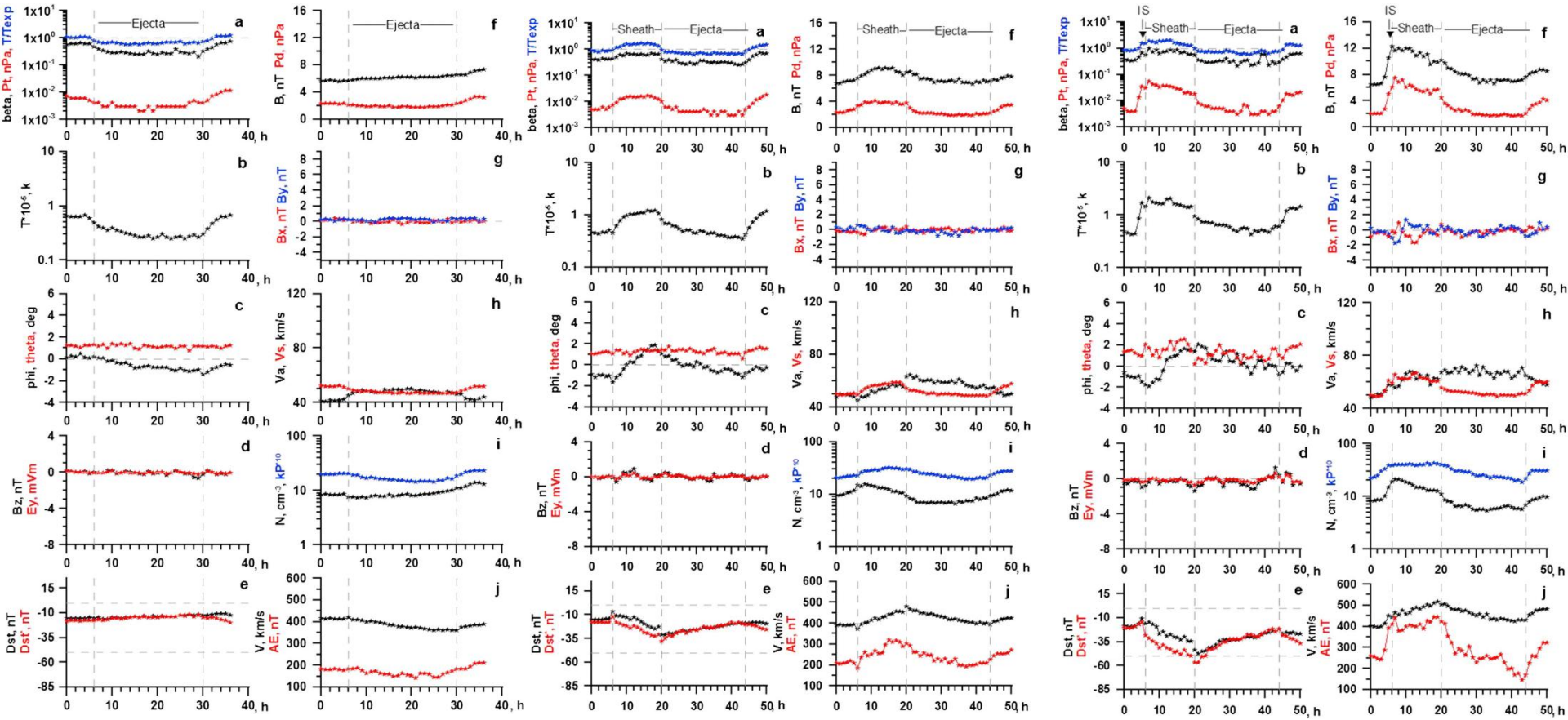
Solar Cycle variations



- yearly number of events (**N**, solid circles),
- probabilities (geoeffectiveness) (**P**, open circles), and
- efficiency of magnetic storm generation (**Ef**, crosses) for CIR, Sheath, MC, and Ejecta.

(from Yermolaev et al.,JGR, 2012)

Average Temporal Profiles of parameters



Ejecta Sheath + Ejecta IS + Sheath + Ejecta

(from Yermolaev et al., JGR, 2015)

Conclusions

- Catalog for **1976-2000** has been made during 2002-2007 (Yermolaev et al., 2009).
- More 20 publications with the Catalog.
- Catalog for **2001-2015** is in process
- Current status ftp://ftp.iki.rssi.ru/pub/omni

Results	Time interval
Calculation of parameters	1976-2015
Visualization of parameters	1976-2015
Identification of SW types	1976-2003
Visualization of SW identification	1976-2002

Thank you