

# Specific Features of the High-speed Streams in the Solar Wind and Geomagnetic Storms during the Last Prolonged Solar Minimum

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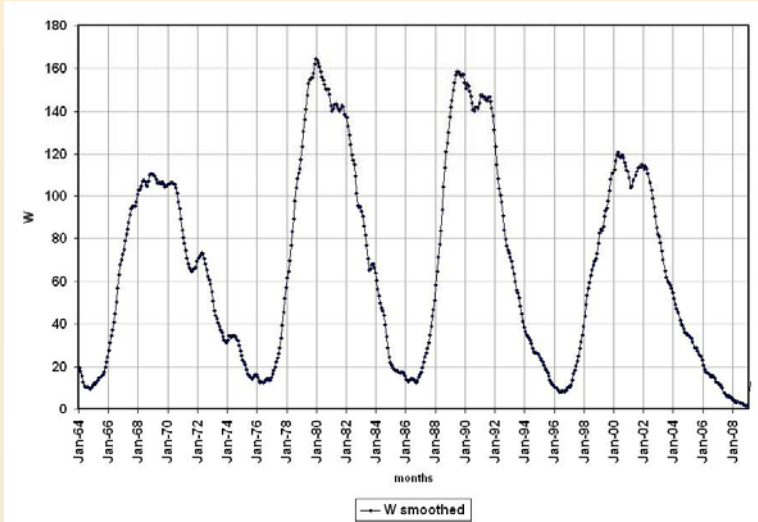
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# OUTLINE

- **Introduction**
  - **Solar Cycle phases;**
  - **Geomagnetic storms**
- **Data used – HSS & GS;**
- **Minimum phases of SC 23 and SC 24**
- **Global behavior of the HSS and  $A_p$**
- **HSS Statistics during SC 23 and SC 24**
- **MINIMA**
- **GS Statistics during SC 23 and SC 24**
- **MINIMA**
- **Summary**

# INTRODUCTION

- **Solar Cycle: phase durations defined as:**



- **Minimum:**  $W < 20$ ;
- **Maximum:** interval to encompass entirely the “shape” of the SC maximum (prolonged more than one year or having two peaks);
- **Ascendant & Descendant:** intervals placed between them

⇒ **SC 23 maximum phase: September 1999 – July 2002**

- **Geomagnetic storms**
- **The main feature** → a decrease in **H** of the geomagnetic field at the equator related to the enhancement of the ring current which flows around the Earth from east to west in the equatorial plane;
- The **Dst** or **disturbance storm time** index is a measure of the geomagnetic activity used to assess the severity of magnetic storms. It is based on the average value of the horizontal component of the Earth's magnetic field measured hourly at four near-equatorial geomagnetic observatories.

# DATA (1)

- **HSS DEFINITION:** „A large increase in the solar wind velocity lasting for several days (at least two days)”.
- **MAIN SELECTION CRITERIUM:**  $\Delta V1 \geq 100$  km/s lasting for two days, where:  $\Delta V1$  – the difference between the smallest 3-hr velocity value for a given day ( $V0$ ) and the largest 3-hr value the following day ( $V1$ ).
- **HSS DATA during 1996 – 2008 (SC 23):**
  - Maris, O., Maris G., 2009, at:  
[http://spacescience.ro/new1/HSS\\_Catalogue.html](http://spacescience.ro/new1/HSS_Catalogue.html));
- **and during 1995 & 2009 – 2010:**
  - Maris, O., Maris G., 2011, unpublished preliminary data
- **HSS PARAMETERS:**
  - HSS duration  $\rightarrow$  **d (days);**
  - HSS maximum velocity  $\rightarrow$   **$V_{\max}$  (km/sec);**
  - HSS velocity gradient  $\rightarrow$   **$\Delta V_{\max} = V_{\max} - V_0$ ;**
  - HSS intensity (importance)  $\rightarrow$   **$I = \Delta V_{\max} \times d$**

# DATA (2)

- **GEOMAGNETIC DATA SOURCE:**

- **Geomagnetic Dst Index, Bz** (hourly values):

<http://omniweb.gsfc.nasa.gov/form/dx1.html>;

- **GEOMAGNETIC STORM (GS) INTENSITY: Dst minim (nT)  $\Rightarrow$  storm classification:**

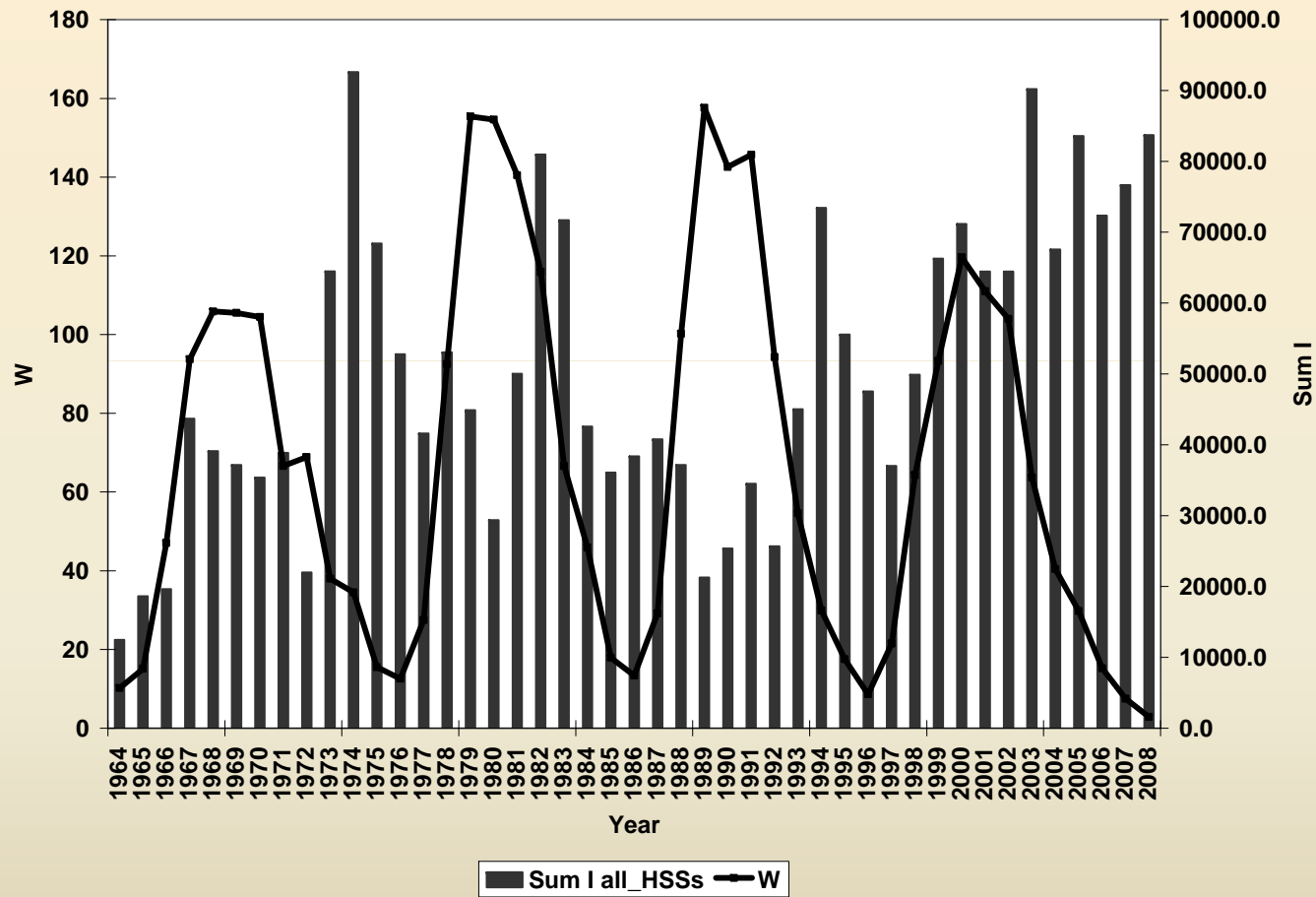
- $-50 < \text{Dst} \leq -30 \rightarrow$  Small storm (typical substorm);
- **$-100 < \text{Dst} \leq -50 \rightarrow$  Moderate storm;**
- **$-150 < \text{Dst} \leq -100 \rightarrow$  Intense storm;**
- **$\text{Dst} \leq -150 \rightarrow$  Severe storm.**

- **STORM PARAMETERS** given in **COMPLEX CATALOGUE (GEOMAGNETIC STORMS – HIGH SPEED STREAMS; 1996 – 2008)**

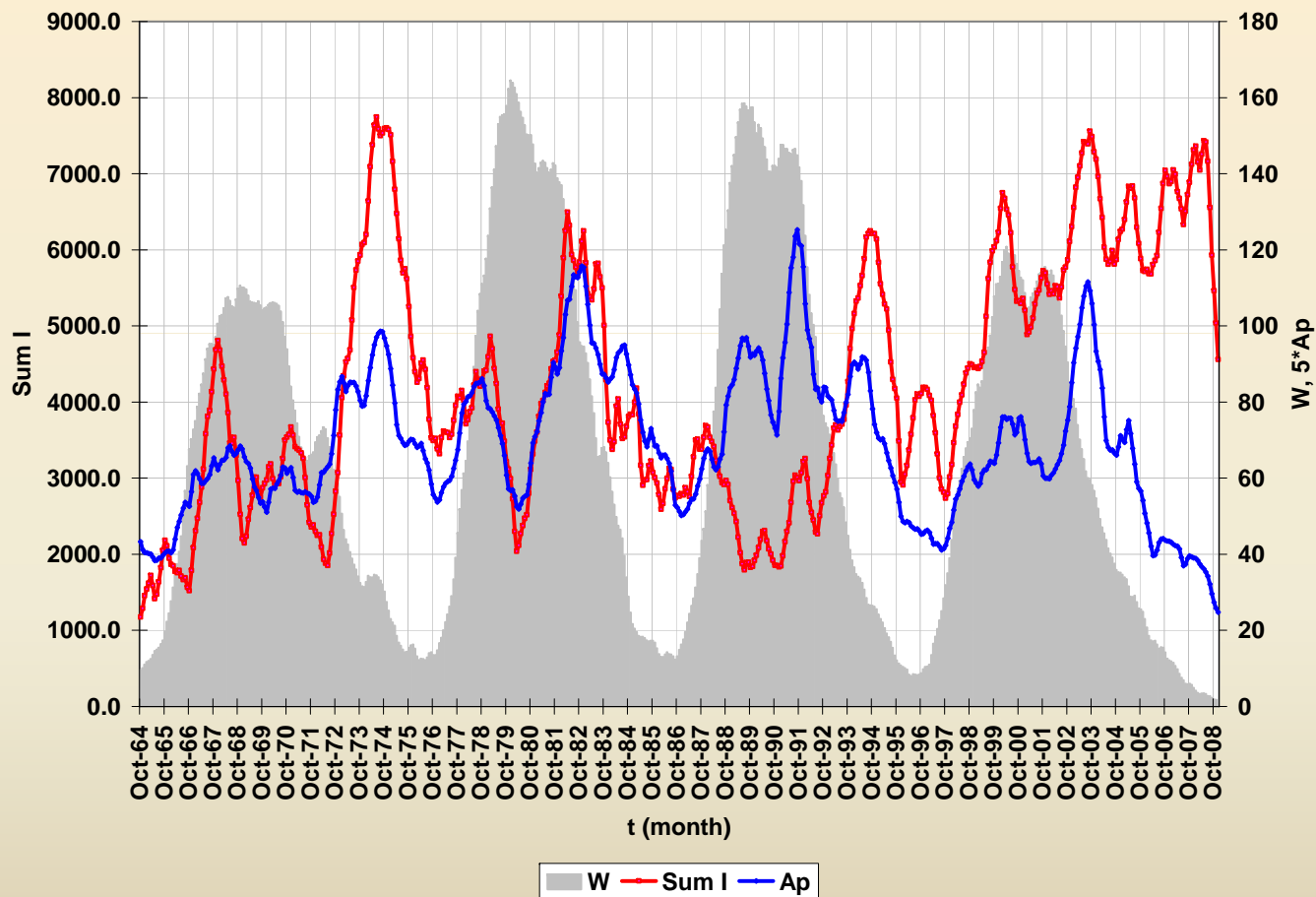
([http://www.space.ro/new1/GS\\_HSS\\_Catalogue.htm](http://www.space.ro/new1/GS_HSS_Catalogue.htm))

- Bz minim (nT) pre-storm;
- Dst minim (nT);
- Time of Dst minim (mm:dd:hh);
- Storm type: SSC – Sudden Storm Commencement or SG – Gradual Storm

# Yearly distribution of the summed HSS importance (SI)



# Global behavior of the $A_p$ and HSS importance



The  $A_p$  and  $I$  variation (monthly smoothed values) in comparison with the monthly smoothed values of the Wolf number during Oct. 1964 – Dec. 2008 interval

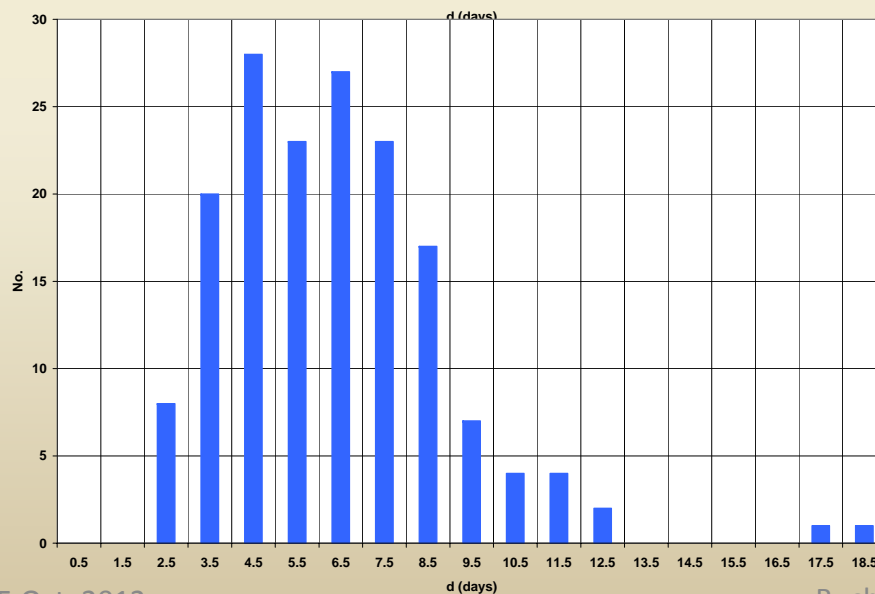
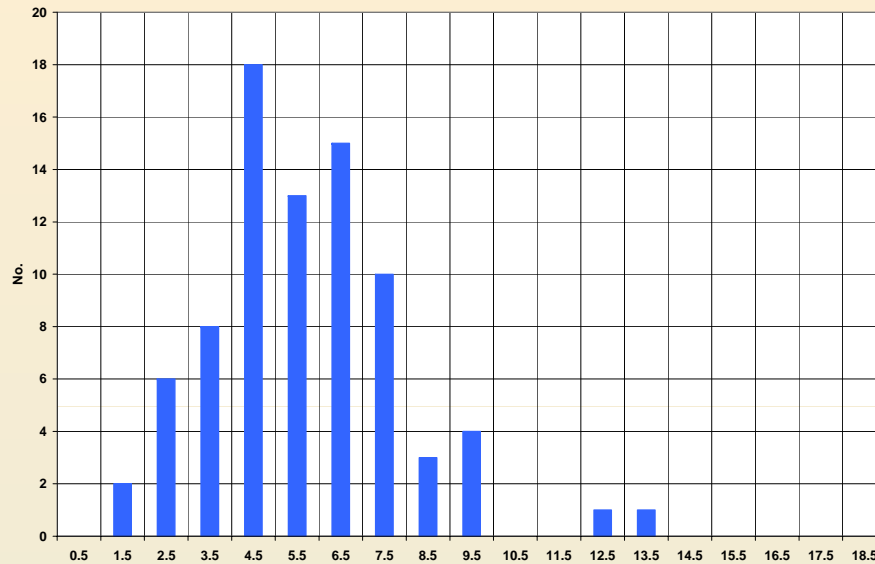
## MINIMUM PHASES of the Solar Cycles nos. 23 and 24

- **The MINIMUM PHASE of the Solar 11-yr Cycle** – the apparent „quiet” phase when the old cycle (the old dipole) is using up its reserves (it’s dying out) but in the underneath levels the new dipole is amplifying its energy and the new cycle is beginning as new active regions with the opposite polarity distribution.
- **Definition: MINIMUM PHASE**– the interval having the monthly sunspot relative number (smoothed values),  $W < 20 \Rightarrow$  there is at most one sunspot group in photosphere.

SC no.	Minimum Phase	Duration	HSS no	HSS no./month	GS no.
20	01.1964 – 10.1965	22 months	34	1.5	
21	04.1975 – 02.1977	23 months	66	2.9	
22	02.1985 – 02.1987	25 months	69	2.8	
23	05.1995 – 05.1997	25 months	79	3.2	43
24	02.2006 – 09.2010	57 months !!!	283	5.0	23

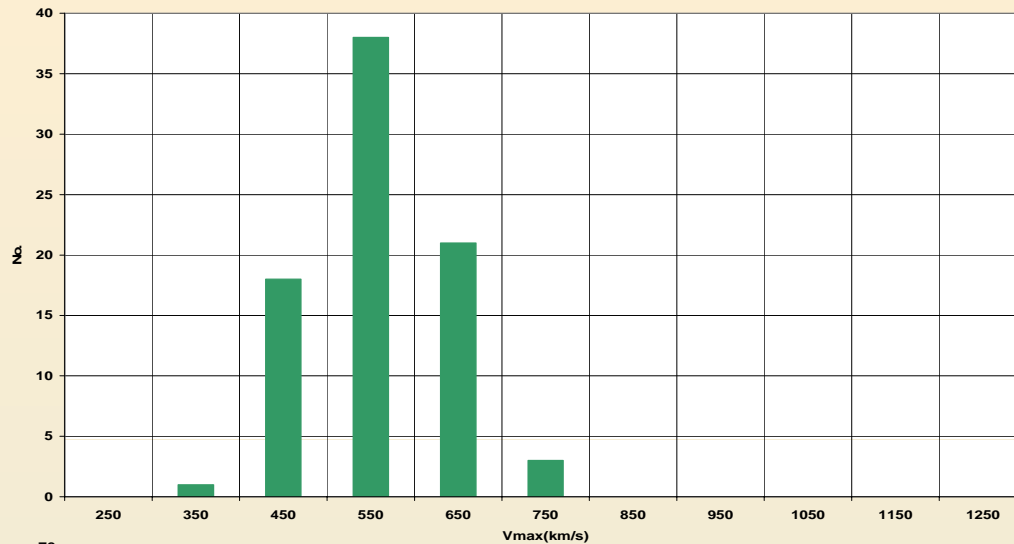


# HSS Statistics during SC 23 and SC 24 MINIMA



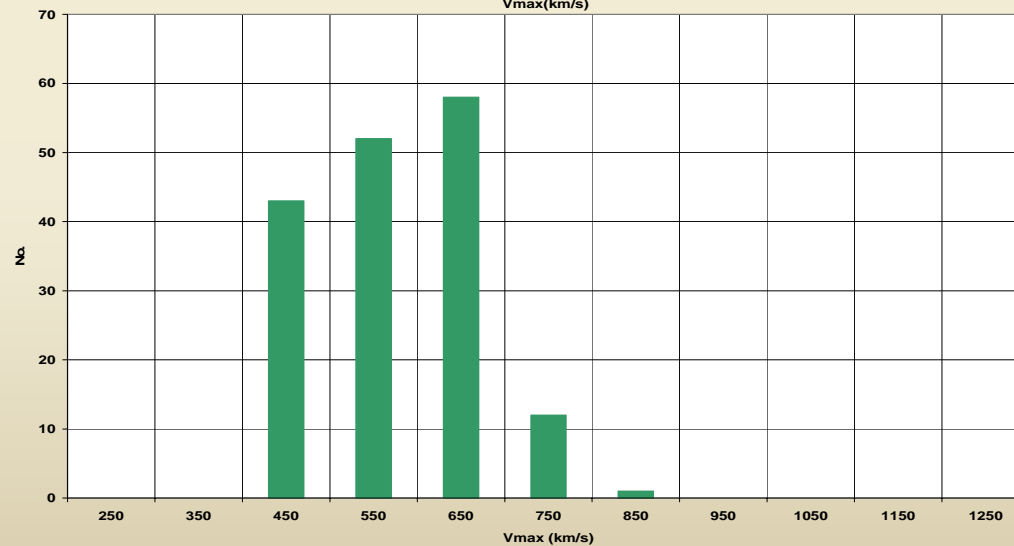
## Duration:

- SC 23 minimum – the majority of HSSs had duration of 4–8 days with **peaks at 4.5 and 6.5 days**;
- SC 24 minimum – the majority of HSSs had larger duration: 3–9 days, with the same **peaks at 4.5 and 6.5 days**.

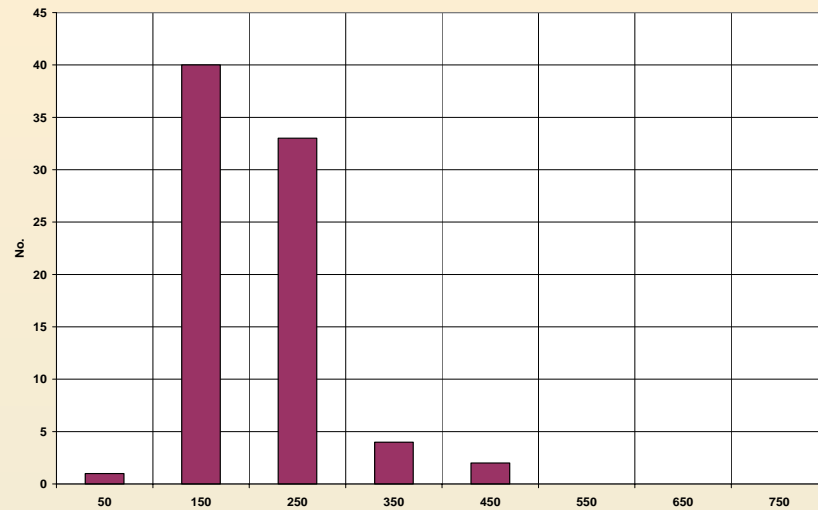


## Vmax – Maximum velocity

•SC 23 minimum  
 $500 \leq V_{max} \leq 600$  km/s;



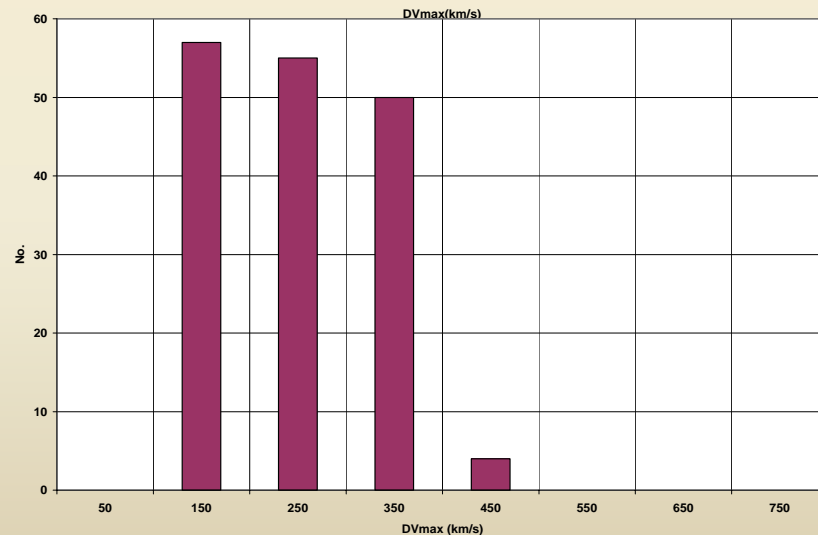
•SC 24 minimum  
 $600 \leq V_{max} \leq 700$  km/s.



$$\Delta V_{\max} = V_{\max} - V_0$$

- SC 23 minimum

$$100 \leq \Delta V_{\max} \leq 300 \text{ km/s};$$



- SC 24 minimum – HSSs are rather equally distributed in the three division of 100 km/s of the 100–400 km/s interval.

## GS Statistics during SC 23 and SC 24 MINIMA

Storm Intensity	SC 23 Minimum				SC 24 Minimum					
	1995	1996	1997	Total	2006	2007	2008	2009	2010	Total
Moderate	18	10	10	38	6	5	3	1	6	21
Intense	2	1	2	5	2	0	0	0	0	2

- **SC 23 minimum:** were registered 38 moderate and 5 intense geomagnetic storms. The moderate ones are equally distributed in 1996 and 1997 (10 GSs in each year) but 18 GSs were registered during 1995 (in the final part of SC 22);
- **31 % geomagnetic storms had SSC → HSS with complex solar sources;**
- **SC 24 minimum:** only 21 moderate and 2 intense geomagnetic storms were registered. The first intense geomagnetic storms registered in April 2006 (SC 23) and the second one, in December 2006 (SC 24) ;
- **34 % geomagnetic storms had SSC → HSS with complex solar sources;**
- **No intense geomagnetic storm was registered during 2007 – 2010 although Vmax and  $\Delta V_{max}$  of the HSSs were higher than the ones of the HSSs registered during SC 23 minimum.**

# Summary

- Durations of the minimum phases for SCs 20-23 are quite equal (they lasted for 22 – 25 months);
- The last minimum phase exceeded two times longer interval (57 months);
- HSS number per minimum is slowly growing from one cycle to the following, but it remains about 3/month for SCs 21 – 23. Frequencies of 1.5 HSSs/months and about 5 HSSs/months are opposite exceptions for the minimum phases of SC 20 and SC 24, respectively;
- Minima after SCs with lower  $W_{\max}$  (nos. 20 and 23) are more active in HSS occurrence;
- **Consequently, the minimum phases of the 11-yr solar cycles are not quiet intervals but they are periods with significant activity in the solar corona where especially more equatorial coronal holes could appear and could be sources of more energetic HSSs.**

***Thank You  
for Your attention !***