

Analysis of the Geomagnetic Activity during the SC 24 Maximum Phase

Maris Muntean G.¹, Besliu-Ionescu, D.¹, Georgieva, K.², Kirov, B.²

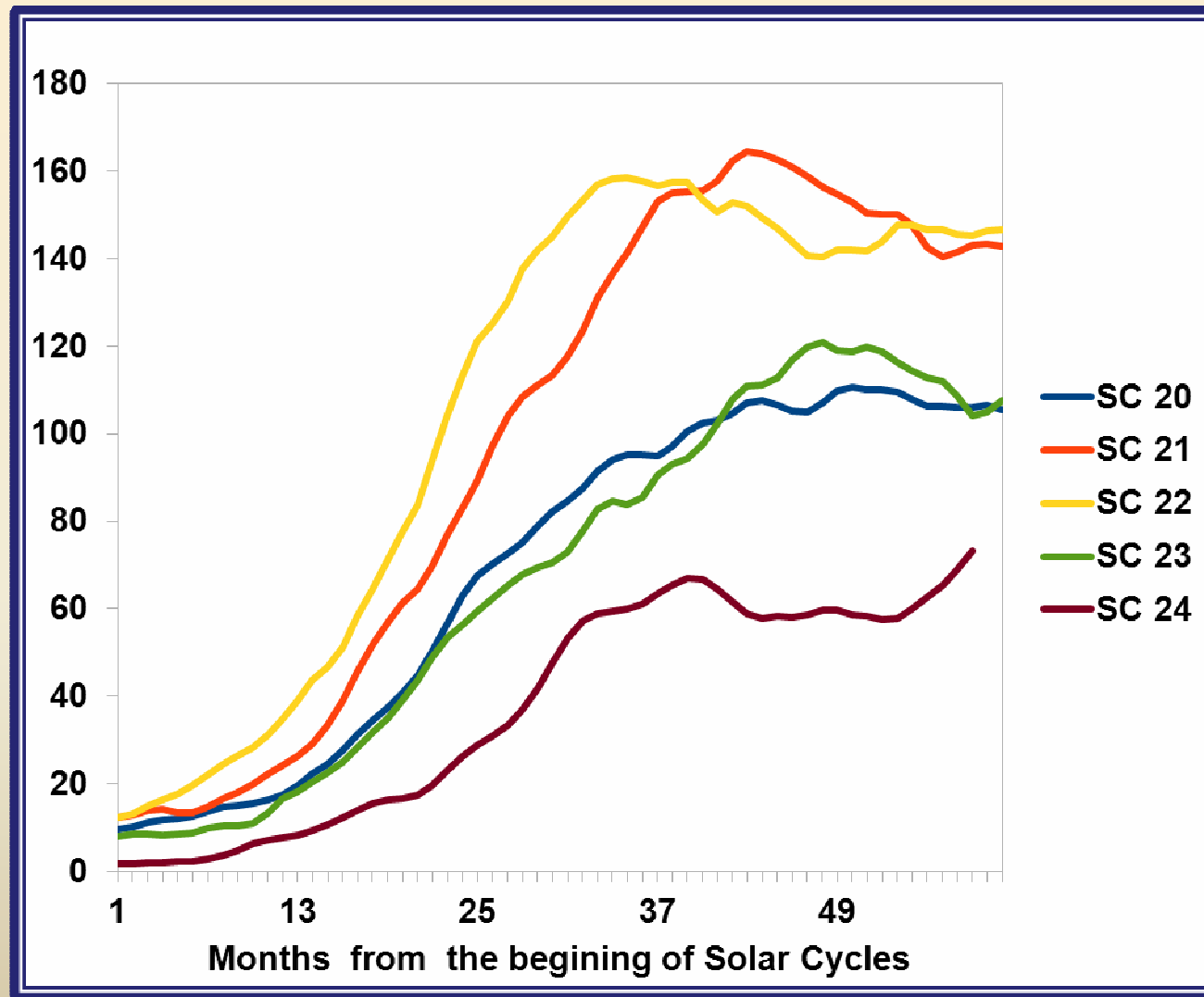
¹ Institute of Geodynamics of the Romanian Academy

² Space Research and Technologies Institute, Sofia, Bulgaria

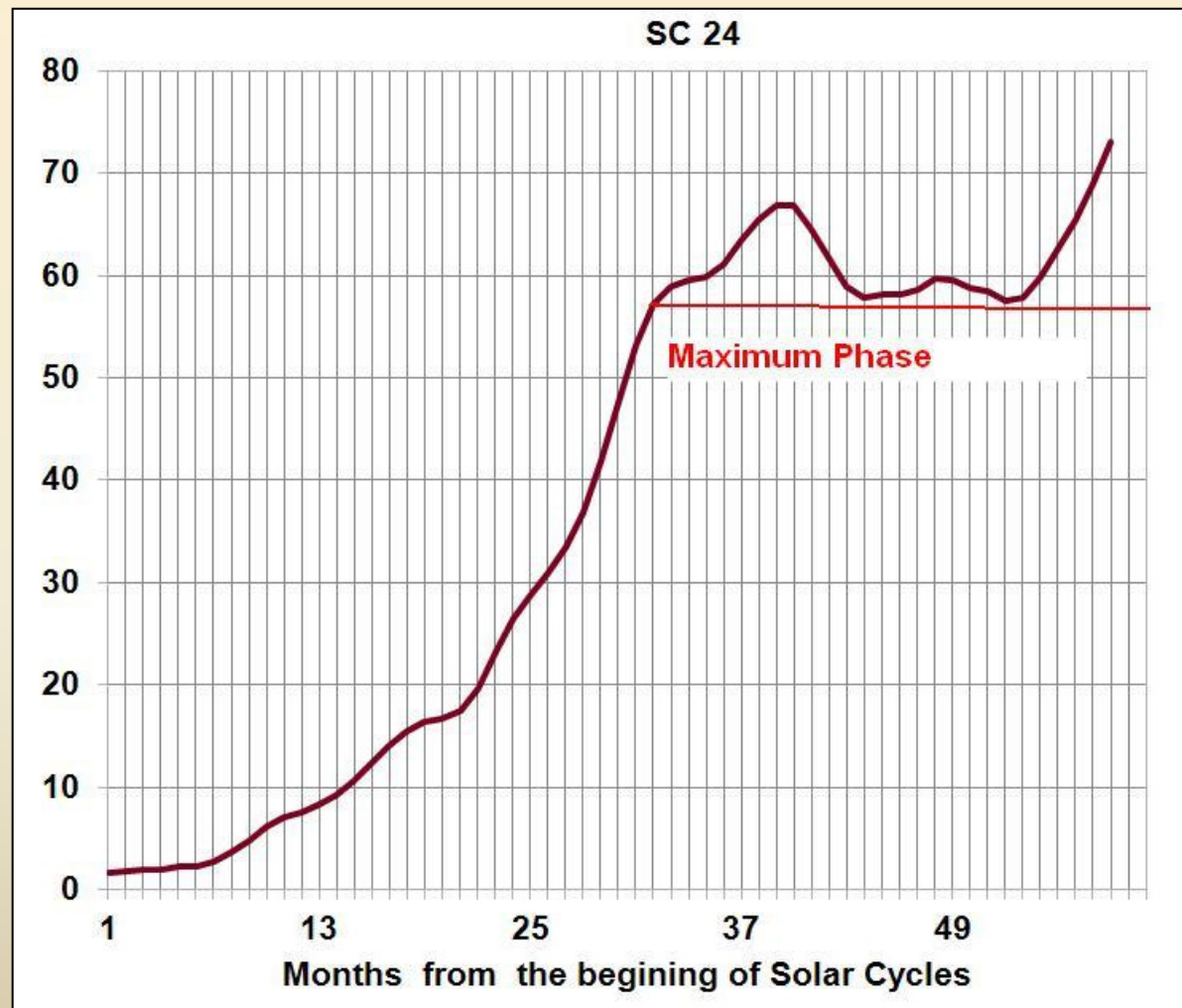
Outline

- Introduction
 - Solar cycle 24 – maximum phase;
 - Geomagnetic variability – indices (Kp, aa, Ap ...), storms;
 - HSS and HSS_GS Catalogues for SC 23
- HSS Catalogue for SC 24 (2009 – 2013):
 - Data sources, HSS parameters;
 - Statistics
- SC 24 maximum phase:
 - Comparative analysis of R, aa, Ap and ΣI ;
 - Event analysis: March 2012 and March 2013
- Future work

Solar Cycles nos. 20 – 24 (60 months)



SC 24 maximum phase



July 2011 –
October 2013
(unfinished)

$R(\text{max.1}) = 66.9$
February 2012

Geomagnetic Storms

Geomagnetic storm classification :

- $-50 < \text{Dst} \leq -30 \rightarrow$ **minor (small) storm** (typically substorm);
- $-100 < \text{Dst} \leq -50 \rightarrow$ **moderate storm**;
- $-150 < \text{Dst} \leq -100 \rightarrow$ **intense (strong) storm**;
- $-\text{Dst} \leq -150 \rightarrow$ **severe storm**.

Three distinct phases:

- **Initial phase**;
- **Main phase** lasting to several hours –
Dst can reach negative values of hundreds of nT;
- **Recovery phase** lasting from tens of hours to a week –
Dst gradually returns to the normal level.

http://www.space science.ro/new1/Pagini_finale/GS_HSS_Catalogue.htm.

HSS definition

HSS – a large increase in the SW velocity lasting by several days

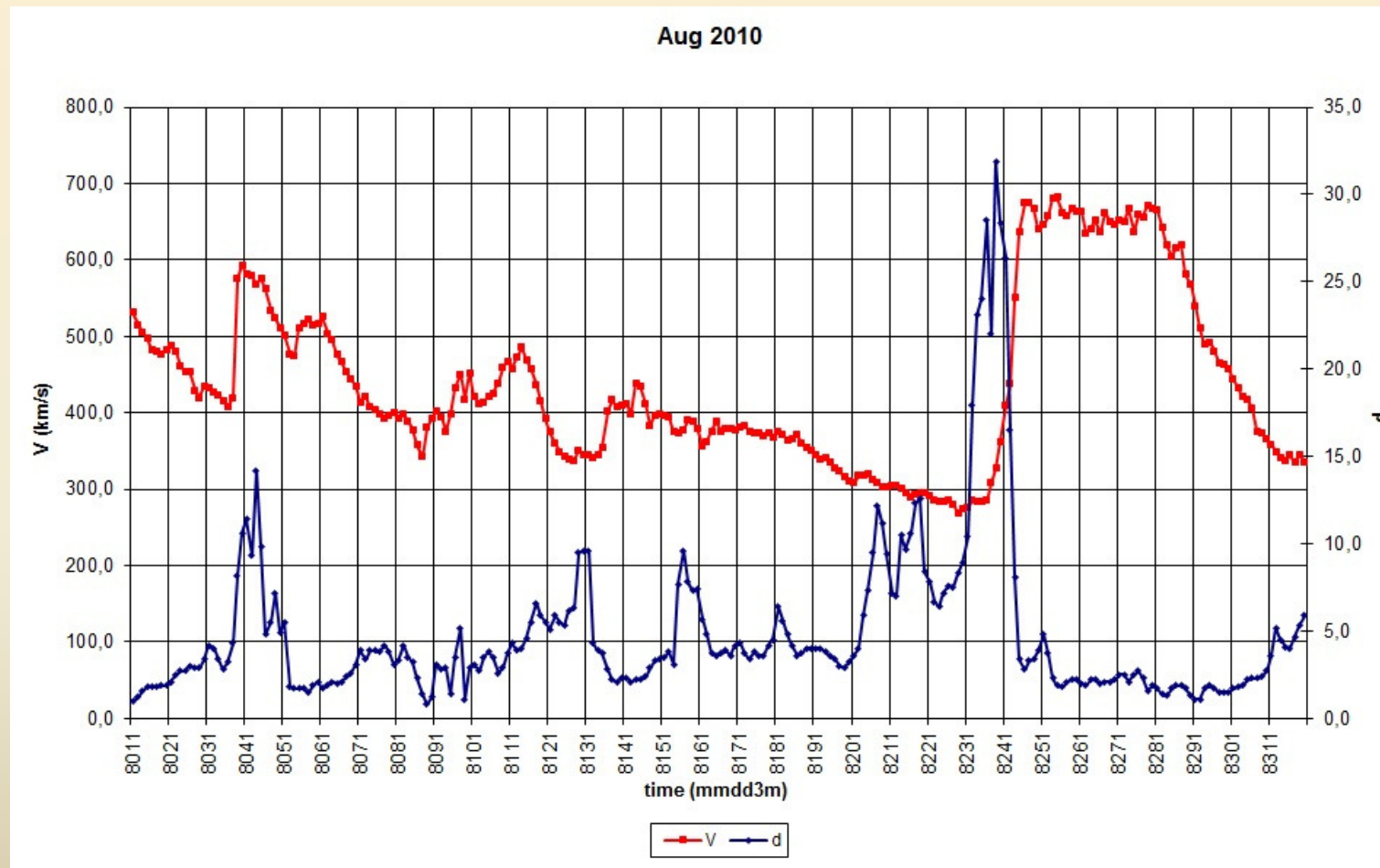
- Intriligator (1973) – HSS as a stream having a rapidly rising increase in solar wind speed and **a peak velocity ≥ 450 km/s**;
- Bame et al. (1976) and Gosling et al. (1976) define a HSS as an observed variation of solar wind speed characterized by **an increase of at least 150 km/s within a 5-day interval**;
- Broussard et al. (1977) define a HSS as wind period in which the **solar wind speed is ≥ 500 km/s averaged over a day**

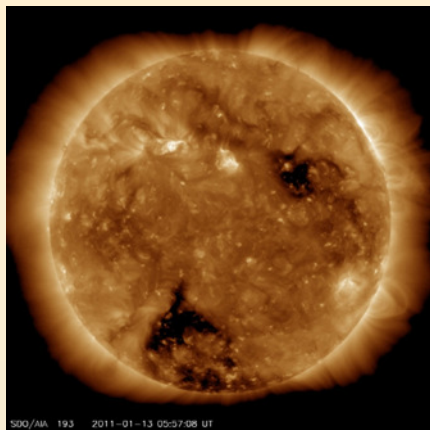
HSS Parameters

- HSS duration – d (days);
- HSS initial velocity – the smallest 3-hr velocity mean value for a given day, V_0 ;
- HSS maximum velocity – V_{max} (km/sec);
- HSS velocity gradient – $\Delta V_{max} = V_{max} - V_0$;
- **HSS importance (or intensity)** – $I = \Delta V_{max} \times d$
(ΣI could be used, calculated per BRs, per months, or per years, as well as, the weighted values : $I_p = \Sigma I / \Sigma d$)

All these parameters characterize in some manner the energy of the events; the HSS Importance is considered to be the best one because it includes the velocity gradient as well as the duration of the event.

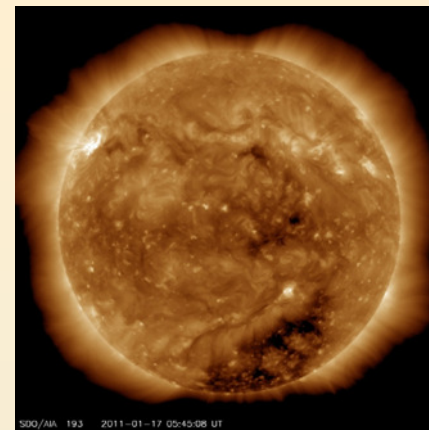
August 2010



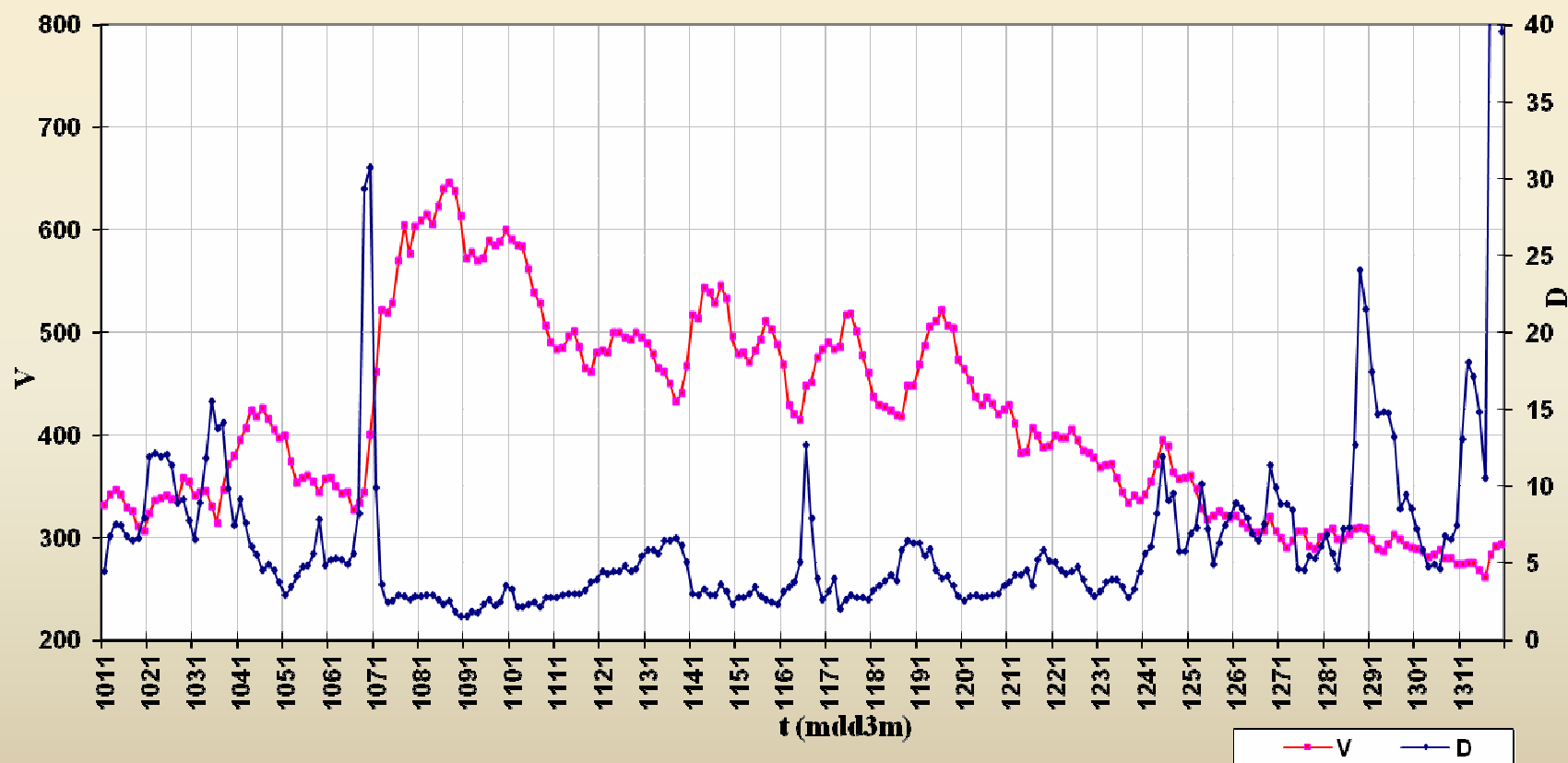


January 2011

Left: 13 January,
Right: 17 January



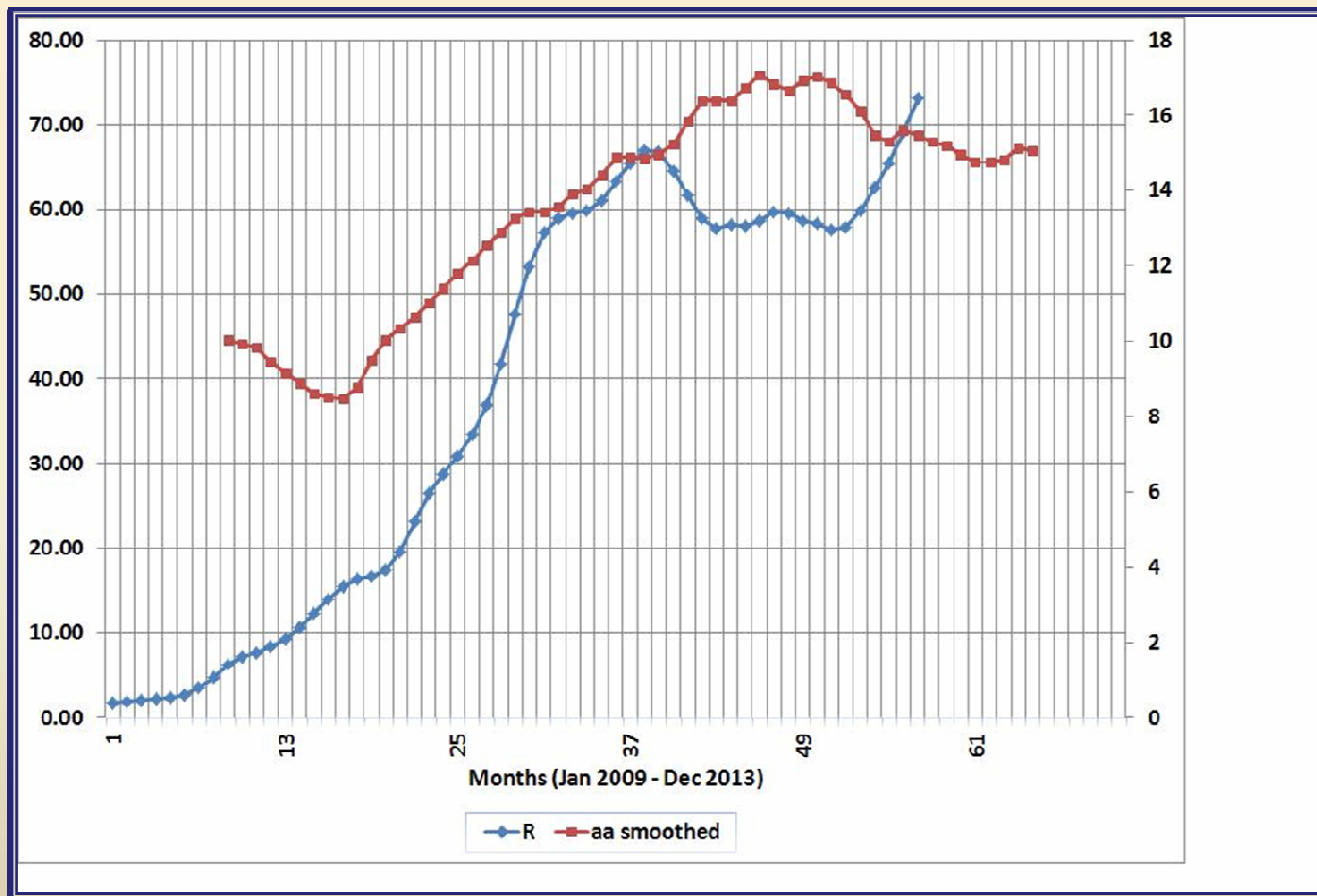
January 2011



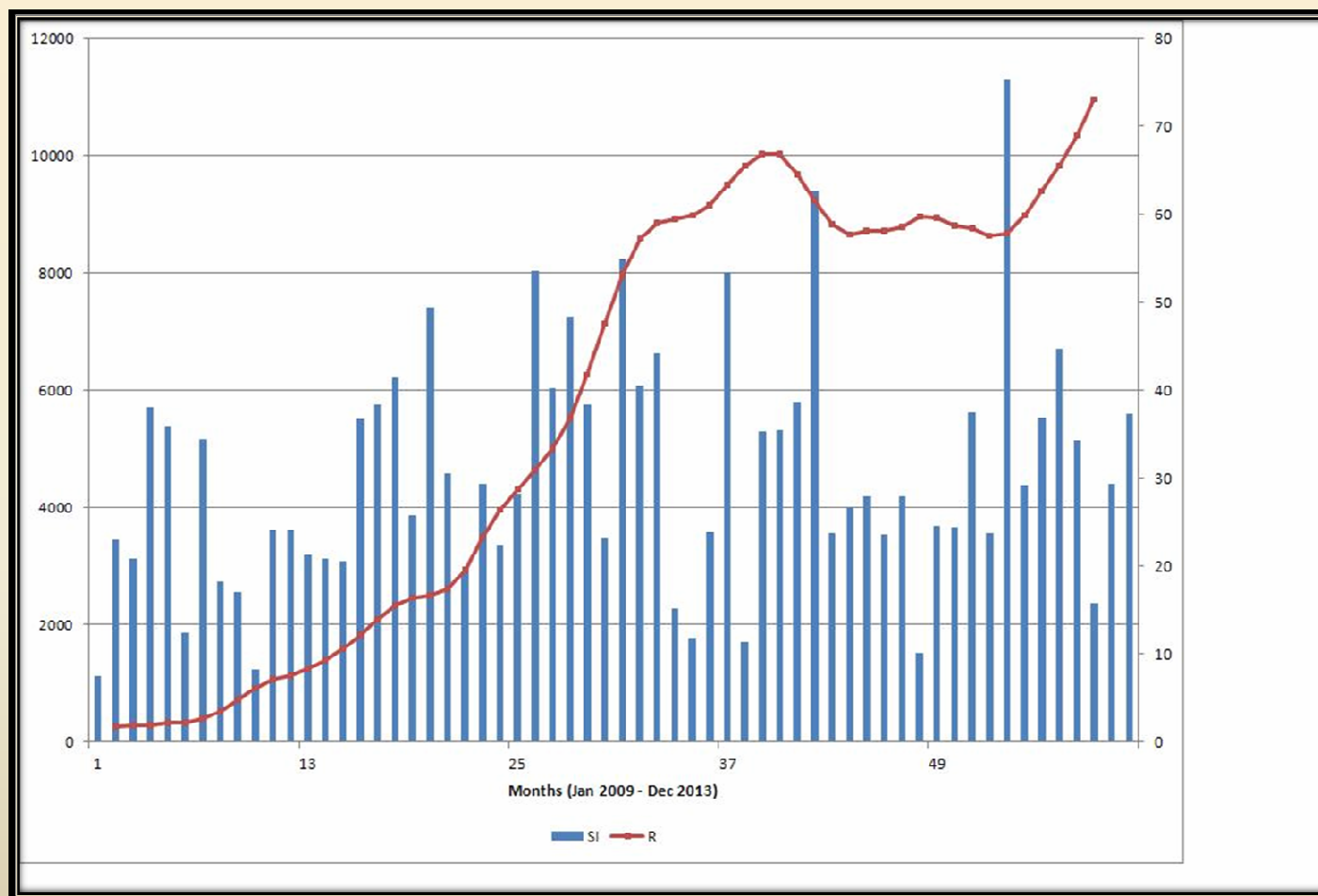
HSSs Statistics during Solar Cycles 23 and 24 (60 months)

Year	SC 23					SC 24				
	1996	1997	1998	1999	2000	2009	2010	2011	2012	2013
all_HSSs	45	35	41	46	48	34	34	44	39	36
CH_HSSs	43	24	26	36	25	34	28	27	31	29
FG_HSSs	2	11	15	10	23	0	6	17	8	7
HSSs/month	3.8	2.9	3.4	3.8	4.0	2.8	2.8	3.7	3.2	3
Vmax>600 km/s	13	4	14	20	19	1	8	13	12	7
Vmax>700 km/s	1	0	3	5	8	0	2	2	4	2
$\Delta V > 400$ km/s	0	0	2	2	5	0	2	0	0	3

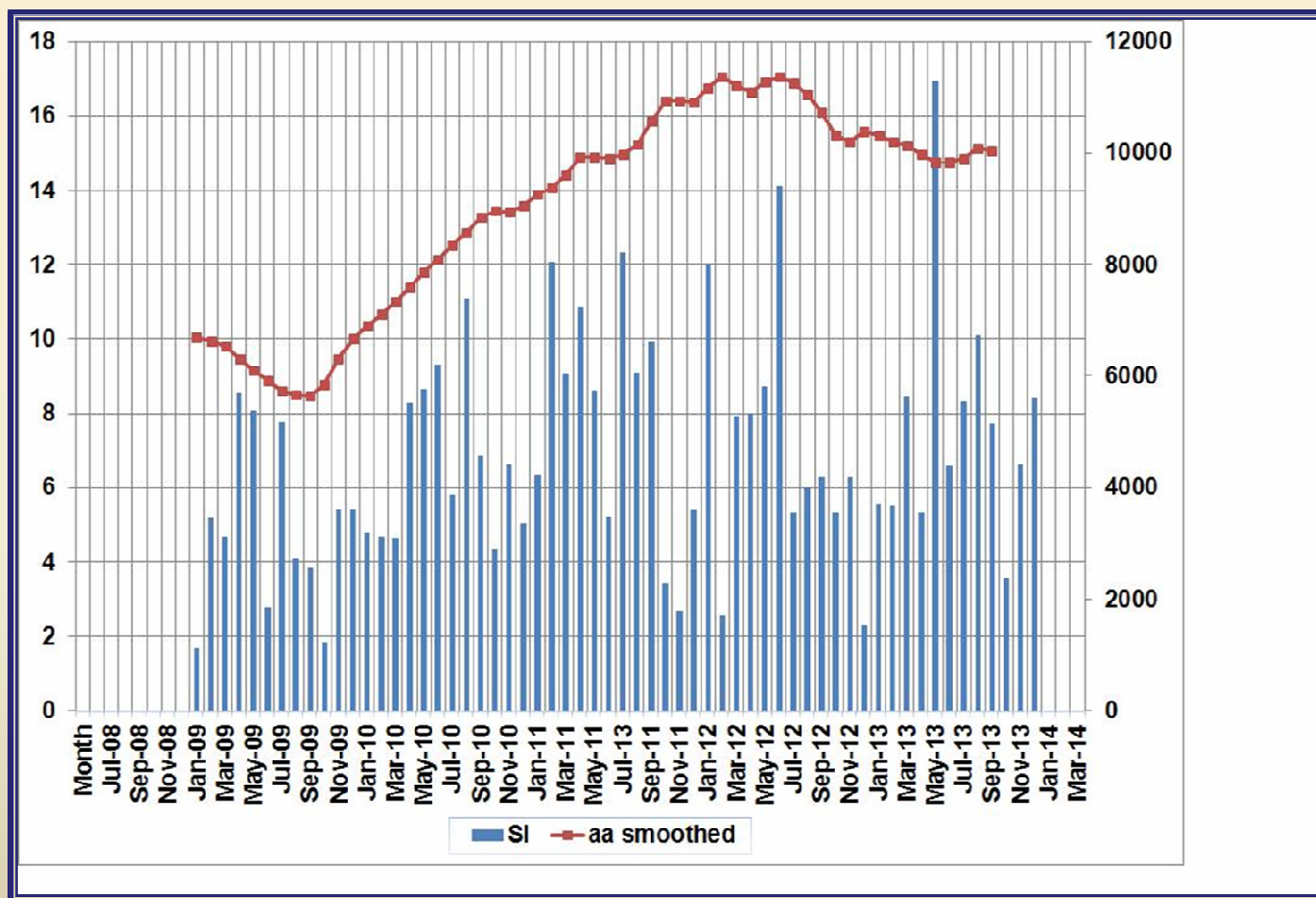
R and aa , smoothed monthly values

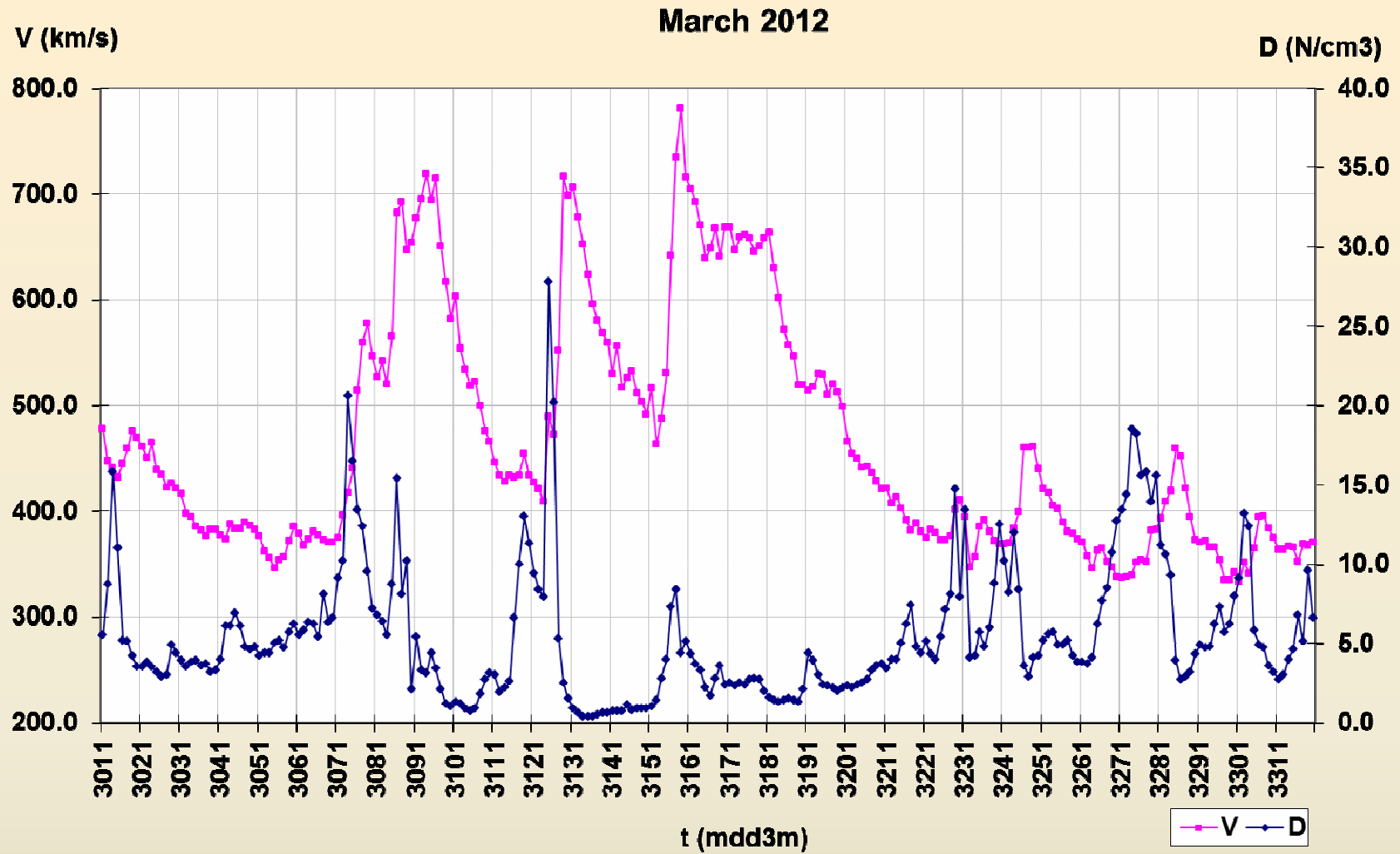


R and Σ , 2009 - 2013



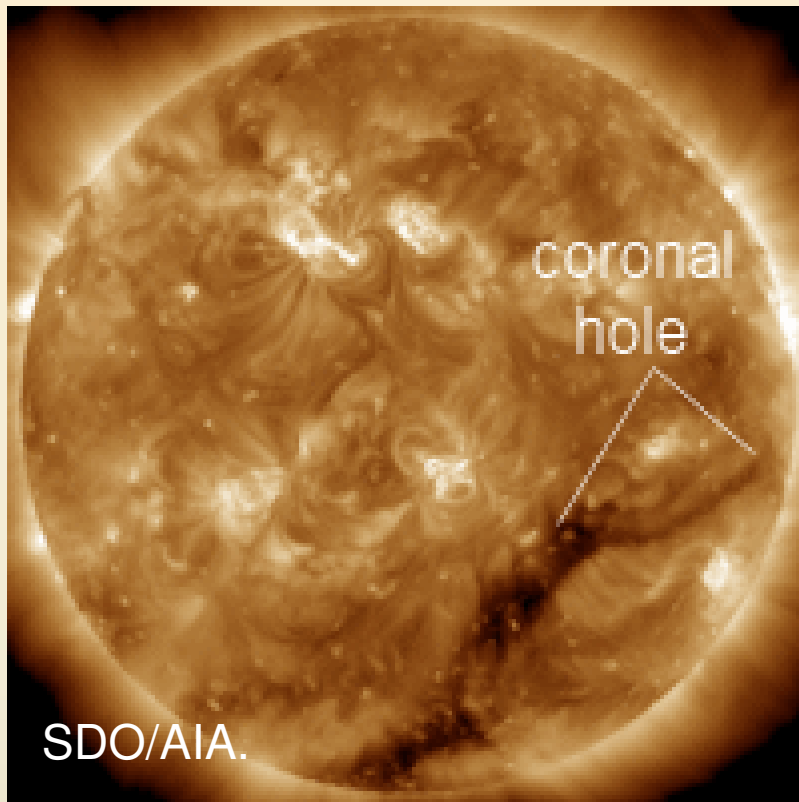
Δ and aa , 2009 - 2013



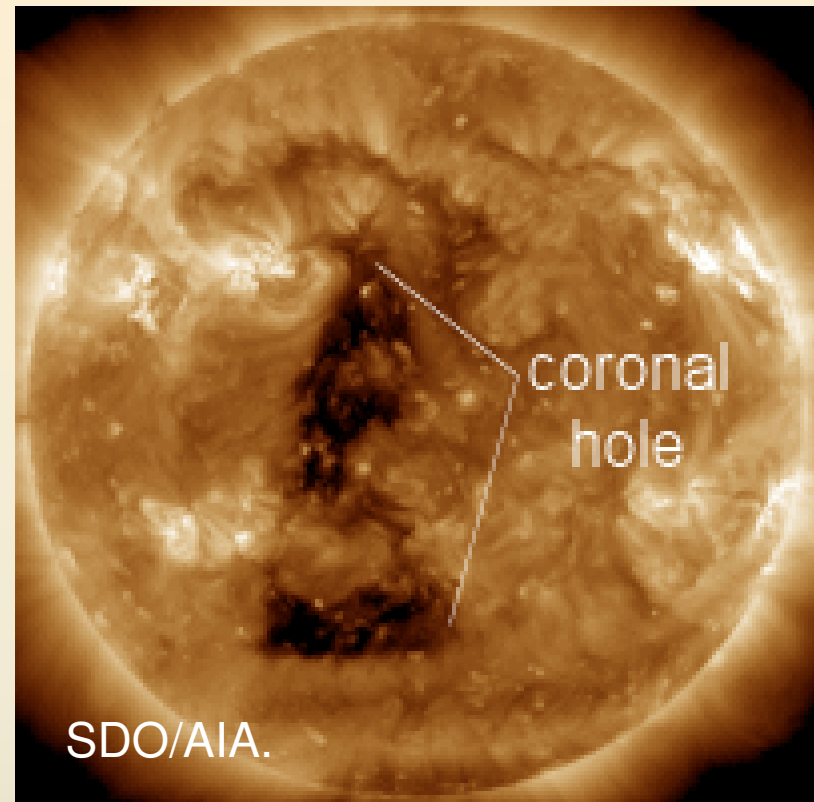


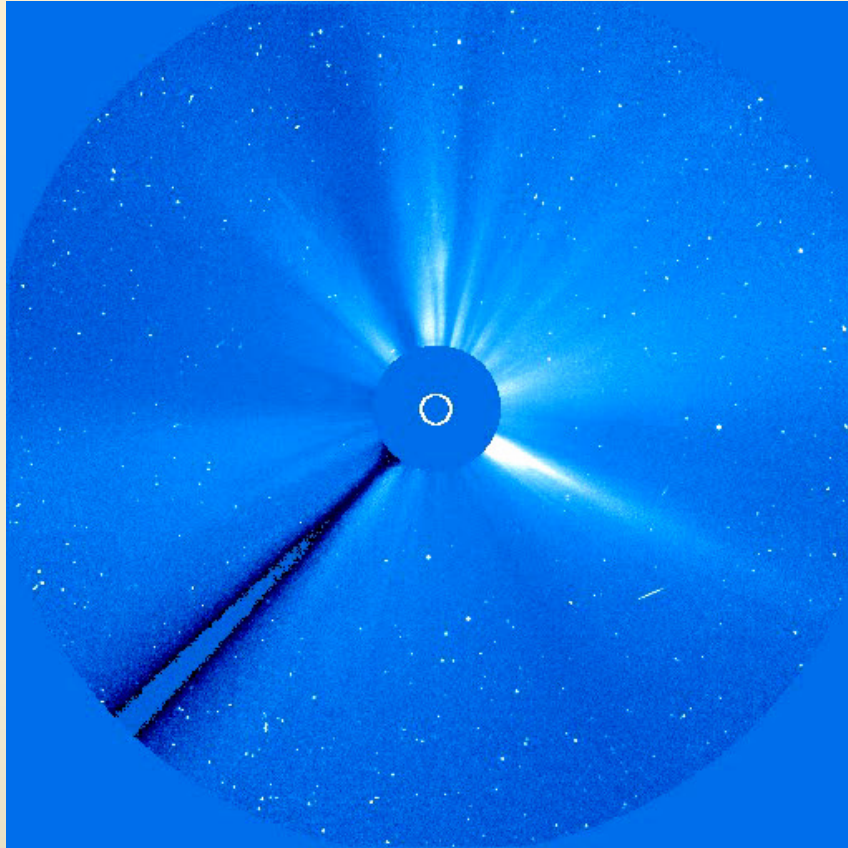
Y	M	D	3-h	V0	V1	VMax	Dur	ΔV1	ΔVM	Source	I
2012	3	12	3	408.7	716.3	716.3	2.9	307.7	307.7	CH, ICME	892.33
2012	3	15	2	463.3	781	781	5	317.7	317.7	CH, ICME	1588.5

8 March 2012



13 March 2012



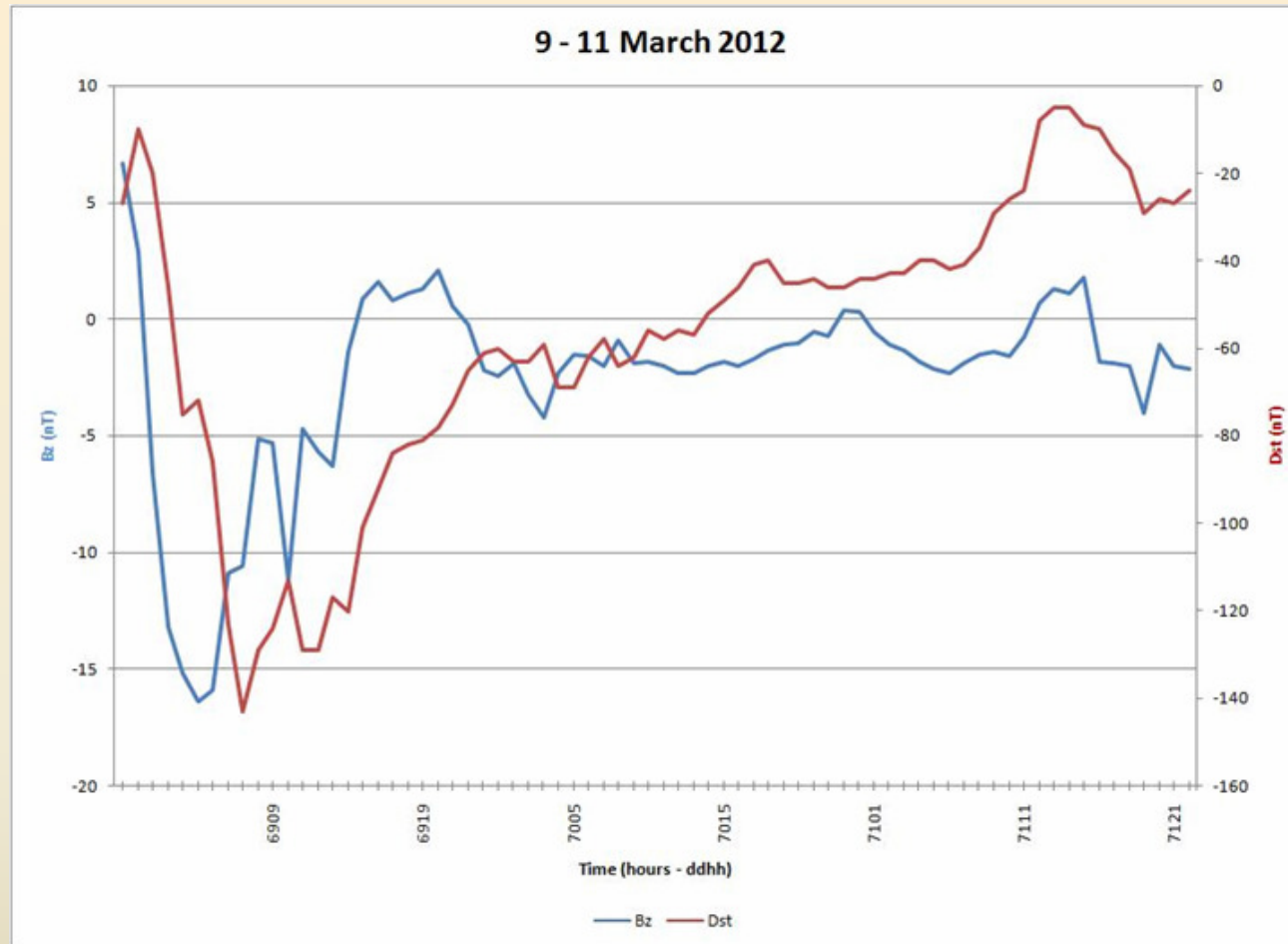


An ICME was recorded on March 9, 05:00 – March 11, 07:00 listed in the Richardson and Cane catalogue, correlated with a Halo CME from March 7, 00:24.

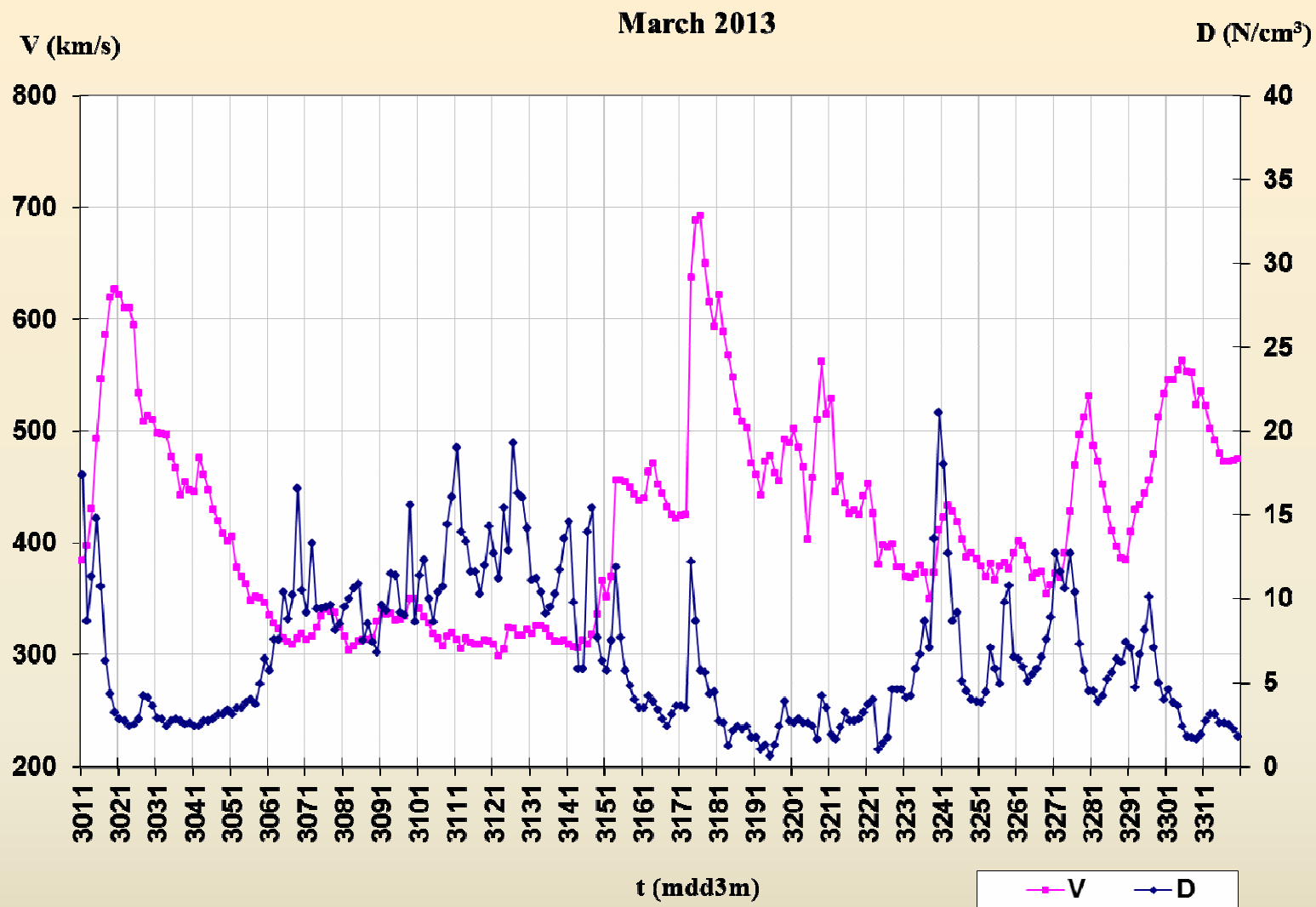
ICME shows evidence of a rotation in field direction, but lacks some other characteristics of a magnetic cloud.

V_m (ICME) = 550 km/s
 V_{max} = 890 km/s

Geomagnetic storm

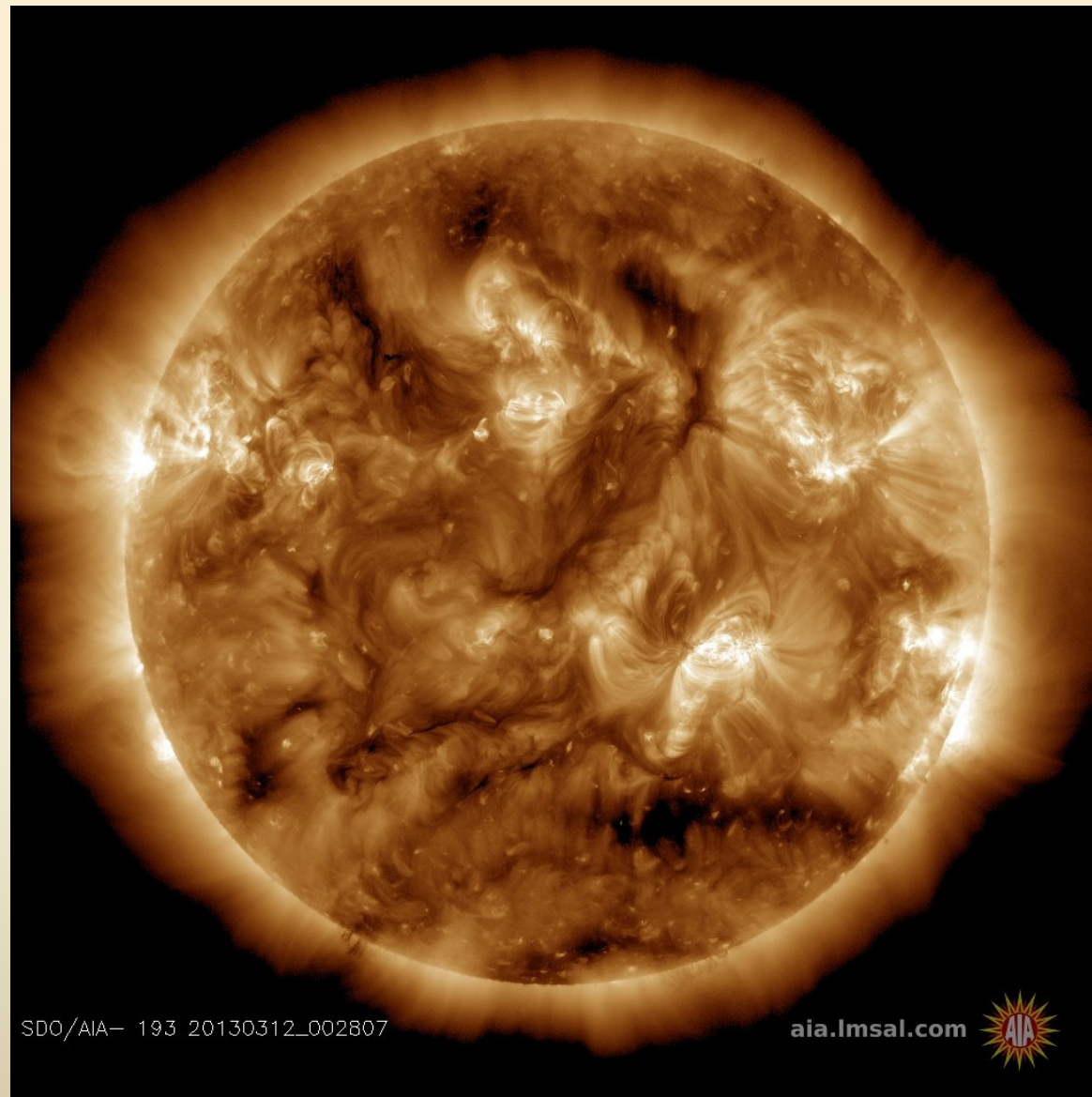


An intense geomagnetic storm with Sudden Commencement (minimum Dst = -131nT; provisional value) was registered on March 9, 2012.

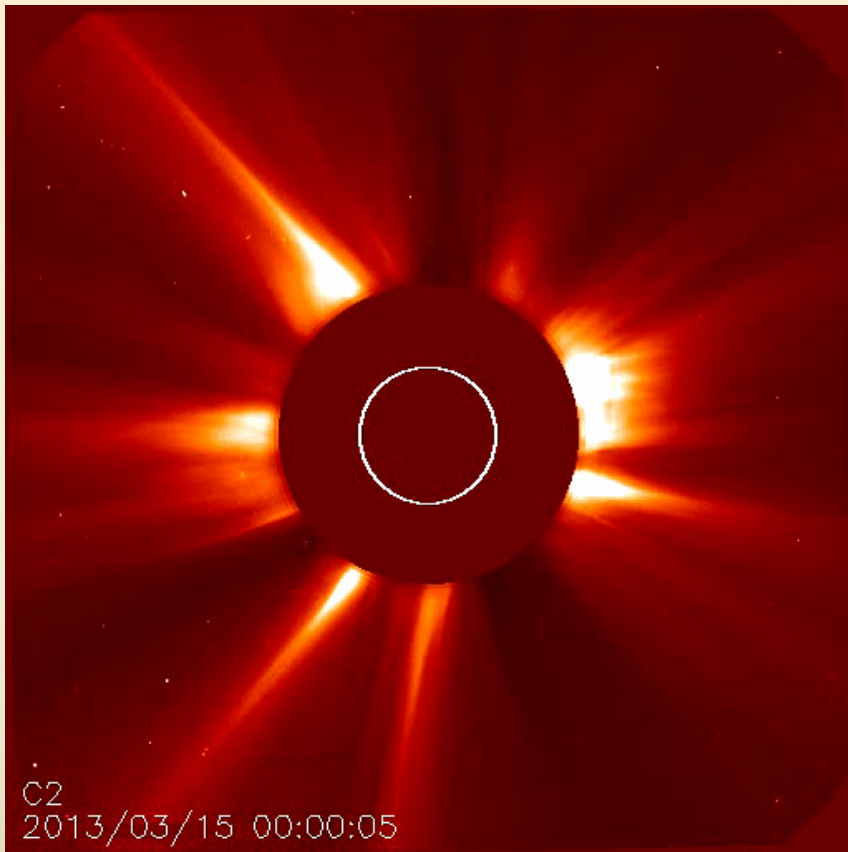


Y	M	D	3-h	V0	V1	VMax	Dur	DV1	DVM	Source	I
2013	3	14	3	306	456	693.3	11.7	150	387.3	CH,ICME	4531.41

12 March 2013



ICME; CME



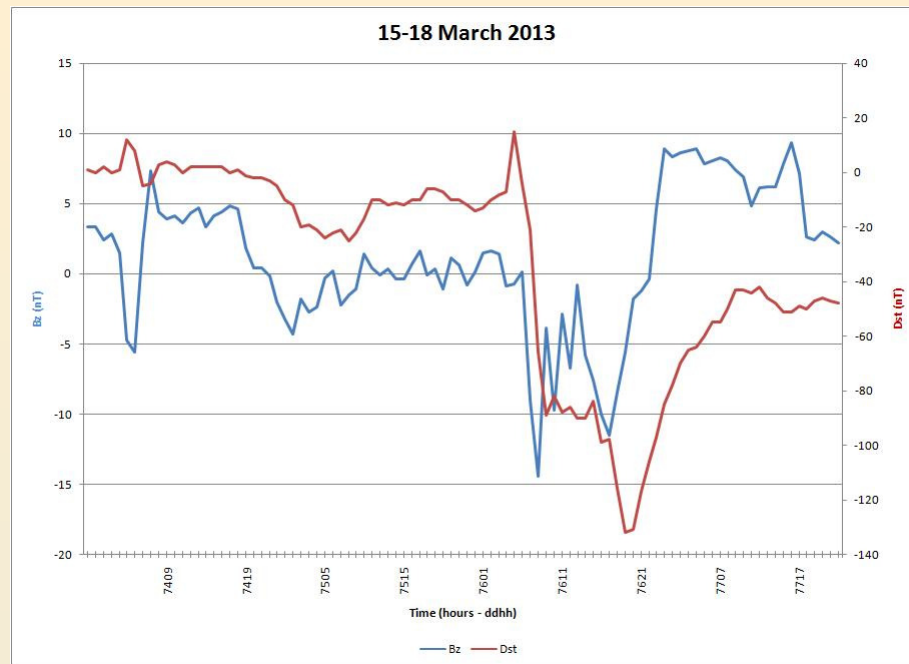
Two ICMEs were recorded:

- **March 17, 15:00 – 19, 17:00;**

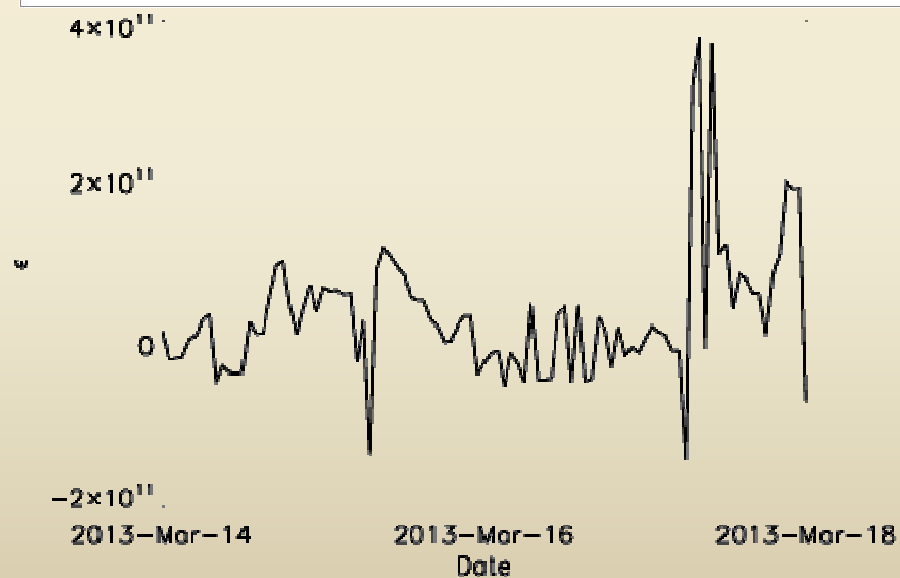
($V_m = 520$ km/s, $V_{Max} = 720$ km/s, a magnetic cloud reported), correlated with a Halo CME from March 15, 07:12.

- **March 20, 18:00-22:00**

($V_m = 520$ km/s, $V_{Max} = 640$ km/s, ICME shows evidence of a rotation in field direction, but lacks some other characteristics of a magnetic cloud)



March 17 : an intense geomagnetic storm with sudden commencement was registered (minimum Dst = -132)



Future work

- HSS and HSS_GS Catalogues for SC 24
 - Solar sources → CH, eruptive event (CME, F, SDF, AP);
 - Interplanetary magnetic field (B, Bz);
 - I and Ip dynamics;
 - Geomagnetic effects
- Energy transfer from SW to the terrestrial magnetosphere

Thank You
for Your kind attention !

HSS Catalogues – SC23 (1996 – 2008); SC24 (2009-2013)



HSS_Catalogue.html

COLUMN SIGNIFICATION:

- Columns 1–6: the start data of the streams by: **Y**–year; **M**–month; **D**–day (calendar data); **3-H**–3-hr interval of the start day; **BR**–Bartels Rotation; **D-BR** – day of Bartels Rotation, corresponding to the calendar day of the stream start;
- Column 7: **V0**–minimum (pre-stream) velocity;
- Column 8: **V1**–maximum velocity in the second day of the stream;
- Column 9: **dt1**–time interval between **V0** and **V1** (in number of 3-hr intervals);
- Column 10: **VMax**–maximum velocity of the stream;
- Column 11: **Dur** – duration of the stream, in days;
- Column 12: $\Delta V1 = V1 - V0$ –gradient of the velocity;
- Column 13: $\Delta VM = VMax - V0$ –maximum gradient of the plasma velocity;
- Column 14: **IMF**–the dominant polarity of the IMF for the duration of stream (+/– or –/+ means a magnetic sectorial border);
- Column 15: **Source** – solar source of the stream: **CH** –coronal hole; **F**– solar flares or other eruptive phenomena.

HSS Catalogue

Maris G. and Maris O., 2012, High speed streams in the solar wind during the 23rd solar cycle, in: Advances in Solar and Solar-Terrestrial Physics, Editors: Maris G. and Demetrescu, C, Chapter 7, Published by Research Signpost, T.C. 37/661(2), Fort P.O., Trivandrum-695 023, Kerala, India, ISBN [978-81-308-0483-5](#), pp. 97-134

www.space-science.ro/new1/HSS_Catalogue.html