

24

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(2018/ 12 / 3 2018/ 8 /2)

(Sunspots) (CMEs)
 24 () (TEC)
 (CAP) (110) .()
 (ERNE) (LASCO) (2009-2016) (360°) "HALO"
 (SOHO)
 () (TEC) .(Silso)
 .
 (IBM SPSS statistics 23.0)
 (TEC) (CMEs)
 .(TEC)
 :SSN :TEC :CMEs :
 :LASCO SOHO
 :ERNE (SOHO)
 .(SOHO)

A Study of Solar Activity Effect on the Total Electronic Content of Ionosphere above Iraq for the Solar Cycle 24

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ABSTRACT

In this study, the effect of the CMEs and the sunspots on the parameter TEC of the ionospheric layer for the earth atmosphere has been achieved for solar cycle 24 (Rising phase, peak and part of the down phase). 110 solar events of halo type with CAP 360° were analyzed for the years (2009-2016), data were extracted from LASCO system and ERNE system on board SOHO, while the SSN related to some cycle 24 were extracted from (Silso). The values of TEC parameters

of ionosphere above Iraq were calculated through the mathematical method of dependent equations. All of these parameters were statistically analyzed using the statistical program (SPSS statistics 23.0 IBM), and according to the statistical results for this study, it has been found that there is a weak relation between the energy and the velocity of CMEs with TEC, while there was a strong relation between the SSN and the TEC of the ionosphere layer.

Keywords: CMEs: Coronal mass ejections, TEC: Total electron content, SSN: Sunspots number, SOHO: Solar heliospheric observation, LASCO: Large angle spectroscopic coronagraph, ERNE: Energetic and relativistic nuclei.

(Solar flare) (Solar wind) (CMEs) " "(SEPs)

(Filaments) (Floculi) (Faculae) (Sunspots)

.(Jenkins, 2013) " (Prominences)

(LASCO) (CME)

360° (Savani and Rouillard, 2009) " (SOHO)

.(Maloney, 2012) (360°) " "

(Stephen *et al.*, 2007)

(1500 K°)

.(Phillips, 1995)

(Ionosphere) " "

(60 Km)

(TEC) (Lagzi, 2014)

" ()

(1m²)

)

(Ionosphere) (

(Normal E-layer) E D "

.(Budden, 2009) "F1 , F2 F (Sporadic E-layer) ES

(Hadi and Aziz, 2013)

(Mardan and Hadi, 2018)

IRI

(TEC)

(Khudur and Hadi, 2015)

.IRI

24

(2011-2012-2013)

(CMEs)

(TEC)

(SSN)

()

(TEC)

(LASCO)

-1

(LASCO)

C1:1.1–3 R_{\odot} , C2: 1.5–6 R_{\odot} ,)

C3

C2

C1

.(Brueckner, 1995)

R_{\odot}

(C3: 3.7–30 R_{\odot})

(LASCO)

(

) 24

(2009-2016)

(CAP=360°)

(Halo)

24

(CMEs)

CAP (The central position angle)

(C2,C3)

(CMEs)

.(1)

(CMEs)

SOHO/LASCO

:1

2014

First C2 Appearance Date Time [UT]	Central PA [deg]	Angular Width [deg]	Linear Speed [km/s]	2nd-order Speed at final height [km/s]	2nd-order Speed at 20 Rs [km/s]	Accel [m/s ²]	Mass [gram]	Kinetic Energy [erg]	MPA [deg]	Movies, plots, & links	Remarks
2014.01.01 00:12:05	3	29	145	166	322	3.6 ⁺¹	1.7e+14	1.8e+28	1	C2 C3 195 PHTX DST Java Movie	Only C2
2014.01.01 00:36:05	90	48	638	661	669	0.7 ⁺¹	1.7e+14	3.6e+29	97	C2 C3 195 PHTX DST Java Movie	Poor Event
2014.01.01 02:24:05	255	65	283	421	752	22.5 ⁺¹	1.0e+14	4.0e+28	263	C2 C3 195 PHTX DST Java Movie	Poor Event
2014.01.01 02:48:07	71	9	493	471	123	-10.2 ⁺¹	----	----	70	C2 C3 195 PHTX DST Java Movie	Poor Event; Only C2
2014.01.01 05:12:05	67	11	709	708	701	-0.6 ⁺¹	----	----	66	C2 C3 195 PHTX DST Java Movie	
2014.01.01 06:36:05	32	23	233	270	486	8.1 ⁺¹	1.5e+14	4.0e+28	33	C2 C3 195 PHTX DST Java Movie	Poor Event; Only C2
2014.01.01 08:00:05	291	185	465	543	939	30.3 ⁺¹	5.3e+14 ⁺²	5.7e+29 ⁺²	288	C2 C3 195 PHTX DST Java Movie	Poor Event; Only C2; Partial Halo
2014.01.01 12:12:05	267	17	170	225	386	5.9 ⁺¹	----	----	263	C2 C3 195 PHTX DST Java Movie	Poor Event
2014.01.01 14:00:06	148	162	497	820	705	18.8	5.2e+15 ⁺²	6.4e+30 ⁺²	157	C2 C3 195 PHTX DST Java Movie	Partial Halo
2014.01.01 19:48:06	245	113	326	352	390	2.6	1.3e+15	7.0e+29	271	C2 C3 195 PHTX DST Java Movie	
2014.01.02 00:24:05	209	27	256	266	345	2.5 ⁺¹	3.0e+14	9.7e+28	210	C2 C3 195 PHTX DST Java Movie	Poor Event; Only C2

https://cdaw.gsfc.nasa.gov/CME_list/UNIVERSAL/2014_01/univ_2014_01.html

(ERNE)

-2

(ERNE)

(1.3-110 MeV)

(intensity-Time profile)

(Torsti *et al.*, 1995)

(ERNE)

(2)

() (TEC)

(1.68-108 MeV)

(SOHO/LASCO)

(2009-2016)

(SOHO/ERNE)

.ERNE

-1

()

ERNE

-2

(SOHO/ERNE)

(SOHO/LASCO)

-3

(SOHO/LASCO)

-4

(110)

(3)

(2009-2016)

(1/ January/ 2016) (22/ May/ 2013) (22/ December/ 2009)

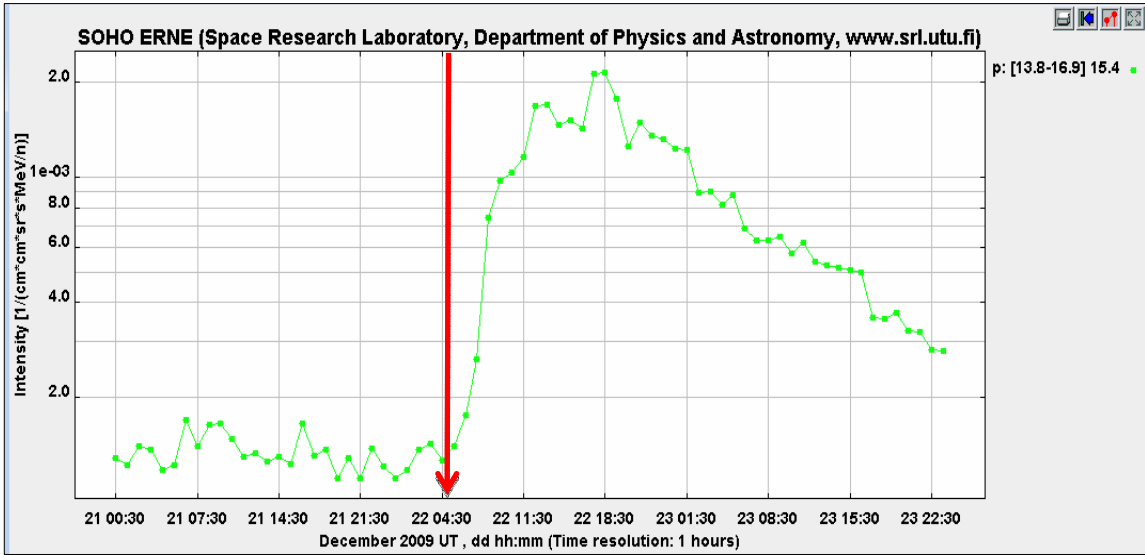
(6) (5) (4)

<table border="1"> <tr> <th>YEAR</th> <th>MONTH</th> <th>DAY</th> <th>HOUR</th> <th>MINUTE</th> <th>SECOND</th> </tr> <tr> <td>2009</td> <td>05</td> <td>01</td> <td>00</td> <td>00</td> <td>00</td> </tr> <tr> <td>2009</td> <td>05</td> <td>03</td> <td>23</td> <td>59</td> <td>59</td> </tr> </table>						YEAR	MONTH	DAY	HOUR	MINUTE	SECOND	2009	05	01	00	00	00	2009	05	03	23	59	59	<p>HELP</p> <p>Isotopes:</p> <p><input checked="" type="checkbox"/> Proton</p> <p><input type="checkbox"/> He-4</p>
YEAR	MONTH	DAY	HOUR	MINUTE	SECOND																			
2009	05	01	00	00	00																			
2009	05	03	23	59	59																			
Resolution: 00 01 00 00																								
<p>New channel</p> <p><input checked="" type="checkbox"/> Channel 0: 3 4 [1.58 - 1.78] 1.68</p> <p><input checked="" type="checkbox"/> Channel 1: 5 7 [1.78 - 2.16] 1.97</p> <p><input checked="" type="checkbox"/> Channel 2: 8 10 [2.16 - 2.66] 2.41</p> <p><input checked="" type="checkbox"/> Channel 3: 11 13 [2.66 - 3.29] 2.98</p> <p><input checked="" type="checkbox"/> Channel 4: 14 16 [3.29 - 4.10] 3.70</p> <p><input checked="" type="checkbox"/> Channel 5: 17 19 [4.10 - 5.12] 4.71</p> <p><input checked="" type="checkbox"/> Channel 6: 20 22 [5.12 - 6.42] 5.72</p>		<p>info screen Available proton channels</p> <table border="1"> <tr> <th>DESCRIPTION</th> <th>PROTON CHANNELS</th> <th>HELIUM-4 CHANNELS</th> </tr> <tr> <td>Channel 0: range: [1.33 - 1.41] nominal: 1.37 MeV/n (LED)</td> <td></td> <td></td> </tr> <tr> <td>Channel 1: range: [1.41 - 1.49] nominal: 1.45 MeV/n (LED)</td> <td></td> <td></td> </tr> <tr> <td>Channel 2: range: [1.49 - 1.58] nominal: 1.53 MeV/n (LED)</td> <td></td> <td></td> </tr> <tr> <td>Channel 3: range: [1.58 - 1.67] nominal: 1.62 MeV/n (LED)</td> <td></td> <td></td> </tr> <tr> <td>Channel 4: range: [1.67 - 1.78] nominal: 1.73 MeV/n (LED)</td> <td></td> <td></td> </tr> </table>				DESCRIPTION	PROTON CHANNELS	HELIUM-4 CHANNELS	Channel 0: range: [1.33 - 1.41] nominal: 1.37 MeV/n (LED)			Channel 1: range: [1.41 - 1.49] nominal: 1.45 MeV/n (LED)			Channel 2: range: [1.49 - 1.58] nominal: 1.53 MeV/n (LED)			Channel 3: range: [1.58 - 1.67] nominal: 1.62 MeV/n (LED)			Channel 4: range: [1.67 - 1.78] nominal: 1.73 MeV/n (LED)			
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<p>Channel options:</p> <p><input type="radio"/> Custom channels</p> <p><input checked="" type="radio"/> EXPORT channels</p> <p><input type="radio"/> Carrington-rotation channels</p> <p><input type="checkbox"/> Clear</p>		<p>SUBMIT REQUEST STOP datasearch Datasearch limitcounter: 0.98848</p>																						

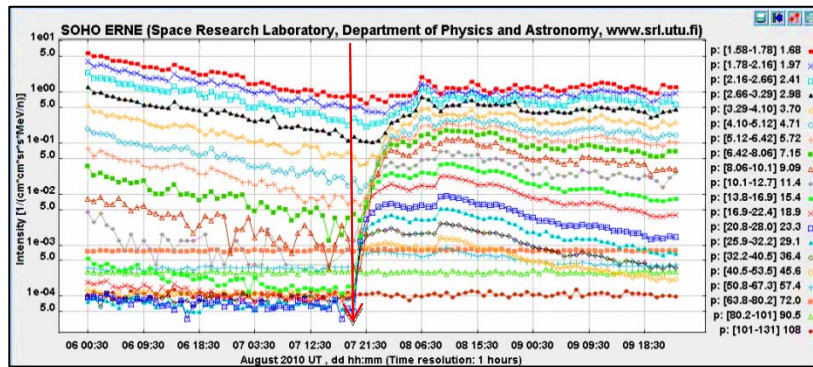
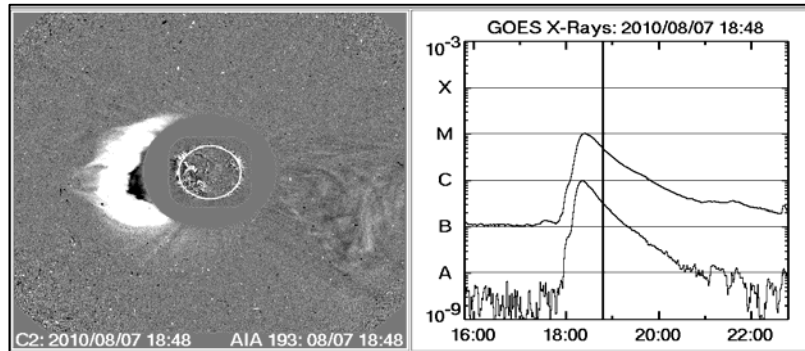
(SOHO/ERNE) ایرنا

:2

(https://srl.utu.fi/erne_data/datafinder/df.shtml)

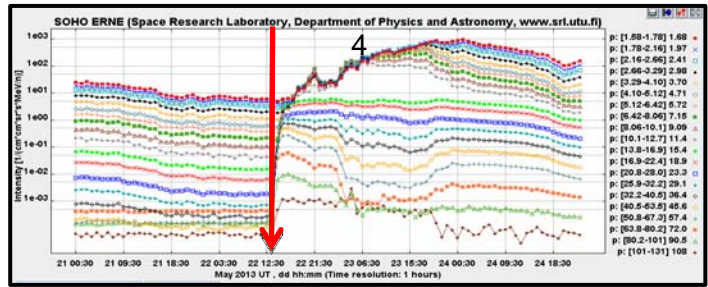
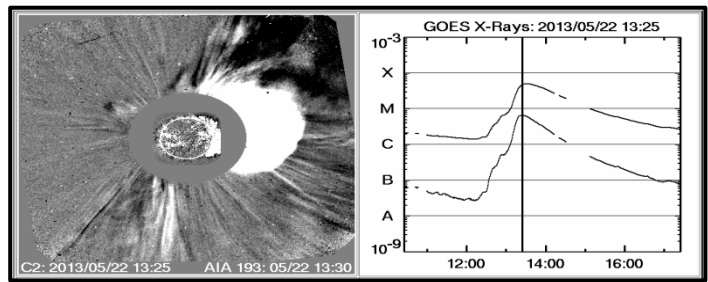


15.4 Mev (22 December 2009) :3
 (SOHO/ERNE) LED



(22 December 2009) () :4
 (CMEs) (SOHO/ERNE)
 (SOHO/LASCO) (C2)

(https://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?stime=20100807_1706&etime=20100807_2126&img)



(22 May 2013) () :5

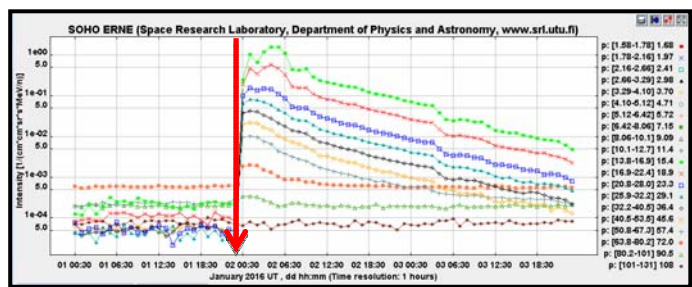
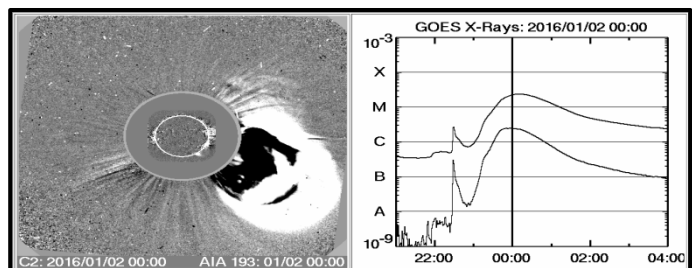
(CMEs)

(SOHO/ERNE)

(SOHO/LASCO)

(C2)

[https://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?stime=20130522_1202_ & img1=lasc2rdf & title\) _etime=2_0130522_1550](https://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?stime=20130522_1202_&img1=lasc2rdf&title_etime=2_0130522_1550)



(1 January 2016) () :6

(CMEs)

(SOHO/ERNE)

.(SOHO/LASCO)

(C2)

(https://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?stime=20160101_2222&etime=20160102_0202&img1=lasc2rdf&title)

.....

(TEC)

-3

Breed and Godwin,)

(SSN)

(TEC)

:(1997

$$TEC = A + B * SSN$$

..... (1)

:(1)

B A

SSN

Hill Sagamore

(1)

B A

:1

(Breed and Goodwin, 1997)

Season	A	B
Summer	7-12	0.1-0.15
Autumn	10-15	0.2-0.25
Winter	5-10	0.25-0.3
Spring	5-10	0.25-0.3

(Sagamore Hill) B A

(37°-29°)

(Sagamore Hill)

(SSN)

(Fahmi, 2004) 2004

(TEC)

(Silso)

(SOHO/ERNE)

(SOHO/LASCO)

(110)

(2-2) (2-1)

(2009-2016)

24

(Halo)

(2-3)

.(CAP=360°)

(SSN)

(TEC)

:2-1

No	D/M/Y	LASCO Time	ERNE Time	Energy (Mev)	Speed (Km/s)	SSN	TEC (10 ¹⁶ e/m ²)
1	07/02/2010	03:54:03	03:30	18.9	421	38	17.95
2	12/02/2010	13:42:04	13:30	18.9	509	41	18.775
3	03/04/2010	10:33:58	10:30	1.97	668	24	14.1
4	23/05/2010	18:06:05	18:30	3.7	258	22	13.55
5	01/08/2010	13:42:05	14:30	1.68	850	24	12.5
6	07/08/2010	18:36:06	18:30	36.4	871	48	15.5
7	14/08/2010	10:12:05	09:30	72	1205	33	13.625
8	31/08/2010	21:17:21	21:30	23.3	1304	30	13.25
9	15/02/2011	02:24:05	02:30	45.6	669	83	30.325

(SSN)

(TEC)

:2-2

No	D/M/Y	LASCO Time	ERNE Time	Energy (Mev)	Speed (Km/s)	SSN	TEC ($10^{16}e/m^2$)
10	07/03/2011	20:00:05	20:30	57.4	2125	138	45.45
11	21/03/2011	02:24:05	02:30	36.4	1341	24	14.1
12	04/06/2011	22:05:02	22:30	1.68	2425	115	39.125
13	07/06/2011	06:49:12	06:30	45.6	1255	58	23.45
14	07/06/2011	19:16:26	18:30	2.98	738	58	23.45
15	03/08/2011	14:00:07	14:30	29.1	610	81	19.625
16	04/08/2011	04:12:05	04:30	29.1	1315	92	21
17	09/08/2011	08:12:06	08:30	11.4	1610	61	17.125
18	06/09/2011	02:24:05	02:30	9.09	782	89	20.625
19	06/09/2011	23:05:57	23:30	23.3	575	89	20.625
20	22/10/2011	10:24:05	10:30	29.1	1005	174	51.65
21	03/11/2011	23:30:05	23:30	15.4	991	125	40.625
22	04/11/2011	01:25:29	01:30	7.15	756	99	34.775
23	26/11/2011	07:12:06	07:30	36.4	933	131	41.975
24	16/01/2012	03:12:10	03:30	5.72	1060	154	49.85
25	19/01/2012	14:36:05	14:30	29.1	1120	105	36.375
26	27/01/2012	18:27:52	18:30	36.4	2508	65	25.375
27	23/02/2012	08:12:06	07:30	2.41	505	55	22.625
28	29/02/2012	09:12:08	09:30	23.3	466	20	13
29	04/03/2012	11:00:07	10:30	1.97	1306	86	31.15
30	05/03/2012	04:00:05	04:30	57.4	1531	108	37.2
31	07/03/2012	01:30:24	01:30	72	1825	106	36.65
32	09/03/2012	04:26:09	04:30	72	950	110	37.75
33	13/03/2012	17:36:05	17:30	23.3	1884	96	33.9
34	28/03/2012	01:36:07	01:30	2.41	1033	88	31.7
35	05/04/2012	21:25:07	21:30	11.4	828	53	22.075
36	07/04/2012	21:15:59	21:30	36.4	708	30	15.75
37	09/04/2012	12:36:07	12:30	23.3	921	14	11.35
38	23/04/2012	18:24:05	18:30	15.4	528	138	45.45
39	27/04/2012	16:24:06	16:30	15.4	681	106	36.65
40	17/05/2012	01:48:05	01:30	23.3	1582	110	37.75
41	26/05/2012	20:57:28	21:30	5.72	1966	80	29.5
42	14/06/2012	14:12:07	14:30	23.3	987	123	41.325
43	06/07/2012	23:24:06	23:30	57.4	1828	132	26
44	12/07/2012	16:48:05	17:30	7.15	885	125	25.125
45	19/07/2012	05:24:05	05:30	57.4	1631	38	14.25
46	28/07/2012	21:12:08	21:30	3.7	420	107	22.875
47	04/08/2012	13:36:23	13:30	11.4	856	152	28.5
48	19/08/2012	18:36:05	18:30	29.1	612	72	18.5
49	25/08/2012	16:36:05	16:30	1.68	636	77	19.125
50	02/09/2012	04:00:06	04:30	23.3	538	142	27.25
51	08/09/2012	10:00:06	10:30	29.1	734	82	19.75
52	21/09/2012	06:24:05	06:30	18.9	639	84	20
53	14/10/2012	00:48:05	00:30	23.3	987	95	33.875
54	20/11/2012	12:00:07	12:30	23.3	619	105	36.125
55	21/11/2012	16:00:05	15:30	23.3	529	106	36.35
56	27/11/2012	02:36:05	02:30	2.41	844	77	29.825
57	02/12/2012	16:36:05	16:30	29.1	678	47	23.075
58	26/02/2013	09:12:08	09:30	36.4	987	53	22.075
59	05/03/2013	03:48:05	03:30	15.4	1316	83	30.325

.....

(SSN)

(TEC)

:2-3

No	D/M/Y	LASCO Time	ERNE Time	Energy (MeV)	Speed (Km/s)	SSN	TEC ($10^{16}e/m^2$)
60	15/03/2013	07:12:05	07:30	36.4	1063	111	38.025
61	11/04/2013	07:24:06	07:30	57.3	861	126	42.15
62	21/04/2013	07:24:07	07:30	45.6	919	93	33.075
63	24/04/2013	22:12:06	22:30	23.3	594	98	34.45
64	13/05/2013	16:07:55	15:30	23.3	1850	153	49.575
65	15/05/2013	01:48:05	02:30	1.79	1366	173	55.075
66	22/05/2013	13:25:50	13:30	11.4	1466	131	43.525
67	17/08/2013	19:12:06	19:30	15.4	1202	100	22
68	19/08/2013	23:12:11	23:30	36.4	877	134	26.25
69	20/08/2013	08:12:05	08:30	15.4	784	129	25.625
70	30/08/2013	02:48:05	02:30	5.72	949	71	18.375
71	22/10/2013	21:48:06	22:30	9.09	459	118	39.05
72	25/10/2013	08:12:05	07:30	57.4	587	138	43.55
73	07/12/2013	07:36:05	07:30	18.9	1085	89	32.525
74	26/12/2013	03:24:05	03:30	29.1	1336	103	35.825
75	28/12/2013	17:36:06	17:30	15.4	1118	100	35
76	04/01/2014	21:22:38	21:30	45.6	977	136	44.9
77	06/01/2014	08:00:05	08:30	15.4	1402	167	53.425
78	07/01/2014	18:24:05	18:30	45.6	1830	140	46
79	12/02/2014	06:00:05	06:30	36.4	373	161	51.775
80	14/02/2014	08:48:26	08:30	23.3	1165	130	43.25
81	18/02/2014	01:36:21	02:30	36.4	779	127	42.425
82	20/02/2014	08:00:07	07:30	72	948	133	44.075
83	25/02/2014	01:25:50	01:30	29.1	2147	171	54.525
84	29/03/2014	18:12:05	18:30	29.1	528	118	39.95
85	18/04/2014	13:25:51	13:30	15.4	1203	178	56.45
86	07/05/2014	16:24:05	16:30	9.09	923	120	40.5
87	09/05/2014	02:48:05	02:30	29.1	1099	139	45.725
88	05/06/2014	11:36:05	11:30	4.71	266	87	31.425
89	17/06/2014	09:12:09	09:30	36.4	1198	95	33.625
90	08/07/2014	16:36:05	16:30	18.9	773	183	32.375
91	22/08/2014	11:12:05	11:30	18.9	600	125	25.125
92	25/08/2014	15:36:05	15:30	57.4	555	116	24
93	10/09/2014	18:00:05	18:30	72	1267	169	30.625
94	22/09/2014	08:48:06	08:30	5.72	761	101	22.125
95	24/09/2014	21:30:06	21:30	57.7	1350	108	36.8
96	21/12/2014	12:12:05	12:30	29.1	669	137	43.325
97	21/02/2015	09:24:07	09:30	45.6	1120	58	23.45
98	10/03/2015	00:00:05	23:30	18.9	995	27	14.925
99	15/03/2015	01:48:05	01:30	29.1	719	53	22.075
100	04/05/2015	03:12:10	02:30	1.68	1014	103	35.825
101	25/06/2015	08:36:05	08:30	23.3	1627	27	12.875
102	01/07/2015	14:36:04	14:30	45.6	1435	54	16.25
103	20/09/2015	18:12:04	18:30	23.3	1239	65	17.625
104	22/10/2015	03:12:07	03:30	23.3	817	107	36.575
105	04/11/2015	14:48:04	14:30	36.4	578	100	35
106	16/12/2015	09:36:04	09:30	15.4	579	63	26.675
107	28/12/2015	12:12:05	12:30	23.3	1212	71	27.025
108	01/01/2016	23:24:04	23:30	18.9	1730	37	17.675
109	11/02/2016	21:17:32	21:30	29.1	719	85	30.875
110	21/02/2016	12:00:04	11:30	15.4	533	47	20.425

(Windows)

(IBM SPSS statistics 23.0)

(Pearson's correlation coefficient)

(Bivariate Correlations)

.(George and Mallery, 2016) (Linear Regression)

(TEC)

(CMEs)

-1

(CMEs)

(7)

(3) (R=0.106)

(TEC)

(Y=28.67+0.07*X) :

(R²=0.011)

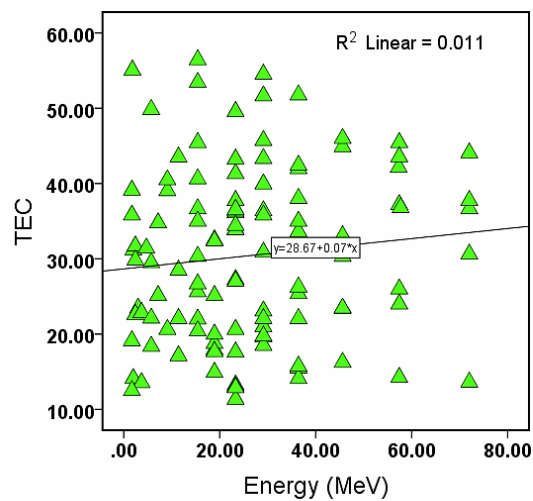
.(Y=TEC,X=CMEs)

. "X" (CMEs)

"Y" (TEC)

:3

X	Y		
0.106	1	Pearson correlations	Y
0.268		Sig.(2-tailed)	
110	110	N	
1	0.106	Pearson correlations	X
	0.268	Sig.(2-tailed)	
110	110	N	



(CMEs)

(TEC)

:7

(TEC)

(CMEs)

-2

(R=0.192)

(R²=0.037)

(TEC)

(CMEs)

(8)

(4)

X

(Y=25.56+4.77E-3*X)

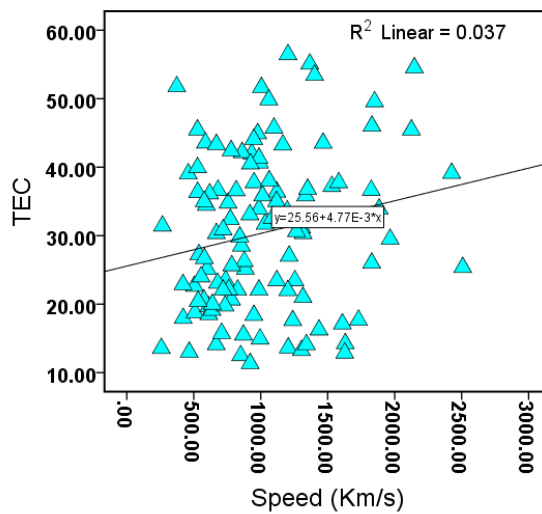
(Y=TEC, X=speed)

"X" (CMEs)

"Y" (TEC)

:4

X	Y		
0.192	1	Pearson correlations	Y
0.044		Sig.(2-tailed)	
110	110	N	
1	0.192	Pearson correlations	X
	0.044	Sig.(2-tailed)	
110	110	N	



(CMEs)

(TEC)

:8

(TEC)

(SSN)

-3

()

(9)

(9)

(5)

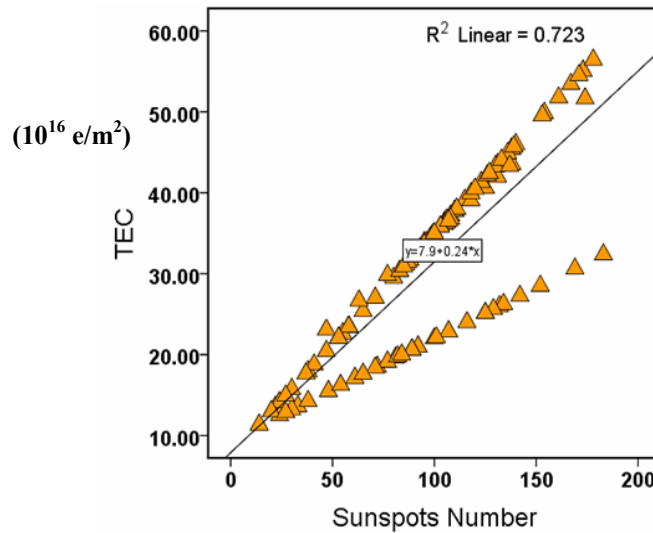
(R=0.85)

(R²=0.723)

($Y=7.9+0.24*X$) : () (TEC)
 . (7.9) (Y=TEC , X=Sunspot number)

."X" (SSN) "Y" (TEC) :5

X	Y		
0.85	1	Pearson correlations	Y
0.0		Sig.(2-tailed)	
110	110	N	
1	0.85	Pearson correlations	X
	0.0	Sig.(2-tailed)	
110	110	N	



(SSN) (TEC) :9

(CMEs) -1

(TEC)

(CMEs) -2

(TEC)

(SSN) () -3

(TEC) (TEC)

(Khudur and Hadi, 2015)

(SSN)

(IRI)

(TEC)

(D)

(TEC)

()

(TEC)

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