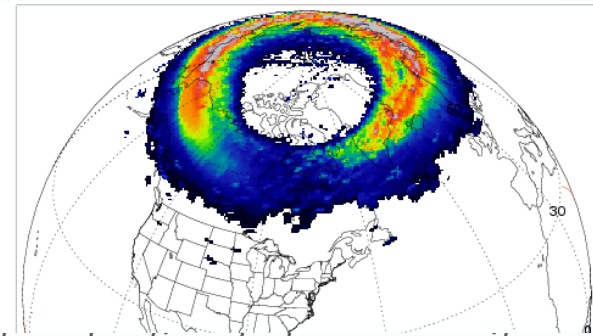


Auroral Model V&V

Past, now and future



- *Validation metrics and methods have been discussed, vetted and refined at community meetings since summer, 2010*
- Validation work has been performed over several Auroral models (Ovation Prime, Old Hardy, New Hardy, SWMF-Fok Ring current, Weimer Model, AMIE) --Lt. Col. Cory Lane, Yihua Zheng et al. (to be submitted to Space Weather)
- *Explored the relationship of auroral precipitation with Joule heating or Ponyting flux*
- Extensive/further validation work is to be performed by working with experts in the community (Dr. Zhang, Dr. Newell JUH/APL, Cheryl Huang AFRL, Dr. J. Minow, MSFC and many others) by utilizing imaging data from DMSP/SSUSI and TIMED/GUVI, and other unconventional data sources
- Auroral validation work is incorporated in other community-wide magnetosphere, ionosphere-thermosphere and its coupling model validation efforts
 - Drag model validation
 - SW driver swap project
 - Utilizing data from ISS for auroral charging study
 - and more...

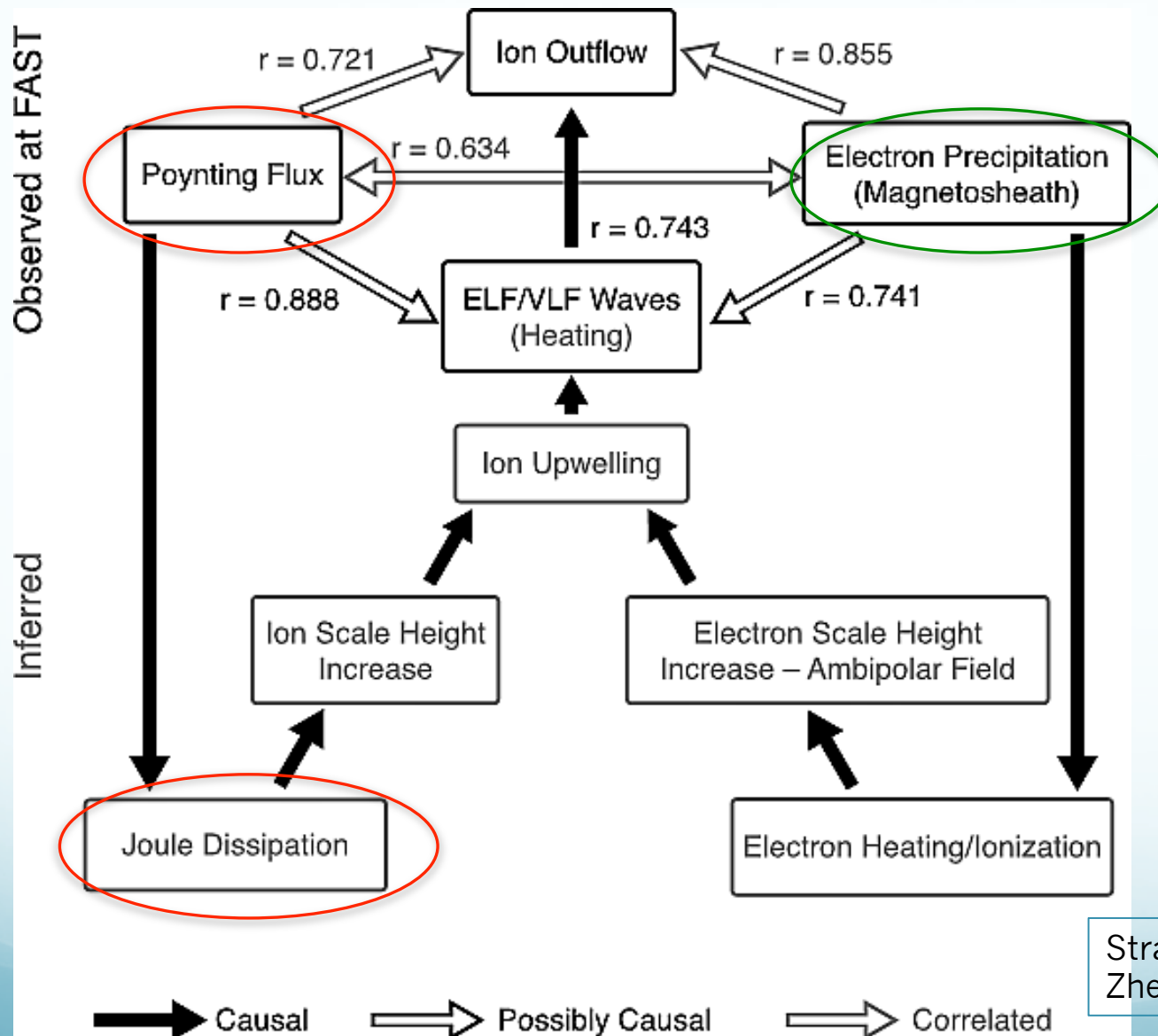
Why Poynting Flux/Joule Heating

- Important physical process/quantity for magnetospheric/ionospheric dynamics. Poynting flux: not the sole cause for ion outflow, but the necessary first step
- May serve as a **proxy** for auroral precipitation, especially useful for models that cannot describe precipitation well

Note: Poynting flux v.s. Joule Heating

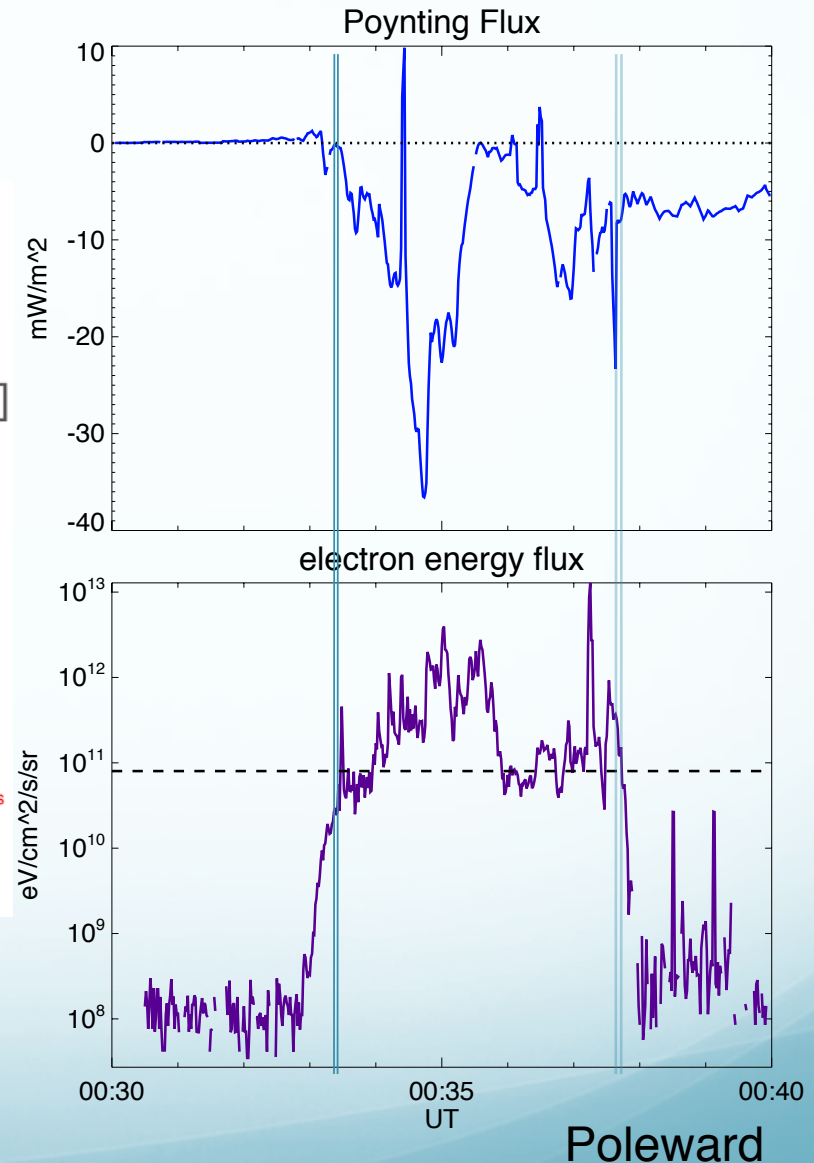
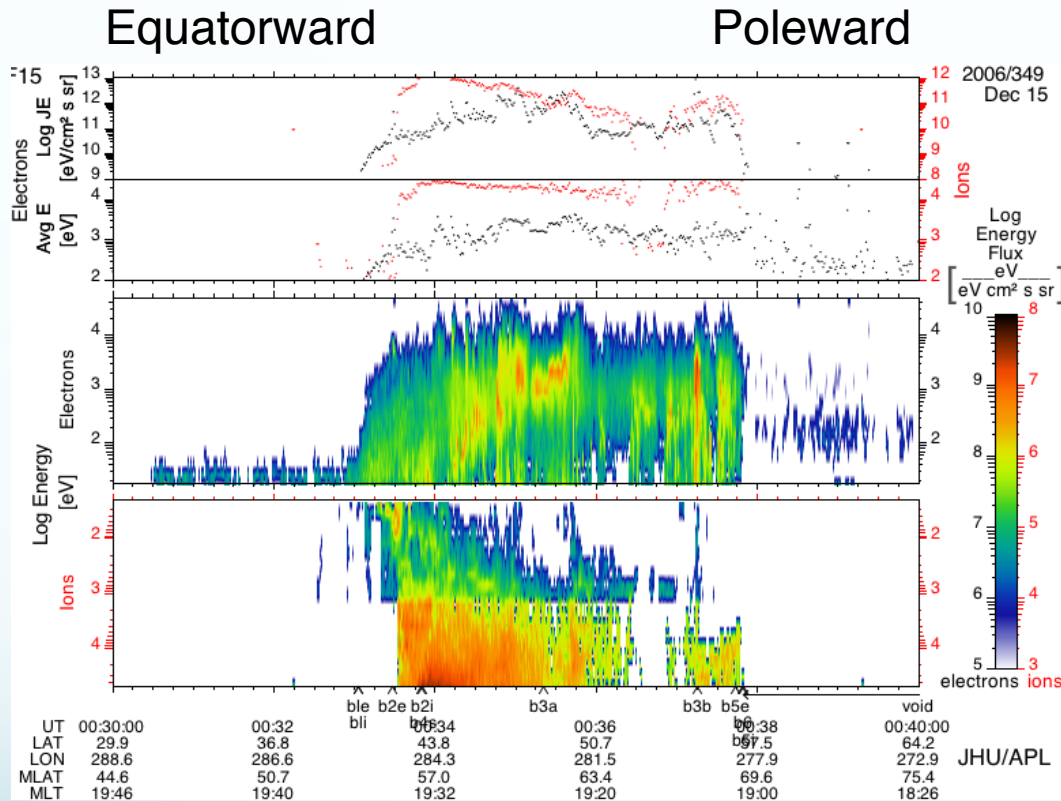
- ✓ Poynting flux: input of electromagnetic energy into the ionosphere
- ✓ Mainly dissipated as heat (Joule Heating) in the ionosphere

Why Poynting Flux/Joule Heating



Strangeway et al., 2005
Zheng et al., 2005

Poynting Flux vs Aurora Precipitation

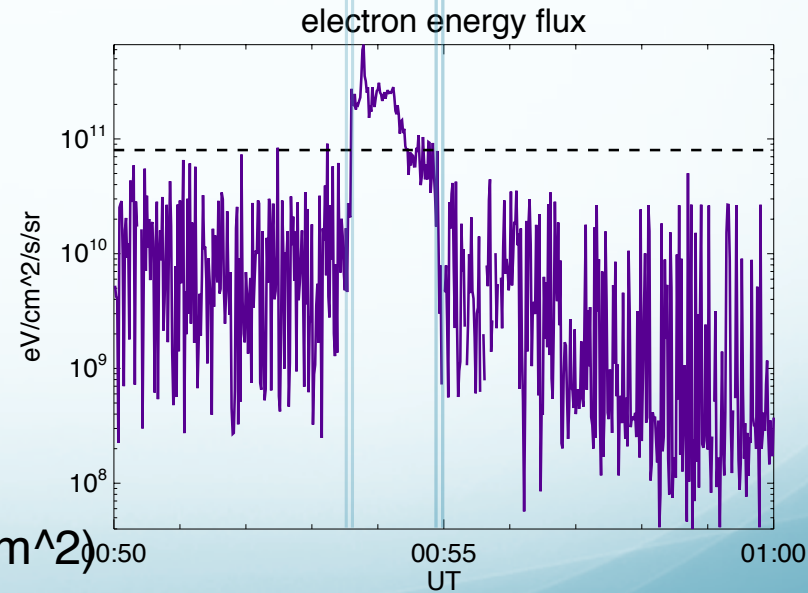
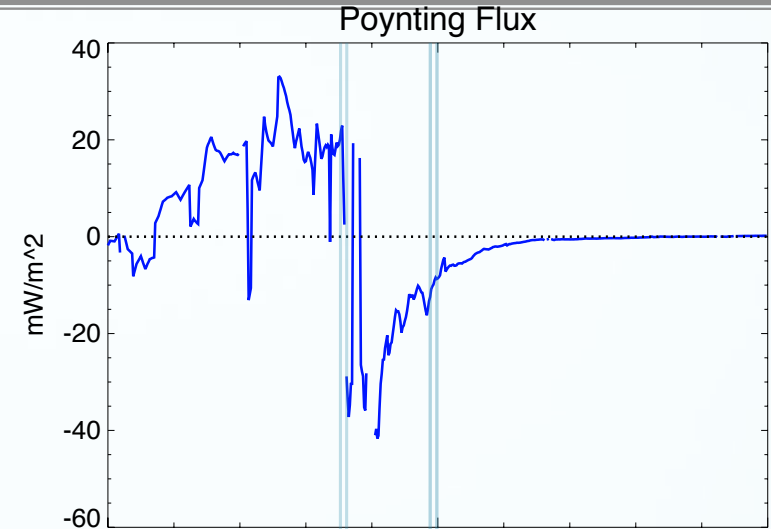
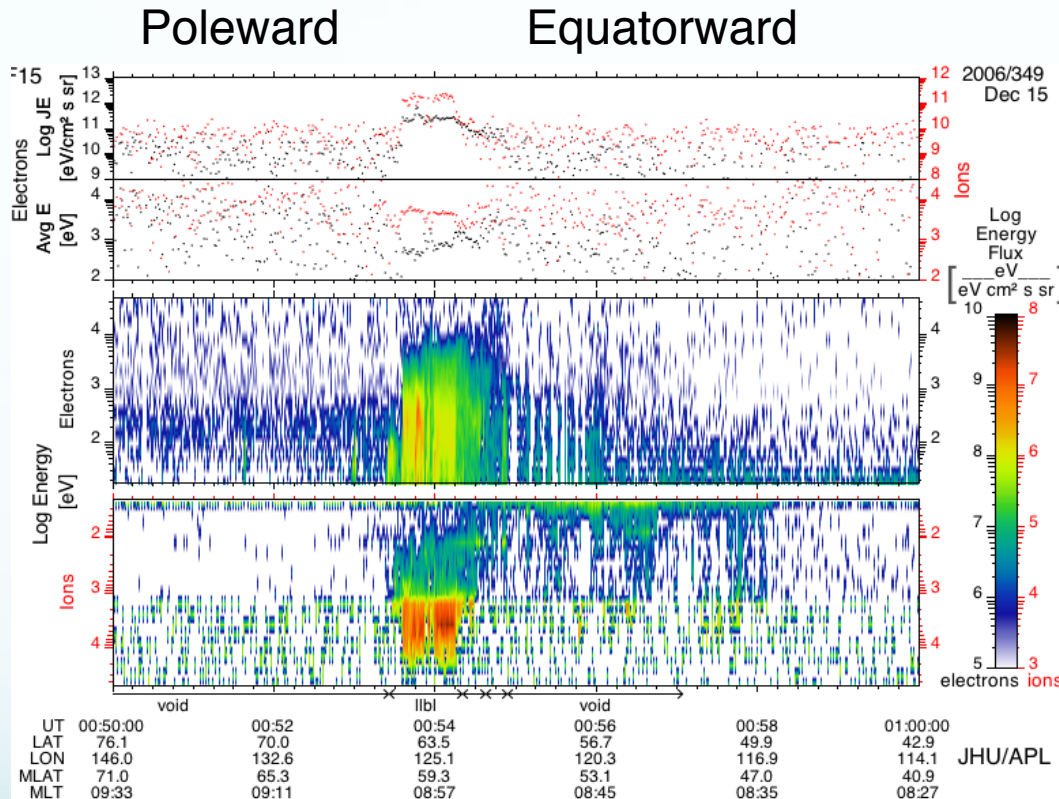


Dusk:

Eqbn: equatorward disturbance of Poynting flux

Pobn: last local maximum on the poleward side

Poynting Flux vs Aurora Precipitation



Dawn:

Eqbn: Poynting flux exceeds a threshold (3 mW/m^2)

Pobn: last local maximum on the poleward side

Poleward

Major Geomagnetic Storms in Solar Cycle 24

Date	Dstmin	Time of Dstmin	Kpmax	Time of Kpmax	Solar Cause
2011-08-06	-107	2011-08-06T04:00Z	7.67	2011-08-05T21:00-24:00Z	Multi-CMEs
2011-09-27	-101	2011-09-27T00:00Z	6.33	2011-09-26T15:00-21:00Z	CME
2011-10-25	-132	2011-10-25T02:00Z	7.33	2011-10-25T00:00-03:00Z	Multi-CMEs
2012-03-09	-131	2012-03-09T09:00Z	8.00	2012-03-09T06:00-09:00Z	Multi-CMEs
2012-04-24	-108	2012-04-24T05:00Z	7.00	2012-04-24T00:00-03:00Z	CME+HSS
2012-07-15	-127	2012-07-15T19:00Z	7.00	2012-07-15T18:00-21:00Z	CME
2012-10-01	-119	2012-10-01T05:00Z	6.67	2012-10-01T00:00-03:00Z	CME
2012-10-09	-105	2012-10-09T09:00Z	6.67	2012-10-09T00:00-03:00Z	CME+HSS
2012-11-14	-108	2012-11-14T08:00Z	6.33	2012-11-14T03:00-06:00Z	Multi-CMEs
2013-03-17	-132	2013-03-17T21:00Z	6.67	2013-03-17T06:00-09:00Z 2013-03-17T18:00-21:00Z	CME
2013-06-01	-119	2013-06-01T09:00Z	7.00	2013-06-01T03:00-06:00Z	CME+HSS

Associated CMEs (Flares)

CME starting time	Speed	LON/LAT	Half-Angle	Flare Class	Peak Time of Flare	Active Region
2011-08-02T06:40Z	900	15/4	35	M1.4	2011-08-02T06:19Z	1261(N17W12)
2011-08-03T13:55Z	1320	30/15	44	M6.0	2011-08-03T13:45Z	1261 (N17W30)
2011-08-04T04:10Z	1950	40/14	60	M9.3	2011-08-04T03:45Z	1261 (N16W38)
2011-09-24T13:09Z	1507	-45/12	50	M7.1	2011-09-24T13:20Z	1302 (N15E56)
2011-10-22T01:36Z *	590	30/42	55	N/A	N/A	Filament eruption
2011-10-22T10:36Z	990	90/52	60	M1.3	2011-10-22T11:10Z	1314 (N25W77)
2012-03-07T00:24Z	2200	-60/30	50	X5.4	2012-03-07T00:24Z	1429 (N18E31)
2012-03-07T00:54Z	1800	-23/4	65	X1.3	2012-03-07T01:14Z	1429 (N15E26)
2012-04-19T15:39Z	650	-18/-28	25	C1.8	2012-04-19T15:15Z	1462 (S22W28)
2012-07-12T16:48Z	1400	-6/-17	70	X1.4	2012-07-12T16:49Z	1520 (S16W09)
2012-09-28T00:18Z	1160	30/5	85	C3.7	2012-09-27T23:57Z	1577 (N06W34)
2012-10-05T03:24Z *	650	10/-28	47	B7.8	2012-10-05T07:30Z	1584 (S22W40)
2012-11-09T15:24Z	570	-11/-13	27	filament	2012-11-09T12:30Z	centered (S16E03)
2012-11-10T05:39Z	900	-16/-20	20	C2.0	2012-11-10T05:40Z	1608 (S20W07)
2013-03-15T06:54Z	1400	-2/-3	66	M1.1	2013-03-15T06:58Z	1692 (N09E06)
2013-05-27T01:39Z **	302	-11/36	34	N/A	N/A	N/A

Geomagnetic Storms (moderate and above) in 2013

Date	Dstmin	Time of Dstmin	Kpmax	Time of Kpmax	Solar Cause
2013-01-26	-51	2013-01-26T23:00Z	4.33	2013-01-26T00:00-03:00Z	HSS mixed with C-CME
2013-01-17	-53	2013-01-17T23:00-01:00Z	4.00	2013-01-17T15:00-18:00Z	S CME
2013-08-27	-54	2013-08-27T22:00Z	5.00	2013-08-27T18:00-21:00Z	HSS
2013-10-31	-55	2013-10-31T00:00Z	4.00	2013-10-30T21:00-24:00Z	CMEs
2013-05-25	-55	2013-05-25T07:00Z	5.67	2013-05-24T18:00-21:00Z	CMEs
2013-0-321	-55	2013-03-21T05:00Z	4.33	2013-03-21T00:00-06:00Z	CMEs
2013-03-01	-55	2013-03-01T11:00Z	5.00	2013-03-01T09:00-12:00Z	HSS
2013-05-18	-57	2013-05-18T05:00Z	5.33	2013-05-18T03:00 -06:00Z	CMEs
2013-03-29	-60	2013-03-29T17:00Z 2013-03-29T18:00Z	5.33	2013-03-29T15:00-18:00Z	HSS
2013-05-01	-67	2013-05-01T19:00Z	5.67	2013-05-01T18:00-21:00Z	S-type CME
2013-10-09	-65	2013-10-09T02:00Z	5.67	2013-10-08T21:00-24:00Z	CME
2013-07-14	-72	2013-07-14T23:00-24:00Z	5.00	2013-07-14T18:00-21:00Z	HSS mixed with C- CME
2013-06-07	-73	2013-06-07T06:00Z	5.67	2013-06-07T03:00-06:00Z	S CMEs+HSS
2013-11-11	-73	2013-11-11T 08:00Z	4.33	2013-11-11T06:00-09:00Z	HSS+CMEs
2013-10--02	-75	2013-10-02T08:00Z	7.67	2013-10-02T03:00-06:00Z	CME
2013-07-06	-79	2013-07-06T19:00Z	4.67	2013-07-09T06:00-09:00Z 2013-07-06T12:00-15:00Z	S CME +C limb CME (?)
2013-11-09	-86	2013-11-09T09:00Z	4.67	2013-11-09T03:00-09:00Z	C-type CMEs+HSS
2013-06-29	-98	2013-06-29T07:00Z	6.33	2013-06-29T03:00-06:00Z	S-Type CME+HSS
2013-06-01	-119	2013-06-01T09:00Z	7.00	2013-06-01T03:00-06:00Z	S-Type CME+HSS
2013-03-17	-132	2013-03-17T21:00Z	6.67	2013-03-17T06:00-09:00Z 2013-03-17T18:00-21:00Z	CME

Top 5 Geomagnetic Storms in 2013 and their associated solar drivers (CMEs)

Date	Dstmin	Time of Dstmin	Kpmax	Time of Kpmax	Solar Cause
2013-07-06	-79	2013-07-06T19:00Z	4.67	2013-07-09T06:00-09:00Z 2013-07-06T12:00-15:00Z	S CME +C- CME(?)
2013-11-09	-86	2013-11-09T09:00Z	4.67	2013-11-09T03:00-09:00Z	C-type CMEs+HS
2013-06-29	-98	2013-06-29T07:00Z	6.33	2013-06-29T03:00-06:00Z	S-Type CME+HSS
2013-06-01	-119	2013-06-01T09:00Z	7.00	2013-06-01T03:00-06:00Z	S-Type CME+HSS
2013-03-17	-132	2013-03-17T21:00Z	6.67	2013-03-17T06:00-09:00Z 2013-03-17T18:00-21:00Z	O-Type CME

CME starting time	Speed	LON/LAT	Half-Angle	Flare Class	Peak Time of Flare	Active Region
2013-06-30T02:24Z	386	4/9	34	N/A	N/A	N/A
2013-07-01T21:24Z	915	-85/11	63	filament	N/A	Northeast limb
2013-11-05T03:12Z	622	-24/46	39	prominence		N25E35
2013-11-05T08:36Z	844	-30/-45	31	M2.5	2013-11-05T08:18Z	1890 (S16E51)
2013-06-23T18:24Z	360	-9/31	61	N/A	N/A	N/A
2013-05-27T01:39Z	302	-11/36	34	N/A	N/A	N/A
2013-03-15T06:54Z	1400	-2/-3	66	M1.1	2013-03-15T06:58Z	1692 (N09E06)

SCORE CME Typification System

S-type: CMEs with speeds less than 500 km/s

C-type: Common 500-999 km/s

O-type: Occasional 1000-1999 km/s

R-type: Rare 2000-2999 km/s

ER-type: Extremely Rare >3000 km/s

<http://swrc.gsfc.nasa.gov/main/score>