Diagnosing LEO Satellite Anomalies Using NOAA 15 Electron Data in Association with Geomagnetic Perturbations

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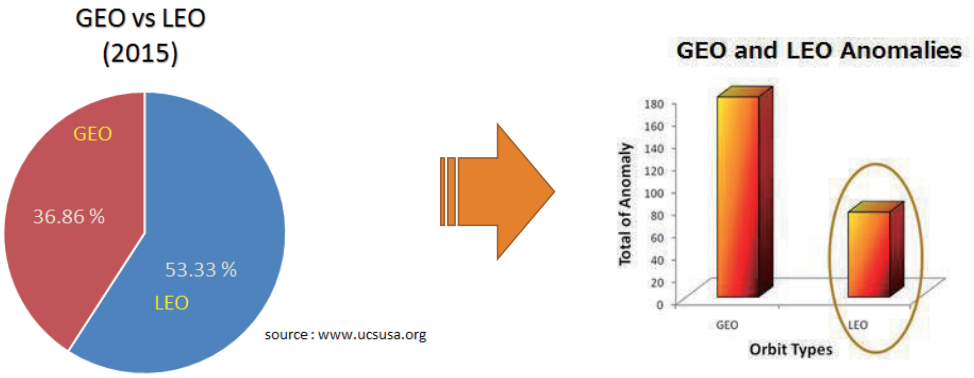
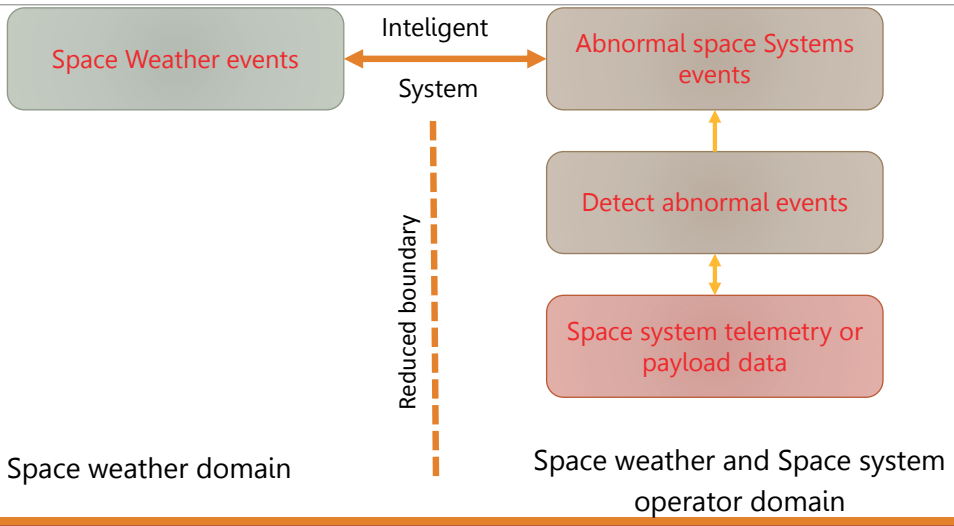
Introduction

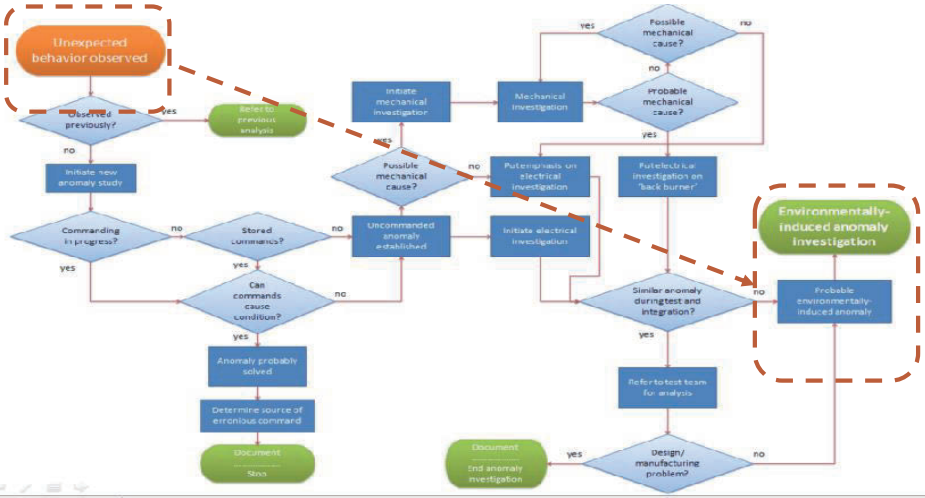


Changes of Paradigm (Tschan et al.,2012)

Now space weather and effects are effectively linked



Anomaly Analysis Methodology (Vampola, 1994)



The cause of many anomalies → ubiguously (telemetry data),

(Gubby and Evans, 2002)

anomaly is often attributed to space weather by default

Point of interest

Which energy particles (low / high) dominantly contribute to the satellite anomalies is still controversial (Choi et al., 2011)

Data and Method

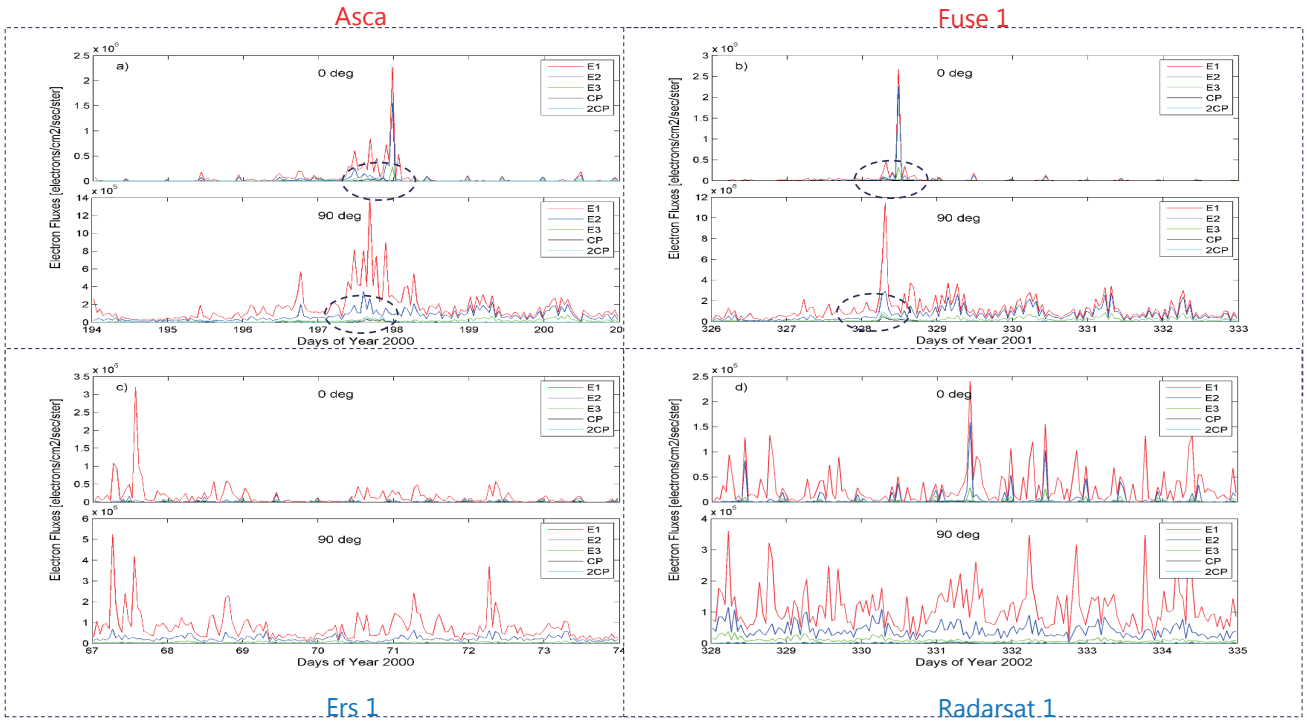
1. Satellite News Digest (SND)

No	Satellite Name	Anomaly Date	Alt. (km)	Incl. (deg)	Anomaly Description
1	ERS 1	10-Mar-00	772	98	total loss
2	ASCA	15-Jul-00	570	31	safe mode, total loss
3	Terra	26-Oct-00	702	98	telemetry Monitor error
4	FUSE	25-Nov-01	752	24	x-axis reaction wheel error
5	FUSE	10-Dec-01	752	24	y-axis reaction wheel error
6	Yohkoh	15-Dec-01	575	31	loss of control
7	Aqua	27-Jun-02	702	98	single Event Upset
8	Radarsat 1	27-Nov-02	792	98	loss of attitude
9	Radarsat 1	30-Dec-02	792	98	attitude control problem
10	Landsat 7	31-May-03	702	98	thematic Mapper failure
11	ICESat	30-Mar-03	595	94	one of three lasers aboard fails
12	Midori	24-Oct-03	805	98	total loss
13	DART	15-Apr-05	554	96	navigational errors
14	Monitor-E	18-Oct-05	527	97	loss of attitude control
15	Kirari	24-Nov-05	593	97	one of four reaction wheels fails
16	KOMPASS 2	29-May-06	422	78	various malfunctions
17	HST	30-Jun-06	564	28	ACS instrument fail
18	MetOp-A	4-Nov-06	821	98	temporary payload shutdow
19	Orbview 3	4-Mar-07	707	97	stops sending usable imagery
20	Orbcomm	10-Nov-08	758	98	satellite operation problems

Orbit

2. NOAA / MEPED Electrons Data

Channel	Ranges (keV)	Contaminant ranges (keV)
E1	30 - 100	210 - 2700
E2	100 - 300	280 – 2700
E3	300 - 2500	440 - 2700



3. Magnetic Data (Kp & Dst)

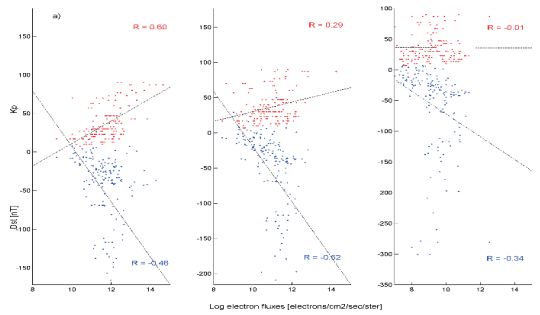
Geomagnetic act → Good indicator of surface charging phenomena

Conditions :

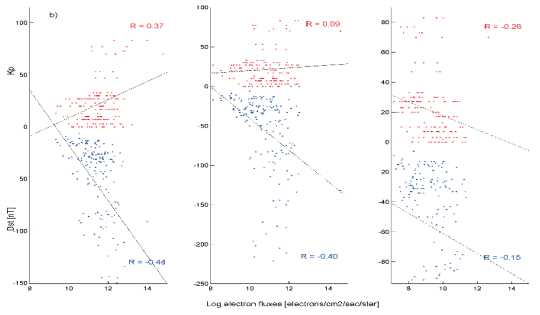
- Anomaly connected with magnetic act (storm)
- Connected with delayed response (Substorm)
- Weak link → not sufficient to determine anomaly

Mag. Activity → represents the change in plasma & particle population in space (Lam & Hruska, 1991).

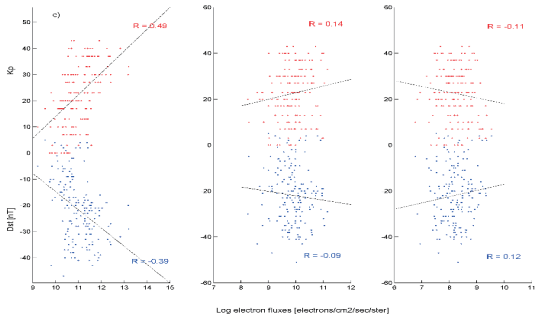
Asca



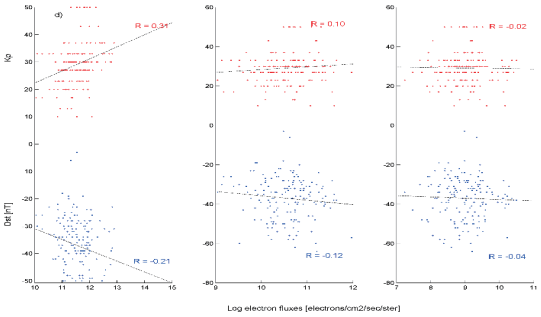
Fuse 1



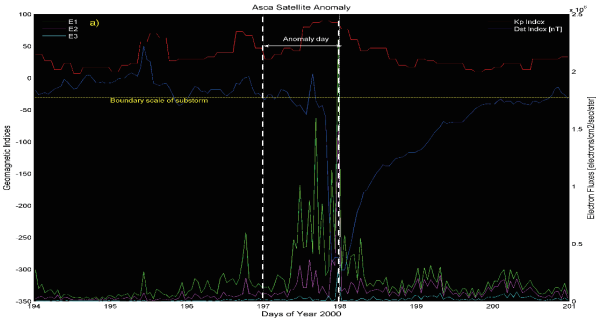
Ers 1

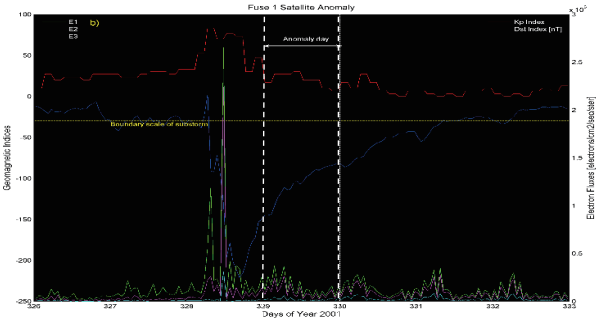


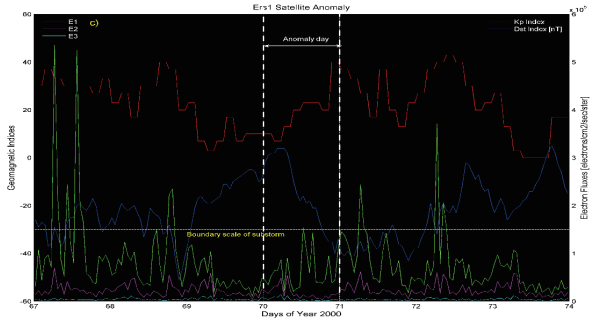
Radarsat 1

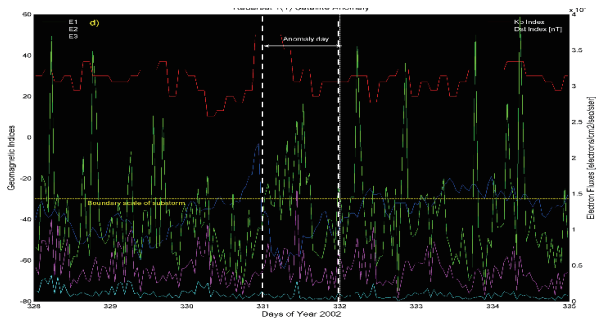


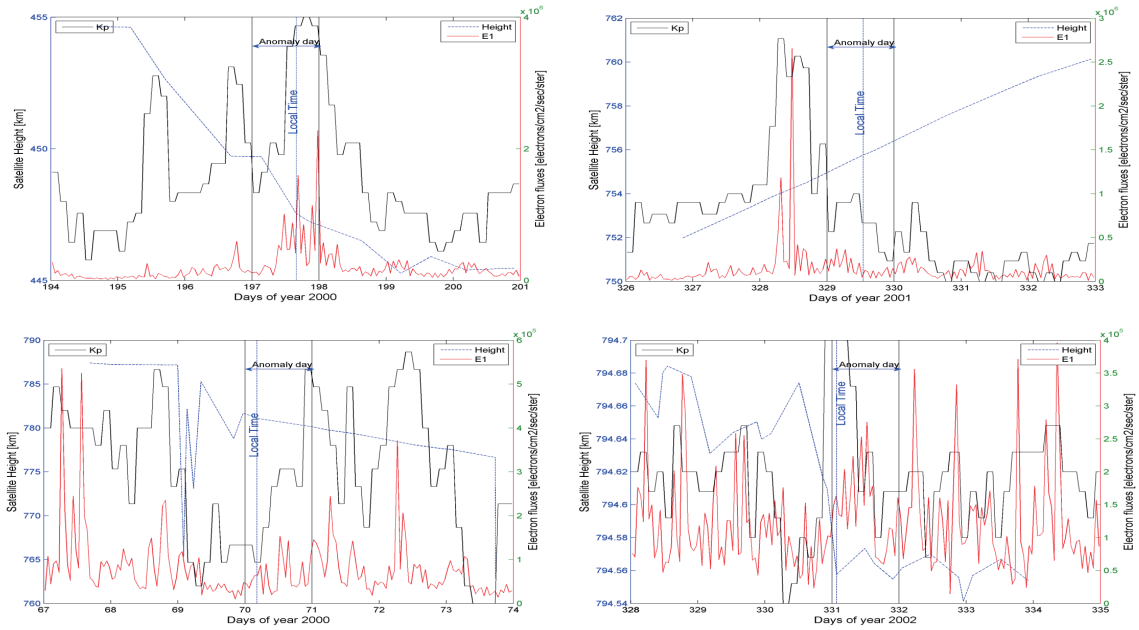
Electrons respond to magnetic perturbation







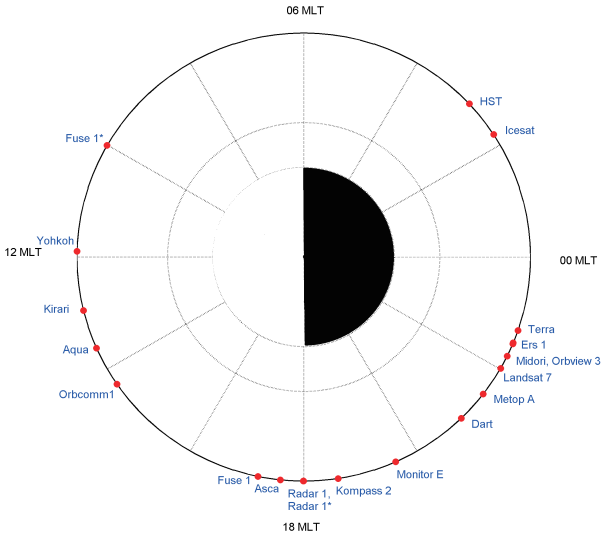




Satellite Local Time (SLT)

Comparison of mean local time between SND and TLE extraction (space-track)

Case Number	UTC (SND)	Local Time		Difference
		SND conversion	Extracted TLE	
#7 (Aqua)	1500	13:35:58	13:34:45	0:01:13 (-)
#11 (Icesat)	2349	2:12:40	2:10:59	0:01:41 (-)
#12 (Midori)	1234	22:28:48	22:29:38	0:01:50 (+)
#17 (HST)	0258	2:52:32	2:51:42	0:01:50 (-)



The majority of LEO anomalies :

Sector 1 : pre-midnight
Sector 2 : pre-dusk

The anomaly occurences are not always linier to magnetic perturbation.

It remains a challenge in predicting the anomaly on satellite in SW perspective.

Conclusion

- ✓ The increase of flux was not always occurred during magnetically disturbed condition.
- ✓ Lower energy electron fluxes linked to the LEO anomalies.
- ✓ The time delay existed in some anomaly occurences.
- ✓ LEO anomalies (LT) distributed within two sectors and dominantly occurred from dusk to midnight sector.